December 2019

City of Waukesha
Proposed Great Lakes Diversion

FINAL
ENVIRONMENTAL IMPACT STATEMENT

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

To the Reader

The City of Waukesha lies within a county that straddles the Great Lakes surface water divide and is therefore eligible to seek an exception from the prohibition of diversions under the Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement (Agreement) and Great Lakes—St. Lawrence River Basin Water Resources Compact (Compact). The Agreement is a good faith agreement between the Great Lake States and Provinces to manage water quantity in the Great Lakes Basin. The Agreement is implemented in the United States through the Compact—a legally binding contract among the eight Great Lakes States. The Applicant seeks to obtain a Lake Michigan water supply as a solution to its current water supply problems that include elevated levels of radium in the drinking water supply above the drinking water standard.

This document is a Final Environmental Impact Statement (EIS), prepared by the Wisconsin Department of Natural Resources (DNR) in compliance with Wisconsin Administrative Code (Wis. Adm. Code) Chapter NR 150, and Wisconsin Statute (Wis. Stat.) s. 1.11. The purpose of an EIS is to inform decision-makers and the public of the anticipated effects on the quality of the human environment of a proposed action or project and alternatives to the proposed action or project. The EIS is an informational tool—it is not a decision document.

The EIS process began when the public was invited to provide comments on the scope of the EIS analysis between February 5, 2010 and August 13, 2011. In 2011, three public scoping meetings were held on July 26, 27 and 28 in Pewaukee, Wauwatosa and Sturtevant, respectively. The DNR received 102 public scoping comments.

In October 2013, the City of Waukesha (Applicant) submitted a revised *Application for a Lake Michigan Diversion with Return Flow* (Application) to the Wisconsin Department of Natural Resources (DNR) and an Environmental Impact Report (EIR) to describe the proposal and potential environmental consequences. By 2015, the DNR prepared a Technical Review and Draft EIS. The Technical Review outlined the DNR's findings related to the Agreement, Compact and Wisconsin's Compact implementing statutes (a requirement of Article 201 of the Agreement, section 4.9 of the Compact, and Wis. Stat. s.281.346(4)(e)1.f.). The DNR invited the public to comment on the Technical Review and Draft EIS between June 25 and August 28, 2015. The DNR received 3,634 written comments from individuals and groups. Additionally, comments were received at three public hearings on August 17 and 18, 2015 in Waukesha, Milwaukee and Racine. Of the 404 people who registered at the hearings, 128 provided oral testimony. The DNR prepared a Preliminary Final EIS, which is included in this Final EIS in Appendix E.

On January 7, 2016, the DNR forwarded the Preliminary Final EIS, Technical Review and Application to the Great Lakes States, and Quebec and Ontario through the Great Lakes – St. Lawrence River Water Resources Regional Body (Regional Body) and Great Lakes – St. Lawrence River Water Resources Compact Council for review and decision as required by the Agreement and Compact. The Regional Body is the governing body of the Agreement and includes the Great Lakes premiers and governors. The Compact Council is the governing body of the Compact and includes the Great Lakes governors. Throughout this process, Great Lakes Tribes and First Nations were informed of the proposal and provided opportunities to comment. The Regional Body approved the proposed diversion with conditions on June 21, 2016, as described in this Final EIS.

In December 2017, the Applicant and the City of Milwaukee entered into an agreement for the supply of Lake Michigan water. In March 2018, the DNR received a supplemental EIR from the Applicant. The DNR subsequently revised the EIS and made it available to the public on August 2, 2019. The DNR invited the public to comment on the revised EIS between August 6 and September 19, 2019 and received 28 written comments from individuals and groups. Additionally, comments were received at a hearing on August 20, 2019 in Waukesha. Of the 17 people who registered at the hearing, 8 provided oral testimony. Summaries of the public comments received in 2015 and 2019, and the DNR's responses to them, are available on the DNR's public comments received in 2015 and 2019 are included with this Final EIS and can be found the DNR's webpage for the proposed diversion.

This Final EIS explains the Applicant's proposal to use water from Lake Michigan (in order to meet its water supply needs) and return wastewater to the Lake Michigan basin as required by the Agreement and Compact. The Final EIS presents the potential impacts of alternative water supply and return flow options, including the current proposal.

The Compact Council and Regional Body has conditionally approved the diversion. Before any specific permits or approvals are issued, the DNR is issuing this Final EIS and will be issuing a WEPA compliance determination. The Applicant will need to acquire all permits and approvals for the diversion from the State of Wisconsin before the DNR can approve the diversion.

The DNR maintains a webpage with information related to the Applicant's diversion application, including the public participation process, communications with the Applicant, and other supporting materials.

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Acronyms and Abbreviations

ADD	average day demand
Agreement	Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement
Applicant	City of Waukesha
Application	City of Waukesha Application for a Lake Michigan Diversion with Return Flow
AWE	Alliance for Water Efficiency
AWWA	American Water Works Association
BPS	Booster Pump Station
CE	Categorical exclusion analysis under NEPA
CEM	conservation and efficiency measure
CFS	cubic feet per second
CMOM	Capacity, Management, Operations and Maintenance
CN	Canadian National Railway Company
Compact	Great Lakes—St. Lawrence River Basin Water Resources Compact
Compact Council	Great Lakes-St. Lawrence River Basin Water Resources Council
CWP	Clean Water Plant (This is the Applicant's name for the Waukesha Wastewater Treatment Plant [WWTP]. This EIS instead uses WWTP.)
DATCP	Wisconsin Department of Agriculture Trade and Consumer Protection
department	Wisconsin Department of Natural Resources
DIP	Ductile Iron Pipe
DNR	Wisconsin Department of Natural Resources
EIS	Environmental Impact Statement
EO	Elemental Occurrence
ER	Environmental Report
EPA	United States Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GIS	Geographic Information System
GLB	Great Lakes basin
GMA	Groundwater Management Area
GPCD	gallons per capita per day

GPD	gallons per day
GWA	Great Water Alliance
HDD	Horizontal Directional Drilling
I/I	infiltration and inflow
KPI	Key Performance Indicator
MCL	maximum contaminant level
MDD	maximum day demand
MG	million gallons
mg/L	milligrams per liter
MGD	million gallons per day
MGY	million gallons per year
MMSD	Milwaukee Metropolitan Sewerage District
MRB	Mississippi River basin
MWWAT	Michigan Water Withdrawal Assessment Tool
NEPA	National Environmental Policy Act
NHI	Natural Heritage Inventory
NRHP	National Register of Historic Places
PCB	polychlorinated biphenyl
piC/L	picocuries per liter
PRESTO	Pollutant Load Ratio Estimation Tool (DNR model)
PSC	Public Service Commission of Wisconsin
psi	pounds per square inch
Regional Body	Great Lakes-St. Lawrence Water Resources Regional Body
RFCB	Return Flow Control Building
RFDS	Return Flow Discharge Site
RFPS	Return Flow Pump Station
ROW	right-of-way
SDWA	Safe Drinking Water Act
SEWRPC	Southeastern Wisconsin Regional Planning Commission
SPARROW	Spatially-referenced Regression on Watershed Attributes (model)
TDS	total dissolved solids
TMDL	total maximum daily load
TP	total phosphorus

TRC	TRC Companies, Inc.
TSS	total suspended solids
ug/L	micrograms per liter
umhos/cm	A unit of electrical conductivity, micromhos
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
WBR	Winter Base-Rate
WDOT	Wisconsin Department of Transportation
WEPA	Wisconsin Environmental Policy Act
WGNHS	Wisconsin Geological and Natural History Survey
WPDES	Wisconsin Pollutant Discharge Elimination System
WQBEL	Water quality based effluent limits
WSPS	Water Supply Pump Station
WWI	Wisconsin Wetland Inventory
WWTP	Wastewater Treatment Plant (The Applicant refers to the Waukesha WWTP as the "Clean Water Plant" or CWP. This EIS only uses WWTP.)
WWU	Waukesha Water Utility

1 Introduction and project summary

1.1 Proposed project

1.1.1 Process summary

The City of Waukesha, Wisconsin, located in southeast Wisconsin, 17 miles west of Lake Michigan, received an exception from the prohibition of diversions under the Great Lakes—St. Lawrence River Basin Water Resources Compact (Compact) and Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement (Agreement). The Compact prohibits diversions of Great Lakes water, with limited exceptions. One exception allows a “community within a straddling county,” such as Waukesha, to apply for a diversion of Great Lakes water.

Figure 1-1. Location of City of Waukesha and Great Lakes Water Basin

The proposed project (current proposal) includes obtaining treated Lake Michigan drinking water from the City of Milwaukee, treating the water after it is used at the Waukesha Wastewater Treatment Plant (WWTP) and returning the water to the Root River, a tributary to Lake Michigan. The current proposal includes construction of drinking water supply and drinking water conditioning features, as well as wastewater treatment and treated effluent return flow features.

The Wisconsin Department of Natural Resources (DNR) received the City of Waukesha’s (Applicant) diversion application in May 2010. In October 2013, the Applicant submitted a revised *Application for a Lake Michigan Diversion with Return Flow* (Application) to the DNR. As part of this process, the Applicant submitted an environmental impact report (EIR). The DNR has completed a draft Environmental Impact Statement (EIS), a Preliminary Final EIS, revised EIS, and this Final EIS under the Wisconsin Environmental Policy Act (Wis. Stat. s.1.11) and the DNR procedures for environmental analysis and review (Wis. Adm. Code ch. NR 150). In March 2018, the Applicant submitted a supplemental EIR and has since submitted additional information. The DNR used this information in the development of this Final EIS.

This Final EIS evaluates the current proposal and alternatives for water supply and return flow, and contains seven sections:

- Section 1: Introduction and Project Summary – An overview of the project, including the review and decision by the Compact Council.
- Section 2: Proposed Project – A description of the proposed route for water supply from the City of Milwaukee and return flow to the Root River.
- Section 3: Project Alternatives – A summary of the proposed pipeline route alternatives and facilities after the Compact Council’s June 21, 2016 decision.

- Section 4: Affected Environment – The existing natural resources that are in the region that could be impacted by this project.
- Section 5: Environmental Effects – An analysis of the potential impacts that could result from the current proposal and alternatives.
- Section 6: Comparison of Alternatives.
- Section 7: Cumulative Effects and Evaluation.
- Appendix A: Proposed pipeline routes
- Appendix B: Alternative pipeline routes
- Appendix C: Alternatives screening process
- Appendix D: Proposed project schedule
- Appendix E: Preliminary Final EIS – Released in January 2016.

The DNR maintains a website on the Waukesha diversion application.

1.1.2 Purpose and need for proposed project

The purpose of the proposed project is to provide a long-term water source that can meet the Applicant's water supply needs, is protective of human health and the environment, and is sustainable.

The Applicant has long relied on a deep aquifer groundwater supply, but depressed water levels have compounded a problem of radium concentrations in the groundwater that are higher than the U.S. Environmental Protection Agency's water quality standard for radium under the Safe Drinking Water Act. Radium is a naturally-occurring carcinogen. As a result, the City's water supply is supplemented by water from the shallow groundwater aquifer, which helps to reduce the radium concentration. In 2017, the Applicant withdrew 5.8 million gallons per day (MGD).

Under a 2009 judgement by the Wisconsin Circuit Court for Waukesha County (State of Wisconsin vs. City of Waukesha, Case No. 2009-CX-000004) the Applicant was required to develop a permanent solution to the radium contamination problem by June 30, 2018. In October 2013, the Applicant submitted a revised application for the use of Lake Michigan water under the Great Lakes Compact (CH2M Hill 2013, Volumes 1-5). A Lake Michigan water supply would allow the Applicant to meet the radium water quality standard. In June 2016, the Compact Council approved the use of Lake Michigan water and affirmed this decision in August 2017 following an administrative challenge (Compact Council 2016 and 2017).

Given the Compact Council's approval and the lead time necessary to permit and install the necessary infrastructure for a Lake Michigan water supply, the Applicant and the State of Wisconsin agreed to an extension of the radium compliance deadline to September 2023. This extension was approved by the Circuit Court and requires the Applicant to have a Lake Michigan water source operational by September 2023. The settlement also provides some interim measures to protect public health:

- The City has purchased back up well pumps to shorten the time radium compliant wells are out of service, if one fails, to a few weeks rather than 4 months or longer.
- The City must notify the public if non-radium compliant wells are in use.

- The City must design and start the approval process for adding temporary additional radium treatment to one of its wells.
- If the City is not meeting court ordered timelines to construct the Lake Michigan supply, the City will need to construct and operate the temporary treatment until the Lake Michigan supply is complete.

Sections 2.2 and 4.2 of the Preliminary Final EIS (Appendix E) address an alternative consistent with temporary additional radium treatment as required by the amended court order in the event that the Lake Michigan supply is not on track to be completed by 2023. This alternative is not a viable permanent solution with sufficient capacity to meet the Applicant's demand estimates.

1.1.3 Diversion area

The delineated diversion area sets the outer boundary of municipal water supply service expansion. The Applicant had its proposed water supply service area delineated by the Southeastern Wisconsin Regional Plan Commission (SEWRPC) in accordance with Wis. Stat. 281.348. The delineated service area included the City of Waukesha, portions of the City of Pewaukee, and portions of the Towns of Delafield, Genesee, and Waukesha. Inclusion in the water supply service area was based on several factors including future land use plans, sanitary sewer area plans, and historic private well contamination.

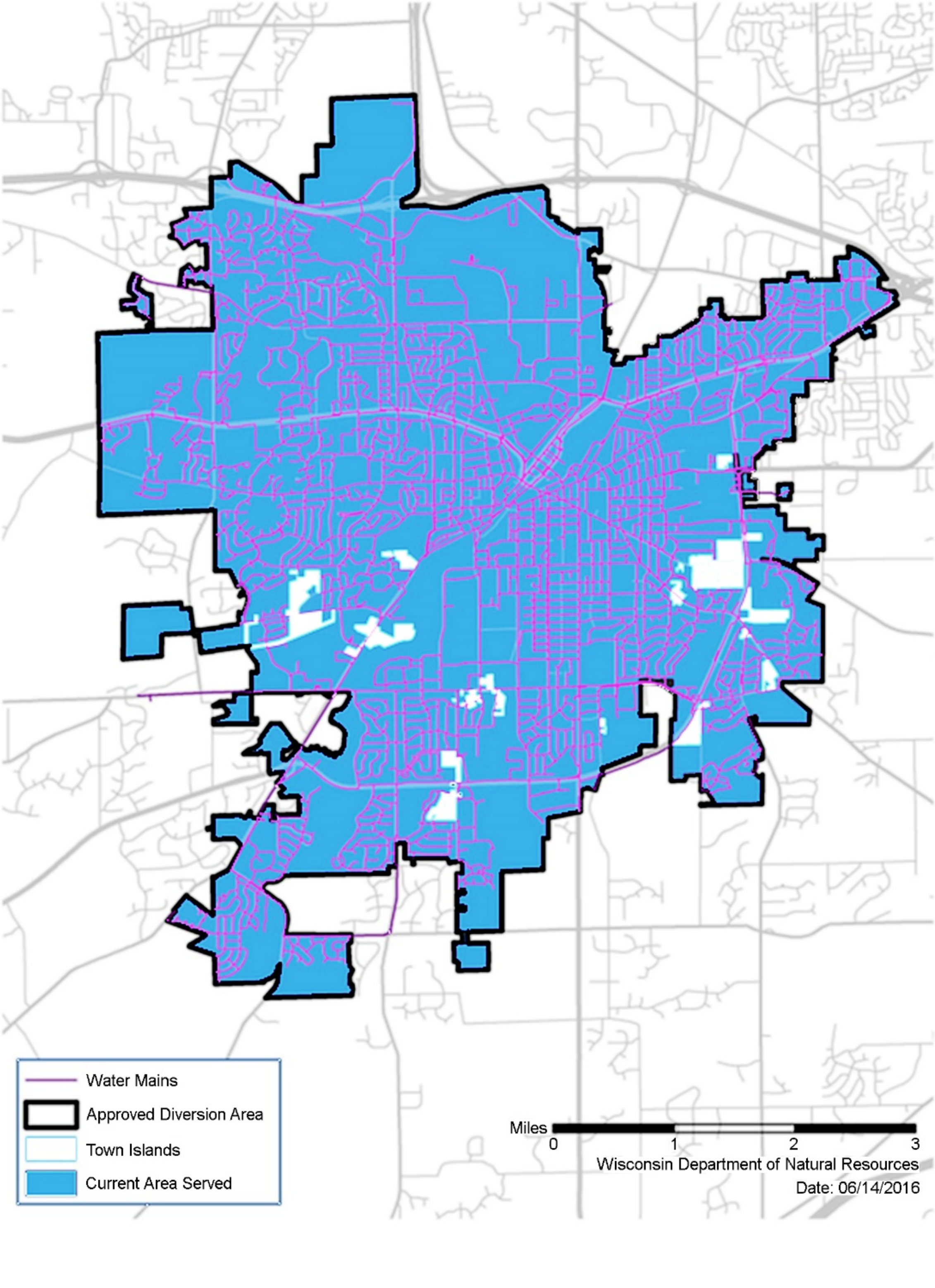
The Compact Council's decision approving the diversion specified that diverted water could only be provided to the following fixed areas:

(i) Incorporated land within the boundaries of the City of Waukesha and land outside the City of Waukesha's jurisdictional boundaries that [was] served with municipal water by the Applicant through the Waukesha Water Utility as of May 18, 2016…

(ii) Land lying within the perimeter boundary of the City of Waukesha that is part of unincorporated land in the Town of Waukesha… (Compact Council 2016: 6)

The approved diversion area is shown in Figure 1-2. The reduced size of the diversion area resulted in a smaller approved diversion amount: 8.2 MDG (rather than the 10.1 MGD requested). Wisconsin state law recognizes that a diversion area approved by the Compact Council becomes the water supply service area for a public water supply system proposing to make a diversion from the Great Lakes basin (sec. 281.348(3)(cr), Wis. Stats).

Figure 1-2. Compact Council-approved diversion area



2 Current proposal

In 2017, the Applicant selected the City of Milwaukee to be its supplier of treated Lake Michigan water, over the City of Oak Creek (the alternative supplier), on account of the relative cost savings to Waukesha Water Utility (WWU) rate payers. The proposed Lake Michigan water supply design would enable the WWU to meet an annual average daily demand (ADD) of 8.2 million gallons per day (MGD). This is the ADD projected at ultimate build-out[1] within the diversion area approved by the Compact Council on June 21, 2016 (see Figure 1-2) (Compact Council 2016). The proposed water supply and return flow facilities are shown in Figure 2-1.

Once used, water diverted from Lake Michigan would be treated by the City of Waukesha Wastewater Treatment Plant (WWTP) and returned to the lake via the Root River. Some treated wastewater would continue to be discharged into the Fox River within the Mississippi River Basin, since the WWTP serves areas outside of the approved diversion area. To ensure that the volume of water returned to Lake Michigan is approximately equal to the volume diverted, Condition H of the Compact Council's approval states that the Applicant

> *must return to the Root River… a daily quantity of treated wastewater equivalent to or in excess of the previous calendar year's average daily Diversion. On any days when the total quantity of treated wastewater is insufficient to meet this target, all treated wastewater must be returned to the Root River.* (Compact Council 2016: 13)

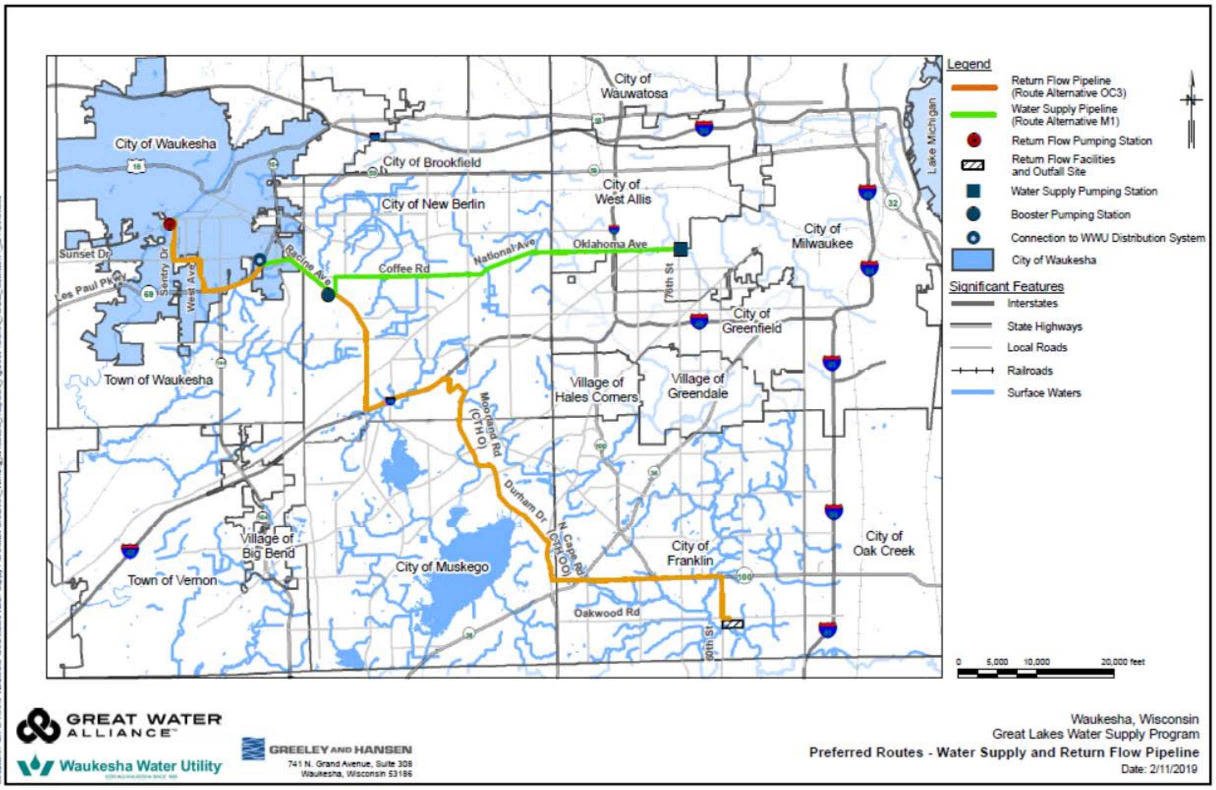
Based on an analysis of historical water demand and treatment flows, the Applicant estimates an annual average return flow to the Root River of between 100 and 113 percent of the previous year's average daily diversion (City of Waukesha 2018). At the projected build-out ADD of 8.2 MGD, this translates to an average daily return flow of up to 9.3 MGD. Potential impacts of treated wastewater on the Root River and Lake Michigan (Section 5.1.1 and 5.1.2) are therefore reported for a range of annual average daily return flows of up to 9.3 MGD.

2.1 Description of proposed facilities

The current proposal includes obtaining treated Lake Michigan drinking water from the City of Milwaukee, treating the water after it is used at the Waukesha wastewater treatment plant (WWTP) and returning the water to the Root River, a tributary to Lake Michigan (Figure 2-1). The proposal includes construction of drinking water supply and drinking water conditioning features, as well as wastewater treatment and treated effluent return flow features. The existing discharge to the Fox River from the WWTP would also be maintained for any daily effluent flow not required to be returned to the Root River. The major features of the infrastructure are described below. Potential construction and operational costs are presented in Section 2.1.13.

[1] According to the Applicant's Water Supply Service Area Plan "buildout condition exists when all the land available for development in the WSSA [water supply service area] has been developed in a manner consistent with the southeastern Wisconsin regional water quality, water supply, and land use plans" (CH2M Hill 2013, Vol. 2, pg. 6-1). Appendix C of that plan reports projected population and water demand at build-out, by civil division.

Figure 2-1. Proposed water supply and wastewater return flow routes



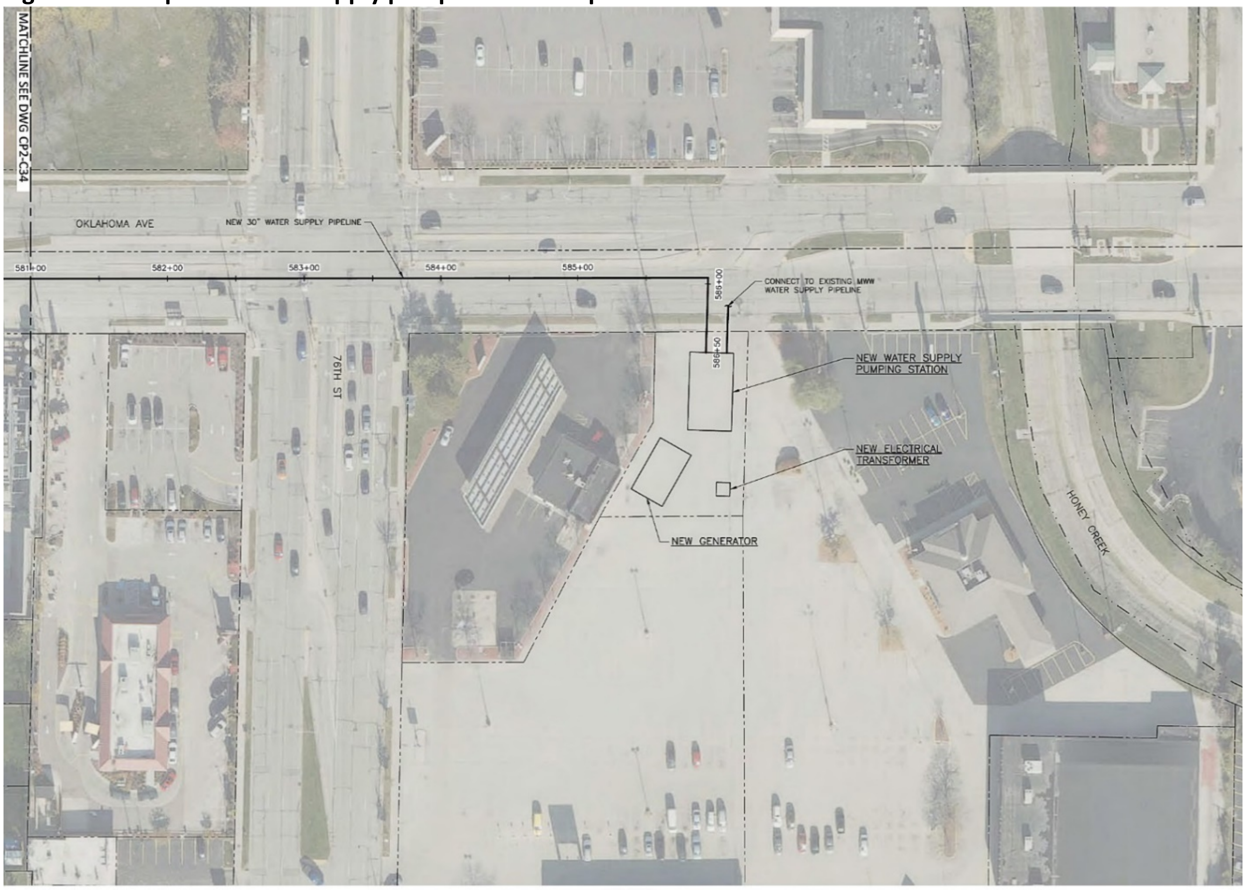
2.1.1 Water supply pump station (WSPS)

The water supply pump station (WSPS) would convey potable water from the supplier to the booster pump station (BPS). The WSPS and other pump stations would include pumps, butterfly and ball valves, and a backup power generator building. The WSPS location is planned to be at a property on the southeast corner of 76th Street and Oklahoma Avenue in the City of Milwaukee. Figure 2-2 shows the preliminary site layout for the WSPS.

2.1.2 Water supply pipeline (alternative M1-preferred)

A 30-inch nominal-diameter supply line would convey water from the water supplier to the BPS and a 36-inch nominal-diameter discharge line would convey water from the BPS to the connection point in the existing Waukesha water distribution system. The proposed Milwaukee water supply pipeline (M1-preferred) would be approximately 11.40 miles long.

Figure 2-2. Proposed water supply pump station site plan



PLAN

Source: Great Water Alliance, September 2018

The proposed pipeline route would include a connection to the City of Milwaukee water distribution system near the intersection of West Oklahoma Avenue and South 76th Street. From this connection, the water supply pipeline would head west through the City of Milwaukee, the City of West Allis, City of New Berlin to the City of Waukesha. The pipeline would follow Oklahoma Avenue, National Avenue, Coffee Road and then Swartz Road to the proposed BPS. After the BPS, the proposed supply pipeline would follow Racine Avenue and Sunset Drive to the WSCB and a connection to the WWU distribution system. For a more detailed description of this proposed pipeline route, see Appendix A – Section A.1.

2.1.3 Booster pumping station (BPS) facility

A booster pumping station with two water storage reservoirs (tanks) will be required to attenuate water demand between the water supply pumping station and WWU's existing water distribution system, and to provide for emergency storage. Each water tank will hold up to 8.6 million gallons. The BPS will convey flow from the tanks to the WWU water distribution system. The proposed site for the BPS facility is at the southeast corner of South Racine Avenue and Swartz Road in the City of New Berlin. The property (Waukesha County parcel # 1224994) is owned by Waukesha County and is part of the 579-acre Minooka Park. The primary land cover of the parcel is open field and wet meadow. The BPS facility would be located on upland on the southeastern portion of the parcel (see Figure 2-3). Based on the most recent site plan, the facility would cover a little over five acres.

Figure 2-3. Proposed BPS location and site plan

Sources: Site plan (September 2019) from Great Water Alliance. Aerial image (2015) from USDA National Agricultural Imagery Program.
Note: For illustration purposes, only that portion of the site plan in which construction/ land disturbance would occur is shown here.

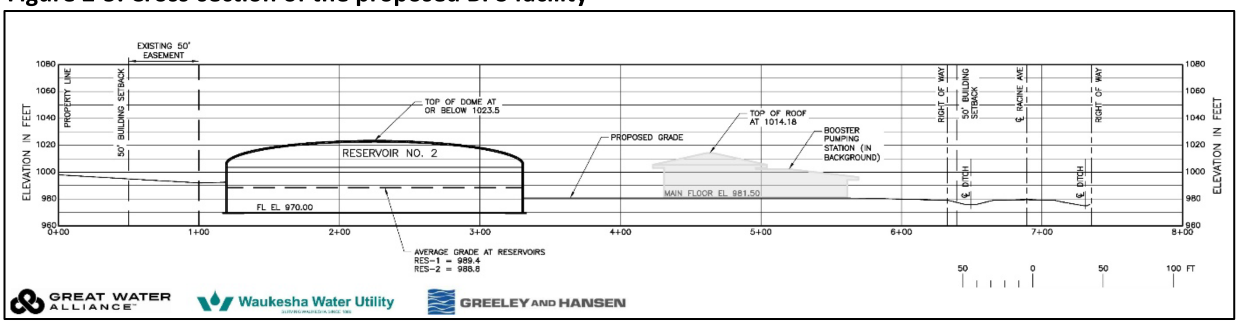
The firm capacity of the BPS will be 19 MGD to meet peak hour demand flow. The BPS will include variable-speed pumps to adjust the pumping rate, all piping and valves, and necessary controls, instrumentation, and electrical equipment for the pumping station, including backup power generation. Chemical feed facilities will provide the ability to maintain water quality characteristics, including residual disinfectant and corrosion inhibitor levels. All supporting infrastructure for the operation of the BPS, including the two water storage tanks and chemical feed facilities, would be co-located on the site.

Figure 2-4 illustrates what the facility would look like viewed from the intersection of Swartz Road and Racine Avenue. To minimize the visual impact, the water supply storage tanks would be constructed partially below grade – to an average depth of approximately 19 feet – such that the average height of the tanks will be approximately 35 feet above grade (see Figure 2-5). Dewatering excavated areas may be necessary depending on the accumulation of runoff during construction and the depth to groundwater. Dewatering would be regulated under one or more of the following: the Wisconsin Pollutant Discharge Elimination System (WPDES) construction stormwater general permit (WI-S067831-5), WPDES dewatering operations general permit (WI-0049344-05-0), and/or an individual WPDES discharge permit.

Figure 2-4. Perspective of the proposed BPS facility facing southwest from the corner of Swartz & Racine Ave.

Source: Great Water Alliance
Note: For illustration purposes, trees are represented at approximately 50% of their mature height.

Figure 2-5. Cross-section of the proposed BPS facility

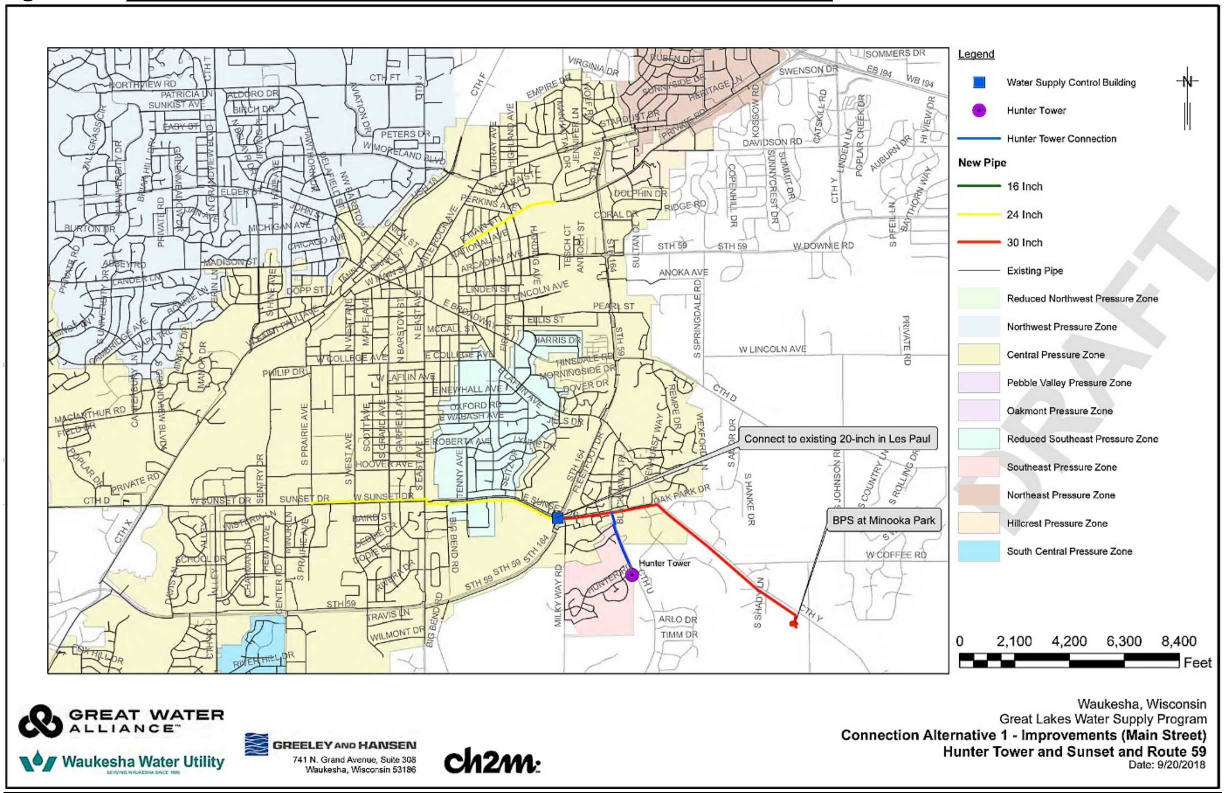


2.1.4 Water supply connection to the Waukesha Water Utility system

From the BPS, a 30-inch connection would supply WWU's existing distribution system with potable Lake Michigan water. The proposed location of the connection is at the intersection of East Sunset Drive and Les Paul Parkway (Wis. Hwy 59) in Waukesha. See Figure 2-6.

A connection to the WWU water distribution system would also be provided to Hunter Tower on Guthrie Road. The Hunter Tower interconnection at the water supply control building (WSCB) would provide an emergency pressure source for the booster pumping station (BPS) discharge pipeline. The WSCB would have a 12-inch pressure reducing valve (PRV) connection the highline booster pumping station/Hunter Tower to the BPS discharge pipeline. During normal operation the PRV would be set to maintain a BPS Discharge Pipeline pressure of 96 psi. If pressure in the BPS Discharge Pipeline would drop below 96 psi the PRV would open and the higher pressure at the highline booster pumping station/Hunter Tower would allow the BPS discharge pipeline to maintain minimum required pressures.

Figure 2-6. Water supply connection to the Waukesha Water Utility system



2.1.5 Wastewater treatment

Once used, water would be collected in the City of Waukesha's existing sanitary sewer collection system and conveyed to the existing wastewater treatment plant (WWTP) to be treated before discharging to the Root River. The Applicant's existing WWTP currently produces high-quality treated effluent.

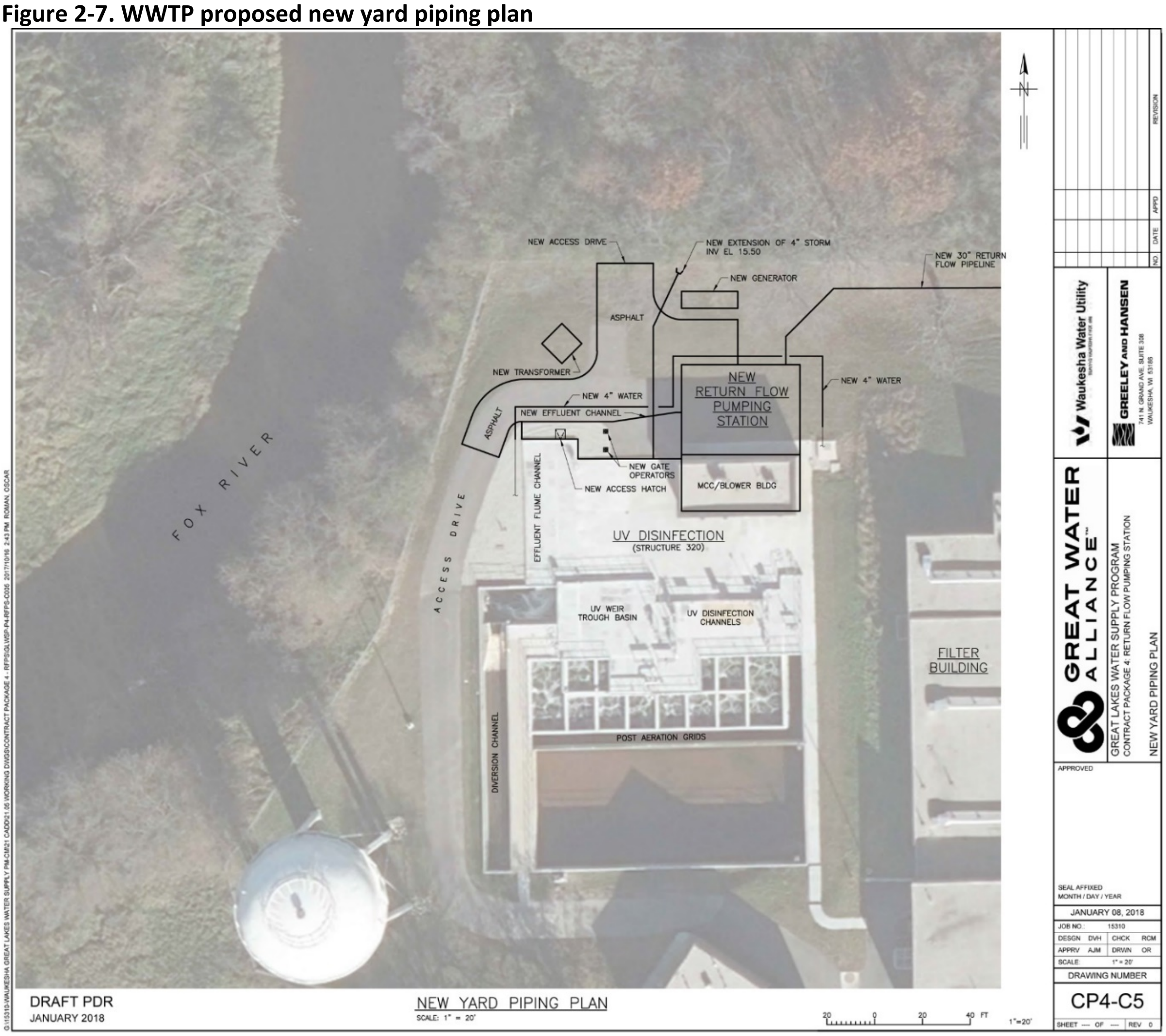
To meet future phosphorus water quality based effluent limits (6-month average May-Oct., Nov-Apr.) for discharge to the Fox River (0.075 mg/L) and Root River (0.060 mg/L) the Applicant will replace or upgrade the existing tertiary treatment facilities. Two ballasted flocculation and settling alternatives, CoMag and ACTIFLO, were evaluated and pilot tested, and had the lowest present worth cost as compared to other alternative technologies (Blue PRO reactive filtration, Veolia Disk Filtration, and the CLEARAS Water Recovery System). The Applicant has completed a facility plan amendment (City of Waukesha Facility Plan, 2018) and is completing a pilot of an Aqua-Aerobics disk filter system in early 2019. The Applicant has begun preliminary engineering of the phosphorus treatment system and will select a final tertiary treatment system for final design after the disk filter pilot. All of the tertiary treatment alternatives being considered reside within the WWTP site.

2.1.6 Return flow pump station (RFPS)

A return flow pump station (RFPS) would be constructed at the WWTP to pump the return flow from the WWTP to the Root River. The RFPS would have a firm capacity of 12.6 MGD and would include variable-speed pumps to adjust the pumping rate according to flow available at the WWTP up to a maximum flow rate to meet daily return flow volume requirements to the Root

River. The return flow would be consistent with the conditions required by the Compact Council approval for Waukesha obtaining Lake Michigan water (Compact Council 2016) so that the previous year's average daily withdrawal amount per day would be returned to the Root River and any additional flow would be discharged to the Fox River via the existing outfall. On days when the return flow requirement cannot be met, the Compact Council decision requires all available wastewater to be returned to the Root River. The RFPS would most likely be located in the northwest portion of the parcel containing the existing Waukesha WWTP (Parcel 1329989, Waukesha County) near Sentry Drive and College Avenue. Figure 2-7 shows the preliminary layout information.

Figure 2-7. WWTP proposed new yard piping plan



2.1.7 Return flow pipeline (alternative OC3-preferred)

A 30-inch nominal-diameter return flow pipeline would convey treated effluent from the WWTP RFPS to the return flow control building (RFCB) and Root River outfall. Where both a water supply and return flow pipeline would be along the same route, the two pipelines would be trenched in a common corridor. The proposed return flow pipeline would be 20.5 miles long.

A brief description of the proposed return flow pipeline alignment (OC3-preferred) is presented below following the flow path from Waukesha to Milwaukee. The proposed pipeline would be installed using open trench construction except as otherwise indicated. For a more detailed description of this proposed pipeline route, see Appendix A – Section A.2.

The RFPS and the start of the return flow pipeline would be built at the WWTP located off Sentry Drive. From the RFPS, the return flow pipeline would run south and east through the City of Waukesha, Town of Waukesha, City of New Berlin, City of Muskego, and City of Franklin to the return flow discharge facilities at the southeast corner of the intersection of West Oakwood Road and South 60th Street. The return flow discharge facilities include the RFCB, the reaeration structure, and conveyance facilities to the outfall at the Root River.

The return flow pipeline would begin on the western side of the Waukesha WWTP located on Sentry Drive. The pipeline would first cross the WWTP property from west to east. The pipeline would then turn south on Sentry Drive and then follow West Sunset Drive, West Avenue, Wisconsin Highway 59 and East Sunset Drive. At the intersection of Sunset Drive and Racine Avenue, the proposed return flow pipeline would converge with the proposed supply pipeline into a common pipeline corridor. The proposed common pipeline corridor would then proceed east along Sunset Drive and Racine Avenue. The two proposed pipelines would diverge from the proposed common corridor at the intersection of Racine Avenue and South Swartz Road. The proposed return flow pipeline would continue south along Racine Avenue while the proposed water supply pipeline would proceed north along Swartz Road. The proposed return flow pipeline would then turn southeast along Racine Court before following Interstate 43. After crossing two private land parcels, the pipeline would then follow Small Road, Westridge Drive, Moorland Road, Durham Drive, North Cape Road and Ryan Road. Along Ryan Road, the proposed pipeline would cross eight private land parcels. The proposed return flow pipeline would then follow 60th Street south to the intersection with West Oakwood Road. The Root River outfall (RFDS) would be located in the southeast quadrant of that intersection.

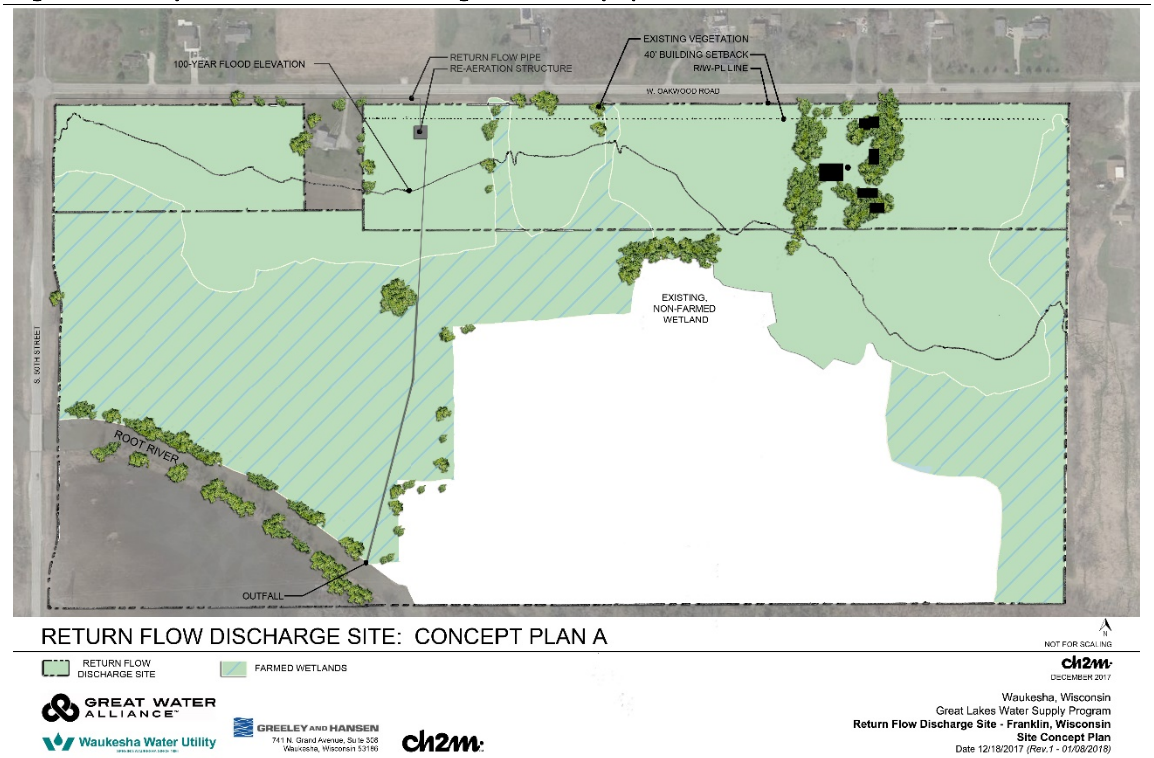
2.1.8 Return flow discharge site (RFDS) facilities

The return flow pipeline would be a pressure pipeline and would end at the return flow discharge site (RFDS), a property in the City of Franklin (Parcel 9489998001, Milwaukee County) at the southeast corner of the intersection of South 60th Street and West Oakwood Road. WWU has an agreement to purchase this property. The RFDS facilities would include the following:

- Return flow sampling and monitoring station for temperature and dissolved oxygen (DO)
- Reaeration structure
- Pipeline from the reaeration structure to the Root River outfall
- USGS Gage

Returned wastewater will be channeled through a low-profile proprietary cascade aeration system, and immediately after, monitored for DO and temperature. A conveyance system (pipeline) would be used to convey the water from the reaeration structure to the Root River outfall. An access road may be required for maintaining and accessing the outfall and USGS gage locations. The outfall would be near the southern boundary of the parcel, just north of the Root River. A USGS flow measurement gage will continue to measure flow and other Root River information at this site. The proposed preliminary site layout is shown in Figure 2-8.

Figure 2-8. Proposed return flow discharge site concept plan



The potential permanent access road at the proposed RFDS could be approximately 1,200 feet long, with a 4-foot-high embankment with a 12-foot-high top width. The total embankment width could be approximately 36 feet. The roadway would consist of either gravel or bare ground. This access road could originate from South 60th Street near the Root River and run along the north side of the Root River. Access roads would be approximately 25 feet wide and would vary in length depending upon facility siting constraints and needs. Access roads would be either paved or gravel depending upon location and facility being accessed. Landscaping at the proposed facilities would conform to the surrounding area and would comply with local and municipal guidelines. Native species would be used where possible.

2.1.9 Common water supply pipeline and return flow pipeline features

The proposed pipeline right-of-way (ROW) would be within existing road ROW along approximately 97.4 percent of the route. Thirty-inch nominal diameter pipes would be used for both the water supply and return flow pipelines. Preferred materials for the water supply and return flow pipelines are DIP or steel pipe for the supply pipeline, and DIP steel or Portland cement concrete pipe for the return flow pipeline. Staging areas for pipeline construction would be predominantly within the road ROW. The contractor would be required to provide additional construction staging area, if the contractor desires to have additional construction staging area beyond what is available within the existing road ROW.

There would be three general types of valves essential to the water supply pipeline and return flow pipeline: isolation valves, air valves, and blow-off assemblies. Each valve would require a valve vault that would be built in accordance with the valve type. Butterfly valves would be used for isolation valves and installed at high points approximately every mile using direct bury whenever possible. There are four types of air valves that would be used—air release, air/vacuum, vacuum relief/air inlet, and combination air valves. Air valves would be located as needed along the pipeline as indicated by elevation and slope. Blow-off assemblies would have either a camlock coupling or hose bib inside of a curb box. Each blow-off assembly would be designed specifically for its location and located at low points on the pipeline, approximately every mile.

The water supply pipeline and return flow pipeline would have trenchless construction requirements in some segments. Horizontal directional drilling (HDD) and jack and bore construction methods would be used. The HDD construction method would be used when the pipelines need to cross some waterways and wetlands. The jack and bore construction method would be used under railroads and busy roadways where the need for increased structural capacity is required due to heavy loads traversing where the pipeline is installed and to minimize transportation impacts during construction. These techniques may also be used when crossing some existing utilities. The type of construction technique will be developed during detailed design in coordination with the roadway or utility owner and consistent with permitting requirements.

2.1.10 Proposed construction methods

Construction would require several different activities at any given location. Construction equipment may include bulldozers, excavators, backhoes, cranes, pick-up trucks, dump trucks, skid steers, and other light-duty equipment.

Major construction activities would include clearing and marking of the construction area, temporary staging of materials in the road ROW, installation of erosion control best management practices (BMPs), construction of facilities, excavation and construction of pipeline, and site restoration.

Pipelines along the same alignment would be trenched in a common corridor. The tops of the pipes would be buried to a depth of six feet six inches through rural areas and nine feet through urban areas. The pipes are required to be separated by eight feet from the center of each pipe per Chapter NR 811, Wis. Adm. Code. Based on the required separation distance and trenching methods, the trench widths at the surface would be up to 24 feet.

Waterway and wetland crossings for the proposed pipelines may be accomplished using: open trench, HDD, jack and bore, dam and pump or flume methods (see Section 5.1.7.1). The specific construction method at a given location would be selected to achieve the most practical solution that minimizes impacts to waterways and wetlands. The majority of waterway crossing construction is expected to occur using HDD or jack and bore methods. Regardless of the method, disturbed areas would be restored and revegetated. Temporary bridges may be installed across waterways to allow the passage of construction equipment and materials. Temporary bridges are not currently planned, but if selected for use would be placed with the lower temporary bridge elements above the ordinary high-water mark. Whenever possible, temporary bridges would be positioned to allow flows above the ordinary high-water mark to pass under the bridge before reaching the height of the low chord on the temporary bridge elements. Equipment crossings of waterways would be restricted to bridges that are authorized under DNR’s permit required under Chapter 30, Wisconsin statutes.

In areas where wetland impacts cannot be avoided, open-trench excavation, HDD, or jack and bore methods would generally be used. In addition, push/pull methods or winter construction may be used for the proposed project. Construction methods would be similar for wetlands as those described for waterway crossings.

Standard precautions would be taken to identify and avoid disturbances to existing utilities. Construction techniques are expected to include open trench, HDD, and jack and bore techniques. The exact construction techniques to be used near existing utilities would be determined during detailed design in coordination with the utility owner. Proper clearance distances from existing utilities would be maintained where applicable. Additional construction method information is provided in Section 5.1.7.1.

The construction disturbance zone would consist of areas within the existing road ROW, areas where related facilities are sited, and the RFDS. The overall planned width of pipeline construction for all alternatives is 50 feet, although in specific areas it may be slightly more or less. Approximately 97.4 percent of the pipeline disturbance zone is within existing road ROW. Construction disturbance zones outside of existing road ROW would consist of easements along the pipeline route, associated facilities, and the RFDS.

The use of permanent access roads outside of an existing ROW would be avoided where possible. The design of the pipeline appurtenances would be laid out to avoid placement outside of existing ROW (or in new easements) to reduce the need for frequent access within new easement areas and to reduce the need for permanent access roads.

Despite these efforts, the proposed return flow pipeline would require permanent off-ROW access in several locations that would require new easements or property purchases. An approximately 2.4-acre easement outside of existing road ROW would be obtained for pipeline construction 1,330 feet southwest of the intersection of West Small Road and South Westridge Drive. This area is on the south side of the proposed I-43 crossing between West Small Road north to the south side of the I-43 crossing. Six easements totaling 4.3 acres would be obtained outside of existing road ROW east of the intersection of West Ryan Road and South 112th Street. These easements along West Ryan Road would be immediately adjacent to Ryan Road; consequently, a permanent access road within the easements is not anticipated. The proposed return flow discharge site (RFDS) may also require permanent off-ROW access.

The potential permanent access road on the south side of the I-43 crossing where an easement is proposed for the pipeline between West Small Road north to the south side of the I-43 crossing could be approximately 2,230 feet long, 12 feet wide, and consist of natural vegetation. The potential permanent access road at the proposed RFDS could be approximately 1,200 feet long, with a 4-foot-high embankment with a 12-foot-high top width. The total embankment width could be approximately 36 feet. The roadway would consist of either gravel or bare ground. This access road could originate from South 60th Street near the Root River and run along the north side of the Root River.

The proposed permanent access roads on the easement south of the I-43 crossing would be necessary to ensure both routine and emergency access to the pipeline. These portions of the pipeline would run along the edge of agricultural fields without adjacent existing ROWs to access the pipeline. The potential permanent access road at the proposed RFDS would be necessary to ensure routine and emergency access to the outfall and USGS gage structure.

The need for permanent off-ROW access routes would be determined based on negotiations with local landowners and/or contractor requirements. The addition of off-ROW access roads would be reviewed for impacts to environmental and cultural resources. Areas used for temporary access roads outside of existing road ROW are expected to be restored to the prior land use conditions, except where pipeline maintenance needs require vegetation management.

All facility staging areas would be located in an effort to minimize impacts to natural resources, include erosion control, and be placed to minimize impacts to flood prone areas. Staging areas for facility construction would be within the facility property. The contractor would be required to provide additional construction staging area, if the contractor desires to have additional construction staging area beyond what is available within the existing road ROW affected by construction, new easements, and at facility locations.

2.1.11 Proposed restoration of disturbed areas

Vegetative disturbances along the pipeline route would be temporary in nature. Specific restoration activities would be based upon site-specific and landowner needs, as well as preconstruction vegetative, soil, and hydrologic regime conditions. Sites would be restored in accordance with all applicable requirements and permit conditions, including the DNR general permit for construction site erosion control (WPDES Permit No. WI-S067831-5 [DNR 2016c]).

Typical revegetation activities may include grading, replacement of topsoil, seeding, planting, and mulching. Over pipelines, site topography would be graded to preconstruction conditions using proper segregated soil replacement. Facility sites would be graded to their final topography prior to revegetation. Construction vehicle rutting greater than six inches deep would be repaired. Site restoration and revegetation would be completed as soon as practicable upon completion of construction activities and consistent with erosion control requirements. Temporary erosion control measures would be used throughout construction and will be removed upon final stabilization.

Because much of the construction would be within existing road ROW, restoration activities would be consistent with the requirements of local municipalities and would follow either DNR and/or WDOT Standard Specifications. Examples include WDOT Standard Specifications for Highway and Structure Construction Section 625 “Topsoil and Salvaged Topsoil,” Section 627 “Mulching,” Section 630 “Seeding,” and Section 632 “Furnishing and Planting Plant Materials.” Active or rotated agricultural sites would not be seeded unless requested by the landowner. Landscaping at the proposed facilities would conform to the surrounding area and would comply with local and municipal guidelines. Native species would be used where possible.

In wetland areas, topography, soils, and vegetation would be restored. Over pipelines, site topography would be graded to preconstruction conditions using proper segregated soil replacement. Facility sites would be graded to their final topography prior to revegetation. Native seed mixes would be used to revegetate wetland areas. Temporary and permanent erosion control measures, including straw bales, silt fence, timber matting, and other materials would be used as necessary throughout construction. Upon final stabilization, all temporary erosion control measures would be removed. Planting of trees or shrubs post-construction would be made consistent with the landscaping plan and local municipality requirements.

At HDD crossing locations, wetlands would be monitored for signs of inadvertent return of drilling lubricant, or “frac-out.” Occurrences would be promptly addressed. For a wetland frac-out, the slurry at the surface would be isolated using silt fence and/or hay bales, then removed by vacuum truck, machinery, or by hand, and disposed of in an acceptable upland location.

In areas dominated by invasive species, or where invasive species are prevalent close to the disturbed area, vegetative restoration would be limited to seeding with a cover crop.

A permanent approximately 10- to 15-foot width above the pipeline would be maintained clear of woody vegetation to facilitate periodic inspections and emergency pipeline access. The width would be approximately 10 feet for single pipeline areas and approximately 15 feet for co-located pipeline areas. Woody vegetation would be allowed to reseed naturally within the easement outside of these maintained areas. Within the approximately 10- to 15-foot-wide portion, woody vegetation would be cut or removed as needed.

Vegetative monitoring would take place during the growing season until vegetative cover has been established with a density of at least 70 percent cover, as required by the DNR general permit for construction site erosion control (WPDES Permit No. WI-S067831-5) conditions. Areas would be reseeded as necessary to meet this requirement. Revegetated areas would be monitored for invasive species through final stabilization or as stipulated in permit requirements. Actions would be taken to control and minimize the spread of invasive species where they occur within revegetated areas.

2.1.12 Anticipated construction schedule

The proposed project schedule has been developed to meet the radium consent order deadline agreement that the City of Waukesha has with the State of Wisconsin. The schedule has been developed in coordination with Wisconsin Department of Transportation (WDOT), DNR, local municipalities, and other regulatory and governing agencies (see Appendix D).

Following Public Service Commission of Wisconsin (PSC) approval and receipt of necessary permits and easements, the Applicant intends to begin construction in early 2021 and have the system in operation by late 2023. Construction activities would follow all applicable seasonal threatened and endangered species restrictions. Additional environmental factors and coordination with stakeholders may affect construction timing.

2.1.13 Proposed project costs

Construction costs for the proposed project are presented in Table 2-1. Operational costs for the proposed supply and return flow pipelines are shown in Table 2-2.

Table 2-1. Construction costs[1] of proposed project

Project element	Construction cost ($-million)
Water connection at Milwaukee[2]	--
Water supply pumping station at water supplier[2]	--
Booster pumping station at Minooka Park	18.3
Water reservoir at Minooka Park	18.6
Water supply pipeline and vaults[3]	49.5
Chemical feed facilities	0.4
Water connections at Waukesha	1.7
Waukesha Water Distribution System improvements	--
Return flow pumping station	5.9
Return flow pipeline and vaults	93.6
Return flow outfall site	2.4
Necessary WWTP improvements (exclusive of the return flow pumping station)[4]	--
Other elements	--
Total of elements construction cost[4,5]	190.4
Engineering and management	**Construction-related cost ($-million)**
Engineering (anticipated fee)	36.6
Engineering services during construction	8.4
Construction management	16.8
Total of engineering and management cost	61.8
Total project elements construction cost	252.2
Other construction-related items	**Construction-related cost ($-million)**
Application permitting, legal, and administration	6.1
Project permitting, legal, and administration	8.8
Distribution system improvements	19.3
Total of other construction-related items	34.2
Total project construction cost	286.4

[1] These construction costs were developed as part of preliminary design. A Class 3 OPCC was prepared for all project elements in accordance with AACE Recommended Practice No.18R-97. Costs were developed in mid-2017 dollars at an Engineering News-Record Construction Cost Index (ENR CCI) value of 10,942. Unit cost information used various resources in effort to provide the best available information for each item, including manufacturer quotes, RS Means, and southeastern Wisconsin bid tabs. These costs were included in Waukesha Water Utility's Type 2 Application for Certificate of Authority submitted to the Public Service Commission of Wisconsin.

[2] Milwaukee Water Works would own and operate these facilities.

[3] Includes the Water Supply Pipeline from West Oklahoma Avenue and South 84th Street to the water supply control building.

[4] The City of Waukesha Department of Public Works (DPW) would fund, own, and operate these facilities.

[5] Construction costs include bonds and insurance (3%), mobilization/demobilization (5%), contingency (20%), and contractor overhead and profit (15%).

Table 2-2. Operational costs[1] of proposed pipelines

	Pumping costs ($-million)		OM&R cost ($-million)		Total operating costs ($-million)	
	Annual	20-year	Annual	20-year	Annual	20-year
Supply (M1-preferred)	0.520	6.565	0.070	0.885	0.590	7.450
Return flow (OC3-preferred)	0.242	3.049	0.110	1.393	0.352	4.442
Total operating costs	0.762	9.614	0.18	2.278	0.942	11.892

[1] These operational costs were developed as part of an economic comparison of the route alternatives in the Facility Plan Amendment and the Route Study - Milwaukee. The costs are Class 4 Opinions of Probable Construction Cost (OPCC) developed in accordance with AACE Recommended Practice No.18R-97 and were not intended to be used in development of proposed project costs. These costs were not included in Waukesha Water Utility's Type 2 Application for Certificate of Authority submitted to the Public Service Commission of Wisconsin.

2.1.14 Authorities and approvals for proposed project

Table 2-3 lists the various permits and approvals that will be or may be required for construction, operation and maintenance of the proposed project.

Table 2-3. Permits and approvals

Permit, approval or evaluation	Statute or regulation	Administering and enforcing agency
Federal		
Great Lakes—St. Lawrence River Basin Water Resources Compact	Public Law 110-342	Great Lakes--St. Lawrence River Basin Water Resources Council
Endangered Species Act Section 7 Consultation	16 U.S.C. s. 1531 et. seq. (Endangered Species Act)	U.S. Fish and Wildlife Service (Green Bay ES Field Office)
Clean Water Act Section 404 Dredge and Fill Permit	33 U.S.C. s. 1344 (Clean Water Act)	U.S. Army Corps of Engineers (St. Paul District and Detroit District)
Section 10 Navigable Waters Permit	33 U.S.C. s. 403 (Rivers and Harbors Act of 1899)	U.S. Army Corps of Engineers (St. Paul District)
State		
Stream Crossings of Navigable Waters	Wis. Stat. ch. 30, Wis. Adm. Code. NR 102, 320, 329, 341, 345	DNR
WPDES Stormwater Discharge Permit	Wis. Stat. s. 283.33, Wis. Adm. Code. NR 216	DNR
Wetland Permit	Wis. Stat. s. 281.36, Wis. Adm. Code NR 103	DNR
Pit/trench Dewatering General Permit	Wis. Stat. ch. 283, Wis. Adm. Code 216	DNR
Wastewater Facilities Plan Review	Wis. Adm. Code NR 110	DNR
Control of Particulate Emission - Fugitive Dust	Wis. Adm. Code NR 415.035, 415.04	DNR
Wisconsin Floodplain Management Program including local floodplain zoning ordinances	Wis. Adm. Code NR 116	DNR
Incidental Take Permit	Wis. Stat. s. 29.604 (6m)	DNR
Water Quality Antidegradation evaluation	Wis. Adm. Code NR 207	DNR
Wisconsin Pollutant Discharge Elimination System Permit	Wis. Stat. ch. 283, Wis. Adm. Code NR 217	DNR
Water Supply Service Area Plan	Wis. Stats. ss. 281.346 and 281.348	DNR
Wastewater systems construction plan review	Wis. Stat. s. 281.41, Wis. Adm. Code NR 108, Wis. Adm. Code NR 110	DNR
Water systems construction plan review	Wis. Stat. s. 281.41, Wis. Adm. Code NR 108, Wis. Adm. Code NR 811	DNR
Wastewater Facilities Plan Amendment	Wis. Stats. ss. 281.41, 283.85, Wis. Adm. Code NR 110.08-110.11	DNR
Soil Management Plan (Notifications and Reporting)	Wis. Adm. Code NR 718	DNR
Contaminated Water Management Plan (Notifications and Reporting)	Wis. Stat. s. 283.35, Wis. Adm. Code NR 205.08	DNR

Table 2-3. Permits and approvals

Permit, approval or evaluation	Statute or regulation	Administering and enforcing agency
Lead and Copper Corrosion Control	Wis. Adm. Code NR 809	DNR
Disinfection Byproduct Sampling Plan Review	Wis. Adm. Code NR 809	DNR
Total Coliform Rule Sampling Plan Review	Wis. Adm. Code NR 809	DNR
Hydrant Flushing Discharge General Permit	Wis. Stat. s. 283.35	DNR
Pit/Trench Dewatering General Permit	Wis. Stat. s. 283.35, Wis. Adm. Code NR 205.08	DNR
Chemical Storage Facilities Construction Permit	Wis. Stat. s. 281.41, Wis. Adm. Code NR 108, Wis. Adm. Code NR 811.40	DNR
Hydrostatic Test Discharge General Permit	Wis. Stat. s. 283.35	DNR
Diversion Approval	Wis. Stat. s. 281.346	DNR
Cultural Resources Review	Section 106 of the NHPA and Wis. Stat. s. 157.70	Wisconsin State Historic Preservation Office
Permit to work in a Burial Site	Wis. Stats. s. 157.70, Wis. Adm. Code HS 2.04	Wisconsin State Historic Preservation Office
Public Lands Field Archaeological Permits	Wis. Stat. s. 44.47	Wisconsin Historical Society – Office of the State Archaeologist
Agricultural Impact Statement	Wis. Stat. s. 32.035	Wisconsin Department of Agriculture, Trade, and Consumer Protection
Certificate of Authority	Wis. Stat. s.196.49, Wis. Adm. Code PSC 184	Public Service Commission of Wisconsin (PSCW)
Water Systems Construction Plan Review (Type 2 Certificate of Authority)	Wis. Adm. Code PSC 4	PSCW
Utility Permit	Wis. Stat. s. 86.07(2)(a)	Wisconsin Department of Transportation (WDOT)
Traffic Management Plan	Wis. Stat. s. 86.07(2)(a)	WDOT
Local		
FEMA Letter of Map Revision	Wis. Stat. s. 87.30, CFR 59-72	Federal Emergency Management Agency (FEMA)
Milwaukee County Department of Transportation		Construction Permit
Milwaukee County		Shoreland Construction Permit
Milwaukee County		Work or Encroachment in County Highway ROW
Milwaukee County		Park District Permits
Waukesha County		Shoreland Construction Permit
Waukesha County		Stormwater Management and Erosion Control Plan
Waukesha County		Permit to Construct, Maintain or Repair Utilities within the ROW
City of Franklin		Stormwater Management Plan (Support Document for Construction Permit)
City of Franklin		Natural Resource Special Exemption (Support Document for Construction Permit)
City of Franklin		Permit to Construct, Maintain or Repair Utilities within the ROW
City of Greenfield		Occupancy of ROW Permit
City of Milwaukee		Occupancy of ROW Permit
City of Muskego		ROW Permits
City of Muskego		Street Excavation Permit
City of Muskego		Land Disturbance Permit
City of Muskego		Curb Permit
City of New Berlin		Grading and Erosion Control Permit
City of New Berlin		Stormwater Management Permit

Table 2-3. Permits and approvals

Permit, approval or evaluation	Statute or regulation	Administering and enforcing agency
City of New Berlin		Road cut/work within ROW Permit
City of New Berlin		Possibly a presentation to City Council
City of Waukesha		Traffic Management Plan
City of Waukesha		Building Permits
City of Waukesha		Plan Commission Approval (needed for any building)
City of Waukesha		Stormwater Management and Erosion Control Permit
City of Waukesha		Utility
City of Waukesha		Construction Permit
City of Waukesha		Public Works, Street & Alley Opening Permit
City of Waukesha		Public Works, Street Occupancy Permit
City of Waukesha		Historic District/Landmarks Commission Review
Town of Vernon		Utility Permit, would also likely review route
Waukesha County		Shoreland Construction Permit
Waukesha County		Stormwater Management and Erosion Control Plan
Waukesha County		Permit to Construct, Maintain or Repair Utilities within the ROW
Milwaukee Metropolitan Sewerage District		Chapter 13 Surface Water and Stormwater (might not be required)
Private		
Canadian National Railway Company (CN)		Railroad Permit

In its Technical Review, the DNR determined that the Applicant's proposed diversion is in compliance with the Boundary Waters Treaty of 1909 because any water lost from the Great Lakes basin (due to consumptive use) would not affect the flows or levels of the boundary waters on either side of the border between the U.S. and Canada.

3 Project alternatives

Since initiating the EIS process in 2010, the department has analyzed and reviewed the environmental impacts of 18 project alternatives. These include 9 water supply alternatives, 8 return flow alternatives, and 1 'No Action' alternative. Water supply alternatives include 4 City of Milwaukee supply alternatives, 3 groundwater supply alternatives, 1 City of Oak Creek supply alternative, and 1 City of Racine supply alternative. Return flow alternatives include 5 Root River return alternatives, 1 direct pipeline to Lake Michigan alternative, 1 Milwaukee Metropolitan Sewerage District (MMSD) return alternative, and 1 Fox River alternative (for groundwater supply only). Eight of these alternatives are described in Section 3.1 below. The other ten are described in the Preliminary Final EIS, which is in Appendix E.

Table 3-1 lists all of alternatives analyzed and reviewed by the department during the course of the EIS process, including references to the sections of this document where they are described and the sections where their potential environmental effects are discussed.

Table 3-1. Alternatives analyzed and reviewed during the EIS process

Alternative	Type [1]	Version [2]	Description	Environmental Effects
'Milwaukee route M1-preferred'	Supply	FEIS	Section 2.1; 3.1.1	Section 5.1; 5.2
'Milwaukee route M2'	Supply	FEIS	Section 3.1.2	Section 5.1; 5.4
'Milwaukee route M3'	Supply	FEIS	Section 3.1.3	Section 5.1; 5.5
'Oak Creek route OC2' (to Root River)	Return	FEIS	Section 3.1.4	Section 5.1; 5.6
'Oak Creek route OC3-preferred' (to Root River)	Return	FEIS	Section 2.1; 3.1.5	Section 5.1; 5.3
'Oak Creek route OC4' (to Root River)	Return	FEIS	Section 3.1.6	Section 5.1; 5.7
'I-43 easement' (to Root River)	Return	FEIS	Section 3.1.7	Section 5.1; 5.8
'Zero demand increase'	Supply	PFEIS	Appendix E: 2.2	Appendix E: 4.2
'Deep and shallow aquifers'	Supply	PFEIS	Appendix E: 2.3.1.1	Appendix E: 4.3.1
'Shallow aquifer'	Supply	PFEIS	Appendix E: 2.3.1.2	Appendix E: 4.3.2
'Milwaukee'	Supply	PFEIS	Appendix E: 2.3.2.1	Appendix E: 4.3.3.1; 4.3.3.2
'Oak Creek (alignment 2)'	Supply	PFEIS	Appendix E: 2.3.2.2	Appendix E: 4.3.3.1; 4.3.3.3
'Racine'	Supply	PFEIS	Appendix E: 2.3.2.3	Appendix E: 4.3.3.1; 4.3.3.4
'Fox River wastewater discharge'	Return	PFEIS	Appendix E: 2.4.1.1	Appendix E: 4.4.1
'Root River (alignment 2)'	Return	PFEIS	Appendix E: 2.4.2.1	Appendix E: 4.4.2.1; 4.4.2.3
'Direct to Lake Michigan'	Return	PFEIS	Appendix E: 2.4.2.2	Appendix E: 4.4.2.1; 4.4.2.4
'Milwaukee Metropolitan Sewerage District (MMSD)'	Return	PFEIS	Appendix E: 2.4.2.3	Appendix E: 4.4.2.1; 4.4.2.2
'No action'	Both	Both	Section 3.1.8; Appendix E: 2.1	Section 5.9; Appendix E: 4.1

[1] Type of Alternative. 'Supply' refers to Water Supply Alternatives. 'Return' refers to Wastewater Return/Discharge Alternatives.

[2] Version of the EIS. 'FEIS' refers to this Final EIS. 'PFEIS' refers to the Preliminary Final EIS released in January 2016.

Prior to the Compact Council Decision, the Applicant reviewed six water supply alternatives. Four of these considered withdrawals exclusively from the Mississippi River Basin, one from a combination of Mississippi River Basin and Lake Michigan sources, and one exclusively from Lake Michigan. Based on public comments, the DNR also modeled and reviewed an alternative scenario that included variations on well placement meant to minimize adverse environmental impacts. These alternatives were all reviewed in the DNR's Preliminary Final EIS (Appendix E).

In late 2016, the Applicant identified possible pipeline routes and facility locations in a screening-level analysis for a water supply from the City of Oak Creek with return flow to the Root River. The Applicant also evaluated two Milwaukee route alternatives (an initial supply route alternative and a sub-alternative) to supply Lake Michigan water from the City of Milwaukee with return flow to the Root River.

In 2017, the Applicant accepted an offer from the City of Milwaukee to supply treated Lake Michigan water at a substantial cost savings ($59.9 million over 20 years) compared to the alternative of acquiring water from the City of Oak Creek. The Applicant and the City of Milwaukee entered into a 40-year contract in December 2017. The Applicant evaluated three Milwaukee supply pipeline routes: M1, M2, and M3. The Applicant further refined route M1 by eliminating a portion of the route on the eastern end and adding an easement on private land. The Applicant selected the revised supply route, M1-preferred, as the proposed supply pipeline route.

The Applicant also evaluated three Oak Creek supply and return flow routes. After Oak Creek was eliminated as a water supplier, only the return flow portions were further evaluated. These are referred to as OC2, OC3 and OC4. The Applicant further refined return flow route OC3 with the addition of an easement on private land, and one different short segment. The Applicant selected the revised return flow route, OC3-preferred, as the proposed return flow pipeline route.

Finally, the Applicant reviewed an easement alternative to part of the OC3-preferred return flow route, along a segment of Interstate 43 (I-43), but did not select this alternative.

The following alternatives were analyzed for this Final EIS:

- Milwaukee supply route M1-preferred (current proposal)
- Milwaukee supply route alternative M2
- Milwaukee supply route alternative M3
- Oak Creek return flow route alternative OC2
- Oak Creek return flow route OC3-preferred (current proposal)
- Oak Creek return flow route alternative OC4
- I-43 easement alternative
- A ‘No Action’ alternative

All of these alternatives (including ‘No Action’) assume that the Applicant will implement a range of water conservation and efficiency measures, as required under the Great Lakes Compact and Ch. NR 852, Wis. Admin. Code, and as set forth in the Applicant’s Water Conservation Plan (CH2M Hill 2013, Vol. 3). The Applicant projects that these measures will reduce water demand by 10 percent, or approximately 1.0 MGD. In its approval decision, the Compact Council found that a diversion cannot be avoided through water conservation and efficiency measures. The 8.2 MGD diversion approved by the Compact Council assumes that the projected reduction in water demand will be achieved (Compact Council 2016).

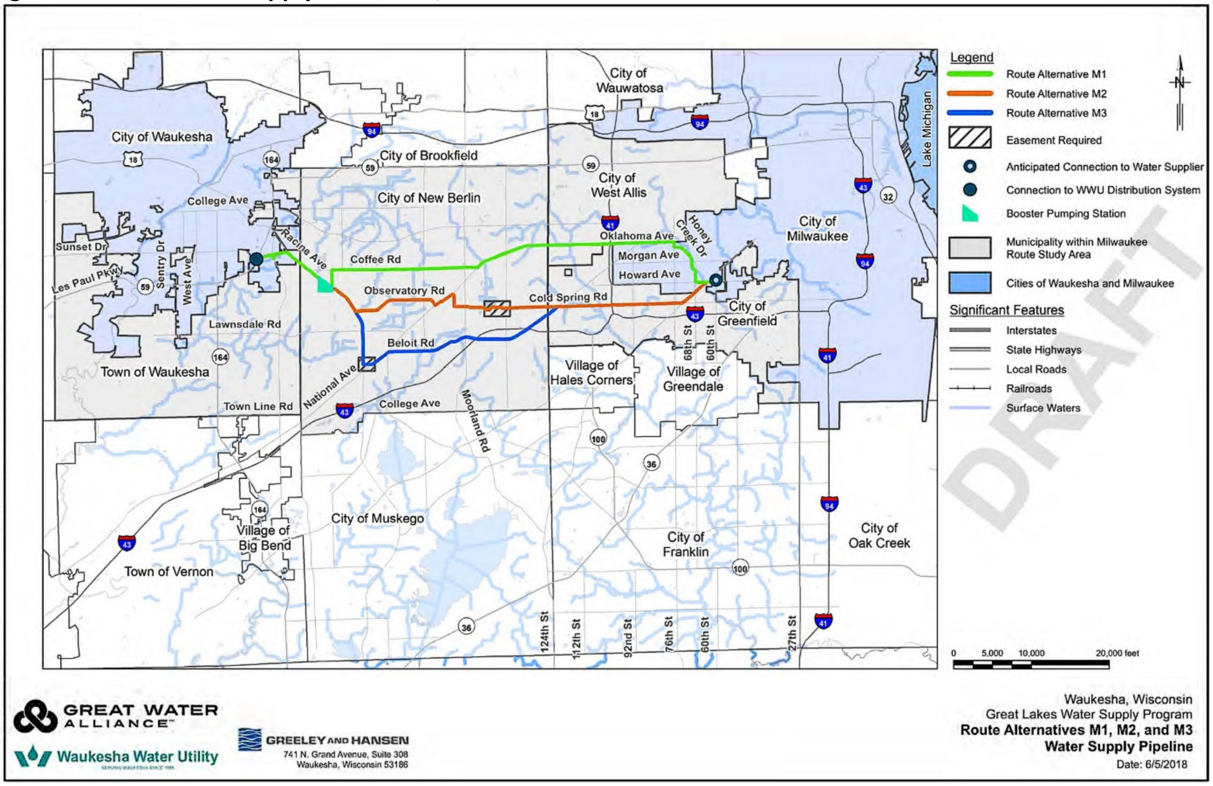
The current proposal consists of the Milwaukee supply route “M1-preferred” and the return flow route “OC3-preferred.” The proposed project is described in Section 1.1. The pipeline alignments for the proposed project are described in Sections 2.1.2 and 2.1.7, and in Appendix A). The pipeline alignments for the alternative routes are described in Section 3.1 and Appendix B). The construction and operational costs for the alternatives are provided in Section 3.2. The potential environmental effects of the water supply and return flow alternatives are evaluated in Section 5 of this EIS. Detailed route maps are available in the Waterway and Wetland permit application.

The Applicant’s supplemental environment impact report (EIR) and the Preliminary Final EIS (Appendix E) provide information on other routes considered for this project, including the City of Oak Creek water supply route pipelines and a “zero demand increase alternative.”

3.1 Description of project alternatives

This section provides brief descriptions of the currently considered alternative pipeline routes.

Figure 3-1. Milwaukee supply routes M1, M2 and M3



3.1.1 Milwaukee supply route M1

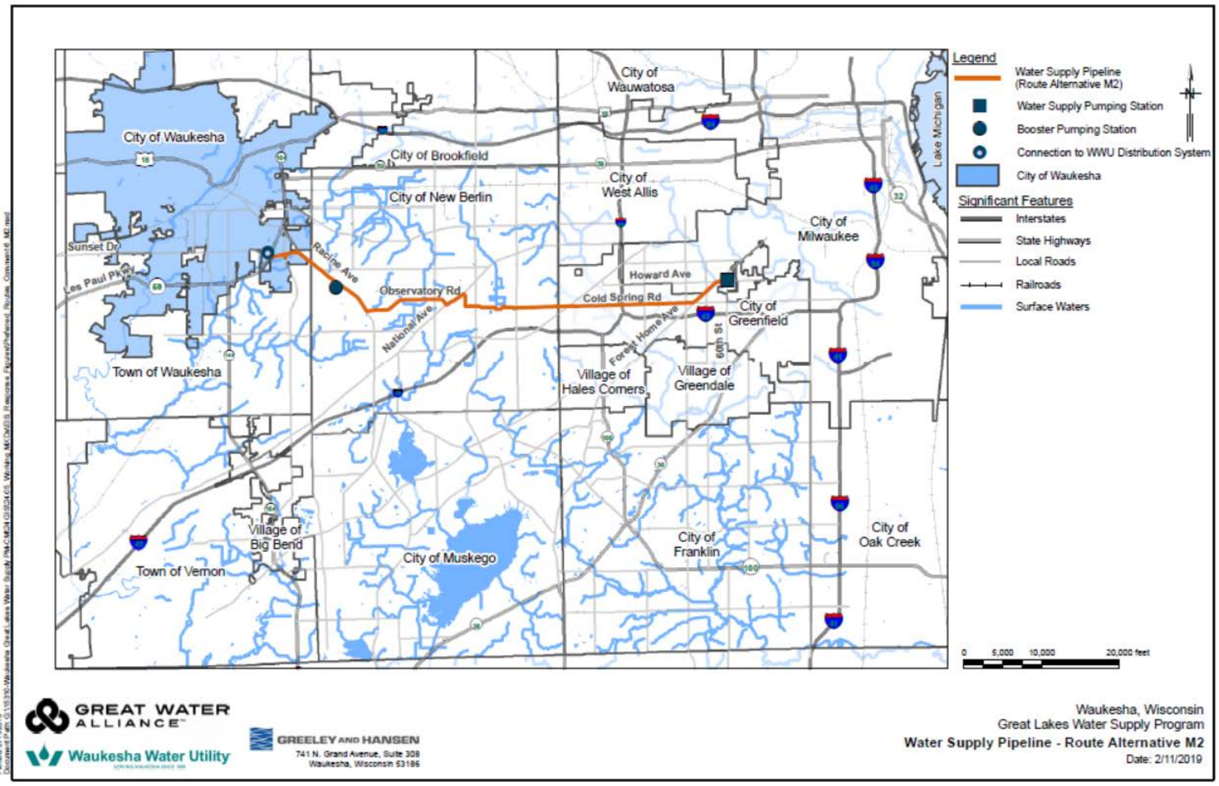
Water supply route alternative M1 follows the same roadways as the proposed supply route (M1-preferred) with two exceptions. M1 has an additional section on the eastern end of the route making this alternative approximately 12.75 miles in length. For M1, the connection to Milwaukee would be at the intersection of West Morgan Avenue and 68th Street. The route would follow Morgan Avenue to the west until reaching South Honey Creek Drive. The route would then turn north to follow South Honey Creek Drive, and then follow West Honey Creek Drive to the west. At South 76th Street, the route would turn north along 76th Street before reaching West Oklahoma Avenue. The remainder of alternative supply route M1 would follow the same roadways as the route for M1-preferred but would not follow an easement along East Sunset Drive just west of Racine Avenue.

3.1.2 Milwaukee supply route M2

This alternative supply pipeline route is shown in Figure 3-2. Milwaukee supply route alternative M2 would begin with a connection to the MWW distribution system at the intersection of West Howard Avenue and South 60th Street in the City of Milwaukee, and end at the connection to the Waukesha Water Utility (WWU) distribution system in the City of Waukesha. This alternative supply pipeline would be approximately 12.59 miles in length.

This alternative supply pipeline would follow Howard Avenue, Forest Home Avenue, Cold Spring Road, and cross a New Berlin Public Schools property. The pipeline would then follow Fenway Drive, Mayflower Drive, Church Drive, National Avenue, Observatory Road, Racine Avenue, and Sunset Drive. The pipeline would connect to the WWU distribution system near the intersection of Sunset Drive and Les Paul Parkway. For a more complete description of this alternative see Appendix B – Section B.1

Figure 3-2. Milwaukee supply route alternative M2

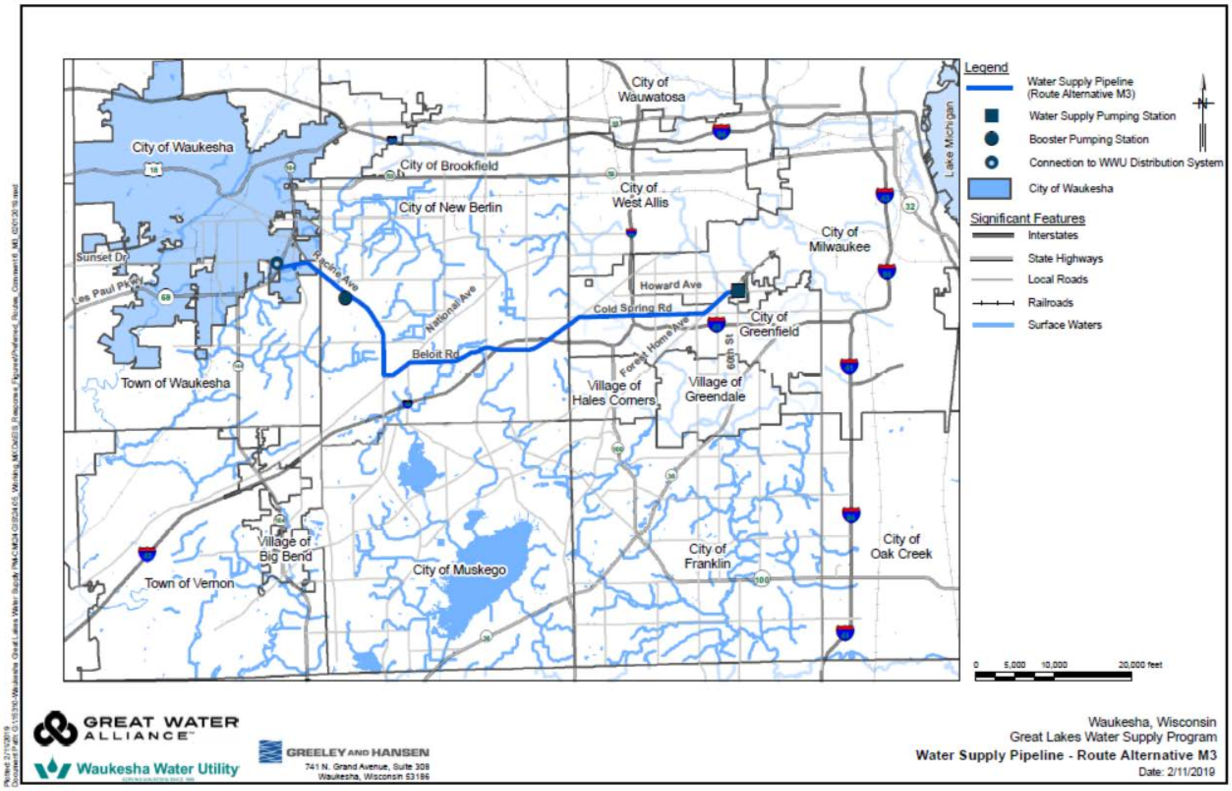


3.1.3 Milwaukee supply route M3

This alternative supply pipeline route is shown in Figure 3-3. Milwaukee supply route alternative M3 would begin with a connection to the MWW distribution system at the intersection of West Howard Avenue and South 60th Street in the City of Milwaukee, and end at the connection to the Waukesha Water Utility (WWU) distribution system in the City of Waukesha. This alternative supply pipeline would be approximately 13.59 miles in length.

This proposed supply pipeline would follow Howard Avenue, Forest Home Avenue, Cold Spring Road, Beloit Road, National Avenue, and cross a private parcel. The pipeline would then follow Racine Avenue and Sunset Drive. The pipeline would connect to the WWU distribution system near the intersection of Sunset Drive and Les Paul Parkway. For a more complete description of this alternative see Appendix B – Section B.3.

Figure 3-3. Milwaukee supply route alternative M3



3.1.4 Oak Creek return route OC2

Oak Creek route alternative OC2 is a 19.9-mile route (shown in Figure 3-4). This alternative would return treated wastewater from the Waukesha WWTP to the Root River[2]. This alternative pipeline alignment is briefly described below and more fully described in Appendix B – Section B.4. This alternative return flow pipeline would begin on the western side of the Waukesha WWTP located on Sentry Drive. The pipeline would first cross the WWTP property from west to east and then turn south on Sentry Drive. The pipeline would then follow West Sunset Drive, West Avenue, Highway 59, East Sunset Drive, Racine Avenue, Lawnsdale Road, and National Avenue. The pipeline would then cross two private land parcels before following Calhoun Road. The pipeline would cross two more private land parcels and then follow Small Road, Westridge Road, Moorland Road, Durham Drive, North Cape Road and Ryan Road. At the intersection of Ryan Road and 60th Street, the pipeline would turn south to the discharge point on the Root River.

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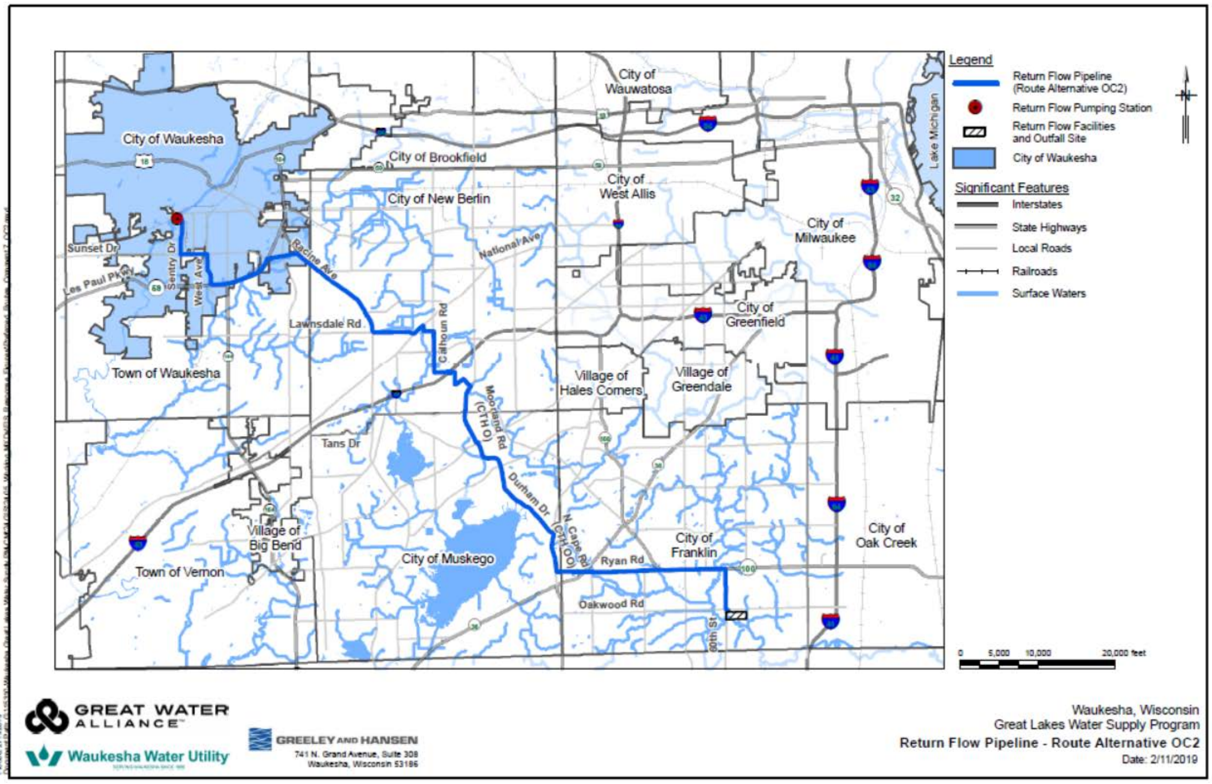
[2] Since the City of Oak Creek is no longer being considered as a water supply option, and most of the pipeline for return flow was co-located in the same corridor as supply, some of the information provided in the Supplemental EIR provides a conservative estimate for impacts for this alternative.

Figure 3-4. Oak Creek route alternative OC2 return flow pipeline



3.1.5 Oak Creek return route OC3

Return flow route alternative OC3 follows the same roadways as the proposed return flow route (OC3-preferred) except that OC3 does not follow Racine Court. OC3 also does not include an easement on private land along West Sunset Drive just west of West Avenue. The remainder of alternative return flow route OC3 would follow the same roadways as the route for OC3-preferred.

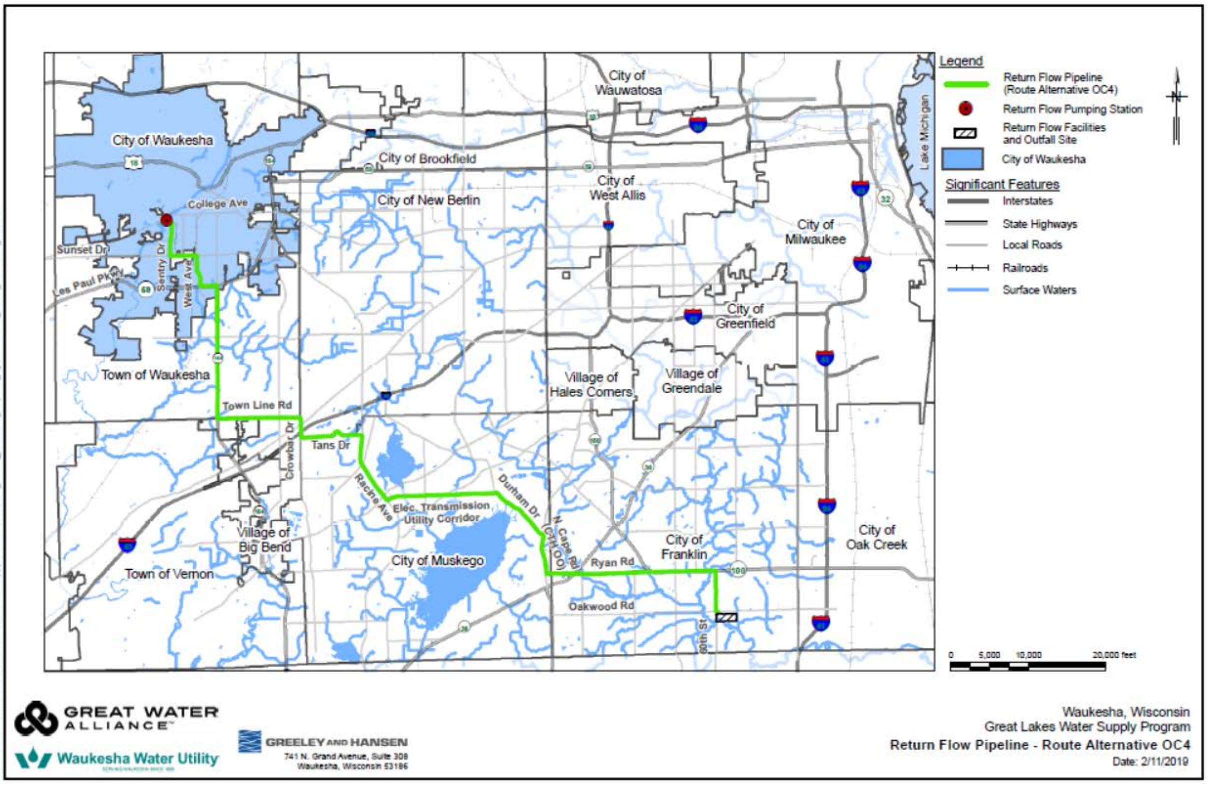
3.1.6 Oak Creek return route OC4

Oak Creek route alternative OC4 is shown in Figure 3-5. This alternative would return treated wastewater from the Waukesha WWTP to the Root River[3]. This alternative return flow pipeline would be approximately 23.2 miles in length. This alternative pipeline alignment is briefly described below and more fully described in Appendix B – Section B.5. This alternative return flow pipeline would begin on the western side of the Waukesha WWTP located on Sentry Drive. The pipeline would first cross the WWTP property from west to east and then turn south on Sentry Drive. The pipeline would then follow West Sunset Drive, West Avenue, Highway 59, Highway 164 and Town Line Road. The pipeline would then cross four private land parcels before following Crowbar Drive, Tans Drive and Racine Avenue. The pipeline would then follow the City of Muskego Recreational Trail to the east. Then the pipeline would follow Durham

[3] Since the City of Oak Creek is no longer being considered as a water supply option, and most of the pipeline for return flow was co-located in the same corridor as supply, some of the information provided in the Supplemental EIR provides a conservative estimate for impacts for this alternative.

Drive, North Cape Road and Ryan Road. At the intersection of Ryan Road and 60th Street, the pipeline would turn south to the discharge point on the Root River.

Figure 3-5. Oak Creek route alternative OC4 return flow pipeline

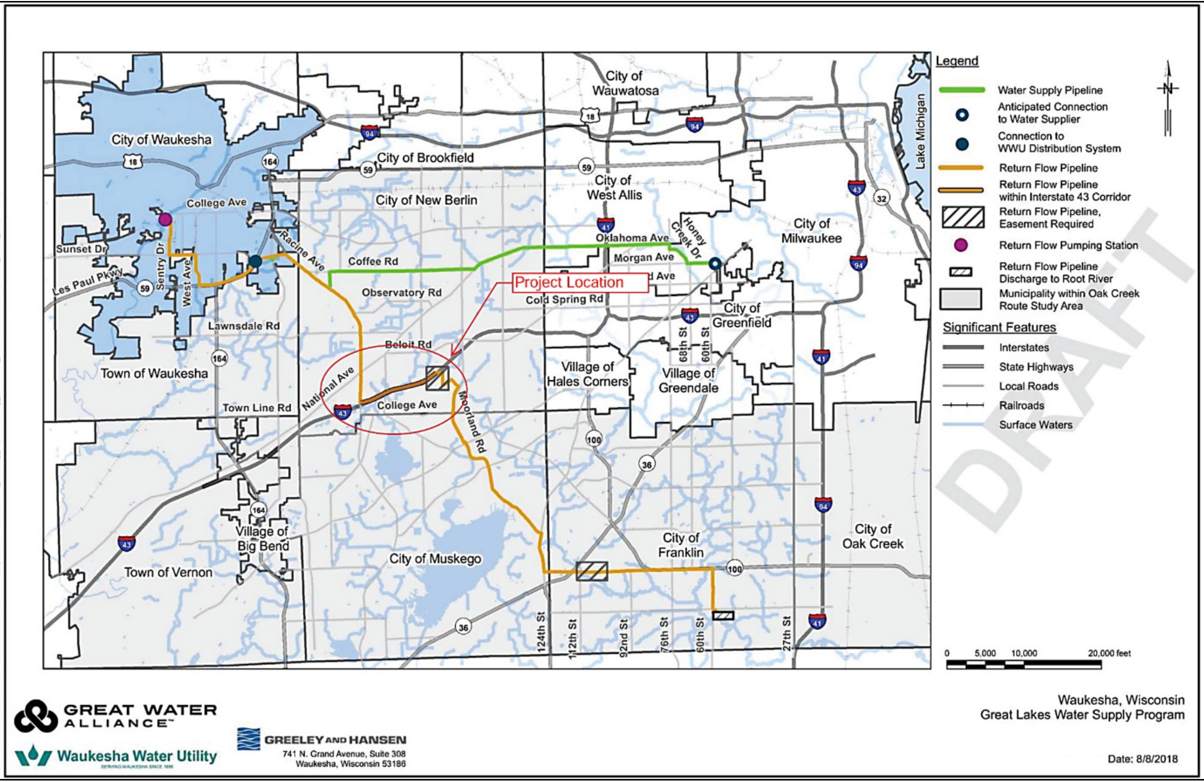


3.1.7 I-43 easement alternative

The Interstate 43 (I-43) easement alternative is an alternative section of return flow pipeline which would be located adjacent to the I-43 right-of-way from Racine Court to approximately half a mile east of Calhoun Road and would account for approximately 2.4 miles of the overall 23 miles of return flow pipeline. Figure 3-6 shows the location of this alternative.

This alternative return flow pipeline route segment would begin at the intersection of Racine Court and the ROW of I-43. The route would follow the northern boundary of the I-43 ROW to the northeast until reaching South Martin Road. The route would then cross the interstate to the south side of the I-43 ROW and follow the ROW to the northeast. To the northeast of South Calhoun Road, this alternative route would turn east across an easement on private land to join the proposed return flow route (OC3-preferred) to the north of West Small Road.

Figure 3-6. Interstate 43 easement alternative location



Source: Great Water Alliance

This alternative was developed because a portion of the proposed return flow pipeline route (OC3-preferred) would be located within interstate ROW, requiring an exception to WDOT's Utility Accommodation Policy. This, in turn, requires the Federal Highway Administration (FHWA) to review and approve a Hardship Application to allow the pipeline to be located in the interstate ROW. The approval by FHWA triggers the U.S. Army Corps of Engineers (USACE) to comply with NEPA via preparation of a categorical exclusion (CE) analysis. The CE, developed for the USACE and FHWA by the Applicant, focuses on impacts of this alternative pipeline segment to the interstate ROW portion of the proposed pipeline. The Hardship Application was approved by FHWA on April 4, 2019.

3.1.8 No action alternative

The Applicant's public water supply system is comprised of groundwater supply (wells), treatment, storage and conveyance assets. The water system consists of ten active wells: seven deep wells and three shallow wells, three water treatment plants for radium and iron/manganese removal, twelve storage tanks, nine booster pump stations, and approximately 326 miles of transmission and distribution water mains.

The 'no action' alternative would continue to use the current public water supply system, with no modifications to the current wells. The deep sandstone aquifer provides approximately 80% of the Applicant's current water supply. The deep wells contain radium, a known carcinogen, at concentrations above the federal and state drinking water standard. Although the Applicant maintains radium treatment to reduce the amount of radium in its drinking water, the water system is not in compliance with state regulations that require less than 5 picocuries per liter (pCi/L) radium 226 and radium 228 at each entry point of the distribution system (see the DNR's Technical Review S1). The no action alternative assumes 7.3 MGD from the deep aquifer and 1.2 MGD from the shallow aquifer under an 8.5 MGD average day demand. The Compact Council approved an 8.2 MGD diversion; however, the groundwater flow modeling conducted to review the Mississippi River Basin alternatives used 8.5 MGD average day demand, which is within modeling error of the 8.2 MGD ADD, approved by the Compact Council in June 2016 (Compact Council 2016).

3.2 Costs of alternative pipeline routes

Estimated construction and operational costs for the alternative pipeline routes and associated facilities are presented in Table 3-2.

Table 3-2. Construction and operational costs of the alternative pipeline routes

Pipeline route alternative	Construction cost[1] ($-million)	Pumping costs[2] ($-million) Annual	20-year	OM&R[3] cost ($-million) Annual	20-year	Total operating Costs ($-million) Annual	20-year
Proposed supply pipeline (Milwaukee supply M1-preferred)	63.2	0.52	6.565	0.070	0.885	0.590	7.450
Milwaukee supply alternative M2	64.6	0.517	6.528	0.068	0.860	0.586	7.388
Milwaukee supply alternative M3	69.5	0.532	6.716	0.073	0.926	0.606	7.641
Oak Creek return alternative OC2	91.2	0.222	2.799	1.107	1.347	0.329	4.146
Proposed return flow pipeline (Oak Creek return OC3-preferred)[3]	94.4	0.242	3.049	0.110	1.393	0.352	4.442
Oak Creek return alternative OC4	106.4	0.265	3.349	0.124	1.570	0.390	4.919

[1] These route alternative costs were developed as economic comparisons of the route alternatives as part of the Facility Plan Amendment and the Route Study - Milwaukee. The costs are Class 4 Opinions of Probable Construction Cost (OPCC) developed in accordance with AACE Recommended Practice No.18R-97 and were not intended to be used in development of proposed project costs. These costs were not included in Waukesha Water Utility's Type 2 Application for Certificate of Authority submitted to the Public Service Commission of Wisconsin.

[2] Life cycle pumping costs are based on an 8.2 MGD ADD conveyed at a throughput equivalent to the firm capacity of each pumping station. Costs include a $0.075/kWh electric rate, a 3% inflation rate and an 8% discount rate.

[3] The Oak Creek Route Alternative 3 return flow pipeline is also part of the proposed project.

[3] Operation, maintenance and repair.

Source: Great Water Alliance

3.3 Review process for alternative pipeline routes

The Applicant considered an array of economic and non-economic considerations to evaluate three Milwaukee supply pipeline routes (M1, M2, and M3) and Oak Creek return flow pipeline routes (OC2, OC3 and OC4). Non-economic criteria included: total pipeline length, special crossings, geotechnical conditions, contaminated materials, wetlands, waterways, endangered resources, cultural resources, agricultural resources, maintenance of traffic requirements, recent and planned regional transportation projects, stakeholder feedback, real property and easement requirements and constructability. Economic criteria included life-cycle pumping costs and Class 4 Opinions of Probable Construction Cost (OPCCs).

The non-economic and economic criteria included the following items.

- Hydraulic analysis
- Total pipeline length
- Trenchless requirements
- Geotechnical conditions
- Contaminated materials
- Maintenance of traffic requirements
- Wetlands
- Waterways
- Floodplain encroachment
- Special habitats
- Protected resources
- Agricultural resources
- Energy consumption
- Stakeholder feedback
- Real property and easement requirements
- Constructability
- Conceptual opinion of probable construction costs

See Appendix C for a detailed description of the pipeline route alternatives analysis.

4 Affected environment

4.1 Geology and soils

The bedrock geology of Southeastern Wisconsin consists of Paleozoic sedimentary units, generally thickening to the east. In most places, Pleistocene deposits of till, sand and gravel, cover the bedrock units making bedrock outcrops rare. The basic geologic framework of the region is shown in Table 4-1. Maps are also available in CH2M Hill (2013, Vol. 5, Appendix 6-8.)

Soils within the southern Lake Michigan coastal ecological landscape are characteristic mainly of glacial lake influence, along with ridge and swale topography, clay bluffs, and lake plains. Ground moraine inland from the lakeshore is the dominant landform, with soils generally consisting of silt-loam surface overlying loamy and clayey tills.

4.1.1 Surficial geology

The Pleistocene deposits in the Region consist of a complex sequence of deposits differing in origin, age, lithology, thickness, and areal extent. Mickelson et al. (1984) recognized five lithostratigraphic units in Southeastern Wisconsin: Kewaunee, Horicon, Oak Creek, New Berlin, and Zenda Formations.

The inland portion of Waukesha county is covered with glacial deposits of the Green Bay Lobe (Horicon Formation) and early advances of the Lake Michigan Lobe (New Berlin and Zenda Formations) that occurred about 15,000 to 35,000 years ago (Clayton et al. 2001, Mickelson and Syverson 1997). These earlier ice advances till units tend to be sandier and more permeable than the younger tills to the east. The till of the Zenda Formation is older, pink, and medium- grained, and only rarely occurs at the surface. The younger Horicon and New Berlin Formations contain yellowish-brown and coarse-grained tills; the New Berlin Formation usually overlies the Zenda Formation (Mickelson et al. 1984). The Kettle Moraine, formed along the junction of these two ice lobes, is a hummocky upland consisting mainly of outwash sediment that collapsed when underlying or adjacent ice melted.

The lakeshore counties of Milwaukee and Racine also contain sandy till units (Horicon and New Berlin Formations) left by earlier advances, but these are mostly buried by younger silty deposits (Kewaunee and Oak Creek Formations) from later advances of the Lake Michigan Lobe.

There are three known major advances of the Lake Michigan Lobe, each of which laid down a distinctive type of till. The first advance of the Lake Michigan Lobe occurred about 15,000 to 35,000 years ago and deposited the sandy tills of the Zenda and New Berlin Formations. During the second major advance of the Lake Michigan Lobe about 13,000 to 14,500 years ago, a gray silty till of the Oak Creek Formation (Mickelson et al. 1984) was deposited in three major morainic belts: the Valparaiso, Tinley and Lake Border systems, formed roughly parallel to the shoreline (Brown 1990, Schneider 1983, Simpkins 1989). This silty, clayey till has a very low permeability, but contains lenses of gravelly outwash and sandy lake deposits. The third major advance of the Lake Michigan Lobe occurred from about 13,000 to 11,000 years ago and deposited a reddish silty till (of the Kewaunee Formation) in a narrow band along the lakeshore north of Milwaukee and into Ozaukee County (Mickelson et al. 1984, Mickelson and Syverson 1997). This till overlies the earlier gray clayey till and is also of very low permeability (Table 4-1).

Table 4-1. Geologic column for bedrock and glacial deposits in southeastern Wisconsin

Geologic time	Rock		Lithologic
QUATERNARY			
Recent	Undifferentiated		Soil, muck, peat, alluvium, colluvium, beach sediment
Pleistocene[1]	Kewaunee Formation		Brown to reddish-brown, silty and clayey till
	Horicon Formation		Coarser, brown, sandy till with associated sand and gravel
	Oak Creek Formation		Fine-textured, gray clayey till; lacustrine clay, silt, and sand
	New Berlin Formation		Upper: medium-textured. gravelly sandy till; Lower: outwash sand
	Zenda Formation		Medium-textured, pink, sandy till; limited distribution
PALEOZOIC			
Devonian	Antrim Formation		Gray, silty shale; thin; limited distribution
	Milwaukee Formation		Shaly dolomite and dolomitic siltstone
	Thiensville Formation		Dolomite and shaly dolomite
Upper Silurian	Waubakee Formation		Dense, thin-bedded, gray, slightly shaly dolomite
	Racine Formation		Finely crystalline dolomite; locally shaly beds and dolomite reefs
	Waukesha Formation		Cherty, white to buff, medium bedded, shaly dolomite
	Brandon Bridge beds		Pink to green shaly dolomite with shaly beds
	Lower Silurian beds (undifferentiated)		Dolomite and shaly dolomite
Ordovician	Neda Formation		Brown hematitic shale and oolite; occurs sporadically
	Maquoketa Formation		Green to gray dolomitic shale; locally layers of dolomite,
	Sinnipee Group	Galena Formation	Cherty dolomite with shaly dolomite at the base
		Decorah Formation	Shaly dolomite with fossils; thin or absent
		Platteville Formation	Dolomite and shaly dolomite
	Ancell Group	Glenwood Formation	Blue to green shale or sandy dolomite; thin or absent
		St. Peter Formation	Predominantly medium-grained quartz sandstone
	Prairie du Chien Group	Shakopee Formation	Light gray to tan dolomite or dolomitic sandstone; locally absent
		Oneota Formation	Massive, light gray to tan, cherty, sandy dolomite; locally absent
Cambrian	Trempealeau Group	Jordan Formation	Fine- to medium-grained quartz sandstone; locally absent
		St. Lawrence Formation	Tan to pink silty dolomite; locally absent
	Tunnel City Group		Fine- to medium-grained sandstone and dolomitic sandstone; locally
	Elk Mound Group	Wonewoc Formation	Medium- to coarse-grained, tan to white, quartz sandstone
		Eau Claire Formation	Fine- to medium-grained sandstone; local beds of green shale
		Mt. Simon Formation	Coarse- to medium-grained sandstone; lower beds very coarse
PRECAMBRIAN	Undifferentiated		Granite or quartzite

[1] All units include lake and stream sediment.

Source: University of Wisconsin - Extension, Wisconsin Geological Natural History Survey

4.1.2 Bedrock geology

The bedrock of Southeastern Wisconsin is separated into two major divisions: 1) younger, relatively flat-lying sedimentary rocks of the Paleozoic Era (younger than 570 million years), and 2) older Precambrian predominantly crystalline rocks.

The Paleozoic rocks form the major aquifers of Waukesha, Milwaukee and Racine counties and consist of sedimentary rocks—dolomite, shale, and sandstone—that range from Cambrian to Devonian in age. The Paleozoic rocks are nearly flat-lying, but dip gently to the east from the Wisconsin Arch into the Michigan Basin, and thicken significantly from west to east (Table 4-1). An older crystalline basement of Precambrian crystalline rock, primarily granite and quartzite, underlies the Paleozoic sedimentary sequence.

Devonian strata, the youngest Paleozoic rock in Wisconsin, are present only along a narrow band parallel to the Lake Michigan shoreline from Milwaukee to the north. They constitute the westernmost occurrence of Devonian strata in the Michigan Basin. The Silurian dolomites are at the bedrock surface throughout most of the Region. The Ordovician-age Maquoketa Formation (shale) and Sinnipee Group (dolomite) underlie the western edge of the Region. The remaining Ordovician rock units, the St. Peter formation and the Prairie du Chien Group, and the Cambrian sandstone sequence are not exposed at the bedrock surface but are encountered in deep wells throughout the Region.

The youngest rocks in the three-county area discussed are the Devonian limestone, dolomite, and shale. Because of the eastward regional dip of the beds, Devonian rocks are exposed only in a small area in eastern Milwaukee County. The Devonian consists, from the top, of the Antrim Shale, the Milwaukee Formation, and the Thiensville Formation. The Thiensville Formation ranges from 55 to 75 feet in thickness and grades from shaly dolomite at the base to clean dolomite at the top. The Milwaukee Formation consists of about 60 feet of shaly dolomite and dolomitic siltstone, and locally in eastern Milwaukee County it is overlain by up to 13 feet of a gray, silty mudstone of the Antrim Formation (formerly Kenwood Shale).

The Silurian section of Waukesha, Racine and Milwaukee counties consists of up to 600 feet of dolomite, subdivided into five formations. These are, from the top, the Waubakee Formation, the Racine Formation, the Waukesha Formation, the Brandon Bridge beds, and the undifferentiated "lower Silurian beds" (Table 4-1). The Waubakee Formation consists of dense, laminated to thin-bedded, slightly shaly, gray dolomite and is present only in Ozaukee and eastern Milwaukee County. It varies from 60 to 100 feet in thickness and is unconformably overlain by the Devonian Thiensville Formation. Locally, reefs developed in the underlying Racine Formation project through the Waubakee Formation and are overlain directly by the Thiensville Formation.

The Racine formation is on average about 170 feet thick in the Milwaukee area, but can reach as much as 290 feet where reefs are developed. The nonreef facies of the Racine Formation is well-bedded, finely crystalline, light olive-gray dolomite, with some shaly beds. Reefs occur locally within the Racine Formation, and consist of massive, coarsely crystalline, porous, fossiliferous, mottled gray to brownish-gray dolomite (Mikulic and Mikulic 1977). The reefs are up to 100 feet thick and over 990 feet in diameter, and grade laterally into typical nonreef Racine dolomite. The contact between the non-reef Racine facies and the overlying Waubakee Formation is gradational.

The Waukesha Formation consists of locally cherty, white to buff-colored, medium-bedded, shaly dolomite. In the southern part of the Region, at Racine and Burlington, the Brandon Bridge beds consist of light pink to green shaly dolomite interbedded with maroon shaly beds in the lower half. The Brandon Bridge beds thin to the north and are not present north of Waukesha (Mikulic and Mikulic 1977). In Milwaukee County, the Brandon Bridge beds and the Waukesha Formation combined, range in thickness from 45 to 80 feet. These two units are sometimes called in the literature the Manistique Formation.

The lower part of the Silurian section is not exposed in Southeastern Wisconsin and has not been extensively studied because few rock cores exist. The "lower Silurian beds" are approximately 175 feet thick in Milwaukee County. The beds consist of dolomite similar to that of other Silurian formations and are probably equivalent to the Byron and Mayville Formations of northeastern Wisconsin. The upper unit, the Byron Formation, is described as a fine-grained mudstone and the lower unit, the Mayville Formation, as a coarser- textured packstone.

The Ordovician rocks of the three-county area discussed consist from, from the top, of the Neda Formation (shale), the Maquoketa Formation (shale and dolomite), the Sinnipee Group (dolomite), the Ancell Group (sandstone), and the Prairie du Chien Group (dolomite). The Ancell and Prairie du Chien Groups are not exposed at the bedrock surface and are known only from well cuttings and logs.

4.1.2.1 Neda Formation

The upper Ordovician Neda Formation is a layer of brown hematitic shale and oolite, which occurs sporadically at the Ordovician-Silurian boundary in eastern Wisconsin and is conformable and gradational with the underlying Maquoketa Formation. Where present, the Neda Formation can be up to 50 feet thick.

4.1.2.2 Maquoketa Formation

The Maquoketa Formation underlies the Silurian dolomite and is exposed at the bedrock surface in the western part of Waukesha County. It consists predominantly of green to gray shale, dolomitic shale, and dolomite. It is approximately 150 feet thick in Racine County and thickens to the north and east. The Fort Atkinson Member is a continuous dolomite unit consisting of coarse, dark brown to brown, shaly dolomite up to 50 feet thick in the middle of the Maquoketa Formation, between the Brainard and Scales Members, which are predominantly shale.

4.1.2.3 Sinnipee Group

The Sinnipee Group consists of dolomite, shaly dolomite, and minor shale, and is divided into three formations (Table 4-1). The uppermost one, the Galena Formation, consists of cherty dolomite with 15 to 20 feet of shaly dolomite at the base. The middle unit, the Decorah Formation, is thin or locally absent in Southeastern Wisconsin, represented by five or less feet of shaly dolomite in Waukesha County (Choi 1995). The lower formation of the Sinnipee Group, the Platteville Formation, consists of dolomite and shaly dolomite, and reaches a thickness of 85 feet in Racine County.

4.1.2.4 Ancell Group

The Ancell Group includes the Glenwood and St. Peter Formations (Table 4-1). The Glenwood Formation consists of 20 feet or less of dolomitic sandstone, blue-green shale, or sandy dolomite. The Glenwood Formation is locally variable in thickness and lithology and is not always present in Southeastern Wisconsin (Mai and Dott 1985). The St. Peter Formation is present throughout the three counties and is subdivided into two members. The upper Tonti Member is a pure quartz sandstone, ranging in thickness from less than 50 feet to locally greater than 250 feet. The lower Readstown Member is variable in character, consisting of white to red sandstone, conglomerate (consisting of shale, chert, sandstone, and/or dolomite clasts), red to brown shale, or any combination of these rock types, in a matrix of fine to coarse sand or clay. The Readstown Member is not continuous and is best developed in areas where maximum erosion of the underlying formations took place prior to Ancell Group deposition.

4.1.2.5 Prairie du Chien Group

The Prairie du Chien Group is subdivided into two formations (Table 4-1). The upper Shakopee Formation, consists of light gray to tan sandy dolomite (the Willow River Member) and a thin (15 feet or less) discontinuous dolomitic sandstone (the New Richmond Member). The New Richmond Member is not always recognizable in well cuttings and is not well defined. The lower formation, the Oneota Formation, consists of massive, light gray to tan, commonly cherty dolomite. The base of the Oneota Formation becomes sandy and is gradational with the underlying Coon Valley Member of the Cambrian Jordan Formation. The Prairie du Chien Group is not exposed at the bedrock surface in Southeastern Wisconsin and is known in the subsurface in parts of Racine County, having been removed by pre- St. Peter erosion to the north. Where present, the Prairie du Chien Group is generally less than 70 feet thick (Mai and Dott 1985).

The Cambrian rocks of the three-county area discussed, are primarily sandstone, with some dolomite and shale. These rocks have not been adequately studied due to the scarcity of good samples. Their stratigraphy is not known in detail. The Cambrian is subdivided into three major divisions, the Trempealeau Group, the Tunnel City Group, and the Elk Mound Group (Table 4-1). The Cambrian section thickens from northwest to southeast, ranging in thickness from around 700 feet in western Waukesha County to around 2,400 feet near Zion, Illinois, south of Kenosha.

4.1.2.6 Trempealeau Group

The Trempealeau Group consists of the Jordan and St. Lawrence Formations. The Trempealeau Group is eroded by the pre-St. Peter unconformity in much of Southeastern Wisconsin. Where not eroded, the Trempealeau Group varies from 70 to 150 feet in total thickness. In its outcrop area of western Wisconsin, the Jordan Formation can be subdivided into five members on the basis of grain size and composition. These members are not easily recognized in the subsurface. The Jordan Formation is predominantly fine- to medium-grained quartz sandstone, commonly with some dolomitic cement. The Coon Valley Member at the top of the Jordan Formation is a sandy dolomite that grades into the overlying Oneota Formation. The St. Lawrence Formation is tan to pink sandy or silty dolomite, becoming more dolomitic to the south, where it is known as the Potosi Dolomite in Illinois (Buschbach 1964).

4.1.2.7 Tunnel City Group

The Tunnel City Group consists of fine- to medium-grained sandstone and dolomitic sandstone, which varies in color from light brown to green, depending on glauconite content. In its outcrop area of western Wisconsin, the Tunnel City group is divided into the Lone Rock and Mazomanie Formations. In Southeastern Wisconsin, these formations are not easily recognized in well cuttings, and the Tunnel City Group is treated as a single unit varying from 50 to 80 feet in thickness. It is equivalent to the Franconia Formation of northern Illinois (Buschbach 1964). The Tunnel City Group is not present in Milwaukee County due to erosion.

4.1.2.8 Elk Mound Group

The Elk Mound Group is the lowermost division of the Paleozoic sedimentary section. It is divided into the Wonewoc, Eau Claire, and Mount Simon Formations. The lowest one, the Mount Simon sandstone, directly overlies the Precambrian crystalline rock basement.

4.1.2.9 Wonewoc Formation

The formation is a medium- to coarse-grained, tan to white quartz sandstone. It is generally poorly cemented but may be locally cemented by dolomite or silica. Where present, the Wonewoc Formation is easily distinguished from the overlying Tunnel City Group and the underlying Eau Claire Formation by coarser grain size, color, and absence of glauconite. The lower contact of the Wonewoc Formation is an erosional surface that locally cuts into the underlying Eau Claire Formation. Total thickness of the Wonewoc and Eau Claire Formations together varies from 160 to 200 feet from north to south across the Region.

4.1.2.10 Eau Claire Formation

This formation consists of fine- to medium-grained sandstone with local beds of green to black shale and dolomite. Dolomite cement, pyrite, and fossils are commonly present. The Eau Claire Formation thickens to the south into northern Illinois, and shale and dolomite content increases to the south as well (Buschbach 1964). It is easily distinguished from the overlying Wonewoc and underlying Mount Simon Formations by finer grain size and glauconite content.

4.1.2.11 Mount Simon Formation

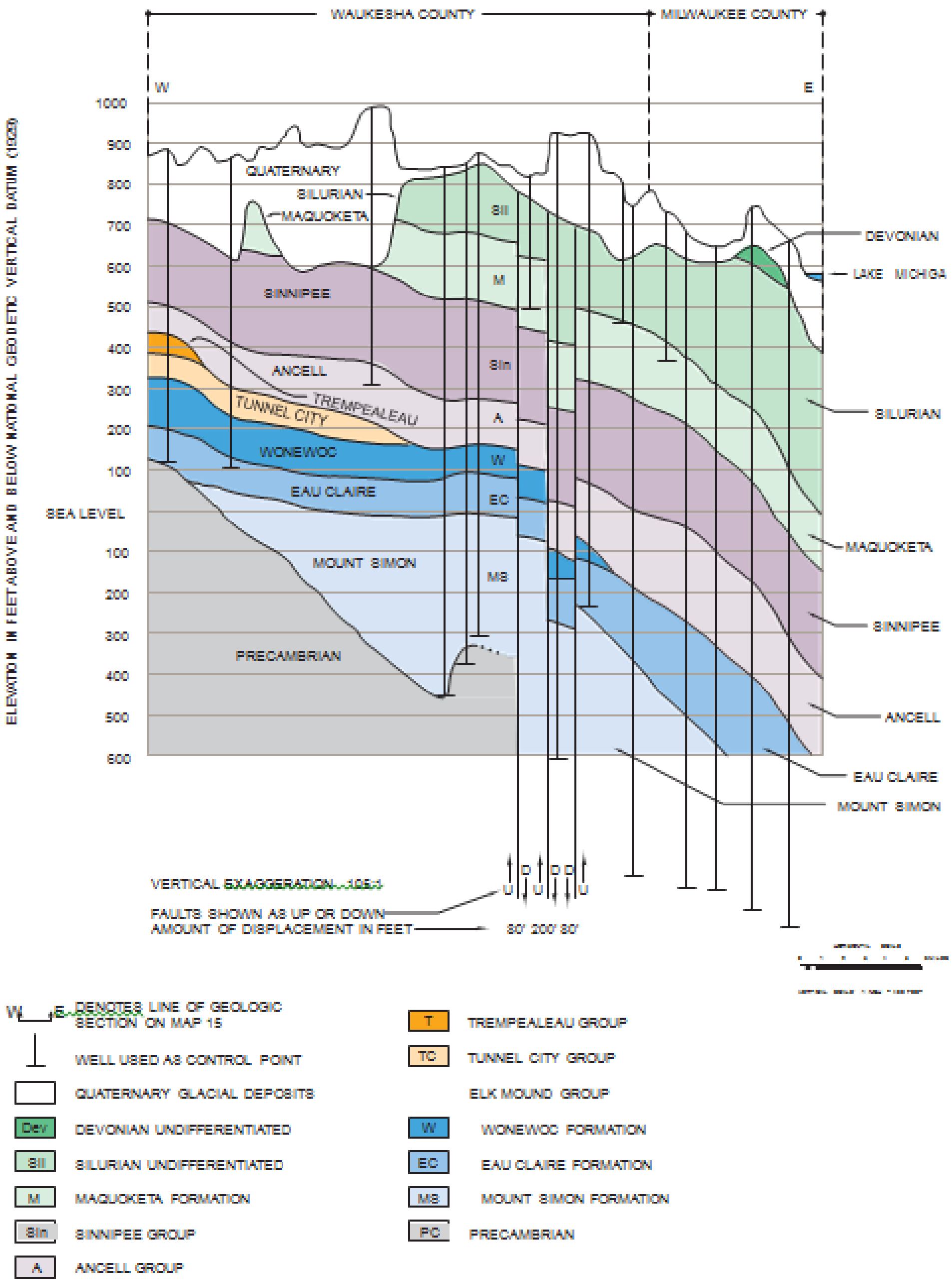
The Mount Simon Formation consists predominantly of coarse- to medium-grained sandstone, with coarser layers commonly containing pebbles. It is generally poorly cemented, but locally may be cemented by dolomite or silica. In Milwaukee and Racine Counties red, black or green shale beds can be present within the Mount Simon Formation. The lower beds are commonly very coarse and pebbly, locally becoming conglomerate near the Precambrian contact. The Mount Simon Formation thickens to the south and east. The maximum complete section penetrated in Southeastern Wisconsin is 1,306 feet in Waukesha County.

The Precambrian crystalline basement of the three counties discussed is poorly known. Limited wells have reached the Precambrian and recovered identifiable samples. The most common recovered rock types, presumably 1,760 million years old or younger, are granitic and quartzite resembling the Waterloo and Baraboo quartzites exposed to the west (Smith 1978). The Precambrian is encountered at a depth of 77 feet in western Waukesha County, and dips to the south and east (Table 4-1), reaching a depth of 3,460 feet in the Zion, Illinois well. The Precambrian basement forms the lower boundary of the lower Paleozoic sandstone aquifer.

4.1.3 Structural geology

The three-county area of Southeastern Wisconsin has largely remained tectonically inactive for approximately one billion years and the structural deformations are minimal there. The cross-section in Figure 4-1 shows diagrammatically the stratigraphic formations and their dip, and the dip of the Precambrian surface across Waukesha County and Milwaukee County. Faults shown on the cross-sections are inferred from the differences in elevation of formation boundaries, both in wells shown on the sections and by comparison with wells located within the several miles of the sections. There are no wells shown on the sections that actually cross a fault trace. Because most large faults in Southeastern Wisconsin are nearly vertical, it is rare that a well will cross a fault trace. There is only one well (in the City of Waukesha) supported by drill cuttings that is known to be drilled through a fault trace.

Figure 4-1. Geologic cross section of Southeastern Wisconsin, west - east



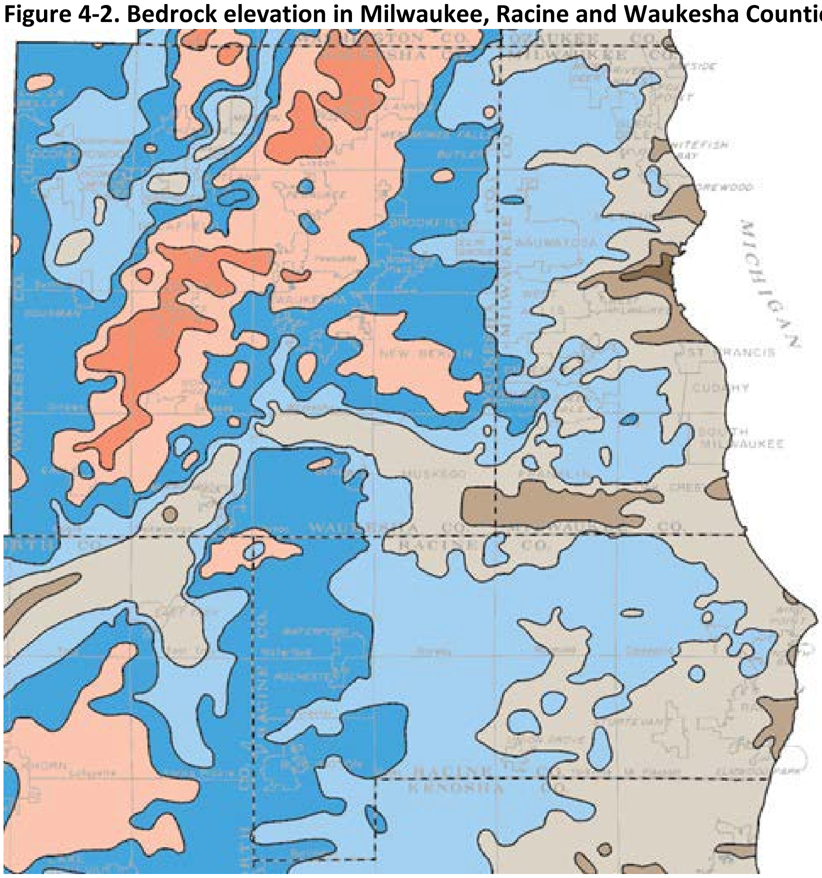
Source: SEWRPC (2002)

The west-east section (Figure 4-1) crosses a major fault zone, the Waukesha Fault, which passes through Waukesha County and trends northeastward into Lake Michigan. The Waukesha Fault is a potentially important hydrologic feature because it offsets major formation and aquifer boundaries and may significantly influence deep groundwater flow systems. Although the existence of the Waukesha Fault in Southeastern Wisconsin has been recognized for some time (Foley et al. 1953), its location and linear extent have been, until recently, poorly defined due to limited data from bedrock wells and only one significant exposure. Sverdrup et al. (1997) used gravity data from geophysical surveys conducted in the early 1980s to trace the Waukesha Fault from the Waukesha-Walworth county line to Port Washington in Ozaukee County.

4.1.4 Bedrock elevation and bedrock valleys

Figure 4-2 shows the approximate bedrock elevations in Waukesha, Milwaukee and Racine counties, which broadly resembles depth to bedrock in these counties. Areas located over the deep bedrock valleys are where the bedrock is farthest from the land surface. The northern valley extends from northeastern Washington County southwest through northwestern Waukesha County to southern Jefferson County. In the southern half of the Region, a long valley curves from southern Milwaukee and Waukesha Counties south through Walworth County into Illinois. Thicknesses of glacial materials in these buried valleys range from 250 feet to more than 450 feet.

Figure 4-2. Bedrock elevation in Milwaukee, Racine and Waukesha Counties



Source: WGNHS

The areas where bedrock is closest to the land surface trend from northeast to southwest, from southeastern Washington County through northeastern Waukesha, bedrock generally is found there at depths less than 25 feet. Numerous outcrops and large quarries are found in the Silurian dolomite, which is the uppermost bedrock formation.

Elsewhere along the same general trend, bedrock lies at depths of less than 50 feet; for example, at the Kettle Moraine in Waukesha County. In most of the rest of Southeastern Wisconsin, depth to bedrock ranges between 50 and 250 feet. This wide range of depth to bedrock is, in large part, caused by end moraines deposited during the last glacial period and the erosion of river valleys since then. For example, there are only a few outcrops or areas where bedrock is less than 50 feet deep in Racine County because of the thickness of glacial deposits. But numerous outcrops are in Milwaukee County, where the Milwaukee, Menomonee, and Root Rivers and their tributaries have formed deep valleys in these same glacial deposits. In some cases, isolated outcrops have been reported in areas where overall bedrock surface is more than 25 feet deep.

4.2 Lake Michigan

4.2.1 Physical description and floodplain of Lake Michigan

Lake Michigan is bordered by four states and has the second largest volume of any of the Great Lakes. It is the only Great Lake located entirely within the borders of the United States. Lake Michigan is 307 miles long, up to 118 miles wide, and up to 925 feet deep. It has a surface area of 22,300 square miles, an average depth of 279 feet, a volume of 1,180 cubic miles (1,300 trillion gallons) and a retention time of 99 years (U.S. EPA and Environment Canada 2012).

4.2.2 Water quality of Lake Michigan

Southeastern Wisconsin's Lake Michigan shoreline water quality has been influenced by nonpoint and point source pollution, as well as changes caused by invasive species, most notably zebra mussels (*Dreissena polymorpha)* and quagga mussels (*Dreissena rostriformis bugensis)*. Nonpoint source pollution to the shoreline includes impervious and pervious surface runoff, boating wastes, bacterial transport in shoreline algae accumulation, and direct input from animals, such as seagulls. Point source pollution generally results from combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), or from stormwater outfalls (Kinzelman 2007).

In recent decades, invasive dreissenid mussels which have covered the lake bottom have resulted in clearer water which in turn has led to algae growth, including the spread of *Cladophora* at deeper water levels than prior to mussel colonization. Research at the Great Lakes Water Institute and elsewhere continues on the interaction between invasive mussels, nutrient cycling in Lake Michigan, and the growth of *Cladophora* (Bootsma 2009).

4.2.2.1 Milwaukee Harbor Area of Concern

The Milwaukee Harbor estuary is designated a Great Lakes Area of Concern (AOC) because of the presence of legacy contaminants (PCBs, PAHs, heavy metals, etc.) and other impairments. The harbor suffers from urban stresses similar to those experienced in other highly urban areas at the other 42 AOCs throughout the Great Lakes. Priorities for the Milwaukee Harbor AOC include remediation of contaminated sediments in tributaries and nearshore waters of Lake Michigan, prevention of eutrophication, nonpoint source pollution control, improvement of beach water quality, enhancement of fish and wildlife populations, and habitat restoration. More information on the Milwaukee Harbor AOC is available at http://www.epa.gov/glnpo/aoc/ or http://dnr.wi.gov/topic/greatlakes/milwaukee.html.

4.2.2.2 Lake Michigan water quality data – MMSD, UW-Milwaukee, and SEWRPC

SEWRPC and the Milwaukee Metropolitan Sewerage District (MMSD) have been measuring water quality in the Greater Milwaukee area since the 1960s (SEWRPC 2007, p. 149). Notable water quality improvements have been documented since the MMSD's deep tunnel system came online in 1994 to reduce the number of combined sewer overflows (CSOs).

Water quality trends at sampling stations in the Milwaukee outer harbor and nearshore Lake Michigan areas over this historical monitoring period have indicated (SEWRPC 2007, p. 155):

- Fecal coliform concentration has trended down.
- Biological oxygen demand has trended down.
- Dissolved oxygen concentration has stayed the same or trended down and generally meets standards.
- Total suspended solids concentration trends varied with some stations increasing and others staying the same.

Total phosphorus concentration has trended down in the outer harbor and up in the nearshore area. Since 1986, average annual concentrations have been less than 0.1 mg/L, except for 1 year. The phosphorous standard for the near shore and open waters of Lake Michigan is 0.007 mg/L (s. NR 102.06 (5) (b), Wis. Adm. Code); however, an interim effluent limit for discharge to Lake Michigan has been set at 0.6 mg/L (Wis. Adm. Code NR 217.13(4)), for all dischargers until a nearshore model can be developed to determine site specific standards. Nearshore phosphorus water quality data ranged from 0.011to 0.014 mg/L TP (Table 4-3: 1979-2010 data, stations NS-01, NS-02, NS-03 and NS-10).

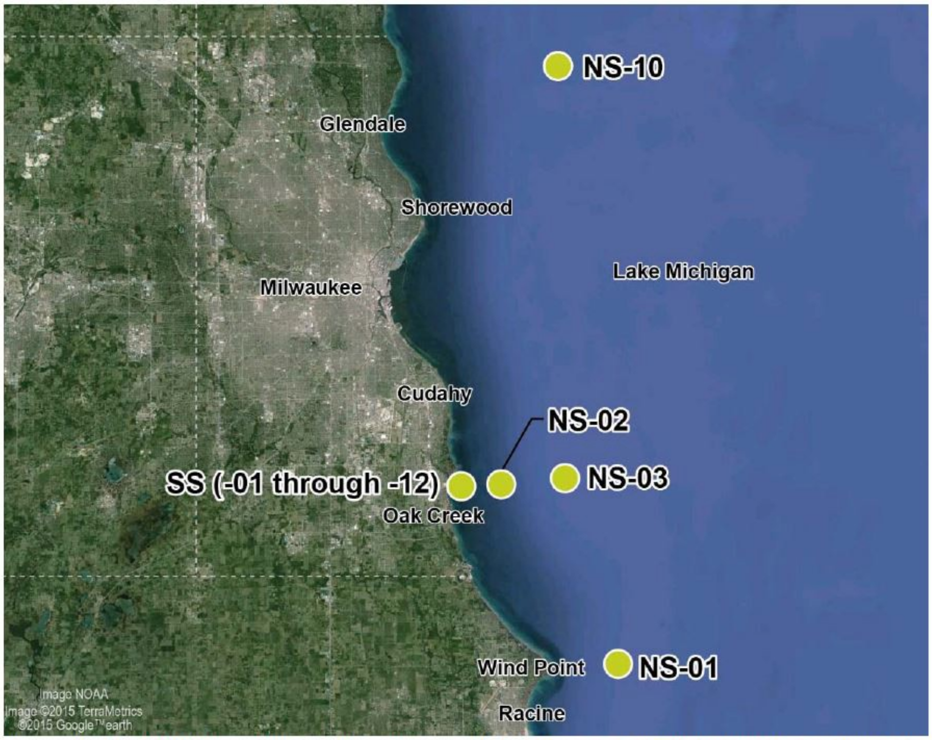
Data collected closest to the Milwaukee Metropolitan Sewerage District (MMSD) South Shore water reclamation facility measurements are closer to the submerged treatment plant outfall. Nearshore data is expected to be more characteristic of overall Lake Michigan water quality than South Shore data because it is further away from a discharge location. South Shore concentrations for TP ranged from 0.015 to 0.111 mg/L (1979-2010 data, stations SS-01 through SS-12).

Figure 4-3 shows the locations of nearshore and South Shore area sampling sites near the cities of Oak Creek and Racine. Nearshore sampling point NS-10 is located north of the Menomonee River. Along the western shoreline of Lake Michigan currents predominantly follow a north-to-south direction (or lake-wide, a counterclockwise rotation). NS-10 is therefore expected to represent water quality without the immediate effects of various discharges to the lake south of the City of Milwaukee. These discharges could include the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers, the MMSD Jones Island and South Shore water reclamation facilities, the Oak Creek power plant, and various stormwater outfalls and direct runoff.

Figure 4-3. WATERBase water quality data sampling locations

Water Quality Data Collection Locations [a]

Locations near Oak Creek, WI, and Racine, WI



[a] Screenshot of WATERBase interface. Nearshore sample locations are individually identified as NS-01, NS-02, NS-03 and NS-10. Clustered samples taken close to the South Shore (SS) Water Reclamation Facility are also indicated.

4.2.2.3 Lake Michigan water quality data near City of Racine

Racine is a coastal community located on the southwestern shore of Lake Michigan. Over the past decade and a half, research has been conducted at the two primary public beaches, Zoo Beach and North Beach (just north of the mouth of the Root River). Between the years 2000-2004, elevated levels of *Escherichia. Coli (E. coli)* caused poor recreational water quality, resulting in beach advisories or closures an average of 25 days for North Beach and an average 32 days for Zoo Beach (Kinzelman and McLellan 2009).

The City initiated strategies to determine the sources of pollution, and in turn, mitigation and remediation techniques. Several mitigation measures have been implemented at the two beaches in the past decade such as: beach grooming, slope improvements, specialized infiltration basins and constructed dune systems to reduce stormwater runoff, and planting beach grasses to reduce overland sheet flow. From 2005- 2017, North Beach had advisories or closures an average of 4 days (action days ranged from 1 to 10 with the highest number of action days occurring in 2014), and Zoo Beach had advisories or closures an average of 6 days (action days ranged from 3 to 11 with the highest number of action days also occurring in 2014).

Although beach conditions have improved, algae along the Lake Michigan shoreline can harbor elevated concentration of bacterial indicators. Stranded algal mats are typically found along the water's edge at Lake Michigan beaches, where nearshore recreational activities occur. Stranded mats have higher concentrations of bacterial indicators than submerged mats. Average concentrations of *E. coli* measured in June 2004 ranged from 333 to 25,000 CFU/gram for stranded mats versus 400 to 1,700 CFU/gram for submerged mats (Kinzelman 2005). The presence of *Cladophora* along the shoreline has been augmented from a variety of environmental factors, including nutrient loading and greater sunlight penetration due to the improved water clarity from the filter feeding by invasive zebra and quagga mussels (Bootsma 2009)

The Root River itself can be a source of bacteria to the City of Racine beaches and Lake Michigan. Microbiological quality has been studied along the Root River. Between 1975-2004 fecal coliform concentrations commonly exceeded state water quality standards (SEWRPC 2007). Historical fecal coliform data have decreased along the mainstem from upstream to downstream (SEWRPC 2007). More recently, levels of *E. coli* have been monitored along the Root River in order to compare Root River watershed concentrations to the coastal recreational waters of Lake Michigan (Koski et al. 2014).

4.2.3 Geomorphology and sediment of Lake Michigan

The geology of Lake Michigan developed during the Pleistocene Epoch as continental glaciers repeatedly advanced across the Great Lakes region and Lake Michigan. Glacial movements deepened and enlarged the basins of the Great Lakes (U.S. EPA and Environment Canada 2012). Near Milwaukee, the nearshore geomorphology is varied. Example lakebed substrates include: rock, cobble and sand, sand, and clay outcrops (PSC 2003).

Groundwater flow into Lake Michigan is a significant component of overall flow. Direct and indirect groundwater inflow contributes 33.8 percent of Lake Michigan water (USGS 2000).

Sediment quality was reviewed in the vicinity of the Wisconsin Electric Power Company (WEPCO, or We Energies) Oak Creek, Wisconsin power plant. Two sediment quality studies were undertaken to investigate lakebed sediment on behalf of We Energies as a requirement for dredging operations. The first study, conducted in 1998, reported low to undetectable amounts of chlorinated organic compounds, such as polychlorinated biphenyls (PCBs) and pesticides.

Metals, which are naturally present at trace levels in Lake Michigan sediment, were also present at or below mean concentrations at other locations on Lake Michigan (DNR, 2003). The second study, conducted in 2002, detected no PCBs at the selected sample sites, and metals were again detected at or below mean background concentrations. Polycyclic aromatic hydrocarbons (PAHs), which are compounds resulting primarily from industrial oil and coal activities, were detected at three of eleven sample locations at concentrations high enough to negatively affect benthic macroinvertebrates. However, elevated levels were expected based on close proximity to the power plant’s coal dock. Locations elsewhere in the lake would be expected to vary in sediment quality.

4.2.4 Flora and fauna of Lake Michigan

Most of the coastal area along Lake Michigan is dominated by urban development and agriculture, although considerable acreage along Lake Michigan in Milwaukee County is in parkland, as well as the Schlitz Audubon Nature Center. Very few forested areas exist, but the remaining stands are dominated by maple and beech trees and also contain oak, hickory, and lowland hardwood species. There are also areas of wet-mesic and wet prairie, but they are limited and occur only in small preserves because of the landscape being heavily disturbed and fragmented. Because of fragmentation and significant disturbance, non-native plants are abundant in those areas. There are no aquatic plant threatened species, endangered species or species of concern within Lake Michigan.

4.2.4.1 Macrophytes of Lake Michigan

The primary aquatic macrophytes found in Lake Michigan include Sago Pondweed (*Stuckenia pectinata*), Coontail (*Ceratophyllum demersum*), Eurasian Watermilfoil (*Myriophyllum spicatum*), Elodea (*Elodea canadensis*), and Curly-leaf Pondweed (*Potamogeton crispus*). These plants are found in harbors and protected areas along the coast.

4.2.4.2 Benthic invertebrates of Lake Michigan

Free-floating or planktonic algae are present in Lake Michigan, dominated by the diatoms (represented by *Synedra, Fragilaria, Tabellaria, Asterionella, Melosira, Cyclotella* and *Rhizosolenia),* among others. Concentrations of free-floating algae fluctuate during the year, subject to the availability of sunlight, water temperatures, and in the cases of diatoms, bioavailability of silicon (PSC 2003). Algae typically found attached to substrate are also present in Lake Michigan. These include *Cladophora, Ulothrix, Tetraspora, Stigeoclonium,* and red algae *Asterocytis.*

In recent years, nuisance algae (genus *Cladophora*) growth has been observed along the Lake Michigan shoreline. The algae grow underwater attached to rocks, are dislodged by waves, and then washed up on shore. The decaying algae create nuisance odors. Similar algae growths were observed in the mid-1950s and again during the 1960s and 1970s, before this most recent occurrence. The cause of this latest resurgence in algae growth is uncertain, but it may be due in part to changes in water clarity and phosphorous availability brought on by the prevalence of invasive zebra and quagga mussels.

4.2.4.3 Benthic invertebrates of Lake Michigan

A survey of the Great Lakes in 1998 identified 20 taxa of benthic macroinvertebrates in Lake Michigan with an average of about seven taxa per sampling site (Barbiero et al. 2000). The amphipod *Diporeia* (formerly *Pontoporeia),* tubificid oligochaetes, and sphaeriid snails dominated the Lake Michigan benthic macroinvertebrate community. However, in nearshore areas, oligochaetes were the dominant taxonomic group. The density of benthic macroinvertebrates typically ranged from 1,500 to 6,500 organisms per square meter. Surveys performed in 2002 near the Great Lakes Water Institute in Milwaukee revealed that oligochaetes and chironomidae are present, as are freshwater sponges, *Ectoprocta*, mayflies, leeches, isopods, and amphipods.

Since 1988, the southern basin of Lake Michigan has had zebra and quagga mussels and undergone major changes in nutrient cycling. Dreissenid mussel infestations have been confirmed on most suitable habitat (USGS 2011).

Changes in nutrient cycling due to dreissenid mussels have repartitioned the productivity of the lake and reduced the density of benthic macroinvertebrate fauna, particularly oligochaetes and snails, observed between 1980 and 1987 (Nalepa et al. 1998). A decline in the abundance of an important amphipod (*Diporeia)* also began in 1988. Filter feeding by zebra mussels in nearshore waters was thought to have decreased the amount of food available to the amphipod (Nalepa et al. 1998). The declining abundance of *Diporeia*, which have been nearly extirpated from Lake Michigan, coincides with the expansion of the dreissenid mussels (Nalepa et al. 2009).

4.2.4.4 Fish of Lake Michigan

Lake Michigan is primarily cold water and relatively infertile. Historically, the fishery consisted mostly of lake trout, burbot, Coregonid fishes, whitefish and sculpins. An introduction of sea lamprey and over-fishing led to declines in the numbers of native piscivorous fish. Alewife populations grew and lake trout, lake herring, lake whitefish, bloater chubs and yellow perch populations declined. Control of invasives, along with a fish stocking program have increased predation and native fish numbers and have assisted in stabilizing alewife numbers. Today, the Lake Michigan fishery consists of nearly 100 species. Table 4-2 summarizes some of the predominant fish species of the nearshore waters of Lake Michigan (PSC 2003). Annual stocking of native lake trout, along with the introduction of Chinook and Coho Salmon, Brown trout and Steelhead has helped develop Lake Michigan into a popular sport fishery.

Both Lake sturgeon and American eel, also nearshore species, are listed as special concern species and skipjack herring is endangered in Wisconsin. The non-native species listed in Table 4-2 include: alewife, Chinook salmon, coho salmon, rainbow trout, brown trout, rainbow smelt, gizzard shad, common carp, round goby, three spine stickleback and sea lamprey.

Even though the Milwaukee Harbor estuary has these stresses, the fishery is reported to contain a high abundance and diversity of species, because the fishery is connected to the rest of Lake Michigan and to parts of the Milwaukee, Menomonee, and Kinnickinnic Rivers that achieve full fish and aquatic life standards (SEWRPC 2007, p. 205).

Table 4-2. Predominant fish species found nearshore in Lake Michigan

Alewife	Emerald shiner	Longnose sucker	Sea Lamprey
Bloater	Fathead minnow	Muskellunge	Slimy sculpin
Bluntnose minnow	Freshwater drum	Nine spine stickleback	Smallmouth bass
Bowfin	Gizzard shad	Northern pike	Spottail shiner
Brook stickleback	Johnny darter	Pumpkinseed	Three spine stickleback
Brook trout	Lake chub	Rainbow smelt	Trout perch
Brown trout	Lake sturgeon	Rainbow trout	Walleye
Burbot	Lake trout	Rock bass	White bass
Chinook salmon	Lake whitefish	Round goby	White sucker
Cisco	Largemouth bass	Round whitefish	Yellow perch
Common carp	Longnose dace	Sand shiner	

Source: DNR data

4.2.4.5 Herptiles of Lake Michigan

The common mudpuppy (*Necturus maculosus*) is a Wisconsin special concern species found near shoals and is a Species of Greatest Conservation Need that is significantly associated with the Lake Michigan natural community per the Wildlife Action Plan (search ‘Wildlife Action Plan at dnr.wi.gov).

4.2.4.6 Birds of Lake Michigan

The Caspian tern (Endangered), common tern (Endangered), Forster’s Tern (Endangered), black tern (Endangered) and horned grebe (Special Concern) are all Species of Greatest Conservation Need that are significantly associated with the Lake Michigan natural community per the Wildlife Action Plan.

4.2.4.7 Mammals of Lake Michigan

Native mammals in the southern region of the Lake Michigan basin in this area include: white-tailed deer, beavers, river otters, foxes, coyotes, and others. Uncommon mammals from Wisconsin's Natural Heritage Working List in the Southern Lake Michigan corridor include: water shrew (special concern), little brown bat (threatened), northern long-eared bat (threatened), silver-haired bat (special concern), eastern pipistrelle (threatened), big brown bat (threatened), franklin's ground squirrel (special concern), prairie deer mouse (special concern), prairie vole (special concern) and woodland vole (special concern). More information can be found at dnr.wi.gov search 'Wisconsin natural heritage working list.'

4.3 Fox River

4.3.1 Physical description of floodplain of the Fox River

The Fox River's headwaters originate near Colgate, Wisconsin and the river flows 202 miles to Ottawa, Illinois, where it empties into the Illinois River. The total watershed area is nearly 2,700 square miles. Eighty-four miles of the River are within Wisconsin. The upper part of the Fox River, 35% of the basin, flows through the City of Waukesha and is the current discharge location for treated effluent from the City's wastewater treatment plant (WWTP).

4.3.2 Flow and flooding in the Fox River

The Fox River stream flow gaging station (USGS Site 05543830) is located in the City of Waukesha and has a contributing drainage area of 124 square miles. The average annual stream flow (flow period 1963 to 2017) is 114.6 cfs at the Fox River in the City of Waukesha. The gage has been in operation since 1963 and has recorded major flood events in 1965, 1973, 1974, 1979, 2000, 2008, 2010, and 2017.

The history of flooding on the streams within the City of Waukesha indicates that flooding can occur during any season of the year. The majority of major floods on the Fox River have occurred in the early spring and are usually the result of spring rains and/or snowmelt. A peak discharge of 2,160 cfs was recorded at the USGS gage for the 1973 flood, which would have an expected frequency of once every 25 years. Highwater marks from this flood were used to verify the current, effective hydraulic model (FEMA 2014).

The Fox River floodplain model was not updated as part of the updated Flood Insurance Study. The current effective profiles and flows for the Fox River are listed in the Waukesha County Flood Insurance Study. Note: A new floodplain study, to be funded by the Federal Emergency Management Agency (FEMA), is in the process of being developed for the Fox River Watershed, which includes new hydrology and hydraulics for the Fox River. This analysis employs the 2008 event to calibrate the hydrologic model. This event is the flood of record and is estimated to have had a peak flow of 2,440 cfs. The tentative effective date of this study in Waukesha is mid-2021.

4.3.3 Water quality of the Fox River

In Wisconsin, the Fox River is designated a Warm Water Sport Fishery with the following uses: fish and aquatic life, recreation, public health and welfare, and fish consumption. Downstream in Illinois, the Fox River is designated as 'general use water,' which includes primary contact uses, and 'public and food water supply standards. The entire Fox River (miles 113.24 – 196.64) is on Wisconsin's §303(d) impaired waters list for PCBs, sediment/TSS and total phosphorus exceedances. Downstream impairments include aquatic toxicity due to PCBs and degraded biological communities due to phosphorus and sediment (Table 4-3).

Table 4-3. Wisconsin's §303 (d) pollutants and impairments for the Fox River - Illinois

Fox River (river miles)	Pollutant	Impairment
113.24 to 196.64	PCBs	Contaminated fish tissue
113.24 to 187.16	Total phosphorus	Degraded biological community, low dissolved oxygen, unknown
171.45 to 187.16	Sediment/total suspended solids	Degraded habitat, low dissolved oxygen

Water quality information has been gathered by a number of organizations in the Fox River watershed including the DNR, USGS and SEWRPC. Long-term water quality trend data are gathered by the DNR about seven miles downstream of the Waukesha WWTP at County Highway I. Parameters collected include: total suspended solids, alkalinity, dissolved oxygen, pH, total phosphorus, dissolved orthophosphorus, chlorophyll a, nitrogen series and *E. coli*. Several biological indices have been developed for three stream reaches along the Fox River. These indices use benthic macroinvertebrate and fish as indicators of water quality and physical conditions present within the stream (see Section 4.3.5.1).

The Applicant's WWTP currently discharges to the Fox River. See CH2M Hill 2013, Vol. 4, Appendix H for more WWTP information and historical effluent data.

4.3.4 Geomorphology and sediments of the Fox River

Near the City of Waukesha, the Fox River has natural channel reaches with minimal modifications, while other reaches have been significantly altered by development. Within the City center, upstream of the City's WWTP, the Fox River is dammed to create the Barstow Impoundment. River banks in the impoundment consist of sheetpile, concrete, rock reinforcements, and vegetation. Upstream of the dam, large sediment depositions are reported to include pollutants that are associated with increased risks to human and aquatic health .

Further upstream, the Fox River meanders through developed landscapes including residential, golf course, commercial and transportation development. In this segment, the river has primarily vegetated banks, with erosion and bank failures common to urban areas. The river generally has a wide floodplain with connected wetlands and some encroachments from development. The river is generally low gradient and primarily consists of pools and glides. The sediments are primarily silts and sands in the pools and sand and gravel in glides.

Downstream of the Barstow Impoundment, the river is confined by development. The river banks are primarily rock riprap and concrete retaining walls. The river is typically narrow and has a higher gradient than upstream reaches. Nearing the WWTP, the river returns to a low gradient meandering stream. Similar to the upstream reaches, the banks are mostly vegetated with some erosion and bank failures (typical in developing watersheds). Continuing downstream, the river has a fairly low gradient, with sediments consisting primarily of silt and sand in pools, and sand in the glides. Occasional areas of gravel are also present. In the downstream reaches, sand point bars have formed due to an increased bedload from agricultural runoff.

4.3.5 Flora and fauna of the Fox River

The riparian vegetation communities of the Fox River at proposed pipeline intersections are typical of higher-order waterways in the Midwest. The floodplains at County Highway H and

State Highway 59 are dominated by reed-canary grass and stinging nettle adjacent to the river; and mature woody trees such as box elder, silver maple, willows, and eastern cottonwood farther from the river. Few other herbaceous or shrub species are present. Four natural communities have been documented adjacent to the river. In addition, six rare plants, including two that are state-listed, are known to occur within the near vicinity of the Fox River.

4.3.5.1 Macrophytes of the Fox River

The Fox River does not have complete documentation of aquatic macrophytes. Observations of aquatic invasive species such as Eurasian water milfoil, curly leaf pondweed, reed canary grass, phragmites and purple loosestrife have been identified in and adjacent to the Fox River.

4.3.5.2 Benthic invertebrates of the Fox River

Aquatic macroinvertebrates have been collected at multiple locations on the Fox River in 1999, 2000, 2002 and 2007. The MIBI (benthic macroinvertebrate index) was developed for this stream reach of the Fox River and samples ranged from 4.62 to 6.58, generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a good to fair water quality. Sampling in the Fox River resulted in the identification of over 90 macroinvertebrate taxa being identified in these samples. Some taxa were identified at a species level, while others were identified to genus, subfamily, or family levels. Insects were the most identified taxa, including: true flies, beetles, caddisflies, mayflies, true bugs, dragonflies, damselflies, dobsenflies. Other groups found included amphipods, crayfish, isopods, annelid worms, nematode worms and turbellarian worms. The most commonly identified organisms were caddisflies, midges, and worms of the family Tricladida.

Surveys for mussels were conducted in the Illinois Fox River watershed and its tributaries from 1997-2001 in Wisconsin and Illinois. 96 main stem and tributary stations were sampled. A total of 27 species were identified of which 23 were live specimens. Three rare mussel species and one caddisfly species are known or have been known to occur within this stretch of the Fox River. An additional 2 introduced bivalve species (zebra mussels and Asian clam) were also found in the Fox River watershed (Schanzle et al. 2004).

Aquatic invasive species such as zebra mussels, rusty crayfish, banded mystery snails and asian clam have also been identified in segments of the Fox River and its tributaries.

4.3.5.3 Fish of the Fox River

Fox River fisheries data have been collected six miles downstream of the WWTP, between County Highway I and the confluence of Genesee Creek in 1999, 2000, 2003, 2004, and 2006 (Table 4-4). The surveys identified 38 species of fish. The most abundant species collected were golden redhorse, common carp, bluegill, channel catfish, largemouth bass, white bass, northern pike, rock bass, common shiner, sand shiner, bluntnose minnow, emerald shiner, longnose gar, white sucker, and creek chub. Most are considered warm water species, although they may also be found in cool water habitats. Several coldwater species (brook and brown trout) were noted at the confluence of Genesee Creek (a coldwater fishery) and the Fox River but were only present in small numbers. The common carp is an invasive species that has also been identified in the Fox River and its tributaries.

A separate fish survey was conducted at the confluence of the Fox River and Pebble Creek, 1.65 miles downstream of the Waukesha WWTP (Waukesha County and SEWRPC 2008). Many species were the same as those collected in the DNR surveys, but species not found farther downstream in the Fox River were collected. These were brook stickleback (a cool water species), and the spottail shiner, golden shiner, orange-spotted sunfish, and tadpole madtom, all warm water species. In addition, one endangered, one threatened, and one special concern species were collected. Outside of these surveys, there are two additional rare fish species that may be present in this stretch of the Fox River.

Table 4-4. Fish species in Fox River found downstream of Waukesha's WWTP

Bigmouth shiner	Freshwater drum	Rock bass
Black bullhead	Gizzard shad	River redhorse
Black crappie	Golden redhorse	Sand shiner
Blackstripe topminnow	Grass pickerel	Shorthead redhorse
Bluegill	Greater redhorse	Shortnose gar
Bluntnose minnow	Green sunfish	Silver redhorse
Bowfin	Honeyhead chub	Spotfin shiner
Brook silverside	Johnny darter	Stonecat
Brook trout	Largemouth bass	Walleye
Brown trout	Log perch	White bass
Central mudminnow	Longnose gar	White crappie
Central stoneroller	Mottled sculpin	White sucker
Channel catfish	Northern hog sucker	Yellow bass
Common carp	Northern pike	Yellow bullhead
Creek chub	Pumpkinseed	Yellow perch
Emerald shiner		

4.3.5.4 Herptiles of the Fox River

One state endangered and two special concern herptile species have been known to use the Fox River and its adjacent wetlands as habitat. However, the endangered herptile is thought to be extirpated from this area.

4.3.5.5 Birds of the Fox River

One state endangered and three special concern bird species are known to use the Fox River and its adjacent habitat for nesting.

4.3.5.6 Mammals of the Fox River

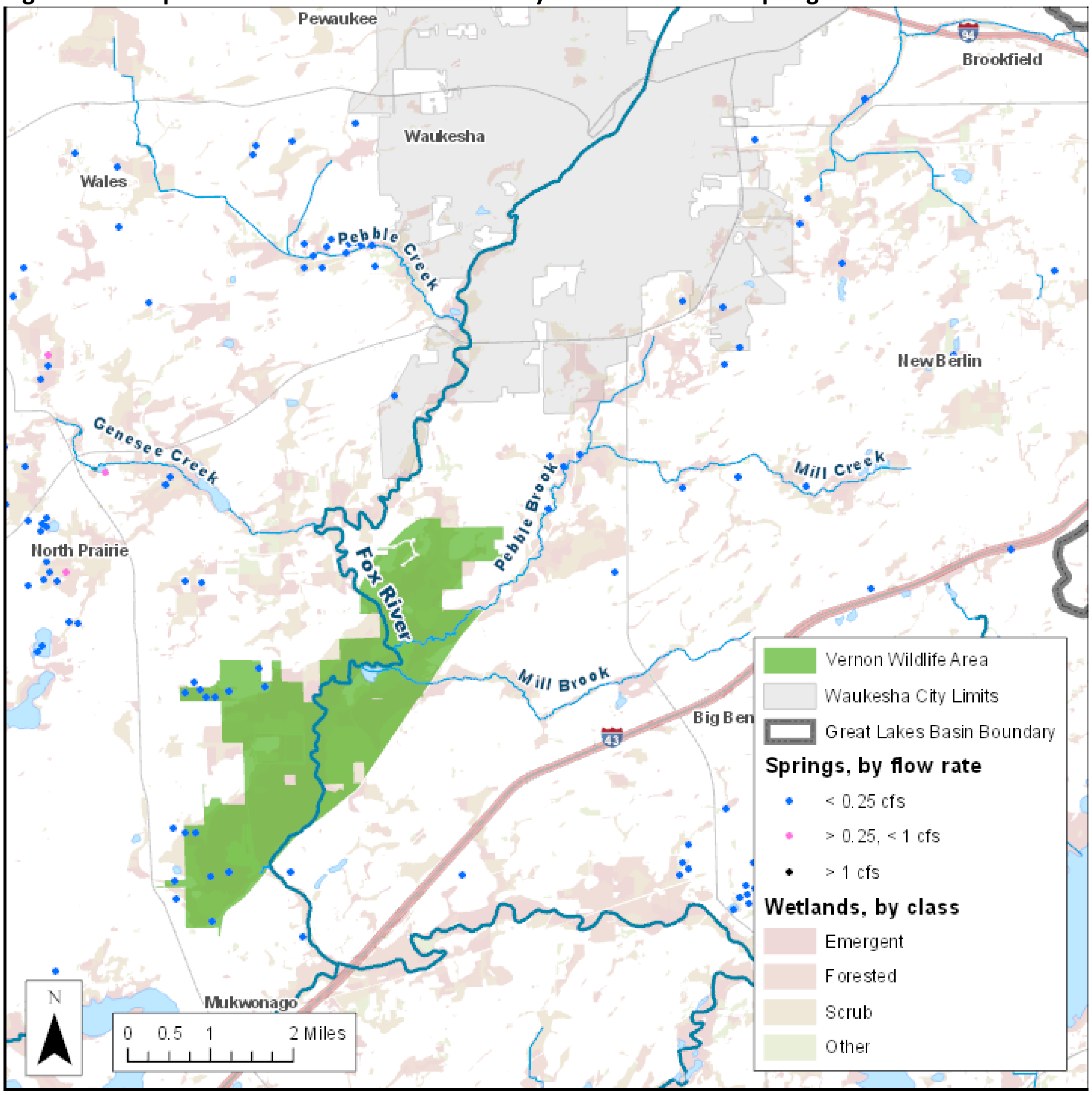
The Fox River also provides habitat for a variety of mammals, mostly furbearers. Muskrats, mink, otter, and beaver thrive in the marsh habitat. Other mammals including opossum, shrews, moles, bats, chipmunk, voles, mice, fox, raccoon, weasels, and skunk are numerous as well. White-tailed deer, eastern gray and fox squirrels, eastern cottontails, and coyotes are popular game species and receive moderate to heavy hunting pressure.

There are two rare mammals, including one that is state threatened, that are known to use the Fox River and/or its adjacent habitats.

4.4 Fox River tributaries

Pebble Brook, Pebble Creek, Mill Brook, Genesee Creek and Mill Creek all are smaller-order streams that empty into the Fox River in the vicinity of the City of Waukesha (Figure 4-4). Pebble Creek, Genesee Creek and Mill Brook are listed as Areas of Special Natural Resource Interest (ASNRI) because they have been designated as trout streams or contain state-listed endangered or threatened species. The riparian vegetation located adjacent to these waterways is often dominated by invasive species due to watershed disturbances (development). Even though the watershed is primarily urban, public parkways often buffer these waterways.

Figure 4-4. Map of Fox-Illinois River and tributary streams and local springs



4.4.1 Pebble Brook description

Pebble Brook is a narrow nine-mile long tributary to the Fox River south of the City of Waukesha. Pebble Brook is classified as a Cool-Warm Mainstem near the convergence with the Fox River and a Cool-Cold Headwater in the upper portions of the watershed.

4.4.2 Pebble Creek description

Pebble Creek is a narrow, six-mile long perennial trout stream in southeastern Waukesha County. It is a tributary to the Fox River south of the City of Waukesha, with a watershed size of 18 square miles. Pebble Creek is classified as a Cool-Cold Headwater stream in the upper portions. Coldwater fisheries are surface waters capable of supporting a community of coldwater fish and other aquatic life or serving as a spawning area for coldwater fish species. Coldwater streams often receive much of their flow from groundwater entering the stream which enables their temperature to remain cold. Pebble Creek is listed as a Class II Wisconsin trout stream (Class II is described as having some natural reproduction but not enough to fully utilize available food and space). The main tributary to Pebble Creek is Brandy Brook, a Class I Trout Stream. SEWRPC has created Watershed Protection Plans for Pebble Creek (SEWRPC 2008). Downstream of the convergence with Brandy Brook, Pebble Creeks classification transitions into a Cool-Cold Mainstem.

4.4.3 Mill Creek description

Mill Creek is a four-mile tributary stream that flows west from the City of New Berlin for four miles past two private dams before entering Pebble Brook. The watershed is approximately seven square miles. Mill Creek is classified as a Cool-Cold (Warm Transition) Headwater.

4.4.4 Genesee Creek description

Genesee Creek is a five-mile-long tributary that reaches its mouth at the Fox River about a mile west of Waukesha. From the mouth to the outlet of the Saylesville Millpond, Genesee Creek is classified as a Cool-Warm Mainstem. Upstream of the Saylesville Millpond, Genesee Creek is classified as a Cool-Cold Headwater. From its mouth to three and a half miles upstream Genesee Creek is classified as a Class II Trout water, and the remainder of the creek is a Class I Trout stream and an Exceptional Resource Water. Class I trout streams are high quality trout waters that have sufficient natural reproduction to sustain populations of wild trout, at or near carry capacity

4.4.5 Mill Brook description

Mill Brook is a narrow, five-mile-long perennial trout stream within an eight square mile watershed in southeastern Waukesha County. It is a tributary to the Fox River south of the City of Waukesha. Mill Brook is classified as a Cool-Warm to Cool–Cold Headwater stream. The headwaters of Mill Brook is listed as a Class I Trout Stream then further downstream as it flows into Vernon Marsh is listed as a Class II Trout Stream.

4.4.6 Flow and flooding in Fox River tributaries

There are no USGS flow gages located on the Fox River tributaries of Pebble Brook, Pebble Creek, Mill Creek, Genesee Creek and Mill Brook. The current effective Flood Insurance Study for these streams is dated November 5, 2014. The floodplain studies for these streams were not updated during this process. The profiles and flows can be found in the Waukesha County Flood Insurance Study. The modeled median low flows for August are: Pebble Brook (5.95 cfs), Pebble Creek (5.56 cfs), Mill Brook (2.34 cfs), Genesee Creek (9.62 cfs) and Mill Creek (2.25 cfs.).

4.4.7 Pebble Brook water quality

Pebble Brook is not listed impaired water on Wisconsin's Impaired Waters §303(d) list. DNR collected water quality data on Pebble Brook in August 2013 and July 2018 at DNR station number 683232 for assessment purposes (see Table 4-5).

Table 4-5. DNR water quality data at Pebble Brook

Parameter (Station 683232)	Result (August 2013)	Result (July 2018)
DO – Instantaneous	8.84 mg/L	13.14 mg/L
Water Temperature	15.95^{o} C	23.77^{o} C
Specific Conductivity	1041 umhos/cm	1165 umhos/cm
Phosphorus (grab sample)	0.0604 mg/L	0.0351 mg/L

Aquatic macroinvertebrates have been collected at multiple locations on Pebble Brook in 1997, 2000, 2002 and 2013. The MIBI for stream segments of the Pebble Brook samples sites ranged from 4.21 - 5.57, generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken in the Pebble Brook Watershed.

4.4.8 Pebble Creek water quality

Water quality data was gathered at DNR station number 683458 on Pebble Creek at Hwy D in 2014 and 2015 as part of a targeted watershed assessment. Total phosphorus samples were taken May through October in 2014. Average total phosphorus levels were 0.07 mg/L in 2014 and 0.06 mg/L in 2015 – both lower than the water quality standard for streams. Temperature, DO, specific conductivity, as well as volunteer and aquatic invasive species monitoring has been conducted at multiple sites on Pebble Creek.

Aquatic macroinvertebrates have been collected at multiple locations on Pebble Creek in 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The mean MIBI for Pebble Creek at Hwy D for the 2018 Clean Water Act assessment was 5.67. Other stream segments of the Pebble Creek and Brandy Brook watershed samples ranged from 2.7 - 6.1506 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken on Pebble Creek and Brandy Brook.

Pebble Creek is not listed as impaired on Wisconsin's §303(d) List; however, two unnamed tributaries to Pebble Creek are listed. Unnamed - Perennial Stream D (Pb016) and Unnamed - Perennial Stream C (Pb108) are both listed as having impairments of degraded habitat and elevated water temperature due to total suspended solids. Nonpoint source runoff, sedimentation, and beaver dams often result in a loss of habitat, water temperature fluctuations, and water quality impacts in Pebble Creek.

4.4.9 Mill Creek water quality

Volunteer aquatic invasive species (AIS) monitoring has been occurring at Station 10011470, Mill Creek at Big Bend Rd in recent years. In 2018, a fish, water quality and habitat survey of Mill Creek @ Big Bend Road occurred in August and September. The 2018 fish survey resulted in an FIBI score of 100, giving the stream an excellent fish IBI score. A grab sample was taken on August 7th, 2018 and had a result of 0.0568 mg/L of total phosphorous which is lower than the water quality criteria. Other parameters and results collected were: dissolved oxygen 7.98 mg/L, temperature 13.2°C, ph 7.27, conductivity 978.9, and flow was 0.077 m^3/sec.

Aquatic macroinvertebrates have been collected at a few locations on Mill Creek in spring and/or fall of 1980, 1997, 2000, and 2002. The MIBI for stream segments of the Mill Creek samples sites ranged from 3.28 - 5.89 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken on Mill Creek. Mill Creek is not listed as impaired water on Wisconsin's Impaired Waters §303(d) list.

4.4.10 Genesee Creek water quality

Water quality monitoring was conducted at Station 10009296 as part of a targeted watershed assessment in June 2018. Dissolved oxygen was measured at 9.32 mg/L, total phosphorus 0.0182 mg/L and specific conductivity 848.1umhos/cm. DNR conducted a fish survey in 2018 and found a very diverse fish population of 35 species. Aquatic macroinvertebrates have been collected at multiple locations on Genesee Creek in 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The MIBI for stream segments of Genesee Creek samples ranged from 4.24-7.36 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a good water quality for samples taken on Genesee Creek. Genesee Creek is also listed as an Exceptional Water Resource with excellent biodiversity and water quality. In 2005 the Genesee Roller Mill Dam was removed; however two dams lower in the watershed remain in place and are having thermal impacts on the lower portions of the watershed. Genesee Creek is not listed as impaired on Wisconsin's §303(d) list.

4.4.11 Mill Brook water quality

Water quality monitoring, as part of a targeted watershed assessment was collected in June 2018. Instantaneous flow was recorded as 0.64 cfs, temperature 20.53˚C, dissolved oxygen 8.93 mg/L, pH 7.82 and total phosphorus 0.0478 mg/L. Aquatic macroinvertebrates have been collected at a few locations on Mill Brook in spring and fall of 1980 and 2004. The MIBI for a stream segment of the Mill Brook ranged from 3.58 - 4.73 generally indicating that the diversity and abundance of macroinvertebrate species are indicative of fair water quality for samples taken on Mill Brook. Construction erosion, nonpoint source contamination, sedimentation, stream realignment, manmade dams and ponds and beaver dams are all minor stressors in the watershed, that result in the loss of habitat and cause water temperature fluctuations and impacts on water quality in Mill Brook. Mill Brook is not listed as impaired water on Wisconsin's Impaired Waters §303(d) list.

4.4.12 Pebble Creek geomorphology

The 18-square mile Pebble Creek watershed contains three main reaches, Brandy Brook and Upper and Lower Pebble Creek. The Brandy Brook and Upper Pebble Creek subwatersheds lie west of the City of Waukesha. The confluence of Upper Pebble Creek and Brandy Brook form Lower Pebble Creek, which then flows into the Fox River within the Fox River Parkway in the southwestern part of the City of Waukesha. Flow data in the watershed is unavailable because it does not have a flow measurement gage. Over half of the reaches within the watershed show evidence of channelization, some of which were widened. Most channelization occurred between the 1940s and 1970s as part of the accepted agricultural practices of the time. Within the Pebble Creek watershed, bank erosion is more common in channelized reaches than in natural reaches. Upper Pebble Creek is the most urbanized and channelized subwatershed and has the most eroding banks (Waukesha County and SEWRPC 2008, p. 82).

Lower Pebble Creek is a non-channelized stream. Its meandering, highly sinuous pattern is indicative of low gradient (less than one percent) natural streams in the area. Most of the Pebble Creek watershed streams are low gradient sand and gravel systems. High quality riffles occur frequently in Lower Pebble Creek. Brandy Brook's headwaters, which is a moderately sloped (1.4 percent) system, and Upper Pebble Creek's 2.2 percent sloped headwater stream, are exceptions to the low gradient prevalent within the watershed (Waukesha County and SEWRPC 2008, p. 78). These higher gradient reaches have predominantly gravel, cobble, and boulder substrates.

All streams within the watershed are dominated by pool and riffle habitat. Most of the streams within Pebble Creek watershed have riparian buffers that exceed 75 feet (Waukesha County and SEWRPC 2008, p. 130). Many reaches are within forested riparian corridors, with a good amount of in-stream cover including large woody debris and undercut banks. Occasionally, the abundant woody debris jams (sometimes with the help from beavers), forming obstructions to flow. Within channelized and incised reaches, these jams exacerbate bank erosion and cause blowouts during storm events.

4.4.13 Pebble Brook and Mill Creek geomorphology

The Pebble Brook and Mill Creek watersheds include residential, some agricultural, commercial, and industrial land uses. They are mostly undeveloped where Pebble and Mill Brook have wide floodplains with large wetland areas bordering the channels. The channels have been straightened in some areas to accommodate road crossings, a railroad, and agricultural developments, but the vast majority of the channel length is natural and highly sinuous with tortuous bends. The channels are low energy systems that include pool-riffle and pool-glide sequences, with few areas of point bar formations. The pools are generally sandy with some silt and organics. The glides and riffles are generally sand and gravel and the point bars are generally gravel.

The channel banks are nearly all earthen with dense vegetation that provides bank stability. Some erosion and bank failures are present that are typical of developing watersheds, but the channel banks are low and the channels have access to their floodplain during high flow events. The banks are undercut in many areas, with exposed root masses and overhanging vegetation. These portions of the channels are still very stable, however, due to the accessible floodplain and because the channels are low energy and the roots provide adequate bank strength.

4.4.14 Mill Brook geomorphology

Mill Brook is approximately 8.5 miles in length with a gradient of 9.4 feet per mile and flows into the Fox River. Construction erosion, nonpoint source contamination, sedimentation, stream realignment, manmade dams and ponds and beaver dams are all minor stressors in the watershed.

4.4.15 Genesee Creek geomorphology

The twenty-four-square mile Genesee Creek watershed contains three main reaches, Spring Brook, North Branch of Genesee Creek and Genesee Creek. The North Branch of Genesee Creek, Spring Brook and a majority of Genesee Creek subwatersheds flow southeast through the Town of Genesee and a small section of the Town of Waukesha before converging with the Fox River. Flow data in the watershed is limited because it does not have a flow measurement gage in the watershed.

The headwater portions of Genesee Creek watershed have wide floodplains with large wetland areas bordering the channels. The channels have been straightened in some areas to accommodate road crossings, multiple railroad crossings, and a large area of agricultural development, but a good portion of the channel length is still natural with a high gradient. These higher gradient reaches have predominantly gravel, cobble, and rubble substrate. In 2005, the Roller Mill Dam was removed, however two dams still remain lower in the watershed.

4.4.16 Pebble Brook flora

Pebble Brook has a riparian plant community typical of southeast Wisconsin. At County Highway XX, near where the pipeline crosses Pebble Brook, the surrounding watershed is less-disturbed relative to the other waterways. Tree species such as hackberry, silver maple, box elder, and several willow species are present. Though the herbaceous layer is dominated by weedy species such as reed canary grass and goldenrod, native sedges, rushes, and grasses are also present in some sections. Gray dogwood is a common shrub located in the floodplain; riverbank grape is also widespread.

Four natural communities and two animal concentration sites have been documented adjacent to or within the near vicinity of Pebble Brook. In addition, four rare plants, including two that are state-threatened, are known to occur within the vicinity of this brook.

The DNR has observed aquatic invasive species such as curly leaf pondweed, reed canary grass and purple loosestrife in or around Pebble Brook.

4.4.17 Pebble Creek flora

The riparian vegetation along Pebble Creek is similar to the riparian community of Pebble Brook and the Fox River, which Pebble Creek empties into. Willows and maples are dominant woody species. They are located at the outer edge of the creek's floodplain. Closer to the waterway, reed-canary grass and stinging nettles dominate. Large populations of cattail are also present along Pebble Creek near Genesee Road.

Two natural communities have been documented adjacent to the creek. In addition, five rare plants, including three that are state-threatened, are known to occur within the near vicinity of the Pebble Creek.

SEWRPC's watershed plan lists examples of typical macrophytes observed such as elodea and curly leaf pondweed. The DNR has observed other aquatic invasive species, such as purple loosestrife and reed canary grass, in or adjacent to Pebble Creek.

4.4.18 Mill Brook flora

Mill Brook empties into the Fox River just south of where Pebble Brook does. Mill Brook riparian vegetation is similar to the other low-order streams in the area. It is dominated by both herbaceous and woody weedy species. Silver maple, green ash, and eastern cottonwood are located frequently along the waterway. Shrubs such as smooth sumac and gray dogwood are also common. Herbaceous species present include common weedy species such as reed-canary grass, goldenrod, stinging nettle, and yarrow.

Two natural communities and one animal concentration site has been documented adjacent to or within the near vicinity of Mill Brook. In addition, four rare plants, including one that is state-threatened, are known to occur within the vicinity of this brook.

The DNR has observed aquatic invasive species such as Eurasian water milfoil and reed canary grass in or around Mill Brook.

4.4.19 Genesee Creek flora

Genesee Creek has seven natural communities that have been documented nearby. The rare plant diversity is also quite high with ten plant species, six of which are threatened, recorded within the vicinity including a couple that are directly associated with the creek.

The DNR has observed macrophytes in or around Genesee Creek such as curly leaf pondweed, reed canary grass and purple loosestrife (all aquatic invasive species). New native species were planted as invasive species management after the removal of the Genesee Roller Mill Dam in

2005. Carroll University staff and students conduct extensive monitoring and projects within the riparian area of Genesee Creek and other information may be available.

4.4.20 Mill Creek flora

Mill Creek is located south of the City of Waukesha in both rural and residential areas. In the areas of lesser disturbance, a relatively diverse riparian plant community is present, consisting of wet meadows species such as sedges, grasses, and forbs. But stretches of Mill Creek are located adjacent to residential areas where reed-canary grass and mowed turfgrass dominate.

Two natural communities and one animal concentration site have been documented adjacent to or within the near vicinity of Mill Creek. In addition, one special concern plant is known to occur within the vicinity of this creek.

The DNR has observed aquatic invasive species such as Eurasian water milfoil and red canary grass in or around Mill Creek.

4.4.21 Pebble Brook benthic invertebrates

Aquatic macroinvertebrates have been collected at multiple locations on Pebble Brook in 1997, 2000, 2002 and 2013. The MIBI for stream segments of the Pebble Brook samples sites ranged from 4.21 - 5.57 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken in the Pebble Brook Watershed. In addition, three rare mussel species and a rare caddisfly are known to be present within Pebble Brook or within connecting waterbodies to Pebble Brook.

4.4.22 Pebble Creek benthic invertebrates

Aquatic macroinvertebrates have been collected at multiple locations on Pebble Creek in the years: 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The MIBI for stream segments of the Pebble Creek and Brandy Brook watershed samples ranged from 2.7 - 6.1506 generally indicating that the diversity and abundance of macroinvertebrate species are indicative of a fair to good water quality. In addition, two rare mussel species are known to be present within connecting waterbodies to Pebble Creek.

4.4.23 Mill Creek benthic invertebrates

Aquatic macroinvertebrates have been collected at a few locations on Mill Creek in spring and fall of 1980, 1997, 2000, and 2002. The MIBI for stream segments of the Mill Creek samples sites ranged from 3.28 - 5.89 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality. In addition, three rare mussel species are known to be present within connecting waterbodies to Mill Creek.

4.4.24 Genesee Creek benthic invertebrates

Aquatic macroinvertebrates have been collected at multiple locations on Genesee Creek in 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The MIBI for stream segments of the Genesee Creek samples ranged from 4.24 - 7.36 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a good water quality. Two rare mussel species (one is classified as threatened) and a caddisfly species are known to be present within connecting waterbodies to Genesee Creek.

4.4.25 Mill Brook benthic invertebrates

Aquatic macroinvertebrates have been collected at a few locations on Mill Brook in spring and fall in 1980 and 2004. The MIBI for a stream segment of the Mill Brook ranged from 3.58 - 4.73 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of fair water quality. In addition, two rare mussel species and a caddisfly species are known to be present within connecting waterbodies to Mill Brook.

4.4.26 Pebble Brook fish

Pebble Brook is classified as a Cool-Warm Mainstem near the convergence with the Fox River and a Cool-Warm Headwater in the upper portions of the watershed. Fish Surveys were conducted in 2000, 2002, 2013 and 2018. The surveys identified species such as bigmouth shiner, black bullhead, blackside darter, blackstripe topminnow, bluegill, bluntnose minnow, bowfin, brook stickleback, central mudminnows, creek chub, common carp, common shiner, fathead minnow, green sunfish, grass pickerel, johnny darter, Iowa darter, largemouth bass, mottled sculpin (coldwater species), northern pike, rock bass, white sucker and yellow bullhead. Most of these species are considered warm water species but several can be found in cool water habitats. Outside of these surveys, four other rare fish species are known to be present within Pebble Brook or within connecting waterbodies to Pebble Brook.

4.4.27 Pebble Creek fish

Brandy Brook and Pebble Creek upstream of County Trunk Highway (CTH) D supports a coldwater fish community. Pebble Creek downstream of CTH D is designated a warm water sport fishery. SEWRPC's report, Community Assistance Planning Report No. 284, Pebble Creek Watershed Protection Plan (2008) documents the presence of a state threatened species and the coldwater brown trout (*Salmo trutta*) and mottled sculpin (*Cottus bairdi)*) in 1999 - 2005 surveys in Pebble Creek. In addition, a special concern species was found in Pebble Creek, at the confluence with the Fox River.

Fish surveys were conducted on Pebble Creek and/or at the confluence with the Fox River 1990, 1995, 1999 and extensive surveying completed in 2004-2005. The fish species found during these surveys included brown trout (coldwater species), mottled sculpin (coldwater species), blacknose dace, brook stickleback, central mudminnow, fathead minnow, johnny darter, northern pike, rock bass, spottail shiner, white sucker, black bullhead, black crappie, blacknose shiner, blackside darter, blackstripe topminnow, bluegill, bluntnose minnow, bowfin, brook silverside, common carp, central stoneroller, channel catfish, common shiner, grass pickerel, green sunfish, hornyhead chub, largemouth bass, largescale stoneroller, longnose dace, mimic shiner, pumpkinseed, orange-spotted sunfish, sand shiner, spotfin shiner, smallmouth bass, one threatened species and one special concern species. Additional species were found during DNR fisheries surveys in 2005 - 2014 including creek chub, emerald shiner, golden shiner, rainbow darter and yellow perch. Most of these species are considered warm water species but several can be found in cool water habitats. Outside of these surveys, two other rare fish species are known to be present within connecting waters to Pebble Creek.

4.4.28 Mill Creek fish

Mill Creek is four-mile tributary stream that flows west from the town of New Berlin past two private dams before entering Pebble Brook. Mill Creek is classified as a Cool (Warm Transition) Headwater.

Fish surveys were conducted on Mill Creek in 1997, 2000, 2002, 2008, 2013 and 2018. The fish species found during surveys included banded darter, black bullhead, black crappie, blackside darter, bluegill, bluntnose minnow, bowfin, brook stickleback, central mudminnow, central stoneroller, common shiner, creek chub, fathead minnow, golden shiner, green sunfish, hornyhead chub, johnny darter, largemouth bass, longnose dace, mottled sculpin (coldwater species), pumpkinseed X bluegill, rainbow darter, rock bass, western blacknose dace, white sucker and yellow bullhead. Outside of these surveys, three rare fish species have also been documented within Mill Creek or nearby in connecting waterbodies.

4.4.29 Genesee Creek fish

Genesee Creek is a 5-mile tributary stream to the Fox River that flows east with a dam at Saylesville Millpond. Genesee Creek is listed as a partially Class I and Class II trout stream (Class I waters are high quality and support natural reproduction of wild trout, at or near carrying capacity. Class II waters have some natural reproduction, but not enough to fully utilize available food and space). The upper portion of Genesee Creek is also an Exceptional Resource Water (ERW). Genesee Creek is a Cool-Cold Headwater upstream of the confluence with Spring Brook and a Cool-Warm Mainstem downstream. Fish surveys from 2007, 2014 and 2018 found shorthead redhorse, walleye, golden redhorse, rainbow darter, banded darter, stonecat, rock bass, logperch, common shiner, johnny darter, white sucker, bluegill largemouth bass, northern pike, pumpkinseed, black bullhead, bluntnose minnow, common carp, fathead minnow, green sunfish, spotfin shiner, yellow bullhead, black crappie, bowfin, channel catfish, tadpole madtom, blackside darter, blackstripe topminnow, brown trout (coldwater species), central mudminnow, creek chub, fantail darter, grass pickerel, orange-spotted sunfish, yellow perch, golden shiner, iowa darter, rosieface shiner, longnose gar, longear sunfish, mottled sculpin (coldwater species), northern redbelly dace, sand shiner, slender madtom, southern redbelly dace, suckermouth minnow, warmouth, western blacknose dace. Outside of these surveys, three rare fish species have also been documented within Genesee Creek or nearby in connecting waterbodies.

4.4.30 Mill Brook fish

Mill Brook is listed in the Wisconsin classified trout streams as a partially Class I and Class II trout stream[4]. Mill Brook is also considered a Cool-Warm to Cool-Cold Headwater stream.

Fish surveys were conducted on Mill Brook in 2004, 2009 and 2018. The fish species found during those surveys included mottled sculpin (coldwater species), brook stickleback, black bullhead, bluegill, central mudminnow, creek chub, largemouth bass, pumpkinseed, green sunfish, grass pickerel, johnny darter and white sucker. Outside of these surveys, three other rare fish species are known to be present within connecting waterbodies to Mill Brook.

4.4.31 Herptiles of Fox River tributaries

One state endangered and two special concern herptile species are known or have been known to use the Fox River tributaries and their adjacent wetlands as habitat. Unfortunately, the state endangered herptile is considered extirpated in this area of Wisconsin.

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[4] Class I waters are high quality and support natural reproduction of wild trout, at or near carrying capacity. Class II waters have some natural reproduction, but not enough to fully utilize available food and space

4.4.32 Birds of Fox River tributaries

Four rare bird species, including one that is state-endangered, are known to nest within the vicinity of the Fox River tributaries.

4.4.33 Mammals of Fox River tributaries

These tributaries provide habitat for several species of mammals, mostly furbearers. Muskrats, mink, otter, and beaver thrive in the marsh habitat. Other mammals including opossum, shrews, moles, bats, chipmunk, voles, mice, fox, raccoon, weasels, and skunk are numerous as well. White-tailed deer, eastern gray and fox squirrels, eastern cottontails, and coyotes are popular game species and receive moderate to heavy hunting pressure. There are two state-threatened and one special concern mammal that are known to use the Fox River tributaries and their adjacent habitats.

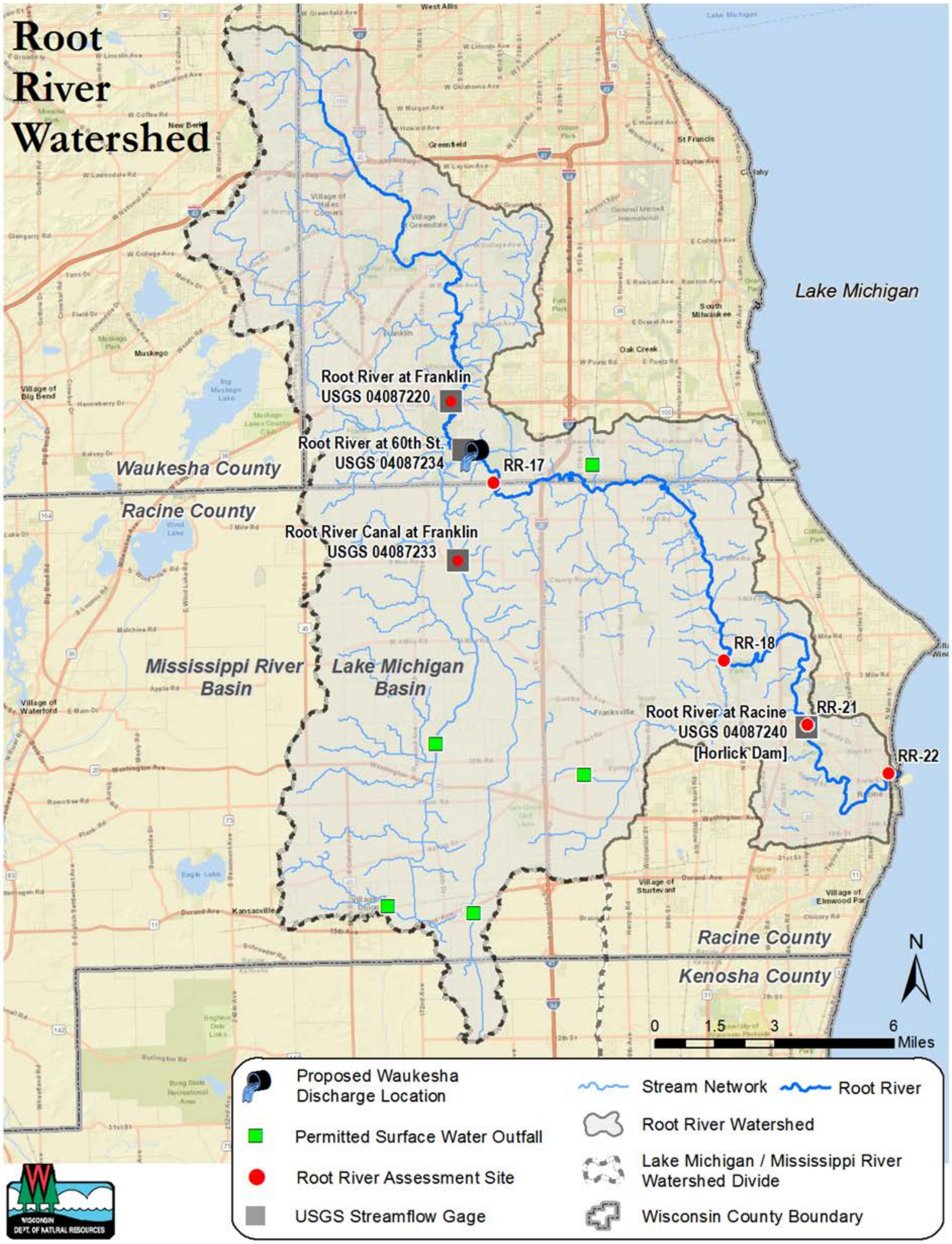
4.5 Root River

4.5.1 Physical description and floodplains of the Root River

The Root River watershed covers 126,484 acres (about 198 square miles) in Waukesha, Milwaukee, Kenosha and Racine counties. The Root River flows 44 miles south and east from the City of New Berlin (Waukesha County) and empties into Lake Michigan at the City of Racine (Racine County) (Figure 4-5). The Root River watershed is within the Lake Michigan Basin.

The headwaters of the Root River are heavily urbanized, the middle reaches are primarily agricultural and lower density development, and the lower parts of the watershed near Lake Michigan are heavily urbanized. The river has primarily natural bottom substrate and vegetated river banks and land uses are mixed between its headwaters and Lake Michigan. The principal tributary, near the Milwaukee/Racine County line, is the Root River Canal, coming from the south and joining up with the Root River southwest of Oakwood Road and 60th Street. The Horlick dam, constructed in 1834, is in the City of Racine just upstream of the STH 38 crossing of the Root River (Figure 4-5. Map of Root River Watershed). The dam is 19 feet high and impounds a surface area of about 60 acres.

Figure 4-5. Map of Root River Watershed



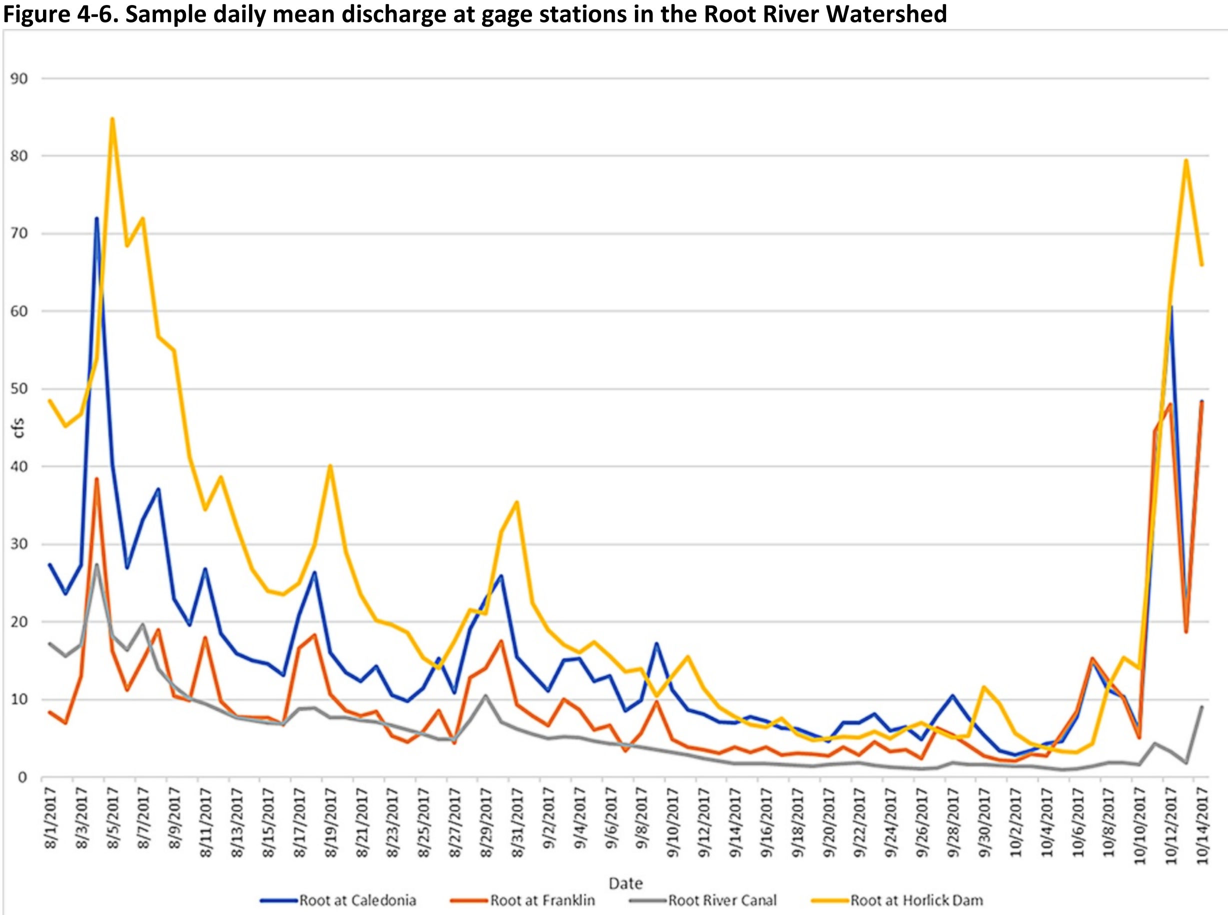
4.5.2 Flow and flooding in the Root River

There are currently four active USGS gaging stations in the Root River Watershed (Figure 4-5):

- USGS Gaging Station 04087220 (near the City of Franklin, approximately 2 miles upstream of the proposed Root River outfall)
- USGS Gaging Station 04087234 (in Caledonia, near proposed outfall, at 60th Street)
- USGS Gaging Station 04087240 (at Horlick Dam, City of Racine)
- USGS Gaging Station 04087233 (Root River Canal)

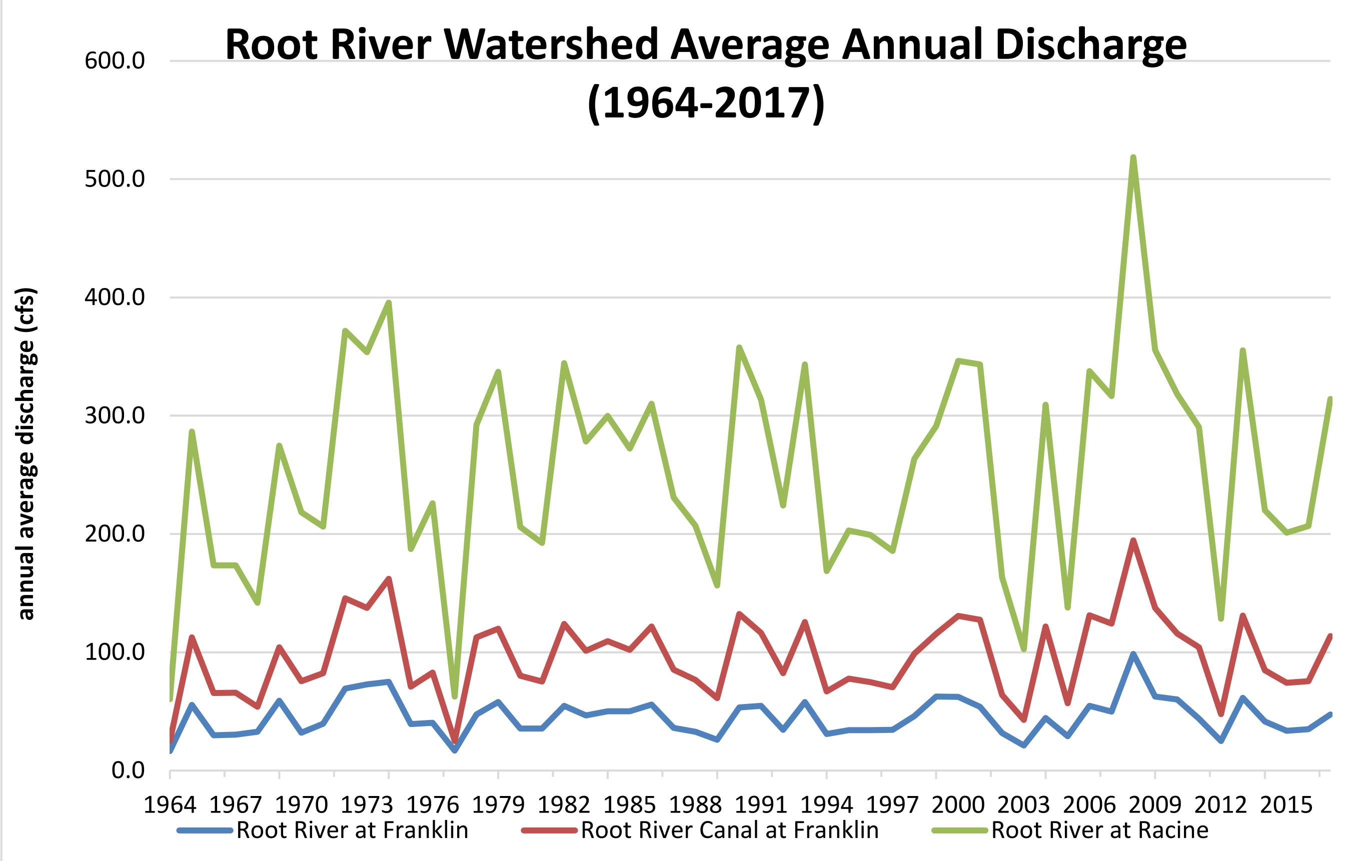
In 2016, the Applicant worked with USGS to install a gaging station in Caledonia, near 60th Street and the proposed return flow outfall (Gaging Station 04087234), to monitor stream discharge on the Root River. Provisional data shows daily flows are slightly higher downstream of the Franklin station, as the Root River canal discharges into the Root River, just upstream of the proposed discharge location (Figure 4-6).

Figure 4-6. Sample daily mean discharge at gage stations in the Root River Watershed



USGS has collected discharge data in the watershed at the other three sites (04087220, 04087240, and 04087233) since the early 1960's. At USGS Root River gaging station (04087220) near the City of Franklin, the average annual stream flow is 45.13 cfs (USGS flow data 1964 to 2017). At USGS Root River stream gage (04087240) in the City of Racine, approximately 20 miles downstream of the proposed return flow location at Horlick Dam, the average annual stream flow is 158.49 cfs (USGS flow data 1964 to 2017) (Figure 4-7).

Figure 4-7. Average annual discharge at three USGS gage sites in the Root River Watershed



4.5.3 Water quality of the Root River

The entire Root River (miles 0 - 43.95) is listed on Wisconsin's Impaired Waters §303(d) list. The upper section of the Root River, the Root River Canal and the West Branch of the Root River Canal, are considered impaired because excessive phosphorus and total suspended solids loading that leads to dissolved oxygen levels below what is necessary to support fish and other aquatic organisms. The harbor is also listed due to unspecified metals. There are no approved Total Maximum Daily Loads (TMDLs) for the Root River. The assessment units and corresponding pollutants and impairments are shown in Table 4-6.

Table 4-6. Root River mainstem §303 (d) pollutants and impairments

River miles	Pollutant	Impairment
0 to 5.82	PCBs, total phosphorus	Contaminated fish tissues, unknown
5.82 to 20.48	Total phosphorus	Degraded biological community
20.48 to 25.8	Total phosphorus, sediment/TSS	Degraded biological community, low dissolved oxygen
25.8 to 43.69	Chlorides, total phosphorus, sediment/TSS	Acute aquatic toxicity, degraded biological community, low dissolved oxygen

The department, USGS, MMSD, the City of Racine Health Department, citizen volunteers, and more recently, UW-Parkside on behalf of the Applicant have gathered water quality data in the Root River watershed (CH2M Hill 2017). Data is being collected at 7 sites within the Root River watershed. This data will provide a baseline for water quality conditions prior to when the proposed return flow is discharged to the Root River near Oakwood and S.60th St. UW-Parkside began collecting data for the following parameters in May 2017: temperature, pH, dissolved oxygen (DO), specific conductivity, biological oxygen demand (BOD), total suspended solids (TSS), total nitrogen (TN), nitrate/nitrite (NO_3/NO_2), ammonia, total kjeldhal nitrogen (TKN), organic nitrogen, chlorophyll, total phosphorus (TP) and orthophosphate. Data is available on the DNR's Surface Water Data Viewer.

SEWRPC has conducted extensive water quality modeling of the watersheds and has finalized the 2014 Root River Watershed Restoration Plan (available at http://www.sewrpc.org/SEWRPCFiles/Publications/CAPR/capr-316-root-river-restoration-plan-part-I.pdf). In support of the restoration plan, additional monitoring was completed between 2011 and 2013 by the City of Racine and the DNR and is summarized in a comprehensive report (Koski et al.2014). Results from this monitoring support the impairment status for phosphorus, total suspended solids and fish consumption advisories in the Root River.

Several biological indices have been developed for three stream reaches along the Root River. These indices use benthic macroinvertebrates and fish as indicators of water quality and physical conditions present within the stream. The MIBI (benthic macroinvertebrate index), the HBI (Hilsenhoff Biotic Index, and warm and coolwater fish IBIs (fish indexes) were developed within each of three stream reaches of the Root River. In general, the MIBI, HBI, and IBI for the lower reach of the Root River (river miles 0 to 5.82) suggests fair to good water quality and physical habitat condition. The middle reach (river miles 5.82 to 20.48) scores range from poor to good quality, with most of the data suggesting fair conditions. The upper reach (river miles 20.48 to 43.95) also ranges from poor to good quality. Overall, these data suggest some limitations in water quality and physical habitat for the middle and upper reaches. The Root River Watershed Restoration Plan includes a complete map of recent fisheries IBI scores and HBI macroinvertebrate sampling locations and scores (SEWRPC 2014, p. 270). Macroinvertebrate and fish sampling are also part of the City of Waukesha's pre-return flow monitoring plan. The 2017 fish community collection efforts are finalized and available in the *2017 Pre-Return Flow Fish Community Surveys of the Root River* (Pauers 2017), showing fisheries IBI scores ranging from very poor to good at locations near the proposed outfall.

4.5.4 Geomorphology of the Root River

The headwaters of the Root River begin near the City of New Berlin, on a glacial ridge. Glaciers shaped the drainage area of the Root River, creating clay bluffs, lake plains, ground moraines and ridge and swales on top of the Niagara Dolomite. The soils are comprised mostly of silt- loams overlying loamy and clay–like tills, which are commonly poorly drained. About 72 percent of the Root River watershed has poorly drained soils with low permeability with moderate to low groundwater recharge potential (SEWRPC, 2014).

MMSD completed a comprehensive study of the portions of the Root River that are within their jurisdiction in 2007 – the data is only available for the portion of the Root River in Milwaukee County and generally consists of data upstream of the proposed return flow location. The purpose of the study was to document existing channel stability in the North Branch of the river and to provide hydrologic, hydraulic and sediment transport predictions on the vertical and lateral stability of the river and tributary channels (MMSD, 2007). The river has a mixture of gradients, with low-gradient reaches dominated by pools and glides with sand, silt, organic and glacial till bottom and bank sediments. Other reaches are higher- gradient with pool and riffle sequences with gravel, cobble and bedrock substrates. The banks of the river are mostly earthen, with vegetation providing bank stability, but there are some areas of erosion and bank failures typical of urbanizing watersheds. The lower reaches of the river in the highly urbanized area of the City of Racine have sheetpile banks.

4.5.5 Flora and fauna of the Root River

The riparian vegetation of the Root River is composed of a variety of woody and herbaceous species. In the agricultural land use portions of the stream, there are often thin strips of non-crop vegetation present. Middle-aged silver maples, eastern cottonwood, and willow trees are scattered along the river. Both forbs and grasses, including reed-canary grass, are also present, with few shrubs intermixed throughout. There are 11 documented natural community types within the near vicinity of the Root River. The most common of these natural communities is the Southern Mesic Forest and Southern Dry-mesic Forest. There are also 18 known rare plant species (four listed as state endangered, four as state threatened, and 10 as special concern) within the near vicinity of the Root River.

4.5.5.1 Macrophytes of the Root River

Aquatic macrophytes found in the Root River include Sago pondweed (*Stuckenia pectinata*), Coontail (*Ceratophyllum demersum*), Eurasian Watermilfoil (*Myriophyllum spicatum*), Elodea (*Elodea canadensis*), Curly-leaf pondweed (*Potamogeton crispus*), and Bur-reed (*Sparganiumsp*).

4.5.5.2 Algae of the Root River

The DNR does not have formal documentation of algae on the Root River, however, an algae survey was completed by USGS and is summarized in “Biological Water-Quality Assessment of Selected Streams in the Milwaukee Metropolitan Sewerage District Planning Area of Wisconsin, 2007” (USGS, 2010).

4.5.5.3 Benthic invertebrates of the Root River

Macroinvertebrate sampling (2000 - 2011) within the Root River watershed is summarized in *A Restoration Plan for the Root River Watershed* (SEWRPC, 2014). This report shows water quality improvement over time for some areas of the river and decreases elsewhere. Macroinvertebrate HBIs scores indicate fairly poor to poor water quality near the proposed outfall location. There is positive water quality improvement shown at a site on the mainstem of the river, at Johnson Park near Racine, WI (SEWRPC, Fig.41, 2014).

Sampling in the Root River resulted in the identification of 384 macroinvertebrate taxa. Some taxa were identified at a species level, while others were identified to genus, subfamily, or family levels. Insects were the most identified taxa, including: true flies, beetles, caddisflies, mayflies, true bugs, dragonflies (including a special concern species), and damselflies. Other groups found included amphipods, crayfish (including a special concern species), isopods, annelid worms, nematode worms, turbellarian worms and snails. The most commonly identified organisms were isopods, caddisflies, midges, worms of the family Tubificidae, and caddis flies. Surveys for mussels in 1977 identified three species: giant floater, lilliput, and white heelsplitter. Additional mussel survey work in 2012 found live mussels from seven native species and dead shells from four additional native species. Most common were creeper, fat mucket, giant floater, and white heelsplitter. Fragile papershells, three ridges, and wabash pigtoes were also found. Nonnative zebra mussels were also found. The rusty crayfish has been identified as an invasive invertebrate species in the Root River. There are no known endangered, threatened, or special concern mussel species within the Root River.

4.5.5.4 Fish of the Root River

The Root River is classified for DNR fish and aquatic life standards and supports a WWSF community. The Root River is a warm-water habitat. There are areas of good quality within parts of the Root River watershed, but also areas of impairment due to agricultural and urban impacts. The Root River watershed has relatively few streambed and bank modifications, with less than one percent of the stream channel being in conduit and none lined with concrete. Fish IBI ratings range from very poor to fair near the outfall location and downstream (Fig.41, SEWRPC, 2014).

Downstream from the Horlick Dam the river supports a stocked trout and salmon fishery. Upstream from the dam, the river supports a poor-quality fishery with relatively few species. This section of the stream is dominated by species tolerant of poor water quality, with few top predators (SEWRPC, 2014).

Fishery data for in the Root River watershed shows that 10 new species have been identified, but 10 of 64 recorded species have not been observed since 1986 (SEWRPC, 2007, pp. 100–14). The most recent fishery surveys by USGS in 2004, 2007, 2010, and by UW-Parkside in 2017 identified a total of 27 species in the Root River near the proposed return flow location (USGS, 2013; UW-Parkside, 2017). There are five rare fish species (two of which are listed as state threatened) that have at one time been known to be present within the Root River; however, none of these fish species were observed during these surveys. Table 4-7. lists the fish species found near the proposed return flow location for Alignment 2. Common carp and goldfish have been identified as invasive fish species in the Root River.

Table 4-7. Root River fish species collected in the area of the proposed outfall, 2004 - 2017

Root River fish species (upstream of proposed outfall)		
Black bullhead	Central mudminnow	Longnose dace
Blacknose dace	Creek chub	Northern pike
Black crappie	Fathead minnow	Orangespotted sunfish
Blackslide darter	Golden shiner	Pumpkinseed
Bluegill	Goldfish	Rock bass
Bluntnose minnow	Grass Pickerel	Sand shiner
Brook stickleback	Green sunfish	White sucker
Brown Bullhead	Johnny darter	Yellow bullhead
Carp	Largemouth bass	Yellow perch

4.5.5.5 Herptiles of the Root River Watershed

Many reptiles and amphibians are known to exist in the Root River watershed. These include mudpuppy and other newts and salamanders, American toad and a variety of frogs (including an endangered species which is thought to be extirpated from this area), turtles (including one special concern species) and a number of snake species (including two special concern and one state-endangered species).

4.5.5.6 Birds of the Root River Watershed

As many as 283 bird species are known or have been known to exist in the Root River watershed, including: loons, grebes, cormorant, bitterns, herons (including a special concern species), turkey vultures, ducks, eagles, hawks (including a state-threatened species), a state- endangered falcon, grouse, partridges, bobwhites, pheasants, turkeys, coost, rails, cranes, plovers, woodcocks, sandpipers (including a state-threatened species), snipes, terns, gulls, mourning doves, pigeons, cuckoos, owls, nighthawks, woodpeckers, flycatchers, wrens, robins, thrushes, vireos, warblers, tanagers, and sparrows. In addition, there is a Migratory Bird Concentration Site that is adjacent to portions of the Root River.

4.5.5.7 Mammals of the Root River Watershed

The Root River watershed includes mammals including: muskrats, white-tailed deer, gray squirrels, rabbits, opossums, shrews, moles, bats, chipmunks, beavers, voles, mice, coyotes, foxes, raccoons, weasels, otters, and skunks. There are no known endangered, threatened, or special concern mammals within the near vicinity of the Root River.

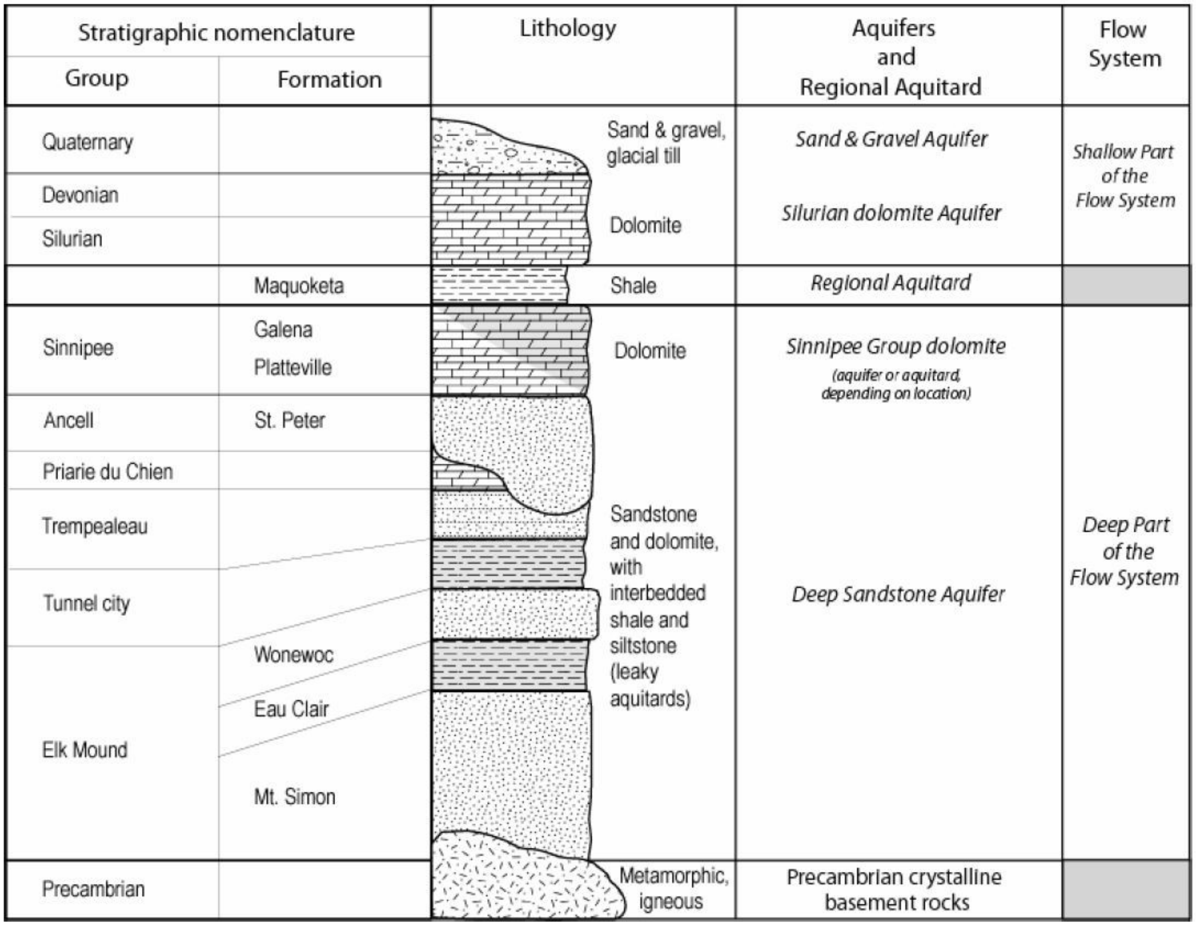
4.6 Groundwater

4.6.1 Aquifers

The major aquifers in counties of Waukesha and Milwaukee are the Quaternary and Late Tertiary unconsolidated sand and gravel aquifer, the Silurian dolomite aquifer and the Cambrian-Ordovician sandstone aquifer. The unconsolidated sand and gravel aquifer is connected hydrogeologically to the Silurian dolomite aquifer where both are present. The combination of the two is generally considered to be the shallow aquifer in Milwaukee County and the eastern portion of Waukesha County. The shallow aquifer is unconfined in these areas whereas the deep Cambrian-Ordovician sandstone aquifer is confined due to the overlying Maquoketa Shale.

The aquifers extend to great depths, reaching a thickness in excess of 1,500 feet in the eastern parts of Milwaukee and Racine. The aquifers are, in descending order, the Quaternary sand and gravel, Silurian dolomite, Galena-Platteville, upper sandstone, and lower sandstone (see Figure 4-8). The confining beds are the Maquoketa Formation and the Precambrian crystalline rock. The shaly Antrim Formation and siltstone and shaly dolomite of the Milwaukee Formation constitute the uppermost semi- confining bed; and silty dolomite and fine-grained dolomitic sandstone of the St. Lawrence Formation/Tunnel City Group, the lower semi-confining bed in parts of the Region.

Figure 4-8. Hydrostratigraphic sequence for southeastern Wisconsin lithologic column



Stratigraphic nomenclature (after Ostrom, 1962) and lithologic column

The aquifer systems in the counties discussed can be divided into two types: unconfined water table aquifers and semi-confined or confined deep bedrock aquifers. Water-table conditions generally prevail in the Quaternary deposits and Silurian dolomite aquifer above the Maquoketa Formation and in the Galena-Platteville aquifer west of the Maquoketa Formation (Figure 4-8). These shallow aquifers provide water for most private domestic wells and some municipal wells.

In the deep sandstone aquifer beneath the Maquoketa Formation, the water can be under artesian pressure. Heavy pumping of deep aquifer high-capacity wells has caused the gradual, steady decline in the artesian pressure and a reversal of the predevelopment, upward flow of groundwater. Flowing wells, common within the Region in the late 1880s, ceased flowing at the beginning of the 1900s, and the potentiometric surface of the sandstone aquifer has been gradually declining and is now lower than the water table throughout most of the Region. On average, water levels in deep observation wells have been declining at the rate of four feet per year in the Milwaukee-Racine area and five feet per year around the City of Waukesha since the beginning of record in the late 1940s (SEWRPC, 2002).

4.6.1.1 Shallow aquifer

The aquifers in the counties discussed are divided into shallow and deep. The shallow aquifer system comprises two or three aquifers, depending on its location relative to the Maquoketa shale

(Figure 4-8). Where the Maquoketa formation is present, the shallow aquifer system consists of the Silurian dolomite aquifer and the overlying sand and gravel aquifer. There, the Maquoketa Formation is the lower limit of the shallow aquifer system. In the westernmost parts of Waukesha County where the Maquoketa Formation is not present, the shallow aquifer system consists of the sand and gravel aquifer, Galena-Platteville aquifer, and upper sandstone aquifer, and its lower boundary, the St. Lawrence semi-confining unit.

The sand and gravel aquifer consists primarily of layers or lenses within alluvial and glacial deposits and is extremely variable in thickness. It is not as continuous as the bedrock aquifers. The sand and gravel aquifer occurs as broad outwash deposits, isolated lenses within less permeable deposits, stream terraces, valley fill directly overlying bedrock, and other materials deposited by water or glacier (Kammerer, 1995). Important features are highly productive layers of sand and gravel in segments of buried bedrock valleys in Waukesha County which can yield large amounts of water to wells.

In Waukesha County, shallow groundwater west of the major groundwater divide discharges to large nearby lakes and their outlet the Oconomowoc River, or to the Bark and Scuppernong Rivers. East of the major water table divide, shallow groundwater discharges to Pewaukee Lake and the Fox River; east of the secondary groundwater divide, it discharges to Muskego Lake and flows into Milwaukee County. Locally, large, deep pits and quarries divert groundwater flow from its original direction. For example, a gravel pit just north of the City of Waukesha captures groundwater that would otherwise discharge into the Fox River.

In Milwaukee and Racine counties, the prevalent direction of groundwater flow is to the east, toward Lake Michigan, which is the major regional discharge area. In Milwaukee County, some shallow groundwater locally discharges into Lincoln Creek, Menomonee River, and Root River. In Racine County, the direction of flow depends on the position of the secondary divide running north-south through the counties. West of the secondary groundwater divide, groundwater flows toward the Fox River and its tributaries Honey Creek, New Munster Creek, Peterson Creek, and Basset Creek. East of the secondary divide, groundwater discharges into the Root River Canal in Racine County. In the easternmost tier of townships, the direction of groundwater flow is to the east, towards Lake Michigan (SEWRPC, 2002).

The extent to which the sand and gravel aquifer is used for water supply depends upon the quality and availability of groundwater from underlying or adjacent aquifers. The aquifer is mostly unconfined, and its yields vary widely. The sand and gravel aquifer is extensively used in Waukesha County where properly constructed wells finished in this aquifer can produce from

100 to more than 1,000 gallons per minute (gpm). The shallow aquifer is the primary source for domestic wells in the area and is also a source of water supply for the Villages of Mukwonago and East Troy, and the Cities of Waukesha and Muskego.

The aquifer is hydraulically connected to sensitive environmental resources, including the Vernon Wildlife Area, Pebble Brook (a Class II trout stream), Genesee Creek, Mill Brook and Mill Creek and Pebble Creek. The Applicant currently obtains approximately 20 percent of its annual water supply from this aquifer.

Shallow aquifer water quality

Groundwater from the shallow aquifer may require treatment to meet secondary drinking water standards, related to cosmetic or aesthetic quality of drinking water, of 0.3 mg/L for iron, 0.05

mg/L for manganese, and a primary standard of 10 ppb for arsenic. To remove these contaminants from the shallow aquifer supply and meet applicable drinking water standards, conventional groundwater treatment, including coagulation, flocculation, sedimentation, filtration and disinfection is needed (CH2MHill, 2013, Vol. 2).

4.6.1.2 Deep sandstone aquifer

The sandstone aquifer consists of alternating sequences of Cambrian and Ordovician age sandstone and dolomite, along with some shale. In the eastern half of Waukesha County, the sandstone aquifer underlies a low permeability layer called the Maquoketa shale. Due to the thickness of the sandstone aquifer, large water quantities can be produced from wells within the aquifer.

The deep sandstone aquifer, corresponding to Cambrian-Ordovician units, rests on the Precambrian crystalline basement rocks which transmit little water and form the bottom boundary to the aquifer system. In ascending order, the major water-producing units of the deep part of the flow system are sandstones of the Mt. Simon Formation, the Wonewoc Formation and the St. Peter Formation.

Between the Mt. Simon Formation and the Wonewoc Formation lies the Eau Claire Formation, composed of shale and sandstone. A laterally extensive shaly zone within the Eau Claire Formation forms an important aquitard, the Eau Claire aquitard, over much of southern Wisconsin. Rocks of the Trempealeau and Tunnel City Groups, between the Wonewoc and St. Peter Formations, also form a leaky aquitard made up of interbedded sandstone, shale, siltstone and dolomite. Overlying the St. Peter Formation, dolomite of the Sinnipee Group and shale of the Maquoketa Formation together make up a major regional aquitard between deep and shallow aquifers. The Sinnipee Group dolomite at the top of the deep part of the flow system was of particular interest in our hydrostratigraphic conceptualization because its hydraulic properties depend on whether it is overlain by the Maquoketa shale. Where the Maquoketa is present, the Sinnipee Group dolomite acts as an aquitard that limits flow to the underlying deep sandstone aquifer. Where the Maquoketa is absent, the Sinnipee dolomite, constituting the uppermost bedrock unit, is highly weathered, relatively permeable, and is considered an aquifer.

Groundwater in the lower sandstone aquifer generally moves eastward from the regional potentiometric divide, paralleling the regional eastward dip of the Paleozoic rocks, and is confined under the Maquoketa Formation. Cones of depression on the potentiometric surface, caused by pumping from high-capacity wells in eastern Waukesha and western Milwaukee Counties and in the metropolitan areas of Racine, divert and capture groundwater from great distances and change the original direction of regional groundwater flow (SEWRPC, 2002).

The Applicant's deep aquifer wells are constructed to depths greater than 2,100 feet. Since the nineteenth century (SEWRPC, 2010a, pp. 108–9), the deep aquifer has been drawn down more than 500 feet. More recently, water levels in this aquifer have begun to rise. The USGS groundwater monitoring network well located in the City of Waukesha shows the aquifer is still drawn down, but approximately 100 feet higher than levels observed in a nearby observation well in 1998. The deep aquifer currently supplies approximately 80 percent of annual water supply for the Applicant.

Near Waukesha, recharge to the deep aquifer occurs further west where the Maquoketa shale is not present. Figure 4-9 and Figure 4-10 illustrate the constraints limiting recharge of the deep aquifer near the City of Waukesha.

In the western part of Waukesha County, the deep sandstone aquifer is unconfined with permeable sand and gravel deposits in direct contact with the sandstone aquifer and acts as a major recharge source for the deep sandstone aquifer in Waukesha County. As the aquifer is unconfined in this portion of Waukesha County, it has not experienced the same drawdown and water quality issues found in the confined portion. This portion of the aquifer is a water supply source for the cities of Oconomowoc and Delafield, and Village of Dousman.

Deep sandstone aquifer water quality

The Applicant's groundwater supply from the deep aquifer has radium levels up to three times the USEPA's drinking water maximum contaminant level (MCL) of five picocuries per liter (piC/L). Radium is a known carcinogen. The naturally occurring radioactive isotopes radium 226 and radium 228 are present in the aquifer because of parent elements in the sandstone. The concentration of radium in the City's groundwater supply is as high as 15 piC/L, one of the highest concentrations of radium in the country for a potable water supply.

The Applicant's deep wells have observed high total dissolved solids (TDS). The secondary drinking water standard is 500 mg/L. One well had TDS concentrations greater than 1,000 mg/L and was rehabilitated by blocking part of the well hole to reduce TDS, but in doing so well capacity was reduced more than 35 percent.

4.6.1.3 Precambrian basement

Precambrian crystalline rock, mostly granite, underlies the Cambrian sedimentary sequence. Its characteristics are poorly known because only a very few wells reach the Precambrian surface in Southeastern Wisconsin. The Precambrian basement is not a source of water supply in the Region. It is assumed to have a very, low permeability and forms the lower boundary of the important lower sandstone aquifer (SEWRPC, 2002).

4.6.2 Groundwater contaminant sites

Areas in Wisconsin where groundwater is most susceptible to contamination are those where most of the groundwater is stored in shallow aquifers (Schmidt, 1987). Milwaukee County has approximately 5,468 environmental repair (ERP) and leaking underground storage tank (LUST) sites, Racine County has approximately 826 ERP and LUST sites, and Waukesha County has approximately 1,717 ERP and LUST sites.

Figure 4-9. Flow of groundwater in the St. Peter Sandstone deep aquifer

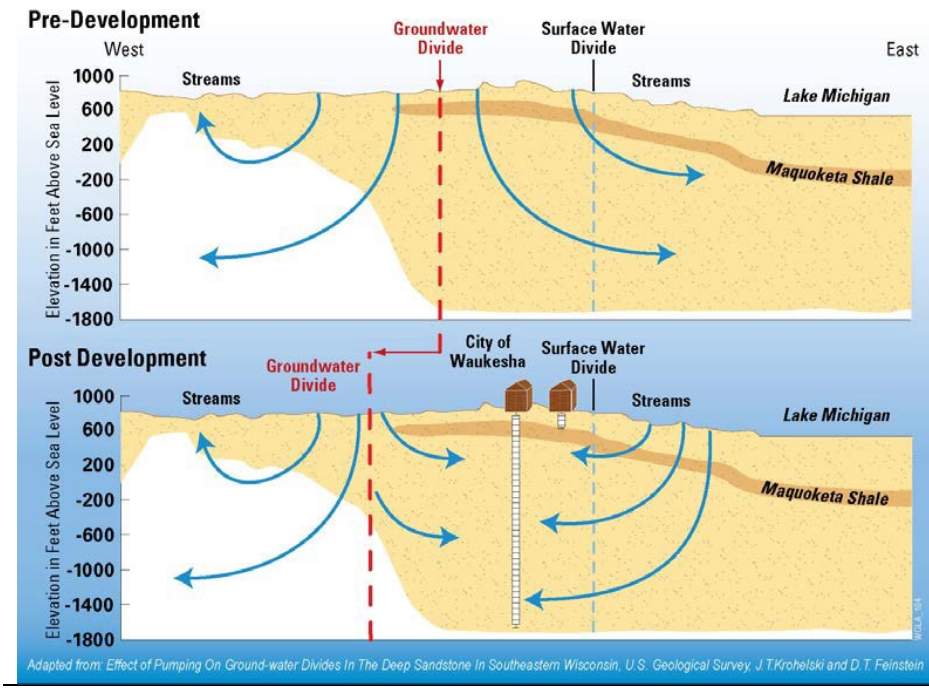
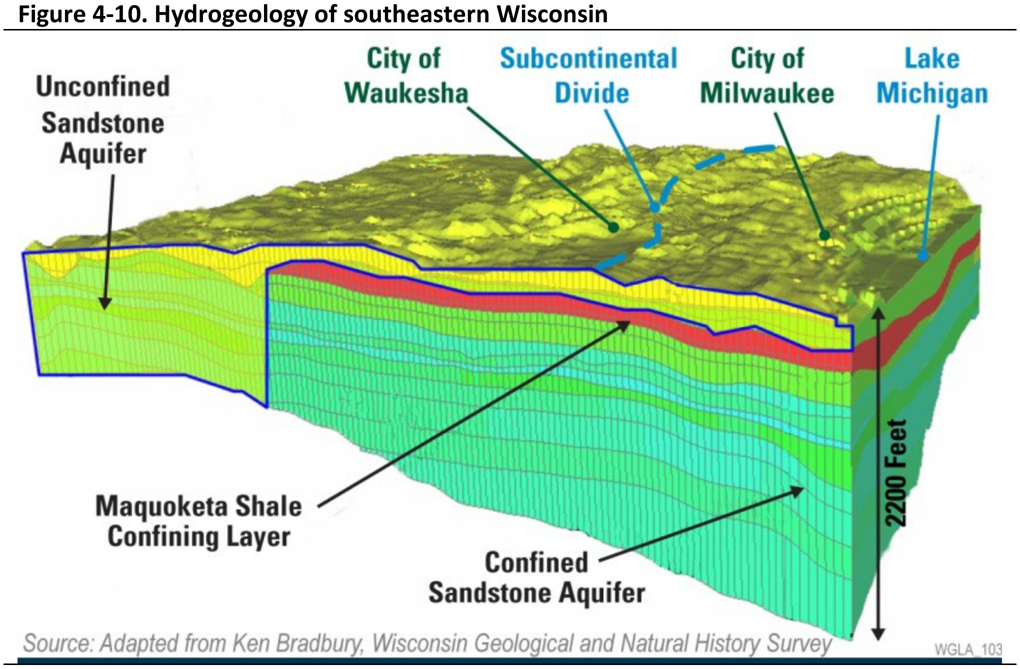


Figure 4-10. Hydrogeology of southeastern Wisconsin



4.6.3 Groundwater divides

The major groundwater divide is about 10 to 20 miles west of the subcontinental surface water divide. In Waukesha County, the major groundwater divide follows the trend of the Kettle Moraine topographic high, which corresponds to a secondary surface-water divide between the Fox River and the Rock River. Shallow groundwater east of the major groundwater divide in

Waukesha County and west of the subcontinental surface-water divide in Racine County, generally discharges to the Fox River, which in turn eventually empties into the Mississippi River.

In addition to the major water table divide, there are several secondary groundwater divides wherever there are high areas in the water table. For example, secondary groundwater divides are found in southeastern Waukesha County and in western Racine County to the east of the Fox River. Other secondary groundwater divides traverse western Waukesha (SEWRPC, 2002).

The groundwater level in the deep sandstone aquifer increases toward the western edge of Waukesha County. The area just west of Waukesha County has the highest heads in the sandstone aquifer and forms the potentiometric divide (deep aquifer groundwater divide). Historical water-level data collected are not adequate to characterize the exact location of this regional divide, nor whether the divide has moved since pre-development time. Nevertheless, the USGS/WGHNS regional model for southeastern Wisconsin published by SEWRPC uses mathematical and calibration constraints to reproduce the behavior of this divide through time. Simulations using the regional model show that the divide has moved west on the order of 10 miles since pre-development times.[5]

Another west-east regional potentiometric divide exists between the Chicago metropolitan area cone of depression and the Waukesha-Milwaukee cone of depression. The exact location of this divide cannot be confirmed without field measurements of current water levels in wells open to the lower sandstone aquifer. Concentrated pumpage in Waukesha-Milwaukee and Chicago areas has created deep cones of depression, and the Chicago cone of depression probably diverts some groundwater from the north, possibly west-east through the middle of Racine County.

4.6.4 Springs

Springs are areas where groundwater discharges from an aquifer to the surface and may occur at the land surface or in a pool, pond, lake, or stream. Springs often provide a positive impact on habitat in surface waters by providing cool, oxygen-rich water. Trout streams, fen-meadows and other wetlands, and numerous sensitive species of plants and animals may be dependent upon spring discharges.

Historically, the Waukesha area had hundreds of springs and was renowned for its many spring spas and resorts in the early 20th century. Since that time, many springs in the area have been lost. Human activities such as dewatering and filling of wetlands, drain tile installation and ditching practices, and high-capacity well pumping may all lower groundwater levels and affect springs (Macholl, 2007). In Waukesha County, much of the land that historically contained springs has been developed for residential or commercial purposes (Swanson, 2007).

The Wisconsin Geological and Natural History Survey maintains an inventory of springs (WGNHS, 2010) and spring locations that have been recently surveyed can be found on the DNR Water Quantity Data Viewer. Multiple springs exist near the City of Waukesha (see Figure 4-4).

[5] See the USGS website http://wi.water.usgs.gov/glpf/ under the Implications section for a map showing the simulated movement of the deep divide.

4.7 Vernon Marsh

4.7.1 Physical description and floodplain of Vernon Marsh

Vernon Marsh is a 4,655-acre state wildlife area in eastern Waukesha County consisting of wetlands and flowages associated with the Fox River. It is more than five miles long and one mile wide in some sections. Vernon Marsh is primarily located in the floodplain on both sides of the Fox River; the river winds north to south through the marsh. Main tributary streams include Pebble and Mill Brooks, both of which are impounded to form flowages on the property before draining into the Fox River. Vernon Marsh was designated a primary environmental corridor by the Southeastern Wisconsin Regional Planning Commission (SEWRPC, 1997).

Broadly, the marsh is dominated by open wetlands. A variety of open wetland types such as wet meadow, shallow and deep marsh, and open water wetland compose most of the Vernon Marsh floodplain. Less abundant wetland types such as scrub/shrub wetlands, forested wetlands, and calcareous fen (at the southern end of the marsh) are also present. Adjacent uplands are dominated by grassland habitats with interspersed hardwood forest. The property provides significant wildlife habitat, especially for migrating and nesting waterfowl (http://dnr.wi.gov/topic/lands/WildlifeAreas/vernon.html).

4.7.2 Geomorphology and depth to groundwater of Vernon Marsh

In southeast Wisconsin, after the Wisconsin Glaciation, broad glacial lakes formed behind the glacier's retreat. Over time, these lakes receded. In the remaining low areas of these glacial plains, wetlands formed, including Vernon Marsh. The retreating glaciers left sand and gravel deposits, which hold groundwater in the form of aquifers (SEWRPC, 2002). In southeast Wisconsin, depths to groundwater vary. In wetlands, and specifically Vernon Marsh, groundwater levels are at or near the ground surface for much of the year.

4.7.3 Flora and fauna of Vernon Marsh

Vernon Marsh consists of wetland and upland communities, and flowages associated with the Fox River. The most common wetland communities include wet meadow, shallow marsh, deep marsh, and open water wetland. Less common wetland community types include scrub/shrub wetland, forested wetland and calcareous fen. Adjacent uplands are dominated by grassland habitats with interspersed areas of limited hardwoods. The property provides significant wildlife habitat, especially for migrating and nesting waterfowl. Many state threatened, endangered, and special concern species are present on the property including five plants, two herptiles, three invertebrates, four birds, four fish, and three mussel species.

4.7.3.1 Flora of Vernon Marsh

Vernon Marsh contains a variety of wetland and upland communities. The most common wetland plant communities include wet meadow, shallow marsh, deep marsh, and open water wetlands. Less common wetland plant community types present include scrub/shrub wetland, forested wetland, and calcareous fen.

Open water wetland communities are common throughout the marsh. Five flowages are managed by water control structures and greatly influence vegetation. Herbaceous species present in this open water community include submergent and floating-leaved aquatics such as water lilies, pondweeds, milfoils, coontail, and duckweed. These open water communities differ from deep and shallow marsh because open water complexes rarely have exposed soil, so emergent aquatic vegetation cannot establish.

The next-driest wetland plant community present at Vernon Marsh is marsh. Marsh wetland communities can be divided into deep and shallow marsh, but because vegetation is often similar between the two, they are combined for purposes of this discussion. In general, marsh communities are seasonally inundated; emergent vegetation is able to establish when bare soil is exposed and seeds can germinate. Cattail, composed of up to three very similar species, is ubiquitous in marsh communities at Vernon Marsh. It is also abundant in other nutrient-rich marsh systems throughout the Midwest. Cattail is the most dominant plant species in Vernon Marsh and is considered an invasive species. Other invasive species present in this wetland community in Vernon Marsh include purple loosestrife and giant reed. There are small areas of native marsh community; these contain various species of bulrush, bur reed, and sedges, but the invasive species limit the cover of these native species.

The final dominant wetland community at Vernon Marsh is wet meadow. This wetland community contains saturated soils which are typically only inundated in the spring. At Vernon Marsh, wet meadow primarily consists of monotypic stands of reed canary grass, another invasive species. Like cattail, reed canary grass thrives in nutrient-rich environments present in floodplain wetlands like Vernon Marsh. Smaller areas of wet meadow contain native species, including a more diverse assemblage of sedges, rushes, grasses, and forbs. Other common wet meadow species include tall goldenrod, tussock sedge, bluejoint grass, and woolgrass. State-listed species are also present in wet meadows at Vernon Marsh.

Other wetland communities are present, but less frequent. Both scrub/shrub and forested wetland communities exist, both dominated by shrubs and trees. Pockets of scrub/shrub containing several willow species are scattered throughout the marsh. Forested wetlands, composed of box elder, ash, willows, and some tamarack, also occur sporadically throughout.

Finally, though small in size, a calcareous fen is located at the southern end of Vernon Marsh. A fen is fed by mineral-rich groundwater and is composed of peat soils. Fens are the rarest wetland plant community in Wisconsin (Eggers and Reed, 1997). The Vernon Marsh fen is located just uphill from groundwater springs at the base of a moderate slope. This fen is densely vegetated with a sparse shrub layer of glossy buckthorn (an invasive species) and shrubby cinquefoil (native) that gives way to an herbaceous-dominated plant community. Signature fen species here include two species of beak-rush (one is state-listed), several forbs including Joe-pye-weed, and several species of spikerush. Two additional state-listed plants (both threatened) are present in this fen.

Small areas of uplands also occur at Vernon Marsh State Wildlife Area. There are several small dry-mesic forests containing canopy species such as red oaks, white ash, black cherry, and sugar maple. Also scattered throughout the site are old fields containing pasture grasses and occasional prairie plantings.

Vegetation at Vernon Marsh is dominated by reed canary grass, monotypic cattail and lowland brush. Small pockets of high quality sedges remain. Some acreage is forested including northern hardwoods, oak woodlots and lowland hardwoods. Upland prairies consist of warm season grasses such as big bluestem, indiangrass, and switchgrass, cool season grasses such as bromegrass and a variety of forbs but dominated by goldenrods and asters.

4.7.3.2 Herptiles of Vernon Marsh

A robust herptile community composed of reptiles and amphibians including two special concern species consistent with open water and marsh is present at Vernon Marsh. Many other turtles, snakes, and frog species occur here.

Common reptiles and amphibians at Vernon Marsh include painted and snapping turtles, common garter snakes, western fox snakes, eastern milk snakes, brown snakes, northern redbelly and northern water snakes, American toads, spring peepers, Eastern gray tree frogs, Copes gray tree frogs, Northern leopard frogs, wood frogs, green frogs, bullfrogs, eastern tiger salamanders and mudpuppies. Other reptile and amphibian species are likely to be present. Vernon Marsh has the best potential for conserving herptiles of any state wildlife area in Waukesha County.

4.7.3.3 Birds of Vernon Marsh

Vernon Marsh, including five flowages, is managed for hunting a variety of species, including waterfowl, deer, and upland game birds. The flowages are managed to consist of 50% emergent marsh and 50% open water, specifically for waterfowl. Also, during migration, at least one flowage is drawn down and maintained as mud flats for migrating shorebirds. The large amount of marsh and open water habitat present at Vernon Marsh provides habitat for a variety of shorebirds, wading, birds, and ducks. Dabbling ducks, cranes, pelicans, herons, and egrets all use the marsh. Three state-listed species all nest on-site. Uplands act as hunting areas for turkey and ring-necked pheasant as well.

Common birds at Vernon Marsh include: Canada geese, mallards, wood ducks, blue-winged teal, American coots, belted kingfishers, herring gulls, ring-bill gull, great blue herons and great egrets. Other waterfowl which use the area as a spring or fall migratory stop-over include widgeon, green-winged teal, northern pintail, gadwall, northern shoveler, bufflehead, common goldeneye, and ring-necked duck. Birds found on the surrounding wetlands and uplands include sandhill cranes, woodcock, owls (great horned, screech and barred), hawks (red-tailed, Coopers, sharp-shinned and American kestrel), wild turkeys and a large variety of songbirds and shorebirds. Vernon is one of two wildlife areas in Waukesha County identified as having the best potential for conserving marsh birds, colonial waterbirds and waterfowl.

4.7.3.4 Mammals of Vernon Marsh

Vernon Marsh provides habitat for several species of mammals. Mammals using the wetlands and riparian areas in Vernon include muskrats, mink, beaver, raccoons, and several bat species. Other mammals on the surrounding uplands include gray and fox squirrels, cottontail rabbits, red and gray fox, coyotes, skunks, opossums, woodchucks, eastern chipmunks, thirteen-lined ground squirrels, white-tailed deer, and various species of shrews, moles, mice, voles and weasels.

White-tailed deer, eastern gray and fox squirrels, eastern cottontails, and coyotes are common in the marsh and receive moderate to heavy hunting pressure. There are no known endangered, threatened, or special concern mammals that reside in Vernon Marsh.

4.7.3.5 Wetland functional values of Vernon Marsh

The Vernon Marsh wetlands (as well as vegetated uplands located adjacent to the marsh), provide many functional values to humans and the environment. Because there are a variety of habitats present, Vernon Marsh provides a wide array of ecosystem functions. The open water and marsh communities are important habitat for waterfowl and furbearers, especially in drought years when more shallow wetlands dry up first. These deeper marsh habitats can also act as spawning grounds for some species of fish. Wildlife heavily use open water and marshes during migration when they feed on submergent vegetation and aquatic invertebrates. The Marsh provides significant opportunities for wetland, bird and herptile conservation.

In addition to wildlife habitat, Vernon Marsh filters runoff and holds flood water. Wetlands in general, and especially riparian wetlands like Vernon Marsh, can trap sediment and take up nutrients, improving water quality. Riparian wetlands can also retain large amounts of floodwater, reducing the risk of flooding to other areas downstream.

Finally, wetlands and open space in general, provide an intrinsic value to humans. Aesthetically, wetlands provide a pleasing environment in addition to their recreational value for hunting, trapping, fishing, and other recreation. Vegetated uplands also add to their aesthetic value and help to buffer the wetlands from runoff and other human-caused impacts.

4.8 Forested and scrub/shrub wetlands

In southeast Wisconsin, forested wetlands are typically dominated by mature deciduous tree species. Forested wetlands are often associated with glacial lake basins or river systems and have seasonally high-water tables. Conversely, scrub/shrub wetlands are dominated by woody vegetation less than 20 feet in height. Scrub/shrub wetlands often occur as a transition between open and forested wetlands, both spatially and temporally. They can be located on the landscape spatially in between open and forested wetlands. Scrub/shrub wetlands can also occur in the same location as an open wetland as it transitions to forested wetland over time. This can happen in the absence of disturbance over many years.

Forested wetlands can consist of deciduous or coniferous tree species. Forested wetlands dominated by hardwood species often occur in the floodplains of rivers in southern Wisconsin but can also occur in ancient lake basins (Eggers and Reed, 1997). Forested wetlands dominated by conifers are more common in the northern part of the state where they grow on organic soils with wide ranges of acidity. Forested wetlands are found in the project area.

Scrub/shrub wetlands typically occur on seasonally-saturated soils that are either organic (pear/muck) or mineral (alluvial) (Eggers and Reed, 1997). They can be located in bands around lakes or ponds, on the margins of floodplains, or more extensively, in glacial lake beds. These communities can persist for very long periods of time if the appropriate hydrologic conditions persist. Scrub/shrub wetlands are less common in southeast Wisconsin, though they are present in the project area.

4.8.1 Flora of forested and scrub/shrub wetlands

Forested wetlands are typically grouped based on the dominant tree species present, either deciduous hardwoods or conifers. Hardwood forested wetlands are typically dominated by black ash, red maple, and yellow birch in northern Wisconsin and silver maple, green ash, and eastern cottonwood, in southern Wisconsin. Coniferous forested wetlands are dominated by different species depending on the pH and water source of the wetland (Eggers and Reed, 1997). Northern white cedars dominate where soils are fertile and have an alkaline to neutral pH. Tamarack and black spruce dominate in nutrient-poor acidic soils, though tamarack can also grow in more basic soils.

A variety of herbaceous species can occur in the understory of all forested wetland types. In the understory of floodplain forests, jewelweed and nettles can be common, though the scouring action of flooding can limit any understory. In coniferous swamps and bogs, sedges, ferns, and forbs dominate. The extent of herbaceous understory also depends on the understory species' tolerance of shade.

Scrub/shrub wetlands are dominated by deciduous shrubs such as red-osier dogwood, gray dogwood, meadowsweet, and several species of willow. Native herbaceous species present in the understory include Canada bluejoint, tussock sedge, joe-pye weed, giant goldenrod, and other species common to sedge meadows. In disturbed scrub/shrub wetlands, reed canary grass can dominate the understory.

4.8.2 Herptiles of forested and scrub/shrub wetlands

A variety of herptiles use scrub/shrub wetlands including frogs, snakes, turtles, and salamanders. The woody vegetation that characterizes forested and scrub/shrub wetlands provide needed cover and habitat for some species. Herptiles ranked as Species of Greatest Conservation Need (SGCN) by the Wisconsin DNR associated with forested and scrub/shrub wetlands include the four-toed salamander, and pickerel frog.

4.8.3 Birds of forested and scrub/shrub wetlands

Forested and scrub/shrub wetlands also provide important habitat to many species of birds. Forested wetlands can contain tree species not common elsewhere, providing unique habitat for birds. Further, trees can be stunted due to saturation and soil conditions, providing even more unique habitat. Numerous passerines, shorebirds, waterfowl, and raptors ranked as SGCNs are associated with forested wetlands.

Because scrub/shrub wetlands can act as a transition between open, herbaceous wetlands and forested wetlands, a wide variety of birds also use this community type. SGCNs such as the American woodcock, black-billed cuckoo, golden-winged warbler, veery, and willow flycatcher all rely on scrub/shrub wetlands for habitat.

4.8.4 Mammals of forested and scrub/shrub wetlands

Again, similarly to herptiles and birds, a variety of mammals use these community types because of their increased cover due to being dominated by woody vegetation. Many species of rodents and furbearers inhabit these wetlands types as they can receive additional protection from predators. In the winter, scrub/shrub wetlands can be important habitat for eastern cottontails and white-tailed deer. Scrub/shrub wetlands may also be used by Franklin's Ground Squirrel, a species of special concern.

4.8.5 Functional values of forested and scrub/shrub wetlands

As previously mentioned, scrub/shrub wetlands can act as a transition zone between open wetlands and forested wetlands. Scrub/shrub wetlands can provide additional habitat to species that normally concentrate in either of these other wetland types (forested or open wetlands). Depending on the location and size of the scrub/shrub wetland, it can provide flood attenuation and water quality improvement to the entire watershed. The same is true for forested wetlands. The tree canopy can provide an added layer of wildlife habitat not found in other wetland types and can help reduce runoff and flooding by intercepting and slowing rainfall.

4.9 Open wetlands

Open wetlands are any wetlands dominated by herbaceous plant species. A variety of wetland communities make up open wetlands. They can be differentiated by vegetation, water chemistry, and water level. Open wetland types include open water, emergent marsh, and southern sedge meadow. Less common wetland types include wet prairies and calcareous fens.

Sedge meadows and wet prairies are dominated by grasses and sedges. Fens support grasses, sedges, and a diversity of other herbaceous plants. Emergent marshes occur along the edges of lakes and streams and are characterized by emergent and submergent vegetation.

4.9.1 Description and locations of open wetlands

Wet meadows are nutrient rich systems dominated by a variety of herbaceous species (wet meadows and sedge meadows are similar, for the department's purposes of this EIS, they are referred to as wet meadows). Calcareous fens are fed by nutrient-rich groundwater while bogs are fed by nutrient poor rainwater. Both are dominated by gramminoids and forbs. Emergent marsh and open water wetlands are wetter, often containing standing water up to six feet with higher level of nutrients. They are dominated by submergent and emergent vegetation. Wet meadows, fens, and open bogs are often located in depressions with less standing water.

4.9.2 Flora of open wetlands

The flora of open wetlands can be separated by plant species' nutrient and water level tolerance. Southern sedge meadows are dominated by terrestrial to emergent gramminoids (grasses, sedges, and rushes) and forbs that can tolerate moderate to high nutrient inputs. Tussock sedge, Canada bluejoint grass, and joe-pye weed are all common wet meadow species.

Fens also contain both gramminoids and forbs, typically terrestrial species, but these species must be able to tolerate low nutrients and high mineral levels. This is due to the fen's primary water source being groundwater-fed springs which contain high levels of calcium and magnesium. Because of this uncommon water source, fens are the rarest wetland type in Wisconsin. Typical calciphiles (calcium-tolerant plants) that thrive in fens include sterile sedge, Ohio goldenrod, and lesser fringed gentian.

Bogs receive their water input mostly via rain, which also contains low nutrients, leading to species that again must tolerate low nutrients and alkaline conditions. Sphagnum moss often dominates the saturated surface of bogs. Other representative species include cottongrass, sundew, pitcher plants, and a variety of ericaceous shrubs.

Emergent and open water wetlands contain grasses and forbs, which can tolerate higher water levels. Both submergent species, which live under water, and emergent species, which root in the bed of waterways but can grow out of the water. Common submergent plants include pondweeds, milfoils, coontail. Typical emergent plants include cattail, bulrushes, giant reed, and bur reed.

4.9.3 Herptiles of open wetlands

Open wetlands act as habitat for a variety of reptiles and amphibians. Open wetlands, and wetlands in general, act as an interface between drier habitats and open water. These ecotones provide both wetland and upland habitat needs for these species that use both. Many species of frogs, snakes, and salamanders use open wetlands. Species of greatest conservation need (SGCN) with an affinity for a variety of open wetlands include four-toed salamander, pickerel frog, chorus frog, and Blanchard's cricket frog.

4.9.4 Birds of open wetlands

Many species of birds use open wetlands because they include both terrestrial and aquatic habitats. For emergent and open water wetlands, waterfowl, shorebirds, wading birds, and raptors all use these habitats. SGCNs with an affinity for emergent and open water wetlands include great egrets, whooping cranes, trumpeter swans, and bald eagles. In drier open wetlands, many raptors, wading birds, and shorebirds all utilize these systems. SGCNs that use southern sedge meadows include black rail, American bittern, and northern harrier.

4.9.5 Mammals of open wetlands

Like other taxa previously mentioned, many mammal species also utilize open wetlands. Furbearers such as beavers, otters, and minks, almost exclusively use open wetlands, while many rodents, ungulates, and larger mammals use wet meadow wetlands, especially in winter.

4.9.6 Functional values of open wetlands

Open wetlands provide a wide range of functions such as wildlife habitat, water quality improvement, flood abatement. Because of the wide-range of water levels contained in open wetlands, their functional values are widespread. Open wetlands adjacent to waterways provide water quality treatment by trapping sediments, nutrients, and toxins, cleaning water as it flows downstream. Similarly, riparian wetlands hold pulses of floodwater, lessening the threat of flooding downstream. Riparian open-water and emergent open wetlands provide wildlife habitat, for many species of birds and mammals. Finally, drier open wetlands, such as wet meadows, fens, and bogs, also provide similar ecosystem functions.

4.10 Upland forests

4.10.1 Description and locations of upland forests

The project area and greater Southeast Glacial Plains Ecological Landscape is known to support bur oak openings of global significance (Wildlife Action Plan 2005-2015).

Wisconsin's southern forest communities occur south and west of the climatic Tension Zone - the approximate area where vegetative communities change from the prairie, savanna, oak and mixed hardwood forests of the south to the mixed deciduous-coniferous forests of the north. Common upland forest communities south of the Tension Zone and which have been documented in this study area include southern dry forest, southern dry-mesic forest, and southern mesic forest. Less common upland forest communities include oak openings.

Southern Wisconsin's landscapes have changed greatly during the past 150 years. The loss of forested land has been widespread in areas suitable for agriculture and residential development.

Another major change occurred as the open landscapes of prairie and savanna succeeded to closed canopy forest following the exclusion of periodic fires. In many areas, canopy composition is now shifting from oak dominance to shade-tolerant mesic hardwoods, primarily due to the absence of fire disturbances. Land use and ownership patterns have resulted in significant forest fragmentation throughout southern Wisconsin, highlighting the ecological significance of the few remaining large forested blocks, particularly those along major river corridors.

4.10.2 Southern dry forest description

Oaks are the dominant species in this upland forest community of dry sites. White oak and black oak are dominant, often with mixtures of northern red and bur oaks and black cherry. In the well-developed shrub layer, brambles (Rubus spp.), gray dogwood, and American hazelnut are common. The most important sites exist in the Kettle Moraine State Forest and vicinity.

4.10.3 Southern dry-mesic forest description

Red oak is a common dominant tree of this upland forest community type. White oak, basswood, sugar and red maples, white ash, shagbark hickory, and black cherry are also important. The herbaceous understory flora is diverse and includes many species listed under southern dry forest. Significant patches of the community type exist in the Southern (Walworth, Jefferson, and Waukesha Counties) Unit of the Kettle Moraine State Forest. Examples of this community type are found at Cudahy Woods State Natural Area and Fall Park Woods (Milwaukee County), Bishop's Woods and Muskego Park Hardwoods (Waukesha County), Silver Lake Bog State Natural Area (Kenosha County), and Sander's Park Hardwoods State Natural Area (Racine County). River corridors offer the best opportunities to develop forest connectivity.

4.10.4 Southern mesic forest description

This upland forest community occurs on rich, well-drained loamy soils, mostly on glacial till plains or loess-capped sites south of the tension zone. The dominant tree species is sugar maple, but basswood, and near Lake Michigan, American beech may be co-dominant. Many other trees are found in these forests, including those of the walnut family, ironwood, red oak, red maple, white ash, and slippery elm. The understory is typically open, or sometimes brushy. Historically, southern mesic forests were quite common throughout southern Wisconsin. This type has been severely reduced from its past extent.

4.10.5 Oak opening description

This is an oak-dominated savanna community in which there is less than 50% tree canopy coverage. Historically, oak openings were very abundant and occurred on wet-mesic to dry sites. Today, very few examples of this type exist. The few extant remnants are mostly on drier sites, with the mesic and wet-mesic oak openings almost destroyed by conversion to agricultural or residential uses, and by the encroachment of other woody plants due to fire suppression. The Southern Unit of the Kettle Moraine State Forest offers some of the best management and restoration opportunities in the upper Midwest, including Eagle Oak Opening (Waukesha County). Other good examples occur at Lulu Lake State Natural Area (Walworth County).

4.10.6 Flora of upland forests

Upland forests, much like forested wetlands, are typically grouped based on the dominant tree species present, and in southern Wisconsin are dominated by hardwoods. Upland forests in the study area represent a transition from drier, oak dominated sites to more mesic uplands where more mesophytic tree species (central and northern hardwood types) become more prevalent. Drier sites are typically dominated by bur, white and black oaks with scattered shagbark hickory, northern red oak and black cherry. As sites become more mesic, northern red oak is a common dominant tree species, with white oak, basswood, sugar and red maples, white ash, shagbark hickory and black cherry also important. On the mesic end of the spectrum the dominant tree species shifts to sugar maple, with basswood also important, and near Lake Michigan American beech may also be co-dominant. Other trees common in mesic upland forests include walnuts, ironwood, northern red oak, red maple, white ash and slippery elm.

A variety of herbaceous species can occur in the understory of upland forest types. The understory of oak openings commonly feature grasses, legumes, composites and other forbs that are best adapted to light conditions of high filtered shade. Southern dry forests tend to have a more well-developed shrub layer of *Rubus* spp. and gray dogwood while frequent herbaceous species include wild geranium, false Solomon's-seal and rough-leaved sunflower. As sites become more mesic the understory flora is diverse with a mixture of species found on both drier and more moist sites such as jack-in-the-pulpit, large-flowered bellwort, lady fern and tick- trefoils. Mesic sites support fine spring ephemeral displays of trout-lilies, trilliums, violets, bloodroot, blue cohosh and mayapple.

4.10.7 Herptiles of upland forests

A variety of herptiles use upland forests, including snakes, frogs and salamanders. The woody vegetation that characterizes upland forests provides needed cover and habitat for some species. Herptiles ranked as Species of Greatest Conservation Need (SGCN) by the DNR associated with upland forest types include the four-toed salamander and pickerel frog.

4.10.8 Birds of upland forests

Upland forests also provide important habitat to many bird species. Upland forests contain a wide spectrum of tree species across the moisture and shade gradient, thus providing habitat diversity for birds for both migration and breeding purposes. Numerous passerines ranked as SGCNs are associated with upland forests.

Because of the unique transition of forested uplands across drier to more mesic sites, a wide variety of birds use these community types. SGCNs such as brown thrasher, red-headed woodpecker, whip-poor-will, blue-winged warbler, American woodcock, wood thrush, and Acadian flycatcher all rely on forested uplands for habitat.

4.10.9 Mammals of upland forests

A variety of mammals use upland forests because of their varied structure and plant diversity, primarily species of woody vegetation. Mammals may rely on woody browse, mast, or the herbaceous understory for food, while others seek cover from forest structure. Many species, including opossums, shrews, moles, bats, chipmunk, voles, mice, foxes, coyotes, raccoons, weasels, skunks, white-tailed deer, eastern gray and fox squirrels, and eastern cottontails may use upland forests during all or a portion of their life cycle.

4.11 <u>Upland grasslands</u>

4.11.1 Description and locations of upland grasslands

Grasslands are characterized by a lack of trees and tall shrubs and are dominated by grasses, sedges and forbs. Grasslands occur on a wide variety of topography, soil types and moisture regimes from water-covered peat to the driest sandy soils. The term grassland often refers collectively to several native vegetation community types known as prairie and bracken grassland.

Prairies are located mostly in the southern and western parts of the state and in addition to playing host to more than 400 species of native vascular plants. Prairies have a diverse and specialized fauna, especially among prairie invertebrates, prairie and grassland herptiles and grassland birds.

Tallgrass prairies are among the most decimated and threatened natural communities in the Midwest and the world. Most native prairies found today in Wisconsin are small remnants that are less than 10 acres in size. Very few exceed 50 acres, too small to support a full complement of species that typically inhabit a native prairie ecosystem. Most of the prairies left today are either of the wet or dry types. Mesic prairie, which was the most common type in pre-settlement days, is almost gone now, with only about 100 acres known to exist today. The greater Southeast Glacial Plains and Southern Lake Michigan Coastal Ecological Landscapes are known to support extensive grassland communities of state significance (Wildlife Action Plan 2005-2015).

4.11.2 Flora of upland grasslands

The flora of upland grasslands varies dependent on the soil's moisture gradient, but also by composition of grass versus forbs (herbaceous plants). Dry-mesic prairies, for example, are typically found on drier, sandy or loamy soils and are dominated by taller grass species such as big bluestem and Indian grass. As soils become richer, additional grass species appear including little bluestem, needle grass, prairie dropseed and switch grass. As sites grade into more wetland-type soils, grass species such as Canada bluejoint grass and cordgrass along with sedges begin appearing.

The herbaceous component can be quite diverse throughout the spectrum of grassland community types. On dry-mesic prairie sites there are often species that occur in both dry and mesic prairie, including legumes, rattlesnake-master and flowering spurge. More mesic sites can have a stronger percentage of forbs overall, but with many of the same species represented. Common species found in mesic prairies include prairie dock, lead plant, asters, prairie coreopsis, monarda and spiderwort. A wet-mesic prairie tends to be a much more herbaceous dominated grassland community. Including aster and sunflower species, shooting-star, goldenrod species, and culver's root; this community can occur in large wetland complexes with wet prairie, southern sedge meadow, calcareous fend and emergent marsh (i.e., open wetland) communities.

4.11.3 Herptiles of upland grasslands

Upland grasslands act as habitat for a variety of herptiles, particularly where one type grades into another to provide a variety of habitats. Many frog, snake, and turtle species use upland grasslands. Species of greatest conservation need (SGCN) that may occur in upland grasslands include pickerel frog and Butler's gartersnake.

4.11.4 Birds of upland grasslands

Over 40 grassland bird species breed in Wisconsin. In the last 30 years this group of birds has declined more than any other in North America (UW-Extension 2000). The shrinking populations of grassland birds can be traced primarily to the loss of grassland habitat as row crop acreage has increased. Additionally, the timing and frequency of hay harvesting can impact nesting efforts, destroying nests before the young birds have fledged.

Passerines, waterfowl, shorebirds, wading birds, and raptors all use upland grassland habitats. SGCNs with an affinity for grassland sites across the spectrum include bobolink, Henslow's sparrow, upland sandpiper, and short-eared owl. Other important grassland bird species include Eastern meadowlark, dickcissel, grasshopper sparrow, vesper sparrow, swamp sparrow, and Northern harrier.

4.11.5 Mammals of upland grasslands

A variety of mammals use upland grasslands during all or a portion of their life cycle. Many species, including shrews, moles, thirteen-lined ground squirrels, voles, mice, foxes, coyotes, skunks, and white-tailed deer may be found in upland grasslands. One species of special concern, Franklin's Ground Squirrel, also uses prairie edges.

4.12 Air quality

The proposed project area is currently in attainment with all National Ambient Air Quality Standards (ozone, $PM_{2.5,}$ $PM_{10,}$ sulfur dioxide, nitrogen dioxide, carbon monoxide and lead).

4.13 Demographic characteristics and trends

4.13.1 Population

The population of Waukesha County and the City of Waukesha more than doubled between 1960 and 2010. The City of Waukesha increased from 30,000 in 1960 to 70,718 in 2010. This growth is much greater than that in the seven county SEWRPC planning region. Changes in population are based on three variables: birth and death rates, migration into and out of the community, and the ability of a community/town to annex neighboring lands, which increases the size and population. The birth and death rate, or the balance between births and deaths in a given area, is considered a population's "natural increase." According to SEWRPC, the region experienced a population increase of 120,800 people. Of this, 97 percent (116,900) was attributed to natural population increase (SEWRPC 2004).

The SEWRPC planning region includes the Counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha. Within this region, there has been substantial migration during the past sixty years. The general trend has been the outward migration of people from the urban centers along Lake Michigan to outlying municipalities, towns, and counties (SEWRPC 2004). This trend corresponds with the reduction in manufacturing jobs in the urban centers and economic development in outlying areas (Levine 2002; Rast and Madison 2010).

As estimated by the Wisconsin Department of Administration, the City of Waukesha's 2018 population was 71,731 (Demographic Services Center 2019). Based on U.S. Census data, the city's population increased by 136 percent between 1960 and 2010 (from 30,004 to 70,718). During the same period, Waukesha County grew by 155 percent (from 158,249 to 403,072), while the overall SEWRPC planning region grew by 30 percent (from 1,573,614 to 2,045,705).

At a local level, population growth can be constrained by the availability of developable land. Build-out occurs when a city or village can no longer expand its boundaries through annexation and all remaining undeveloped land has either been set aside for public uses (e.g., parks) or determined to be undevelopable. Milwaukee is an example of a city that reached build-out and subsequently experienced population decline, although urban infill and re-development have enabled population to rebound in some parts of the city. In 2012, SEWRPC projected that the City of Waukesha's population will be 76,330 when it reaches build-out (CH2M Hill 2013, Vol. 2, Appendix C).

4.13.2 Age

Based on the results of the 2010 census, the median age in Waukesha County is 42. Table 4-8 summarizes age statistics for the state, Waukesha County, and the City of Waukesha.

Table 4-8. Waukesha and southeastern Wisconsin regional population age statistics for 2010

Age Group	State of Wisconsin % of Total	Waukesha County % of Total	City of Waukesha % of Total
Under 5 years	6.3	5.5	7.1
5 to 9 years	6.5	6.7	6.8
10 to 14 years	6.6	7.2	6.1
15 to 19 years	7.0	6.8	6.7
20 to 24 years	6.8	4.7	7.8
25 to 29 years	6.5	5.1	8.6
30 to 34 years	6.1	5.2	8.1
35 to 39 years	6.1	6.0	7.0
40 to 44 years	6.7	7.3	6.7
45 to 49 years	7.7	8.8	7.0
50 to 54 years	7.7	8.8	6.8
55 to 59 years	6.8	7.5	5.8
60 to 64 years	5.5	6.1	5.1
65 to 69 years	4.0	4.2	3.2
70 to 74 years	3.1	3.1	2.2
75 to 79 years	2.5	2.7	1.9
80 to 84 years	2.1	2.2	1.6
85 and over	2.1	2.0	1.7
Median age	38.5	42.0	34.2

Source: U.S. Census Bureau

4.13.3 Racial

The UW-Milwaukee's Center for Economic Development (CED) conducted a detailed study of socioeconomic factors for SEWRPC's Regional Water Supply Plan (Rast and Madison, 2010). Data and trends from that study are summarized here.

Within the Southeast Wisconsin region, the number and proportion of the non-white population has grown over the past five decades. Census data for 1960 indicates that whites constituted about 95 percent of the regional population. By 2007, racial minority populations increased, from less than five percent to nearly 23 percent in the region. Table 4-9 shows the change in minority populations in the region between 1960 and 2007. In 1960, nearly 91 percent of racial minorities in the region lived in Milwaukee County. Racine and Kenosha counties had 7.6 percent and 1.4 percent of regional minority populations, respectively, while the other counties in the region totaled less than one percent of non-white population. The Waukesha County non-white population is projected to almost double by 2035, to almost 17 percent of the total population.

Table 4-9. Racial minority distribution for southeastern Wisconsin

	1960				2007			
	Total population	Non-White population			Total population	Non-White population		
County	Number	Number	Percent	Percent[1]	Number	Number	Percent	Percent[1]
Kenosha	100,615	1,090	1.1	1.4	161,254	22,745	14.1	5.0
Milwaukee	1,036,041	66,777	6.4	90.6	951,026	359,791	37.8	79.3
Ozaukee	38,441	46	0.1	<0.1	85,345	3,503	4.1	0.8
Racine	141,781	5,459	3.9	7.6	194,522	34,664	17.8	7.6
Walworth	52,368	230	0.4	0.2	100,140	6,912	6.9	1.5
Washington	46,119	59	0.1	<0.1	126,636	4,089	3.2	0.9
Waukesha	158,249	290	0.2	0.2	376,978	21,854	5.8	4.8
Region	1,573,614	73,951	4.7	100.0	1,995,901	453,558	22.7	100.0

Source: US Census Bureau and American Community Survey for the Year 2007, as reported by Rast & Madison (2010)

[1] Percent of Regional Non-White Population

As shown in Table 4-10, the City of Waukesha is predominately White, but racial diversity has increased since 1960. The percent of Non-Whites increased from 0.5 percent in 1960 to almost nine percent in 2000. More than 5,500 Non-White residents moved into the City over the period. The percent increase in Non-Whites is like that in other communities in the southeastern Wisconsin region.

Table 4-10. Racial minority distribution for southeastern Wisconsin in 1960 and 2000 for selected communities

	1960				2000			
	Total population	Non-White population			Total population	Non-White population		
Community	Number	Number	Percent	Percent	Number	Number	Percent	Percent
Kenosha	67,899	1,015	1.5	1.4	90,352	14,786	16.4	3.7
Milwaukee	741,324	65,752	8.9	88.9	596,974	298,595	50.0	74.9
Oak Creek	2,549	7	0.3	0.0	28,456	2,287	8.0	0.6
Port Washington	5,984	8	0.1	0.0	10,467	317	3.0	0.1
Racine	89,144	4,812	5.4	6.5	81,855	25,447	31.1	6.4
Brookfield	19,812	18	0.1	<0.1	38,649	2,242	5.8	0.6
Cedarburg	5,191	2	<0.1	<0.1	10,908	200	1.8	0.1
Elm Grove	4,994	4	0.1	<0.1	6,249	179	2.9	0.0
Germantown	622	0	0	0	18,260	762	4.2	0.2
Grafton	3,748	3	0.1	<0.1	10,312	235	2.3	0.1
Muskego[1]	--	--	--	--	21,397	405	1.9	0.1
New Berlin	15,788	14	0.1	<0.1	38,220	1,589	4.2	0.4
Saukville	1,038	0	0	0	4,068	105	2.6	0.0
Waukesha	30,004	141	0.5	0.2	64,825	5,692	8.8	1.4

Source: US Census Bureau, as reported by Rast & Madison (2010)

[1] The Village of Muskego was incorporated in 1964.

The City of Milwaukee's White population declined by about 56 percent between 1960 and 2000 largely because of Whites moving to suburban communities. The City of Racine likewise experienced a 33 percent decline in its White population. Racine, Milwaukee and Kenosha had the most significant increases in minority populations during this time period. Table 4-11 shows the difference and percent change in racial distributions between 1960 and 2000 for selected communities in the region. Little of the growth in minority populations in suburban areas has been by growth in African-American populations.

Table 4-11. Difference and percent change in racial distribution between 1960 to 2000 for selected communities in southeastern Wisconsin

	Total		White		Black or African American		Other Non-White	
County	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Kenosha	22,769	100	9,075	39.9	5,770	25.3	7,924	34.8
Milwaukee	-144,368	100	-375,387	-260.0	158,312	109.7	72,707	50.4
Oak Creek	19,084	100	16,826	88.2	651	3.4	1,607	8.4
Port Washington	4,380	100	4,027	91.9	46	1.1	307	7.0
Racine	-7,317	100	-27,833	-380.4	11,627	158.9	8,889	121.5
Brookfield	18,995	100	16,927	89.1	258	1.4	1,810	9.5
Cedarburg	5,584	100	5,451	97.6	20	0.4	113	2.0
Elm Grove	1,282	100	1,158	90.3	9	0.7	115	9.0
Germantown	17,638	100	16,876	95.7	247	1.4	515	2.9
Grafton	6,571	100	6,329	96.3	15	0.2	226	3.4
Muskego[1]	--	--	--	--	--	--	--	--
New Berlin	22,574	100	20,930	92.7	189	0.8	1,455	6.5
Saukville	3,116	100	2,940	94.4	50	1.6	124	4.0
Waukesha	34,368	100	29,180	84.9	639	1.9	4,549	13.2

Source: US Census Bureau as reported by Rast & Madison (2010)

[1] The Village of Muskego was incorporated in 1964.

CED projected that between 2000 and 2035, the regional population will continue to grow by about 18.5 percent (see Table 4-12). All counties in the region are expected to increase in population and proportions of minority populations are also expected to continue to increase. By 2035, CED estimates that the minority population in the region will increase from 23.5 to about 36.8 percent of the total population due to mostly by increases in the Hispanic population.

Table 4-12. Year 2035 population projections by race and ethnicity within the region

	Total population	Non-Hispanic population								Hispanic population[1]	
		White alone		Black alone		Asian alone		Other[1]			
County	Number	Number	%	Number	%	Number	%	Number	%	Number	%
Kenosha	213,886	146,646	68.6	18,611	8.7	5,374	2.5	4,351	2.0	38,904	18.2
Milwaukee	1,012,538	442,183	43.7	268,916	26.6	47,201	4.7	32,534	3.2	221,703	21.9
Ozaukee	98,922	86,238	87.2	2,543	2.6	2,958	3.0	2,374	2.4	4,809	4.9
Racine	234,467	159,866	68.2	21,289	9.1	3,152	1.3	6,668	2.8	43,492	18.5
Walworth	122,275	97,398	79.7	1,110	0.9	2,063	1.7	2,900	2.4	18,805	15.4
Washington	162,462	145,711	89.7	3,019	1.9	2,551	1.6	3,547	2.2	7,634	4.7
Waukesha	445,569	370,199	83.1	14,465	3.2	19,727	4.4	7,440	1.7	33,737	7.6
Region	2,290,118	1,448,240	63.2	329,954	14.4	83,026	3.6	59,814	2.6	369,084	16.1

Source: US Census Bureau and CED as reported by Rast & Madison (2010)

[1] "Other" represents the aggregated Census data from the following populations; American Indian or Alaska Native Alone, Native Hawaiian and Pacific Islander, Some Other Race Alone, Two or More Races.

[2] Hispanics may be of any race.

CED projects that by 2035 Waukesha County will have the largest total population gain in the region and increase of 23.5 percent over the 2000 level. Racial and Hispanic population growth will amount to 64.3 percent of this projected growth. The total minority population of Waukesha County is expected to increase to 16.9 percent of population in 2035. The population of Milwaukee County is anticipated to net the second greatest population gain, an increase of 72,374 people, or about 7.7 percent. The CED analysis is that the White Alone, Non-Hispanic population in Milwaukee County will decline by 24 percent. This is the only projected net loss in any racial or ethnic population group within the region.

Selected communities within southeastern Wisconsin were analyzed by CED, and most are expected to increase in population between 2000 and 2035. CED's projection indicates that the population of Non-White Alone racial and ethnic minorities will increase in each of the selected communities. They further predict that the percent of each minority population will continue to increase relative to the White Alone populations over the 35-year period. Hispanic populations are expected to have the most significant increases in each of the selected communities.

As shown in Table 4-13, the CED model projects that the total population of the City of Waukesha will increase by a little over 25 percent between 2000 and 2035, from 64,825 to about 81,186 people. The greatest portion of this increase is anticipated to be the Hispanic population. The White Alone, Non-Hispanic population is projected to continue to decline, which would be a new pattern since this group has not experienced a decline over the past 50 years.

The combined minority population is projected by CED to account for all of the population growth in Waukesha. Non-White, Non-Hispanic racial minorities are expected to increase from 1.2 to 5.7 percent of the City population, the Asian population increasing from 2.1 to 7.5 percent, and the aggregated "Other" population increasing from 1.4 to 2.8 percent. The greatest increase will be in the Hispanic population with an increase, from 8.6 to 26.6 percent of the population.

Table 4-13. Population by race and ethnicity for the City of Waukesha

	2000		Projected 2035		Change		
Population	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Percent of change**
Totals	64,825	100.0	81,186	100.0	16,361	25.2	100.0
Non-Hispanic	59,262	91.4	59,618	73.4	356	0.6	2.2
White alone	56,191	86.7	46,539	57.3	-9,652	-17.2	-59.0
Black alone	797	1.2	4,644	5.7	3,847	482.7	23.5
Asian alone	1,389	2.1	6,127	7.5	4,738	341.1	29.0
Other[1]	885	1.4	2,308	2.8	1,423	160.7	8.7
Hispanic[2]	5,563	8.6	21,568	26.6	16,005	287.7	97.8

Source: US Census Bureau and CED

[1] "Other" represents the aggregated Census data from the following populations; American Indian or Alaska Native Alone, Native Hawaiian and Pacific Islander, Some Other Race Alone, Two or More Races.

[2] Hispanics may be of any race.

4.13.4 Health and disabilities

In 2000, 10.8 percent of the population of Waukesha County reported one or more disabilities, while 14.9 percent of the City of Waukesha reported one or more disabilities. The state and national average that year, respectively, were 14.7 and 19.3 percent (Rast and Madison 2010).

4.14 <u>Economy</u>

There has been a historic trend toward decentralization of jobs from the urban centers to the outlying counties in the region between 1960 and 2000. Table 4-14 and Table 4-15Table 4-15. show job distribution and growth patterns for southeastern Wisconsin counties.

Table 4-14. Job distribution for Southeastern Wisconsin

	1960		1970		1980		1990		2000	
County	Jobs	%	Jobs	%	Jobs	%	Jobs	%	Jobs	%
Kenosha	42,200	6.3	42,100	5.4	54,100	5.7	52,200	4.6	68,700	5.6
Milwaukee	503,300	74.8	525,200	66.9	583,200	61.5	609,800	53.3	624,600	51.1
Ozaukee	10,200	1.5	21,300	2.7	28,200	3.0	35,300	3.1	50,800	4.2
Racine	49,900	7.4	64,600	8.2	81,200	8.6	89,600	7.8	94,400	7.7
Walworth	19,600	2.9	26,400	3.4	33,500	3.5	39,900	3.5	51,800	4.2
Washington	15,200	2.3	24,300	3.1	35,200	3.7	46,100	4.0	61,700	5.0
Waukesha	32,600	4.8	81,000	10.3	132,800	14.0	189,700	16.6	270,800	22.1
Region	673,000	100.0	784,900	100.0	948,200	100.0	1,143,700	100.0	1,222,800	100.0

Source: Bureau of Labor Statistics and the US Census Bureau as reported by Rast & Madison (2010)

Table 4-15. Job growth in Southeastern Wisconsin

			1960 to 2000		
County	1960	2000	Change	Percent	Compound annual growth rate
Kenosha	42,200	68,700	26,500	62.8	1.23
Milwaukee	503,300	624,600	121,300	24.1	0.54
Ozaukee	10,200	50,800	40,600	398.0	4.10
Racine	49,900	94,400	44,500	89.2	1.61
Walworth	19,600	51,800	32,200	164.3	2.46
Washington	15,200	61,700	46,500	305.9	3.56
Waukesha	32,600	270,800	238,200	730.7	5.44
Region	673,000	1,222,800	549,800	81.7	1.50

Source: Bureau of Labor Statistics and the US Census Bureau

Economic growth in the Waukesha County has been much greater than the overall southeastern Wisconsin region, increasing from nearly five percent of the total in 1960 to more than 22 percent in 2000 (Table 4-16). This is consistent with the regional trend of employment migration from the urban areas to the more suburban areas and the shift from manufacturing to service sector jobs in the southeastern Wisconsin region.

Table 4-16. Waukesha and regional economy

	1960		1970		1980		1990		2000	
	Jobs	%	Jobs	%	Jobs	%	Jobs	%	Jobs	%
Waukesha	32,600	4.8	81,000	10.3	132,800	14	189,700	16.6	270,800	22.1
SE Wisconsin	673,000	100	784,900	100	948,200	100	1,143,700	100	1,222,800	100

Source: Bureau of Labor Statistics and the US Census Bureau as reported in Rast & Madison (2010)

SEWRPC has developed long-term economic and jobs projections for southeastern Wisconsin. The most recent projections are in Planning Report No. 48 *A Regional Land Use Plan for Southeastern Wisconsin: 2035* (SEWRPC 2006). The most recent projections were developed for the planning year 2035 (see Table 4-17).

Table 4-17. Projected jobs distribution for southeastern Wisconsin

County	2003		Projected jobs			
	Jobs	Percent of regional jobs	2035	Change (2000 – 2035)	Percent change	Percent of regional jobs
Kenosha	69,500	5.9	88,500	19,000	27.3	6.5
Milwaukee	589,800	50.0	628,900	39,100	6.6	46.0
Ozaukee	49,200	4.2	62,300	13,100	26.6	4.6
Racine	90,000	7.6	106,600	16,600	18.4	7.8
Walworth	52,300	4.4	69,400	17,100	32.7	5.1
Washington	61,800	5.2	78,900	17,100	27.7	5.8
Waukesha	266,400	22.6	333,700	67,300	25.3	24.4
Region	1,179,000	100.0	1,368,300	189,300	16.1	100.0

Source: SEWRPC and US Bureau of Economic Analysis

The economy in Waukesha County is projected to increase by 67,000 jobs, or 25 percent, by 2035. This is considerably higher than for Milwaukee County (seven percent increase) but similar to the surrounding counties.

Much of the industry in the southeastern Wisconsin region is considered to be water-intensive, but many large industrial water users rely on private high-capacity groundwater wells rather than municipal water. A review of the large businesses in Waukesha County indicates there are no known major water-intensive businesses or industries using municipal supplies (Rast and Madison 2010).

SEWRPC also developed job projections for each urbanized service area under the Regional Water Supply Plan. Table 4-18 shows population and job predictions for each selected water utility service area for 2000 and 2035. Each utility service, except Milwaukee Water Works is expected to have some job growth. The Milwaukee Water Works service area is not anticipated to expand over this period.

Table 4-18. Existing and forecast population for selected water service areas

	2000			2035		
Community	Population	Jobs	Jobs per 100 persons	Population	Jobs	Jobs per 100 persons
Kenosha Water Utility	98,700	45,269	45.9	105,100	48,693	46.3
Milwaukee Water Works	650,750	410,929	63.1	664,550	404,650	60.9
City of Oak Creek Water and Sewer Utility	26,000	19,916	76.6	50,850	28,349	55.8
City of Port Washington Water Utility	10,600	7,092	66.9	15,000	8,933	59.6
City of Racine Water and Wastewater Utility	103,800	58,601	56.5	113,500	59,644	52.5
City of Brookfield Municipal Water Utility and Village of Elm Grove[1]	30,249	34,772	115.0	51,600	50,711	98.3
City of Cedarburg Light and Water Commission	11,250	8,120	72.2	14,900	8,754	58.8
Village of Germantown Water Utility	15,050	10,545	70.1	23,450	18,071	77.1
Village of Grafton Water and Wastewater Commission	10,500	8,473	80.7	16,450	12,662	77.0
City of Muskego Public Water Utility	7,800	4,344	55.7	28,650	8,068	28.2
City of New Berlin Water Utility	30,100	24,237	80.5	41,300	33,058	80.0
Village of Saukville Municipal Water Utility	4,150	3,306	79.7	5,650	5,245	92.8
City of Waukesha Water Utility	65,000	51,792	79.7	88,500	58,196	65.8

Source: SEWRPC and CED

[1] Based on the analysis methodology, SEWRPC combines forecast jobs data for the Village of Elm Grove with the City of Brookfield Municipal Water Utility. Job estimates are based on both the City of Brookfield Municipal Water Utility and the Village of Elm Grove sewer service area. The year 2000 population projections include the estimate of 24,000 people served by the City of Brookfield Municipal Water Utility and the estimated population of the Village of Elm Grove served by municipal sewer, or 6,249 people.

There has been a widening gap in median household income between the counties over the past 50 years. In 1960, the median income in five of the seven counties was relatively similar, but by 2008 this gap had grown to 40 percent. Table 4-19 shows this increase. Waukesha County had the highest median household income in the region in 2008.

Table 4-19. Historic median household income for southeastern Wisconsin[1]

County	1960	1970	1980	1990	2000	2008
Kenosha	50,305	57,599	52,477	50,470	60,701	54,464
Milwaukee	50,691	60,929	47,351	45,906	49,238	45,091
Ozaukee	52,022	70,029	66,770	70,332	81,088	73,186
Racine	48,894	60,862	54,725	53,951	54,354	54,241
Walworth	41,402	53,754	45,613	49,988	59,802	55,988
Washington	45,163	62,566	57,455	63,308	73,706	65,061
Waukesha	52,298	71,000	67,483	73,412	81,209	74,688

[1] Data from Table 4-I. Dollars are adjusted to 2008 dollars based on the Consumer Price Index.

Source: US Census Bureau and American Community Survey as reported by Rast & Madison (2010)

An estimate of the ranges in household incomes provides information about the distribution of household incomes and provides an assessment of low-income households in each county. This data is shown in Table 4-20. In 2008, Ozaukee, Washington, and Waukesha Counties had the lowest percentages of households with annual incomes under $10,000.

Table 4-20. 2000 Annual household income ranges for southeastern Wisconsin

	< $10,000		$10,000 - $14,999		$15,000 - $24,999		$25,000 - $34,999		$35,000 – $49,999		$50,000 - $75,999		> $75,000	
County	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Kenosha	3,554	6.3	2,926	5.2	6,896	12.3	6,957	12.4	9,300	16.6	12,959	23.1	13,501	24.1
Milwaukee	40,098	10.6	25,500	6.7	54,013	14.3	53,352	14.1	66,510	17.6	72,565	19.2	65,945	17.4
Ozaukee	837	2.7	881	2.9	2,453	7.9	2,850	9.2	4,360	14.1	7,324	23.7	12,182	39.4
Racine	4,423	6.2	3,643	5.1	8,428	11.9	8,453	11.9	11,812	16.7	17,196	24.3	16,841	23.8
Walworth	2,106	6.1	2,024	5.9	3,913	11.3	4,459	12.9	6,256	18.1	8,307	24.1	7,450	21.6
Washington	1,479	3.4	1,414	3.2	3,494	8.0	4,642	10.6	7,298	16.6	12,255	27.9	13,328	30.4
Waukesha	3,698	2.7	4,416	3.3	9,696	7.2	12,097	8.9	19,686	14.5	33,478	24.7	52,379	38.7
Region	56,195	7.5	40,804	5.4	88,893	11.9	92,810	12.4	125,222	16.7	164,084	21.9	181,626	24.2
Kenosha	3,554	6.3	2,926	5.2	6,896	12.3	6,957	12.4	9,300	16.6	12,959	23.1	13,501	24.1

Source: US Census Bureau as reported by Rast & Madison (2010)

Table 4-21 shows, among selected communities in the region, that there has been a widening gap in median incomes over the past 50 years. Other than Brookfield and New Berlin, in 1960 median income in most of the communities was similar. By 2008, four of the smaller suburban communities for which data are available had higher incomes than Kenosha, Milwaukee, Racine, and Waukesha.

Table 4-21. Historic median household income for selected communities in southeastern Wisconsin

Community	**1960**	**1970**	**1980**	**1990**	**2000**	**2008**
Kenosha	7,035	10,191	18,927	27,770	41,902	46,356
Milwaukee	6,664	10,262	16,028	23,627	32,216	37,022
Oak Creek	6,984	11,715	23,413	39,995	53,779	69,304
Port Washington	6,801	11,465	21,914	36,515	53,827	NA
Racine	6,758	10,526	18,437	26,540	37,164	40,976
Brookfield	8,909	16,052	32,159	57,132	76,225	89,361
Cedarburg	6,729	12,521	22,716	38,322	56,431	NA
Elm Grove	NA	21,969	38,922	66,852	86,212	NA
Germantown	NA	13,128	25,314	43,486	60,742	NA
Grafton	6,980	12,669	23,647	40,596	53,918	NA
Muskego	NA	12,581	25,648	46,119	64,247	82,327
New Berlin	7,503	13,185	28,547	49,394	67,576	77,299
Saukville	NA	NA	22,264	34,461	53,159	NA
Waukesha	6,779	11,547	21,175	36,192	50,084	55,157

Note: 1960 and 1970 Census reports Median Family Income not Median Household Income. 2008 ACS estimates are not available for communities under 25,000 people (Cedarburg, Elm Grove, Germantown, Grafton, Port Washington, and Saukville).

Source: US Census Bureau and American Community Survey s reported by Rast & Madison (2010)

Between 1970 and 2000, poverty levels in southeastern Wisconsin counties have fluctuated as shown in Table 4-22.

Table 4-22. Population with incomes at or below the poverty level in southeastern Wisconsin

	1970		1980		1990		2000	
County	Persons	Percent	Persons	Percent	Persons	Percent	Persons	Percent
Kenosha	8,844	7.5	12,437	10.1	14,613	11.4	11,218	7.5
Milwaukee	95,920	9.1	135,098	14.0	181,303	18.9	143,845	15.3
Ozaukee	2,449	4.5	3,081	4.6	1,602	2.2	2,140	2.6
Racine	12,471	7.3	16,621	9.6	19,779	11.3	15,862	8.4
Walworth	6,535	10.3	8,581	12.0	8,025	10.7	7,876	8.4
Washington	3,383	5.3	6,194	7.3	3,146	3.3	4,230	3.6
Waukesha	9,255	4.0	12,609	4.5	9,751	3.2	9,741	2.7
Region	138,856	7.9	194,621	11.0	238,218	13.2	194,912	10.1

Source: US Census Bureau as reported by Rast & Madison (2010)

Table 4-23 shows the historic percentage of population living at or below the poverty threshold by county in in the region. The data indicates that all counties share declined somewhat, except that there was an increase in Milwaukee County's share.

Table 4-23. Percent of regional population with incomes at or below the poverty level in southeastern Wisconsin

County	1970	1980	1990	2000
Kenosha	6.4	6.4	6.1	5.8
Milwaukee	69.1	69.4	76.1	73.8
Ozaukee	1.8	1.6	0.7	1.1
Racine	9.0	8.5	8.3	8.1
Walworth	4.7	4.4	3.4	4.0
Washington	2.4	3.2	1.3	2.2
Waukesha	6.7	6.5	4.1	5.0
Region	100	100	100	100

Source: US Census Bureau as reported by Rast & Madison (2010)

4.14.1 Industries

As shown in Table 4-24, the leading industry in Wisconsin shifted from manufacturing in 2000 to educational services by 2010. In Waukesha County, educational services remained the leading industry from 2000 to 2010. Like the Wisconsin trend, the City of Waukesha experienced a shift in leading industries, from manufacturing in 2000 to educational services in 2010.

Table 4-24. Employment percentage in leading industries in 2000 and 2010

	Industries										In labor force[a]	
	Manufacturing		Educational services		Retail trade		Recreation & entertainment		Professional, scientific & management			
Geography	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010
Wisconsin	22.2	17.9	20.0	23.0	11.6	11.6	7.3	9.1	6.6	7.9	69.1	68.3
Milwaukee County	18.5	14.3	22.4	27.1	10.4	10.4	7.7	9.6	9.3	10.7	65.4	66.8
City of Milwaukee	18.5	13.6	23.4	27.7	9.9	11.0	8.6	10.4	8.9	11.2	63.9	66.0
Waukesha County	14.1	16.5	19.9	23.3	11.7	12.1	7.9	7.1	9.3	10.6	63.9	70.3
City of Waukesha	22.0	16.6	20.5	22.3	12.0	14.2	6.8	10.7	9.2	9.6	73.2	74.8

[a] Population 16 yrs and older.

Source: U.S. Census Bureau

As reported by the CED (Rast and Madison, 2010), all commercial and industrial businesses and industries use water, but most would not be considered water-intensive users. The most water-intensive industries in southeastern Wisconsin include brewing and bottling manufacturers, mining, thermoelectric power generators, and agriculture. There are also some large food processors and manufacturers in the region that likely rely on large quantities of water.

Many of the largest water users do not rely on the use of municipal water, instead relying on private high-capacity wells. The most intensive water-using industries are those that generate thermoelectric power, and most are located within the Lake Michigan watershed using Lake Michigan water. There are currently no known major water-intensive businesses or industries located within the regional communities that rely on municipal groundwater. All but one of the bottling and brewing/beverage manufacturers in southeastern Wisconsin are in the Lake Michigan basin.

4.14.2 Unemployment

Unemployment throughout the Milwaukee-Waukesha-West Allis Metropolitan Statistical Area has increased over the past decade. In 2005 the annual average unemployment rate was 5.0 percent. For 2010 the annual average unemployment rate had risen to 8.9 percent, before falling to an annual average 6.0 percent for the 2014 the Bureau of Labor Statistics (BLS 2015).

Waukesha County and the City of Waukesha reported similar unemployment trends over the past decade. The County's annual average unemployment rate in 2005 was 3.8 percent, it had risen to an annual average of 7.3 percent for 2010 and fallen to an annual average of 4.5 percent for 2014 (BLS 2015). The City of Waukesha's average annual unemployment rate was 4.8 percent for 2005. It had risen to an annual average of 9.2 percent for 2010; and had fallen to an annual average of 4.8 percent for 2014 (BLS 2015).

Another study by CED looked at the impact of this shift on inner city populations in Milwaukee. Unemployment in the inner city was about four times higher than the average for metropolitan Milwaukee. From 1970 to 2000, the inner-city population dropped by 45 percent (Levine 2002).

4.14.3 Employment trends

As described in the CED report *A Socio-Economic Impact Analysis of the Regional Water Supply Plan for Southeastern Wisconsin* (Rast and Madison 2010), Waukesha County experienced an annual increase in jobs from 1960 to 2000 by approximately 5.4 percent. Before 1960, less than five percent of the regional distribution of jobs was from Waukesha County. By 2000, Waukesha County provided 22 percent of the jobs in southeastern Wisconsin. Percent increases and decreases in the number of jobs in a specific area is considered separately from changes in employment and unemployment rates, which are based on the total number of employable persons in an area.

A similar increase was reflected in the historical labor force pattern. Before 1960, most of the regional labor force, about 68 percent, resided in Milwaukee County. Although Milwaukee County's labor force continued to grow through 1990, its share of the regional labor force decreased to 46.5 percent by 2000. Meanwhile, Waukesha County's share of the regional labor force grew from 9.1 percent in 1960 to 19.9 percent in 2000. Waukesha County experienced an average annual growth rate of 3.15 percent from 1960 to 2000, whereas Milwaukee County experienced an annual growth rate of only 0.21 percent.

4.14.4 Tax base

Municipal tax rates (tax base) are based on the total value of all taxable property in a particular municipality. To compare tax bases accurately across multiple municipalities, the State of Wisconsin equalizes assessed values by using tools such as market sales analysis, random appraisals, and local assessors' reports to bring values to a uniform level. Tax base analysis uses equalized values determined by the Wisconsin Department of Revenue. An overview of relevant equalized values for 2010 (Table 4-25) within the seven-county region of southeastern Wisconsin, Waukesha County is 28 percent of the tax base (Public Policy Forum 2011).

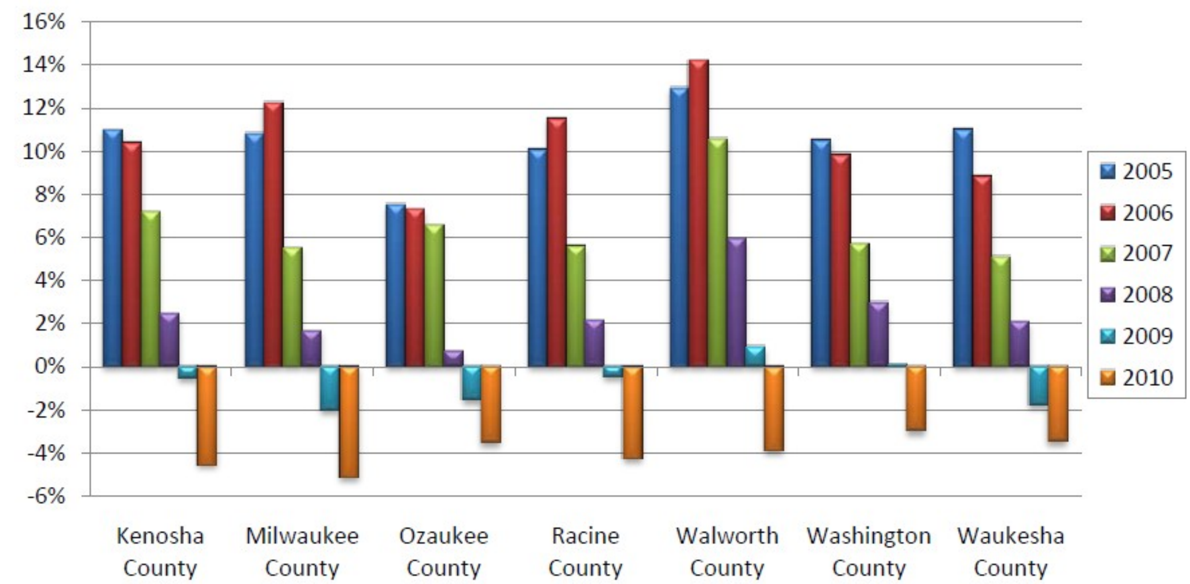
Table 4-25. Total equalized value in southeastern Wisconsin 2010

Geography	2010 Total equalized value ($)	1 Year % change in property value
Milwaukee County	63,403,508,200	-4.9
City of Milwaukee	29,500,535,100	-5.6
Waukesha County	50,270,294,500	-2.9
City of Waukesha	5,904,933,100	-3.2
SE Wisconsin (7 counties)	182,621,628,700	-4.2

Source: Public Policy Forum, 2011

In recent years, property values in southeastern Wisconsin have declined by at least three percent in each of the seven counties (Public Policy Forum 2011). Figure 4-11 provides a visual representation of property value trends in southeast Wisconsin from 2005 to 2010.

Figure 4-11. County aggregate changes in property values: 2005-2010



Source: Public Policy Forum, 2011

The Public Policy Forum (2011) reported that the major factors contributing to the decline in property values in southeastern Wisconsin were the economic change in real estate values and the slowed growth of new construction in the region (Table 4-26). The noticeable decline of five percent is believed to be a result of declining property values. New construction is an important criterion in measuring real estate values, as "new construction drives total value growth because as parcels are used more intensively, they generate a higher land utility and thus a higher value" (Public Policy Forum 2011).

Table 4-26. Changes in aggregate real estate values: 2009-2010

County	2009 Real estate value ($USD)	Economic change ($USD)	New construction ($USD)	Other change ($USD)	2010 Real estate value ($USD)
Kenosha	14,641,117,700	(885,124,100)	237,637,200	(56,119,800)	13,937,511,000
Milwaukee	64,849,423,300	(3,611,491,400)	398,632,100	(213,156,700)	61,423,407,300
Ozaukee	11,053,112,400	(459,394,700)	89,167,800	(40,538,800)	10,642,346,700
Racine	15,584,722,400	(713,582,400)	69,673,000	(39,075,600)	14,901,737,400
Walworth	15,450,442,800	738,054,200)	134,579,100	1,621,600	14,848,589,300
Washington	13,857,974,100	(512,119,500)	120,946,200	(26,570,000)	13,440,230,800
Waukesha	51,011,477,100	(2,182,165,900)	394,097,100	(37,613,800)	49,185,794,500
SE Wisconsin	186,448,269,800	(9,101,932,200)	1,444,732,500	(411,453,100)	178,379,617,000
Wisconsin	499,856,206,900	(19,377,213,300)	4,575,602,300	(1,087,907,700)	483,966,688,200

Source: Public Policy Forum (2011)

Table 4-27 shows data from the year 2000 for median housing values and median gross rents selected communities in the region.

Table 4-27. Year 2000 median housing values and median gross rents within the selected communities

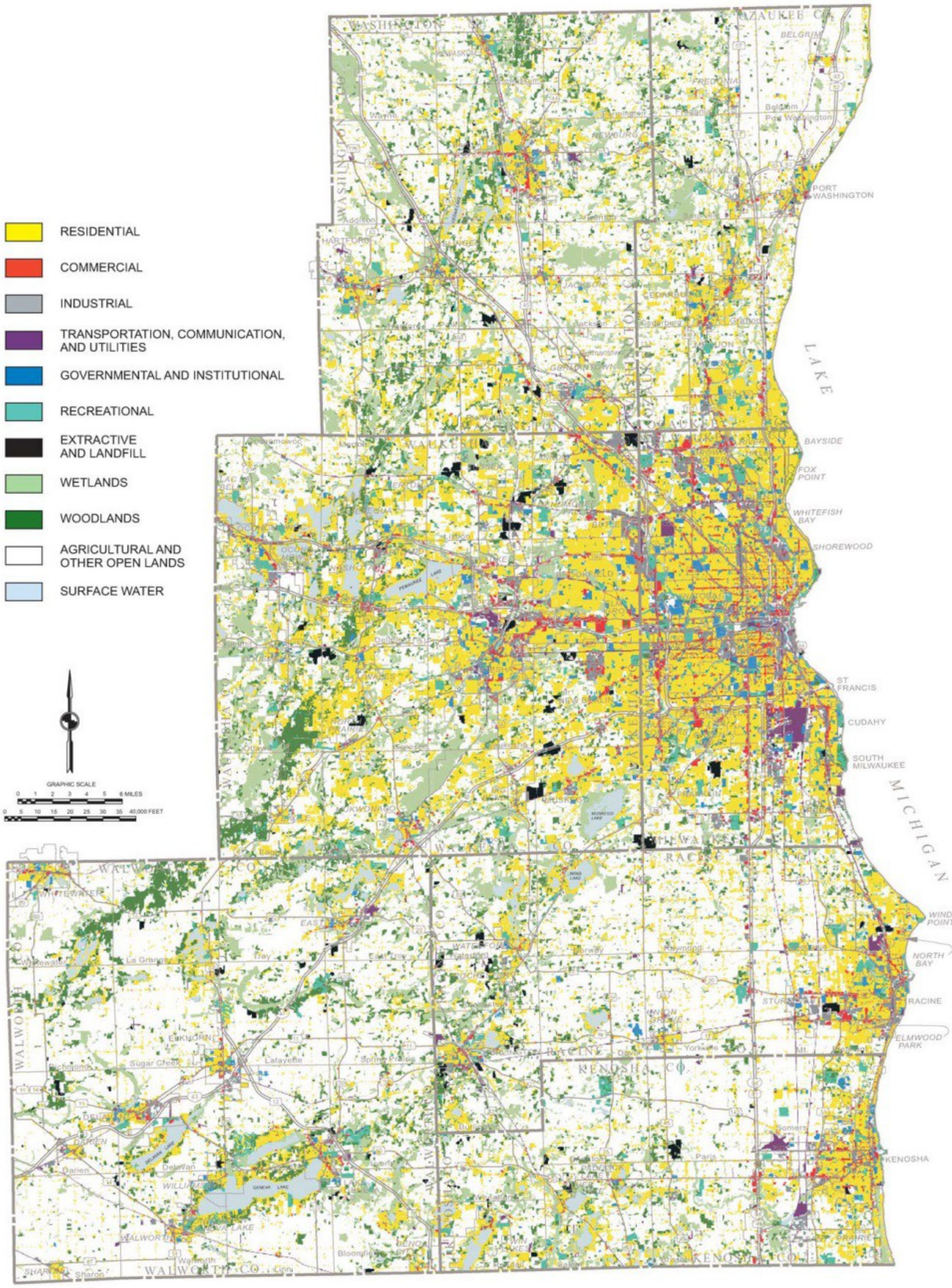
Community	Median housing value ($)	Median gross rent ($)
Kenosha	108,000	571
Milwaukee	80,400	527
Oak Creek	139,100	704
Port Washington	136,200	624
Racine	83,600	520
Brookfield	189,100	1,014
Cedarburg	179,900	670
Elm Grove	263,900	673
Germantown	169,900	709
Grafton	145,800	625
Muskego	166,700	785
New Berlin	162,100	830
Saukville	135,700	589
Waukesha	139,900	675

Source: US Census Bureau as reported by Rast & Madison (2010)

4.15 Land use, zoning and transportation

In 2000, there were about 761 square miles of urban land uses in southeast Wisconsin, or 28 percent of the total area of the region. Areas considered “urban” include residential, commercial, industrial, transportation-communication-utility, governmental-institutional, and intensive recreational lands. The largest category of urban land was residential land comprising about 362 square miles, or about 48 percent of all urban land and about 14 percent of the overall area of the region. Sixty-three square miles were commercial and industrial lands, or about eight percent of all urban land and about two percent of the region overall. Land used for governmental and institutional purposes covered 34 square miles, or four percent of all urban land and one percent of the region overall. Intensive recreational use lands encompassed about 50 square miles, or seven percent of all urban land and two percent of the region. A total of 201 square miles was used for transportation, communication, and utilities. This included areas used for streets and highways, railways, airports, and utility and communication facilities and covered 26 percent of all urban land and eight percent of the region overall. Unused urban lands encompassed 51 square miles, which was seven percent of all urban land and two percent of the overall area of the region. Land use as of year 2000 in the region is shown in Figure 4-12 and is listed in Table 4-28.

Figure 4-12. Land use in the southeast Wisconsin region in 2000



Source: SEWRPC (2006)

Table 4-28. Land use area in SE Wisconsin region and Waukesha County in 1963 and 2000

	Region				Waukesha County			
	1963		2000		1963		2000	
Land Use Category	Ac	%	Ac	%	Ac	%	Ac	%
Urban								
Residential	115,170	6.7	231,737	13.5	28,148	7.6	75,221	20.2
Commercial	7,390	0.4	19,397	1.1	1,197	0.3	5,351	1.4
Industrial	8,651	0.5	21,053	1.2	924	0.2	5,525	1.5
Transportation, communication, & utilities	86,366	5.0	128,570	7.5	16,079	4.3	30,001	8.1
Governmental & institutional	13,980	0.8	21,543	1.3	2,550	0.7	4,887	1.3
Recreational	16,669	1.0	32,245	1.9	3,311	0.9	8,253	2.2
Unused urban land	34,895	2.0	32,566	1.9	8,509	2.3	7,806	2.1
Subtotal urban	283,123	16.4	487,111	28.4	60,717	16.3	137,045	36.8
Non-urban								
Natural areas								
Surface waters	45,794	2.7	49,566	2.9	16,076	4.3	16,892	4.5
Wetlands	175,564	10.2	176,450	10.2	52,588	14.2	52,661	14.2
Woodlands	119,583	6.9	116,905	6.8	31,181	8.4	28,932	7.8
Subtotal natural areas	340,941	19.8	342,921	19.9	99,846	26.9	98,484	26.5
Agricultural	1,047,740	60.9	806,011	46.8	200,242	53.9	112,611	30.4
Unused rural & other open land	49,378	2.9	85,413	4.9	10,786	2.9	23,397	6.3
Subtotal non-urban	1,438,059	83.6	1,234,345	71.6	310,873	83.7	234,492	63.2
Totals	1,721,182	100.0	1,721,456	100.0	371,591	100.0	371,537	100.0
Source: SEWRPC (2006)								

The occupancy and tenure (owner- or renter-occupied) housing stock for the year 2000 is shown in Table 4-29 for selected communities. Several communities in the region have housing policies in place. The Applicant's policy calls for a desirable mix of housing types; 65% single family units and 35% multi-family units.

Table 4-29. Year 2000 occupancy and tenure for households in selected communities

		Occupied housing units						
	Total housing	Total occupied	Owner occupied units		Renter occupied units		Vacant units	
Community	units	housing units	Number	%	Number	%	Number	%
Kenosha	36,162	34,546	21,488	59.4	13,058	36.1	1,616	4.5
Milwaukee	249,215	232,178	105,186	42.2	126,992	51.0	17,037	6.8
Oak Creek	11,897	11,239	6,907	58.1	4,332	36.4	658	5.5
Port Washington	4,225	4,050	2,554	60.4	1,496	35.4	175	4.1
Racine	33,458	31,498	18,977	56.7	12,521	37.4	1,960	5.9
Brookfield	14,246	13,947	12,555	88.1	1,392	9.8	299	2.1
Cedarburg	4,534	4,408	2,831	62.4	1,577	34.8	126	2.8
Elm Grove	2,557	2,444	2,202	86.1	242	9.5	113	4.4
Germantown	7,068	6,898	5,380	76.2	1,518	21.5	170	2.4
Grafton	4,211	4,075	2,870	68.2	1,205	28.6	136	3.2
Muskego	7,694	7,530	6,229	81.0	1,301	16.9	164	2.1
New Berlin	14,939	14,505	11,787	78.9	2,718	18.2	434	2.9
Saukville	1,644	1,585	950	57.8	635	38.6	59	3.6
Waukesha	26,858	25,665	14,480	53.9	11,185	41.6	1,193	4.4
Source: US Census Bureau as reported by Rast & Madison (2010)								

SEWRPC is the statutorily designated regional planning agency for the southeastern Wisconsin region, and is responsible for making and adopting a master plan for the physical development of the region, including land use, transportation, communications, sewer infrastructure, and this first generation Regional Water Supply Plan. The regional plans that SEWRPC develops are advisory by nature and implementation is based on local or county actions or initiatives.

4.15.1 Recreation and aesthetic resources

Southeastern Wisconsin Regional Planning Commission Planning Report No. 48, *A Regional Land Use Plan for Southeastern Wisconsin: 2035*, provides an overview of recreational lands and aesthetic resources in the project area (2006). Land devoted to intensive recreational uses encompassed about 50 square miles, or 7 percent of all urban land and 2 percent of the Region overall. The most important elements of the natural resource base and features closely related to that base including: wetlands, woodlands, prairies, wildlife habitat, major lakes and streams and associated shorelands and floodlands, and historic, scenic, and recreational sites. When these elements or features are combined, are often elongated segments referred to as “environmental corridors.”

“Primary” environmental corridors, which are the longest and widest type of environmental corridor, are generally located along major stream valleys, around major lakes, and along the Kettle Moraine; they encompassed 462 square miles, or 17 percent of the total area of the Region, in 2000.

“Secondary” environmental corridors are generally located along small perennial and intermittent streams; they encompassed 75 square miles, or 3 percent of the Region, in 2000. In addition to the environmental corridors, “isolated natural resource areas,” consisting of small pockets of natural resource base elements separated physically from the environmental corridor network, have been identified. Widely scattered throughout the Region, isolated natural resource areas encompassed about 63 square miles, or 2 percent of the Region, in 2000.

Vernon Wildlife Area is a 4,655-acre property (4,154 acres owned, and 501 acres leased) located just north of Mukwonago in eastern Waukesha County. The wildlife area provides opportunities for public hunting, fishing, trapping and other outdoor recreation while protecting the qualities of the unique native communities and associated species found on the property. The Vernon Wildlife Area offers many recreational opportunities: birding, boating, canoeing, cross country skiing, dog trial grounds, fishing, hiking, hunting - especially noted for pheasant, snowmobiling, trapping, wild edibles/gathering, and wildlife viewing.

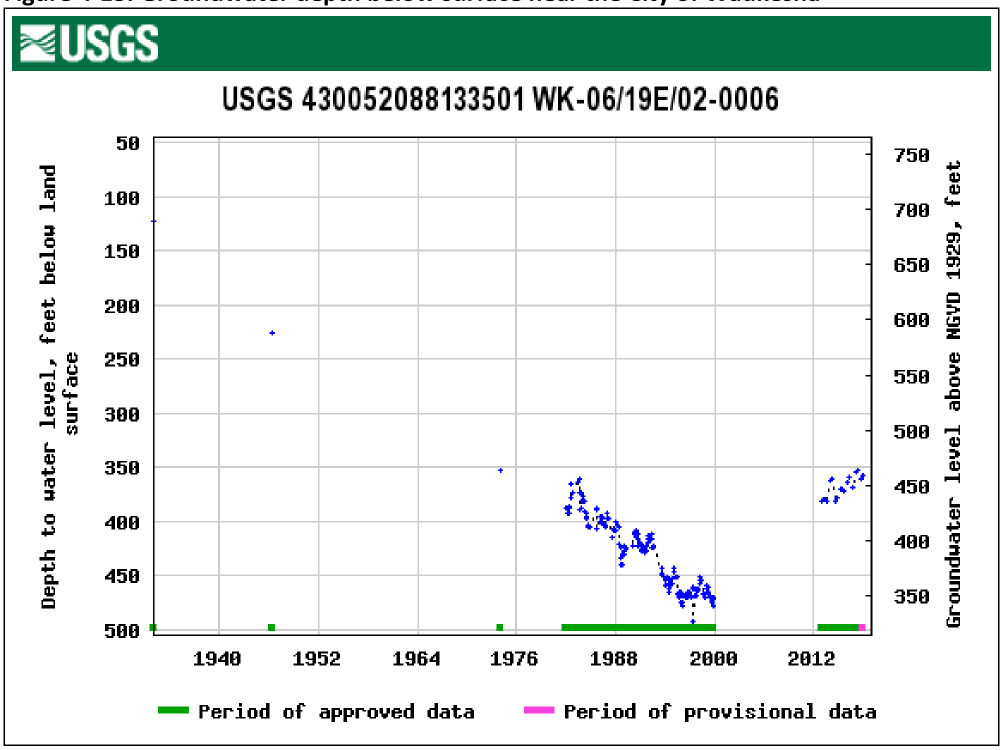
4.15.2 Archaeological and historical resources

Sites and structures representing all of the recognized prehistoric culture periods are found throughout the area, from Paleo-Indian (ca. 10,000-8000 BC), through Archaic (ca. 8000 - 500 BC), Woodland (ca. 500 BC - 1000 AD), and Oneota (ca. 900 - 1650 AD). Associated sites include Native American camps, villages, burial and effigy mounds, and more. Historic period sites (ca. 1650-present) include farmsteads, dams, mills, cemeteries, and others. The region’s towns and rural roads are dotted with numerous historic homes, businesses, bridges, and other early structures, many used continuously to this day. Whether populated by ancient Indian peoples or more recent arrivals, the area’s numerous archaeological sites and historic structures reflect a lengthy record of settlement, as well as intensive utilization of the diverse water, mineral, plant, animal, and other resources characteristic of the region.

4.16 City of Waukesha public water supply sources

Currently, the Applicant obtains water from two aquifers: the deep sandstone aquifer and the shallow Troy Bedrock aquifer. The deep aquifer is confined by the Maquoketa shale layer, just east of the City, that limits natural recharge of the aquifer. The deep aquifer supplies 83 percent of the Applicant's water (2013-2017 data). Continued use of the deep aquifer by the City and surrounding communities since the 19th century and the presence of the Maquoketa shale confining layer have led to the decline of 500 feet in aquifer water levels (SEWRPC 2010, pp. 108, 113). However, reductions in groundwater pumping of the deep aquifer over the last 20 years have resulted in a gradual rebound of the aquifer by approximately 150 feet (Figure 4-13). Groundwater level monitoring near Waukesha shows the rebound in the deep aquifer.

Figure 4-13. Groundwater depth below surface near the City of Waukesha



Source: US Geological Survey

Water quality issues occur with declining water levels in this deep aquifer, including increased levels of salts and radium, a naturally occurring element that is carcinogenic. As the aquifer water levels have rebounded, radium concentrations continue to be a problem.

The Applicant currently treats some deep aquifer water by mixing it with radium-free water from the shallow Troy Bedrock aquifer. The City obtains 17 percent of its water supply from the shallow aquifer (2013 - 2017 data). Increased pumping of the shallow aquifer will stress surface water resources by reducing baseflows to local streams and wetlands (SEWRPC 2010).

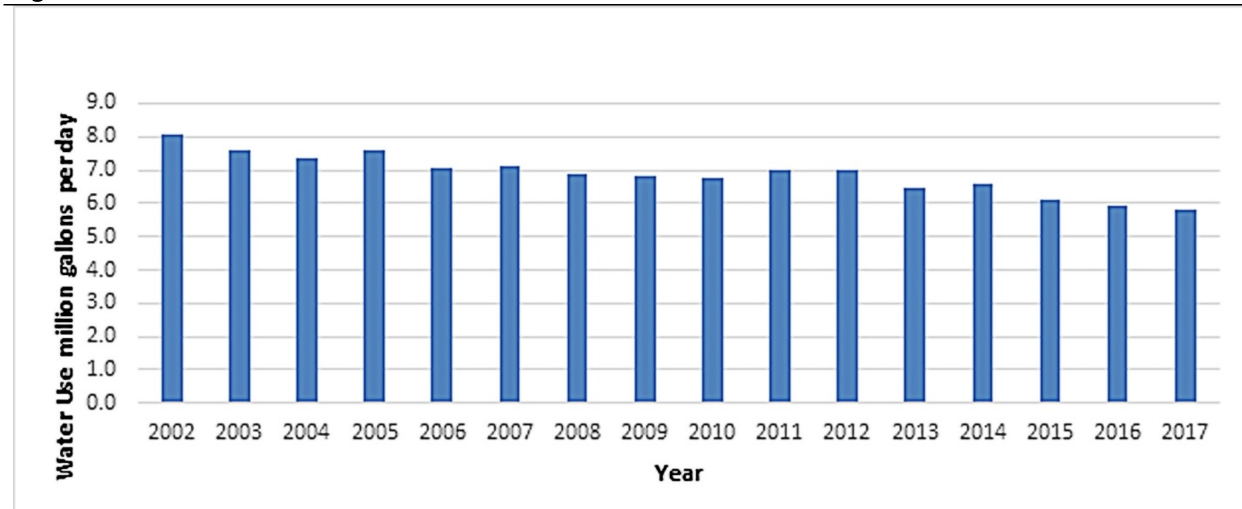
More information on historical withdrawals and water use can be found in the Preliminary Final EIS (Appendix E).

4.17 City of Waukesha water use

Water use and demand is typically influenced by several factors including: precipitation, temperature, personal income, and community conservation goals. After the Applicant adopted its 2006 Water Conservation and Protection Plan, additional focus was placed on water use efficiency. While some water use reduction in recent years may be attributed to weak economic conditions and seasonal rainfall over the same time period, much of the decline can be attributed to decreased water demand resulting from more efficient water use, conservation education, regulation, and incentives. Details of trends, historic water use and conservation can be found in the Water Supply Service Area Plan and the Preliminary Final EIS (Appendix E).

As illustrated in Figure 4-14, the Applicant's water use has decreased in recent years, averaging 5.8 MGD in 2017.

Figure 4-14. Trends in Waukesha Water use 2002 – 2017



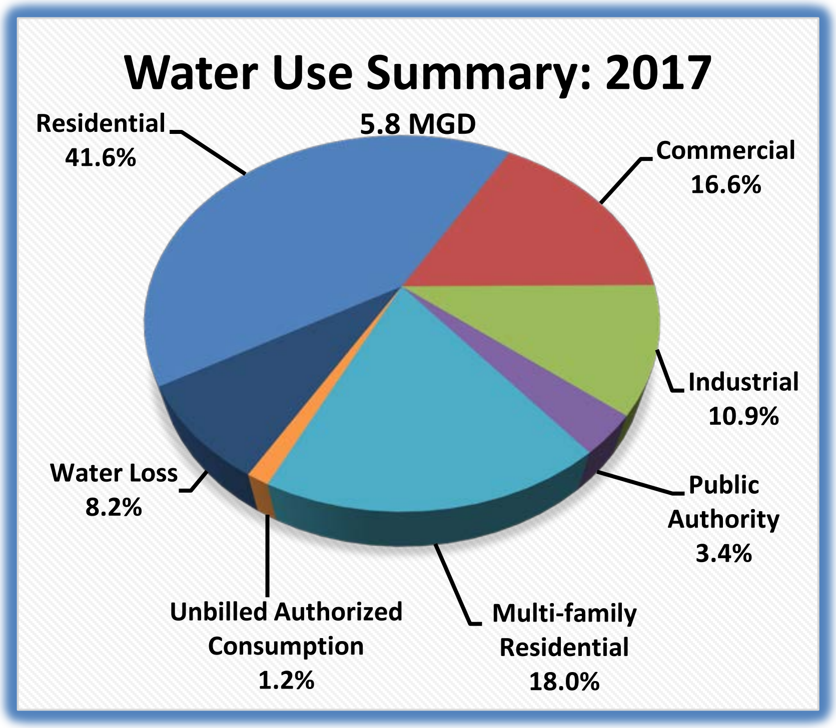
The Applicant actively tracks water use by water use categories following PSC regulations. For summary purposes, residential water use is measured in accordance with requirements set forth by the PSC.

- *Residential*. Residential water demand typically includes indoor water-using activities, such as those for bathroom, kitchen, and laundry, and outdoor water use, such as lawn irrigation, swimming pools, and car washing.
- *Multi-family residential*. Is a building that is intended primarily for residential purposes, has three or more dwelling units, and is served by a single water meter.
- *Industrial*. Manufacturing, processing, warehouses, foundries, and dairies.
- *Commercial*. Commercial water use is presented by customers such as retail, restaurants, office buildings, medical facilities, and private schools.
- *Public*. Public water use includes water demands for municipal buildings, public facilities, parks, public schools and institutions.

- *Unbilled authorized consumption.* Water uses that are measured (or estimated) but not included in sales. Examples of this water use include water used in annual water main flushing to maintain water quality and water used in firefighting exercises.
- *Water loss.* PSC defines water loss as water placed into the distribution system that does not find its way to billed customers or unbilled authorized users.

Water use by sector for 2017 is shown in Figure 4-15. Single family and multi-family residential water use accounted for nearly 60 percent of all water use by the Applicant.

Figure 4-15. Water use by customer class for the Waukesha Water Utility



4.17.1 Water demand projections

The Compact Council approved a diversion amount of 8.2 MGD based on the Applicant's projection of average daily water demand (ADD) at build-out[6] within the approved diversion area. As discussed in Section 1.1.3, the approved diversion area is smaller than the Applicant's proposed water supply service area (WSSA), so the approved diversion amount is lower than the amount originally requested. Projections were made for each civil division (local jurisdiction) comprising the proposed WSSA. Across the entire proposed WSSA, the ADD projected at build-out is 10.1 MGD. For just the City of Waukesha (plus those portions of the Town of Waukesha already served by the city) ADD projected at build-out is 8.2 MGD.

[6] According to the Applicant's Water Supply Service Area Plan, "buildout condition exists when all the land available for development in the WSSA has been developed in a manner consistent with the southeastern Wisconsin regional water quality, water supply, and land use plans" (CH2M Hill 2013, Vol. 2, pg. 6-1). Based on state statute, the diversion area approved by the Compact Council constitutes the WSSA (sec. 281.348(3)(cr), Wis. Stats).

The methodology used to project water demand at build-out (both ADD and maximum daily demand) is detailed in the Applicant's Water Supply Service Area Plan (CH2M Hill 2013, Vol. 2, Chapter 6 and Appendix C). Population was projected by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) using a cohort-component model for county-level population, which was allocated to civil divisions based on historical trends, land availability, and local land use plans. Water demand was projected using demand coefficients for residential, commercial, industrial, and public customers of the Waukesha Water Utility, based on historical data. Using different assumptions, a range of future water demand was projected. Alternative assumptions included: industrial demand under strong economic conditions (using 2001 as a reference), industrial demand under weak economic conditions (using 2008-2012 as a reference), the implementation of a water conservation program, and the absence of a water conservation program. The ADD projections used in the Compact Council's approval assume strong economic conditions and the implementation of a water conservation program that will achieve a reduction of 0.5 MGD by 2030 and 1.0 MGD at build-out, following the regional water supply plan developed by SEWRPC (2010).

4.17.2 City of Waukesha water conservation

Proposed diversions are held to Tier 3 water conservation and efficiency standards of Wis. Adm. Code NR 852. The Applicant is required to implement all mandatory Conservation and Efficiency Measures (CEM), create a water conservation plan, undertake a CEM analysis prior to applying for a diversion, and provide annual water conservation reporting to the department.

Within its water conservation plan the Applicant identified a number of conservation measures that it has implemented or plans to implement that would result in water savings. These include:

- High efficiency toilet rebates. Customers who replace a pre-1994 high volume (3.5 gallon or more) toilet with a WaterSense High-Efficiency toilet (1.28 gallons/flush) will receive up to a $100 rebate.
- A Lawn sprinkling ordinance which limits lawn watering to twice a week, and limits times to before 9 am or after 5 pm.
- Targeted reductions at municipally owned buildings and school facilities.
- Promoted discounted replacement of spray rinse valves for commercial customers.
- Facilitated major water use reductions with several industrial customers.

As of 2014, the Applicant's conservation plan implementation has directly resulted in an estimated water savings of nearly 90,000 gallons per day. These quantifiable plan savings are in addition to an estimated 170,000 gallons per day passive savings stemming from conservation education, outreach and ongoing replacement of inefficient fixtures and appliances.

Under current water service rules promulgated by the Wisconsin Public Service Commission (PSC), all customers are subject to the City's conservation measures. If water service is extended to areas outside the City, within the approved diversion area, customers will be required to adhere to the City's conservation program. The City will provide water conservation public education to new customers and make available information, services and incentives to help its customers use water wisely.

5 Environmental effects

This section describes the potential environmental impacts of the current proposal and alternatives. Potential impacts common to the current proposal and all of the alternative water supply and return flow routes are described in Section 5.1. Impacts unique to the current proposal for water supply (M1-preferred) and return flow (OC3-preferred), respectively, are described in Sections 5.2 and 5.3. Impacts unique to the alternative water supply and return flow routes are described in Sections 5.4 through 5.8. Section 0 describes impacts of the no-action alternative.

5.1 Environmental effects common to all alternatives

All the water supply alternatives considered, except the no-action alternative, would obtain Lake Michigan water from the City of Milwaukee, treat wastewater at the Waukesha WWTP, and return diverted water to the Root River at the proposed return flow discharge site (RFDS). Effects on Lake Michigan, the Root River, the Fox River and its tributaries, and groundwater are expected to be the same for all water supply alternatives, other than the 'no-action' alternative. Socioeconomic effects would also be the same for these alternatives. Other than the specific resources crossed, and the degree of impact, similar environmental effects are also expected for all of the alternative pipeline routes. The environmental effects common to all of the alternatives, other than the no-action alternative, are discussed in this section.

5.1.1 Lake Michigan effects

Impacts of the proposed project on Lake Michigan could occur in two areas: The Root River estuary and the nearshore zone of Lake Michigan proper. The estuary extends upriver from Racine Harbor to the point where the river is no longer influenced or augmented by backwater from the lake. The size of the estuary varies with changes in lake level, dredging of the river bed, and the seiche effect, which occurs when windblown lake water stacks-up at the mouth of the river and temporarily slows or reverses its flow.

5.1.1.1 Lake Michigan water quality effects

To evaluate potential impacts on Lake Michigan water quality, the DNR analyzed available data collected by several agencies, including the DNR, MMSD, SEWRPC, and the City of Racine Health Department. Using the Pollutant Load Ratio Estimation Tool (PRESTO), the DNR estimated that the Root River currently discharges approximately 66,000 pounds of total phosphorous (TP) into Lake Michigan in an average year. For this estimate, the DNR assumed that all of the phosphorus delivered to the stream network within the Root River Watershed reaches Lake Michigan.[7]

The proposed phosphorus concentration for the Applicant's wastewater effluent is a six-month average of 0.06 mg/L. This is lower than the water quality standard of 0.075 mg/L. At build-out, the average daily return flow of treated wastewater could be up to 9.3 MGD (City of Waukesha 2018). At this volume, the loading of phosphorus would contribute approximately 1,700 pounds of additional TP per year, or 2.5 percent of the overall phosphorus loading from the Root River Watershed. The Applicant will be required to meet all discharge requirements to comply with state water quality standards.

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[7] Spatially-referenced Regression on Watershed Attributes (SPARROW) model developed by the USGS.

The Root River return flow is expected to have no impacts to minimal impacts on the water quality of deep waters of Lake Michigan.

The primary construction-related impact to Lake Michigan water quality would be elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed by pipelines. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would tend to be minimized by adhering to environmental permit conditions and BMPs designed to reduce the turbidity and erosion (see CH2M Hill 2013, Vol. 5, Appendix 5-2).

5.1.1.2 Lake Michigan volume effects

Withdrawal from Lake Michigan with required return flow is not anticipated to result in a measurable change in Lake Michigan water levels (Table 5-1). The Compact Council approved maximum annual diversion of 8.2 MGD is equivalent to 2,993 million gallons a year.

Table 5-1. Maximum annual Waukesha water withdrawal compared to Great Lakes volume

	Total volume (million gallons)	Maximum annual withdrawal (million gallons)	Maximum annual withdrawal (%)
Lake Michigan	1,299,318,237	2,993	0.000238
Great Lakes	6,056,144,311	2,993	0.000049

This diversion represents 0.000238 percent of the volume of Lake Michigan and 0.000049 percent of the volume of the Great Lakes as a whole. These percentages do not include treated wastewater return flow via the Root River. Under the Compact Council's approval, the previous year's average annual withdrawal would be returned, on a daily basis, to Lake Michigan. On days when the WWTP cannot meet this volume all available water would be returned to the Root River. This requirement ensures that the amount of treated wastewater returned to Lake Michigan will be equivalent to amount of water withdrawn.

5.1.1.3 Lake Michigan geomorphology and sediment effects

The geomorphology and sediments of Lake Michigan would not be adversely affected by the current proposal and alternatives because the supply would use existing treatment plant intakes in the lake, and no construction would occur within the lake. However, increased loading of phosphorus could contribute to aquatic plant and algae growth within the estuary, and to a much lesser degree, along the nearshore Lake Michigan area beyond the Harbor breakwater and south. The death and subsequent decomposition of these plants and algae could result in increased organic sedimentation. No direct impacts from the Waukesha return flow to Root River estuary geomorphology and inorganic sediments are expected.

5.1.1.4 Lake Michigan flora and fauna effects

The current proposal and alternatives would have negligible effects on the lake's aquatic habitat. No new infrastructure is needed in Lake Michigan, so no construction impacts to aquatic habitat in the lake would occur. Increased pumping of water through the existing Lake Michigan communities' intake pipes would not affect aquatic organism entrainment and entrapment.

This discharge would not have an immediate impact within the estuary or along the nearshore Lake Michigan area beyond the Harbor breakwater and south. Phosphorus will be discharged at 0.06 mg/L, below the water quality standard of 0.075 mg/L and modeling results indicate a slight lowering of in-stream concentrations directly downstream of proposed outfall site (see Section 5.1.2.1 below). However, since phosphorus is a conservative pollutant, and the Root River Harbor is a semi-confined area, the eventual effects of cumulative nutrient loading from the entire Root River watershed, with a small contribution from the proposed discharge, could result in increased aquatic plant and algae growth. Increased plant growth within the estuary could alter fish spawning and available resident habitat, both positively and negatively. Fish and aquatic macroinvertebrate communities within the estuary could shift in density and species. Racine Harbor may require an increase in aquatic plant management, such as expanded herbicide treatments or mechanical plant harvesting. These activities require permits under Wis. Adm. Code chapters NR 107 and 109.

Increased chlorides within the Root River from the return flow could present a slight increase in risk to fish and aquatic invertebrates within the Root River estuary. Potential effects from pharmaceuticals are addressed in Section 5.1.1.2 below.

No long-term pollutant loading effects are expected on deep-water Lake Michigan invertebrates, plants, or fish. No direct impacts to Lake Michigan birds or mammals are expected from the proposed Root River return flow.

The Applicant would be required to meet all water quality based effluent limits and permit conditions, designed to protect fish and aquatic life.

5.1.2 Root River effects

5.1.2.1 Root River water quality effects

The United States Environmental Protection Agency delegates Clean Water Act authority to Wisconsin. Wisconsin’s Pollutant Discharge Elimination System (WPDES) program has the authority to permit the discharge of treated wastewater effluent from wastewater treatment plants into the waters of the state under Wis. Stat. s. 283.31. All wastewater returned to the Root River would be required to meet all DNR water quality-related permit requirements under Wisconsin Statutes and Administrative Codes.

On December 12, 2017, the Applicant reapplied for a WPDES permit to continue to discharge treated effluent to the Fox River and indicated its intent to return treated effluent to the Root River, once the proposed diversion of Great Lakes water begins. A Root River return is proposed for the current proposal and alternatives. The proposed return flow discharge site (RFDS) would outfall at the Root River near the intersection of West Oakwood Road and South 60th Street, in the City of Franklin, directly downstream of the confluence of the Root River Canal and the Root River mainstem (WBIC 2900).

The DNR calculated draft water quality-based effluent limits (WQBELs) based on current applicable water quality standards under Wis. Adm. Code Chapters NR 102, 103, 104, 105, 106, 207, 210 and 217, to assess whether the Applicant could meet applicable water quality discharge standards. WQBELs are calculated using water quality criteria, which are designed to protect fish and aquatic life, as well as public health and recreational uses in some cases.

Wastewater treatment facility upgrades must be reviewed and approved by the department under Chapters NR 108 and 110 of the Wisconsin Administrative Code. A facility plan must evaluate the capability of the proposed facilities to meet WQBELs (NR 110.09(2)(d)) and the Applicant must provide treatment facilities that meet WQBELs (NR 110.09(2)(f)).

To determine discharge effects on the Root River from the proposed return flow, the DNR focused on the primary pollutants of concern discussed in the sub-sections below.

Root River phosphorus effects

Excessive phosphorus in the Root River, from existing point sources (urban stormwater and wastewater treatment plants) and nonpoint sources (runoff from agricultural and natural land areas, and failing septic systems) has contributed to degraded stream habitat, increased eutrophic conditions, and unbalanced resident fish and macroinvertebrate populations. As a result, the Root River is listed on Wisconsin's 303(d) Impaired Waters List for excessive phosphorus.

To meet s. NR 217.13(8), Wis. Adm. Code (New Dischargers to Impaired Waters), the Applicant would be subject to WQBELs for phosphorus well below the current Wisconsin water quality criterion for phosphorus of 0.075 mg/L. The anticipated phosphorus limits for a new discharge to the Root River for the Applicant are 0.180 mg/L as a monthly average, and 0.060 mg/L as a 6-month average from May through October and November through April.

Phosphorus concentrations in the river downstream from the proposed RFDS will likely decrease due to the lower phosphorus concentrations of treated wastewater discharging into the river. The DNR ran a *Weighted Regressions on Time, Discharge and Seasons* model to predict the change in phosphorous concentrations at Johnson Park near Racine (Diebel 2018). At an average daily discharge of 5.8 MGD (equivalent to the Applicant's average withdrawal in 2017), with a wastewater TP concentration of 0.06 mg/L, the model predicted that TP concentrations in the Root River during the growing season (May-October) would be reduced from a median of 0.126 mg/L to 0.103 mg/L. At a discharge of 9.3 MGD, at build-out, the model predicted that median TP concentrations during the growing season would be further reduced to 0.096 mg/L.

Regardless, phosphorus is a conservative pollutant. The addition of phosphorus loading to the Root River from the return flow could slightly increase the planktonic algal, periphyton, and aquatic plant communities in the river. An increase in these communities could increase the range of diurnal dissolved oxygen swings within portions of the Root River where the biological community is utilizing the increased phosphorus. Turbidity increases due to planktonic algae growth could also occur. Biological community effects could occur further downstream in the Root River and in the Root River estuary from cumulative loading impacts but are expected to be minimal as a result of return flow from the Applicant's proposed discharge.

Root River total suspended solids effects

Total Suspended solids (TSS) consist of a wide variety of materials including: silt, sand and clay particles, decaying plant and animal matter, sewage, and industrial waste. High concentrations of TSS can increase turbidity, blocking light from reaching beneficial aquatic vegetation and algae. Decreased light penetration can reduce photosynthesis, leading to decreased dissolved oxygen levels in the water column. Macrophytes, algae, and periphyton communities may die, increasing bacterial decay processes and using up more of the oxygen in the water. Decreased water clarity from TSS can also affect fish, reducing their ability to see and catch food. TSS can also abrade and clog fish gills. Increased loading of TSS can alter suitable habitat for macroinvertebrates and bury fish spawning beds and can lead to increased water temperatures.

The effluent limits for TSS will be based on the narrative water quality standard (typically 10 mg/L as a weekly average). Current levels of TSS in the Applicant's effluent are consistently much lower (approximately 1 mg/L) as stated in the City of Waukesha's Facility Plan Amendment (2018). As a result, addition of the return flow could reduce instream TSS concentrations through dilution, and improve sediment carrying capacity due to increased stream velocity. Therefore, little to no impact is expected from the proposed return flows TSS concentrations and loadings to the Root River.

Root River chlorides effects

Chlorides are found in both salt and fresh water . Chlorides in the Root River primarily result from anthropogenic sources (e.g. deicing road salt and discharge from water softeners), since the background geology in the area contains relatively little chloride (SEWRPC 2014). High chloride concentrations in freshwater can be harmful to aquatic organisms, hindering reproduction, growth and survival. The DNR sets chronic and acute toxicity water quality limits for chlorides to prevent long-term and immediate exposure effects to aquatic organisms.

The Applicant would have to reduce chloride sources to achieve compliance with return flow effluent limits based on the water quality standards for chlorides. As part of the original Application, the Applicant drafted a compliance plan to demonstrate how future chloride effluent limits could be met . Currently, the Applicant is required to submit annual chloride progress reports to the DNR to comply with requirements outlined in its current WPDES permit to discharge to the Fox River. The Applicant submitted its Final Chloride Progress Report to the DNR on December 22, 2017. The final report documents the steps the Applicant has taken to reduce chlorides in its WWTP discharge in the current permit term - primarily by concentrating on source reduction measures. The final report also includes a compliance plan to demonstrate how future chloride effluent limits for return flow to the Root River could be met.

In its final chloride report, the Applicant examined several sources of chlorides:

- Residential and commercial water softening
- Residential (non-softened background)
- Groundwater infiltration and inflow (I/I)
- Industrial softening and industrial processes
- Road salt (through I/I)
- Hauled waste
- Ferric Chloride at the WWTP

On April 4th, 2014, the City of Waukesha approved an amendment to their sewer use ordinance with respect to water softening and brine reclamation (Waukesha, Wis. Code § Ord 29.036, 2014). The ordinance requires that all residential, commercial and industrial users installing new or replacement water softeners must install high efficiency, demand-initiated regeneration softeners equipped with a water meter or sensor. In addition, the City encourages brine reclamation systems for all significant industrial users where feasible.

The Applicant is taking steps to determine required chloride source reductions to meet the proposed effluent limits (City of Waukesha 2017). The Applicant has started a public education program through newsletters and public forums to reduce water softening, even before the proposed switchover to Lake Michigan water. The Applicant is working with water softener dealers to formulate an optimization program. The Applicant would need to fully implement all efforts outlined in the current annual chloride progress report, as well as additional efforts, including education and outreach, to meet the proposed draft water quality based effluent limits.

A change from a groundwater water supply to a Lake Michigan surface water supply would significantly reduce the need for home water softening. Currently, salt residue from residential home water softening is the largest source of chlorides to the Applicant’s WWTP (estimated at about 22,000 lbs/day in the Applicant's annual chloride progress report). Groundwater wells supply 'hard' water to customers, consequently many homeowners use water softeners. The current hardness concentration ($CaCO_3$) based on an average range of well concentrations of approximately 300-500 mg/L.[8] Recent alkalinity data (hardness $CaCO_3$) from the City of Oak Creek Water Utility shows an average of about 130 mg/L, which is a level that does not necessarily require home water softening.[9]

In addition, the City could also expect reductions in baseline effluent chloride concentrations and loading since concentrations of chloride would be lower with a Lake Michigan water supply (approximately 13 mg/L[10]), versus the current groundwater supply (approximately 31 mg/L[11]). Depending on the return flow rate and effluent concentration, the change in source water could reduce loading by a weekly average of up to approximately 1440 lbs/day.[12]

In conclusion, minimal impacts to the Root River could occur downstream of the discharge over a short time period after switching from groundwater water to a Lake Michigan water supply and while the applicant would be working with property owners to disconnect their water softeners. After the short transitional period, the discharge should not cause any exceedances of the applicable water quality standards for chlorides.

Root River dissolved oxygen effects

Dissolved oxygen (DO) contained within the water column is essential to aquatic life. Air pressure and temperature, water temperature, photosynthesis, organic and chemical demand, and turbulence all contribute to oxygen levels. The Root River mainstem at and downstream of the proposed outfall has typically met state water quality criteria of 5 mg/L for maintaining fish and aquatic life.

Due to the long length of the return flow pipeline (approximately 27 miles), and the lack of exposure to air in the force main, the return water emerging from the outfall pipe could contain low dissolved oxygen levels if untreated. To address this possibility the Applicant plans to install a reaeration system at the return flow location to meet the proposed daily minimum dissolved oxygen limit.

Downstream, DO levels of the Root River could be affected by possible increases in periphyton, suspended algae, and aquatic plant growth caused by phosphorus loading. Oxygen levels can rise and fall throughout the 24-hour photosynthetic growth period – at times oxygen is released into the water, while at other times it is absorbed. Where excessive plant and algae growth is present, these diurnal swings can result in periods of very low dissolved oxygen levels; typically, in the early morning hours.

Root River biochemical oxygen demand effects

Biochemical oxygen demand (BOD) is the measured amount of oxygen utilized by microorganisms during aerobic breakdown of primarily organic material at a certain temperature over a specific period. The 5-day test is most common. The amount of organic matter in treated

[8] City of Waukesha IOC samples from 1993 to 2012 for wells 10, 11, 12 and 13.
[9] Milwaukee Water Works average (2006-2015), approximately 130 mg/L.
[10] Result from Milwaukee Water Works intake data (average 2006-2015)
[11] City of Waukesha IOC samples from 1993-2012 for wells 10, 11, 12 and 13.
[12] The Applicant's estimates were based on a return flow of up to an average of 9.3 MGD at build-out. At a return flow of 5.8 MGD (equivalent to the average daily withdrawal in 2017) the reduction would be closer to 870 lbs/day.

wastewater effluent depends on the level of treatment endured at the WWTP, and 5-day BOD ("BOD_5") WQBELs are put in place to limit the oxygen demand and ensure that discharges do not cause a lowering of the dissolved oxygen below the water quality standard (5 mg/L for warmwater streams).

Like TSS, the Applicant's current WWTP achieves very low BOD_5 concentrations. Over 99% of effluent data from the last 5 years was below the analytical level of detection (2 mg/L). Return flow would be required to meet BOD_5 permit limits. The Root River downstream of the proposed outfall could face a slight risk from elevated levels of organic material and the associated drop in dissolved oxygen levels due to this microbial facilitated decomposition. Additionally, the Root River in the vicinity of the outfall could experience a slight increase in attached microbial/algae growth associated with organic materials and sulfur.

Root River temperature effects

Water temperature is an important factor for the health and success of fish and aquatic communities. Temperature can affect embryonic development, growth cycles, migration patterns, competition with aquatic invasive species, and risk and disease severity. The water temperature can affect the ability of water to retain oxygen and can influence respiration of aquatic communities, and the activity of bacteria and other toxic chemicals in water.

The effect on the Root River downstream of the return flow outfall would depend on the time of year, temperature of the discharge water, and temperature and amount of flow in the Root River. During summer months, effluent temperatures could be cooler than the background river temperatures. During fall, winter, and spring months, the discharge water temperature would likely be higher than current background temperatures.

Using methods for WQBEL calculation included in subchapter V. of ch. NR 106, Wis. Adm. Code, weekly average effluent limits are triggered from the months of October through February. However, because temperature is not a conservative pollutant, s. NR 106.59(4), Wis. Adm. Code, allows publicly owned treatment works (POTWs) to complete Dissipative Cooling demonstrations. Dissipative cooling (DC) is the cooling effect associated with heat loss to the ambient water, the atmosphere, and the surrounding environment. The general idea of the demonstration is to show that the sub-lethal (weekly average) criterion for the specific waterbody classification (warmwater in this case) is not exceeded for an unreasonable distance beyond the outfall. The Applicant has submitted a DC demonstration for the Root River return flow with their December 2017 WPDES permit application. The demonstration included modeling of expected temperature changes (losses) along the return flow pipeline and in-stream temperatures using a range of stream and effluent flow rates and various levels of mixing with the Root River. Based upon the information provided, the demonstration supports the idea that the discharge will not cause an exceedance of the sub-lethal weekly average criteria outside of a small area of mixing and cooling, and that temperature limits are not needed in the WPDES permit (see NR 106.09, Wis. Adm. Code).

The WPDES permit will include a temperature monitoring requirement at the return flow outfall location to provide temperature data moving forward. Looking beyond the immediate mixing zone, the return flow discharge could potentially improve temperature water quality conditions for fish and aquatic life by insulating the river from extremely cold or warm air temperatures. Little to no impact is expected to the Root River outside of the primary mixing zone due to temperature from the effluent.

Root River bacteria (pathogens) effects

Bacteria are single-celled organisms which live in various environments and provide functions that can be beneficial or harmful. Bacteria that can cause diseases are referred to as pathogenic. Coliform bacteria in surface water can originate naturally from soil. Fecal coliform bacteria originate in the intestinal tracks of humans and animals, such as pets, livestock, and wildlife. Human sources of fecal coliform bacteria include wastewater treatment plants, leaking sewer lines and septic systems, illicit discharges, and urban stormwater runoff. *E. coli* are a subgroup of fecal coliform bacteria that are commonly monitored as pathogen indicators. With rare exceptions, the *E. coli* detected by routine monitoring are not pathogenic; however, they indicate the presence of fecal material and the likelihood that pathogenic bacteria or viruses are also present.

The proposed return flow would be subject to fecal coliform bacteria limits under a WPDES permit. The Applicant recently replaced the WWTP's UV disinfection system in 2016. The WWTP shows historical operations (less than 100 CFU/100 mL) during the recreational season, would meet draft WQBELs for fecal coliform bacteria to the Root River. The DNR is currently developing water quality standards for *E.coli* as well and the WWTP would be required to meet those limits after standards are promulgated.

Treated wastewater can contain residual pathogens, so there is a slight risk to human health due to unknown pathogens in the Applicant's wastewater. Wastewater treatment, such as UV disinfection, to meet fecal coliform and future *E. coli* limits, reduces these risks.

Root River water quality monitoring

To address any water quality concerns, the Applicant will be required to implement a plan to monitor the mainstem of the Root River (such as volumes, water temperatures, water quality and periodicity or discharge) for a minimum of 10 years from the beginning of return flow to the Root River, to determine if changes have resulted from return flow and if return flow should be adapted in order to minimize potential adverse impacts (Compact Council, 2016). This requirement would be required under the Applicant's diversion approval from the State of Wisconsin.

Root River invasive species effects

During the operation phase, multiple barriers would prevent the spread of invasive species. Drinking water treatment includes filters and disinfection procedures to remove and inactivate viruses. This level of treatment would not allow transfer of invasive species through the water distribution system. Once the water is distributed in pipelines, an ongoing disinfectant residual would be maintained, as required, to prevent microbial growth within the pipelines.

Once water is used and collected in the sanitary sewer collection system, the Applicant's WWTP would provide treatment before the water was discharged. The WWTP is an advanced facility with settling and biological treatment systems, dual media sand filters, and ultraviolet light disinfection designed to meet WPDES requirements. The treated wastewater would be contained within the WWTP before being discharged as return flow. Consequently, there would be no opportunities for invasive species or VHS from the Mississippi Basin to be introduced to the Lake Michigan basin from the proposed return flow discharge.

Root River pharmaceuticals and personal care product effects

Pharmaceuticals and personal care products, along with endocrine disruptors, are known to pass-through wastewater treatment plants. However, it is also known that the rate of pass-through is fairly dependent upon the level of wastewater treatment before discharge. The higher level of treatment present, the smaller amount of pass-through is expected in the discharged effluent. Therefore, the expected level of pass-through in the return flow discharge is minimal due to the primary, secondary, and tertiary treatment processes at the Waukesha WWTP. In some rare cases, the discharge of pharmaceuticals can lead to surface water contamination and toxicity to fish and wildlife. Endocrine disruptors are a diverse class of chemicals that are known to disrupt or act like hormones that can disrupt the endocrine systems of fish, wildlife, and possibly humans. While no studies to date have definitively demonstrated harmful effects on human health from long-term exposure to trace amounts of active pharmaceutical ingredients, such as through drinking water, studies have found pharmaceuticals present in some ecosystems at levels likely to harm entire populations of aquatic organisms. Pharmaceutical exposures in treated effluent have been shown to alter sex ratios in some fish species (Woodling et al., 2006).

The DNR recognizes that pharmaceuticals and endocrine disruptors are a growing concern. However, the DNR does not have regulatory authority to mandate the monitoring of pharmaceuticals and endocrine disruptors or require limits in wastewater effluent. If these limits were established in the future, the Applicant would be required to comply with them under their WPDES discharge permit. Under the Compact Council’s Diversion Approval, the Applicant must implement a comprehensive pharmaceutical and personal care products recycling program and continually use the best available methods to encourage the further reduction of such products into the wastewater as recommended by the State of Wisconsin (Compact Council 2016).

5.1.2.2 Root River flow and flooding effects

As discussed in Section 2, the proposed return flow to the Root River would be up to an average of 9.3 MGD at build-out. Currently, two municipalities discharge treated wastewater to tributaries of the Root River. The Village of Union Grove in Racine County discharges 1.0 MGD to the West Branch Root River Canal. The Village of Yorkville discharges 0.08 MGD to Ives Grove Ditch. The proposed discharge of treated wastewater from the City of Waukesha would increase flow in the Root River downstream of the return flow discharge site (RFDS).

The effect of the additional flow is dependent on the existing flow regime of the Root River. To calculate the effect, the DNR modeled Root River flow regimes (high, base, and low-flow)[13] at the RFDS and downstream in the City of Racine. The proposed return flow was added to the modeled flow allowing the calculation of the percent contribution of the proposed return flow. Table 5-2 summarizes the Root River flow regimes, while Table 5-3 summarizes the percent contribution to river flow that could be attributed to the proposed discharge under different scenarios.

Table 5-2. Root River flow at the proposed return flow discharge site (RFDS) and the City of Racine

Flow regime	Flow at the proposed RFDS (cfs)	Flow at the City of Racine[1] (cfs)
High flow (Q10 – Q5)	230 - 392	358 – 607
Baseflow (Q50)	35.9	62.6
Low (Q90 - Aug Q50)	7.92 – 16.7	11.2 – 26.1

[1] USGS gage #04087240 (at Horlick Dam, City of Racine)

[13] Flow conditions were tied to specific flow statistics: Q5 and Q10 represent high flow, hydrograph separation for baseflow, and Q90 and Aug Q50 represent low flow.

Table 5-3. Contribution of proposed return flow to Root River flow under different scenarios

Return flow scenarios	Location on Root River	Return flow contribution (High flow regime)	Return flow contribution (Baseflow regime)	Return flow contribution (Low flow regime)
5.8 MGD[1] (8.97 cfs)	Return flow discharge site (RFDS)	2.2 – 3.8 %	20.0 %	34.9 – 53.1 %
	Root River at Racine	1.5 – 2.4 %	12.5 %	25.6 – 44.5 %
8.2 MGD[2] (12.7 cfs)	Return flow discharge site (RFDS)	3.1 – 5.2 %	26.1 %	43.2 – 61.6 %
	Root River at Racine	2.1 – 3.4 %	16.9 %	32.7 – 53.1 %
9.3 MGD[3] (14.1 cfs)	Return flow discharge site (RFDS)	3.5 – 5.8 %	28.2 %	45.8 – 64.0 %
	Root River at Racine	2.3 – 3.8 %	18.4 %	35.1 – 55.7 %

[1] Equivalent to the average daily withdrawal in 2017
[2] Equivalent to the projected average daily demand at build-out
[3] The Applicant's upper-estimate of average return flow at build-out (City of Waukesha 2018)

The Applicant analyzed the effect of proposed return flow on river flow and water-depth at the proposed RFDS[14] and roughly 20 miles downstream at the Root River Steelhead Facility in the City of Racine, under flood conditions ranging from a 2-year frequency event to 100-year event (CH2M Hill 2015b). This analysis was conducted for a return flow of 10.1. MGD. At a return flow of 9.3 MGD (the Applicant's upper-estimate of average return flow under the approved 8.2 MGD diversion) the volume of water discharged at the proposed RFDS would constitute less than two percent of river flow during a 2-year flood, and less than one percent during a 100-year flood.

The relative effect of the proposed return flow on river flow and water levels during flood conditions would be less downstream at the Root River Steelhead Facility than at the proposed RFDS. Based on the Applicant's analysis, a return flow of 9.3 MGD would increase water depth during a 100-year flood event by less than 0.01 feet (an eighth of an inch) at the Steelhead Facility, versus 0.02 feet (a quarter of an inch) at the proposed RFDS. Discharges of the estimated maximum day return flow of 11.1 MGD (City of Waukesha 2018) are expected to be infrequent.

The flows calculated for the Flood Insurance Study (FIS) are not expected to be affected by the addition of the return flow. The Flood Insurance Rate Map (FIRM) would not be required to be revised for the area along the Root River. Typically, when calculating floodplain hydrology, wastewater treatment plant discharge is not added to the flow calculations because a conservative approach is used when calculating flows that accounts for standard error.

An increase of approximately 10 percent to the 100-year flow would be required for the Federal Emergency Management Agency (FEMA) to incorporate revised hydrology into the Flood Insurance Study (FIS). For example, the maximum return flow would need to be approximately 482 cfs before a Letter of Map Revision would be required for significant changes in hydrology.

The Applicant reviewed the RFDS for potential floodplain impacts. At the RFDS, a single outfall will be constructed near the Root River and a USGS gaging station will remain to monitor stream flow characteristics. The outfall and the gaging station will not restrict flow within the floodway and will result in less than 0.01 inches of elevation increase. However, a permanent change will

[14] Flow profiles were based on historical monitoring at USGS gage 04087220 (Root River near Franklin), which is approximately 1.75 miles upstream of the proposed RFDS. Because the Root River Canal converges with (i.e., discharges into) the Root River at a location between the USGS gage and the proposed RFDS, the actual watershed area draining at the proposed RFDS is more than twice the size of that of the USGS gage: 126 square miles vs. 49 square miles. As such, the relative effect of return flow on Root River flow at the RFDS would likely be less than what was estimated by the Applicant.

occur within the floodplain as infrastructure will be installed below the Base Flood Elevation (BFE, 100-year floodplain) (Great Water Alliance, 3-110 D1, June 2019).

5.1.2.3 Root River geomorphology and sediment effects

At the proposed return flow discharge site (RFDS), an outfall structure will be placed beneath the ordinary high water mark, permanently impacting 133 square feet of the Root River bed, including riprap to minimize scour. An additional 2,216 square feet would be temporarily impacted by the placement of a coffer dam and dewatering devices and equipment.

Potential outfall designs are discussed in the City of Waukesha WWTP Facility Amendment (City of Waukesha 2018) and the Wastewater Treatment Plant Facility Plan Amendment, which is an attachment to the Return Flow Plan (Strand Associates 2011). The outfall structure would be designed to blend in with the streambanks along the Root River and be required to not adversely affect regional flood elevations. A recent Root River sediment transport study concluded that the river stability in the location of the proposed outfall is relatively insensitive to changes in flow because of the erosion resistance of the channel boundary materials, the relatively flat channel gradient, and the presence of a functional floodplain (MMSD 2007). For these reasons, and because the proposed return flow would be a small fraction of higher flow events where the majority of fluvial processes occur, the return flow is not expected to adversely affect the geomorphic conditions in the river.

5.1.2.4 Root River flora and fauna effects

Root River flora effects

The algal community in the Root River, represented by attached and suspended species, as well as those contained within periphyton complexes, could experience an increase in total biomass. During low-flow periods, there would be more stream bottom substrate and water column available for colonization and growth. The added nutrient load could also fuel growth. Similarly, the aquatic macrophyte community of the Root River could experience an increase in biomass.

Impacts of increased biomass downstream of the outfall could be both positive and negative. Positive impacts of increased biomass would provide expanded direct and secondary grazing opportunities for benthic invertebrates and fish, as well as expanded refuge habitat. The potential negative impact would be the risk of an expanded lower range of the diurnal oxygen cycle (low DO).

Root River benthic invertebrate effects

The proposed Root River return flow would increase available habitat for aquatic invertebrates during low-flow periods due to the increased dimensional wetted area of the stream bottom. Riffle and pool depths could increase. Aquatic macroinvertebrates would be able to utilize or benefit from these areas. If algal and periphyton amounts increase due to phosphorus loading, aquatic macroinvertebrate communities could experience a shift in species composition and an increase in numbers.

Root River fishery effects

The proposed Root River return flow has the potential to both positively and negatively affect the fishery of the Root River. Positive effects could result from the addition of flow during low-flow periods (late summer/early fall), while both potential positive and negative effects could be evidenced from added phosphorus. Temperature effects would likely have a slightly positive effect throughout the year. The addition of chlorides could have a marginal effect on the Root River and Root River estuary fishery, but any negative effects would likely be eliminated after the water supply transition is fully completed and chloride source reduction measures are completed as planned.

The Applicant's wastewater will contain low concentrations of nutrients, principally phosphorus. Phosphorus loading could increase algal, periphyton, and aquatic plant communities in the Root River and the estuary. This growth could increase the forage base for fish that consume algae or the macroinvertebrates that reside on aquatic plants. Alternately, there could be a corresponding decrease in some fish that depend on sight to catch prey, should excessive suspended algae growth occur.

Under NR 102.04 (3), Wis. Adm. Code, the Root River is designated as a Fish and Aquatic Life – warm water sport fish community. The Root River from the proposed outfall location downstream to the Horlick Dam, is classified in the SEWRPC 2014 Root River Watershed Restoration Plan as a Warm Mainstem fishery.

The DNR has made recent refinements to the classification methodology, confirmed by the biological community, and the results show that this segment of the Root River should be classified as Cool (Warm-transition) Mainstem. The DNR describes a Cool-Warm Mainstem fish community as, "moderate to large but still wadeable perennial streams with cool to warm summer temperatures. Coldwater fishes range are uncommon to absent, transitional fishes are abundant to common and warm water fishes are uncommon to absent. Headwater species are common to absent, mainstem species are abundant to common and river species are common to absent (see https://dnr.wi.gov/topic/rivers/naturalcommunities.html). The added flow from the proposed Waukesha outfall would likely not alter this classification and the fish community associated with this temperature range, assuming that current effluent temperatures reflect future output.

Chlorides contained in the proposed discharge could have a minimal negative effect on the fish community of the Root River. Upstream of the discharge location, current chloride levels in the Root River exceed both chronic and acute toxicity. Adding effluent flow from Waukesha could exacerbate chloride issues in the Root River, resulting in a negative effect on the fish community. The WPDES permit will require that the Applicant reduce sources of chlorides to meet the proposed WQBELs. For more information see Section 5.1.2.1 (above) under the sub-heading *Root River chlorides effects*.

The addition of up to an average daily discharge of 9.3 MGD to the Root River, could compound the availability of wetted fish spawning and resident habitat during the very low flow periods, increase the ability of fish to mobilize between shallow river segments, and enhance forage opportunities. This would all have a positive effect on the numbers, and possibly diversity, of the Root River fishery. During periods of higher flow, there would be no positive or negative impact to the Root River fishery from the flow addition.

Additionally, during low-flow periods, the proposed Waukesha return flow could benefit the department's Root River Steelhead Facility. The Root River Steelhead Facility is Wisconsin's main source of rainbow trout (steelhead) eggs and brood (parent) stock and is the back-up facility for the collection of eggs of other trout and salmon species. During some years when flow on the Root River is low, the DNR has not met fish egg collection quotas. The DNR has evaluated flow augmentation of the Root River to improve fish migration for egg collection. The proposed return flow would provide the flow augmentation (during low-flow periods) considered by the DNR to allow more fish to reach the Steelhead Facility, meet egg collection quotas, and fish stocking goals.

Root River mammal effects

Nutrient loading could have negative health impacts on semi-aquatic mammals, resulting in population declines. However, due to the minimal nutrient loading expected from the proposed discharge to the Root River (approximately two percent of the overall watershed load), no significant negative impacts on semi-aquatic mammals are expected. It is more likely that the increased flow to the Root River from the proposed discharge could create more riparian habitat for semi-aquatic mammals, thus positively impacting local mammal populations.

For potential human health impacts see Section 5.1.2.1 (above) under the sub-headings *Root River bacteria (pathogens) effects* and *Root River pharmaceuticals and personal care product effects*.

5.1.3 Fox River effects

5.1.3.1 Fox River water quality effects

The portion of effluent at the WWTP that would continue to be discharged into the Fox River would be required to meet water quality discharge limits. Some water quality based effluent limits for the Root River return flow would be more stringent than the Fox River, and therefore, effluent added to the Fox could be of higher quality than it is currently. For example, chloride levels should decrease after a switch from groundwater to Lake Michigan water supply. Consequently, water quality impacts to the Fox River are not anticipated with return flow to the Lake Michigan watershed.

5.1.3.2 Fox River flow and flooding effects

The average annual flow of the Fox River upstream from the WWTP is 128 cfs (years1994-2017, USGS Gage Station 5543830). The current proposal and alternatives all include a portion of wastewater flow continuing to be discharged to the Fox River, once the required daily volume of return flow to the Root River is achieved.

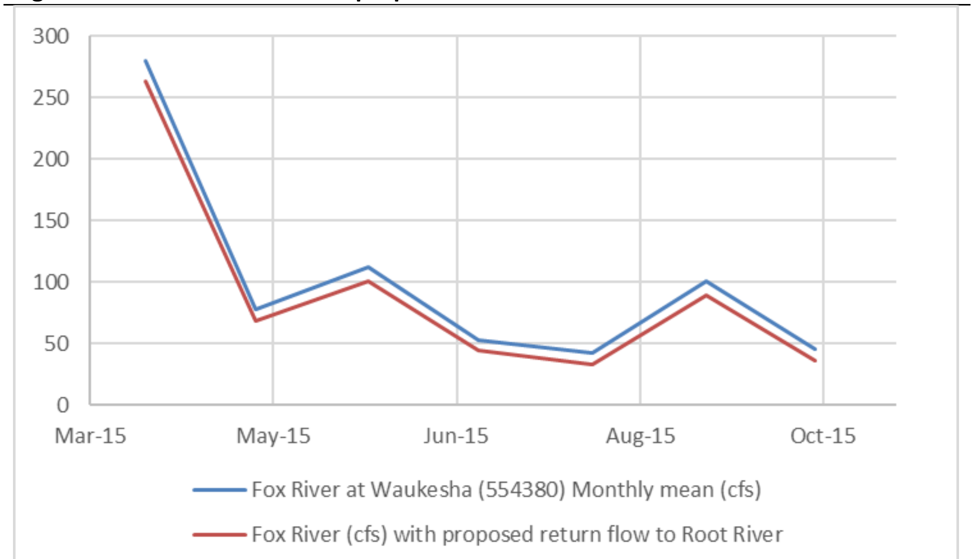
The DNR used historical data to estimate what the effect of a diversion would have been on average daily Fox River flows between 2013 and 2017. Based on the previous year's water withdrawals (2012-2016) and WWTP effluent data (2013-2017), the Fox River would have received between 1.7 MGD (2.6 cfs) and 4.9 MGD (7.5 cfs) depending on the year (Table 5-4.). Based on this analysis, Fox River flow directly downstream of the WWTP could decrease approximately 10 percent (~10 cfs decrease) and if the City were to return up to an average of 113% of the previous year's annual withdrawal per day to the Root River, average daily flows to the Fox River could decrease up to 14.5 percent.

Table 5-4. Average daily return flow to the Fox River after proposed Root River return based on historical data

Year	Previous year's average annual withdrawal (rounded gal/day)	Days with no flow to Fox River	Average daily return to Fox River (gal/day)	Average % reduction to the Fox River downstream of WWTP
2013	7,015,000	0	3,798,000	10.30
2014	6,492,000	1	2,760,000	10.97
2015	6,594,000	14	1,677,000	13.02
2016	6,125,000	0	3,393,000	8.96
2017	5,949,000	0	4,851,000	7.23
			Average % decrease	10.10

During dry years the average flow to the Fox would be less under a Lake Michigan supply, due to limited infiltration and inflow, and during wet years, this average would increase. Figure 5-1 shows an example of what flow conditions would have been like for the Fox River based on actual effluent data from 2015, and a hypothetical return of the previous year's average daily withdrawal to the Root River of 6.6 MGD.

Figure 5-1. Fox River flow with proposed return flow to the Root River



A reduction in flow to the river could reduce habitat, impact water quality and increase temperature and related stresses in the biological community of the Fox River watershed. Lower flow conditions could also increase stresses on some fish species and macroinvertebrate populations, including mussels.

The current proposal and alternatives would include new aboveground pump stations. None of these structures would be located in a flood-sensitive area.

No regulatory floodplain changes are anticipated as floodplain studies look at the watershed infiltration capabilities and surface water runoff as a system. Flow changes due to point sources such as wells are not considered in the calculations.

Fox River geomorphology and sediment effects

While some additional sediments may be more frequently exposed, no significant change in geomorphology or sediments is expected on the Fox River from the current proposal.

Fox River flora and fauna effects

A reduction in daily flow in the Fox River could have a minimal impact to the flora and fauna of the river by reducing habitat - possibly increasing temperature, which can stress the biological community. Coolwater species including walleye may be negatively affected as a result of the removal of the City's wastewater discharge to the Fox River. Adult and juvenile coolwater species of the Fox River including walleye and northern pike depend upon connectivity to coldwater tributaries which provide refuge during hot summer months as well as critical nursery habitat throughout the year. Lower baseflow conditions can stress macroinvertebrate populations including mussels. Reduced baseflow can alter the environment and change the competition, predation and organic decomposition that the macroinvertebrate community depends upon.

The reduction of flow in the Fox River due to the removal of the City's wastewater effluent would not likely affect any mammal species in the Fox River or its associated habitats. Baseflow reduction would likely impact semi-aquatic mammal species including beavers, muskrats, otters, and mink. Increased depth to groundwater would cause a change in wetland type, therefore impacting mammal species that rely on a variety of wetland types that have surface water throughout the year. The slight flow reduction in the Fox River would not likely affect any mammal species in the Fox River or its associated habitats.

5.1.3.3 Pebble Brook, Pebble Creek, Mill Brook and Vernon Marsh flora and fauna effects

The Applicant would cease shallow groundwater pumping from existing shallow aquifer wells along the Fox River between Pebble Creek and Genesee Creek. Consequently, groundwater flows to the Fox River, Pebble Brook, Pebble Creek, Mill Brook, Mill Creek, Genesee Creek and Vernon Marsh would not be negatively affected. These streams may see up to a 2% increase in baseflow (see Appendix C of the Preliminary Final EIS, here) that would be beneficial to these streams.

5.1.4 Groundwater effects

The current proposal and alternatives would not involve groundwater withdrawals, except for emergency purposes. The proposed Lake Michigan water supply would eliminate the need for pumping the deep aquifer, which would continue to rebound in southeast Wisconsin. Withdrawal from Lake Michigan with return flow is not anticipated to result in a change in lake water levels, and thus is not expected to result in adverse effects to regional aquifer supplies influenced by Lake Michigan. Because of the small water depth change anticipated in Lake Michigan tributaries under the current proposal and alternatives, no impacts to regional aquifers or groundwater quality are anticipated. The current proposal and alternatives are also not anticipated to result in impacts to springs.

If a proposed pipeline were to cross a property with groundwater contamination, there is the potential for the groundwater contamination to migrate along the assumed permeable backfill around the pipeline. If the pipeline leaked in the area of a contaminated property with soil and/or groundwater contamination, it is possible that the influx of water due to the leak could, under unique conditions (strong downward vertical gradient, contaminant with a high solubility or specific gravity greater than water, etc.), cause the contamination to migrate to the shallow aquifer or to a spring if the leak is not repaired. Following a proper permitting process would mitigate these risks.

5.1.5 Stream crossing effects

The DNR typically limits open trench installation of proposed pipelines to intermittent waterways with no flowing water at the time of construction. If there is flowing water, one of the other crossing methods would have to be used. This EIS assumes that open trench construction would be allowed only during times of no stream flow. Many of the stream crossings are proposed to be made using HDD, thus avoiding trenching-related effects. With HDD, pressurized drilling mud may leak to the surface, or "frac-out." In most cases the volume of sediment resulting from seepage of drilling mud would be far less than the amount produced by conventional open-cut crossing (see Section 5.1.7).

The Applicant evaluated waterways using the National Hydrography Dataset (NHD) from the U.S. Geological Survey. See Appendix C for a complete description of the waterway and wetland review done by the Applicant.

5.1.5.1 Stream crossing effects on water quality

The primary construction-related impact to the water quality of affected streams could be possible elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in streams that are crossed. Increased water temperatures due to bank clearing of large trees could also occur. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would tend to be minimized by adhering to environmental permit conditions and best management practices to reduce the turbidity and erosion (CH2MHill, 2013, Vol. 5, Appendix 5-2).

5.1.5.2 Stream crossing effects on floodplains

The proposed project and alternatives would include new aboveground pump stations. None of these structures would be located in a flood-sensitive area.

5.1.5.3 Stream crossing effects on flora and fauna

The pipeline stream crossings of the current proposal and alternatives would not likely result in impacts on the flora and fauna assuming proper stream crossing methods are used (Section 5.1.7). There are other special concern species that may be present on land at these crossings and avoidance/minimization measures would be recommended.

5.1.6 Wetland effects

A two-mile common route corridor exists for water supply routes M1, M2 and M3. The Applicant used the Wisconsin Wetland Classification System (WWI) and air photo interpretation to determine wetland effects. Within the common route, there are three photo-interpreted wetlands, totaling of 0.18 acres.

The return flow discharge site (RFDS) proposed for all of the alternatives was sited and designed by the Applicant to minimize wetland impacts to the extent practicable. The site is located at the southeast corner of the intersection of South 60th Street and West Oakwood Road in the City of Franklin. The site is zoned R-2 residential and the current land use is agricultural. Upland conditions exist on the north side of the site, along West Oakwood Road, while farmed wetland and a non-farmed wetland exist within the southern portion, with the Root River located on the southwest boundary of the site. Impacts would be minimized by aligning the pipelines through farmed wetlands to the extent possible. The workspace within wetland areas would be constrained to 50 feet wide, or 25 feet on either side of the centerline of the pipeline.

Total wetland impacts at the RFDS would be 0.94 acres. Of this, 0.86 acres are currently farmed, while 0.05 is wet meadow. The Applicant proposes to limit the duration of the impacts to three months. 587.4 square feet (0.01 acres) of floodplain forest would be converted to wet meadow. The installation of manholes would result in 93 square feet of permanent fill in what is currently farmed wetland.

5.1.7 Pipeline construction effects

All of the water supply and return flow alternatives would include the construction of pipeline through waterways and wetlands. There are a variety of methods of installing pipeline across a waterway or wetland. The DNR has authorization under Chapter 30, Wis. Stats to permit and dictate the construction method authorized at each waterway.

To allow the passage of construction equipment and materials along the right of way (ROW), temporary bridges may be installed across waterways. Equipment crossings of waterways would be restricted to bridges that are authorized under the DNR's Chapter 30 permit.

5.1.7.1 Waterway crossing methods

Waterway crossings for the current proposal and alternatives may be accomplished using five distinct construction methods:

- open trench
- dam and pump
- flume
- horizontal direction drill (HDD)
- jack and bore.

These methods have common procedures and unique components, which are discussed below.

Common construction procedures

Standard crossing methods normally require a gradual and uniform approach to the waterbody to prepare a suitable work area for construction equipment and place the pipeline. This usually requires removing bank vegetation and grading the banks away from the waterbody. This process could temporarily increase the potential for soil erosion until construction is complete and the right of way is stabilized and reseeded.

Erosion control measures would be required to be installed before construction. Since the project will involve more than one acre of land disturbance regardless of which project alternative is used, coverage under the WPDES construction storm water discharge general permit will be required. Erosion and sediment control measures would be required before, during, and after construction until vegetation has established in disturbed areas. To prevent sediment from reaching waterbodies and drainageways, excavated spoil will be stored in containment areas, and sediment controls (such as silt fence, straw bales, and/or fiber rolls) will be installed. To prevent erosion, erosion controls (such as erosion control matting, mulch, tackifier or seed, or combinations of these) will be applied to disturbed soils. Inspections of all project erosion and sediment controls are required weekly and within 24 hours after a precipitation event of 0.5 inches or greater (within any continuous 24-hour period). Repair or replacement of erosion and sediment controls is required to occur within 24 hours of an inspection or of DNR notification that repair or replacement is needed.

Other temporary erosion controls include storing all excavated spoil in containment areas that prevent the spoil from entering the stream, and installation of silt fence and/or straw bales to prevent runoff from upland areas from entering the stream. Additional temporary workspaces on each side of the waterbody are generally required for staging the crossing. These are typically 50 feet wide by 150 feet long. There would be an undisturbed buffer between the additional temporary workspace and the waterway.

Following installation of the pipeline across the waterway, the ROW on either bank would be re-graded to its approximate preconstruction contours. Disturbed stream and river banks would be stabilized with biodegradable geotextile fabric, jute thatching, or bonded fiber blankets. Disturbed soils would be fertilized, seeded, and mulch would be applied as needed. Temporary bridges would be removed after seeding and mulching are complete. Temporary erosion control measures would be removed after permanent erosion control measures are installed and vegetation is re-established. Construction equipment would be required to be decontaminated to prevent the spread of invasive species which may be attached from previous construction sites.

In areas where wetland impacts cannot be avoided, open-trench excavation, HDD, or jack and bore methods would generally be used. In addition, push/pull methods, or winter construction may be used. Construction methods would be similar for wetlands as those described for waterway crossings.

The typical width of the workspace is often reduced through a wetland area to minimize impacts. Impacts would also be minimized by using matting in travel areas in wetland workspaces to prevent soil mixing. Additional temporary workspace may be required in the adjacent uplands.

Temporary erosion control devices would be installed at the base of cleared slopes leading to wetlands. If there is no slope, erosion control devices would be installed as necessary to prevent exposed soils from flowing off the ROW into the wetland or to prevent sediment from flowing from adjacent uplands into the wetlands.

During clearing, woody wetland vegetation would be cut at ground level and removed from the wetland, leaving the root systems intact. In most areas, stump and root removal would be limited to the area directly over the trench. Stumps from areas outside of the trench line would be removed, if necessary to provide a safe work surface.

Grading activities in wetlands would be limited to the areas directly over the trench line, except where topography requires additional grading for safety purposes. To facilitate revegetation of wetlands, topsoil would be stripped over the trench, except in areas where standing water, saturated, or frozen soils make it impracticable, where no topsoil layer is evident, or where the topsoil layer exceeds the depth of the trench. In areas that require topsoil segregation, topsoil and subsoil would be segregated during ditching and stockpiled separately. Topsoil would be removed to its actual depth or to a maximum depth of 12 inches, and would not be used for padding, backfill, or trench breakers. This work typically requires the use of a tracked excavator.

Staging areas and extra workspace would be needed on both sides of larger wetlands. These areas would be at least 50 feet away from the wetland boundaries where topographic conditions permit and would be limited to the minimum area needed for assembling the pipeline. Storage of hazardous materials, chemicals, fuels, and lubricating oils would generally be prohibited within 100 feet of wetland boundaries.

If the open-trench crossing method is not practical because of saturation or standing water, either a push/pull method or winter construction might be used. Use of the push/pull method is generally limited to large wetlands with standing water and/or saturated soils that have adequate access for pipeline assembly and equipment operation on either side of the wetland. If this method is used, a long section of pipeline would be assembled on an upland area of the ROW adjacent to the wetland. Usually this requires use of extra temporary workspace adjacent to the ROW. The trench would be dug by a backhoe supported on timber mats. The prefabricated section of pipeline would then be floated across the wetland. When the pipeline is in position, the floats would be removed, and the pipeline would sink into position. The trench would then be backfilled, and the original contours would be restored by a backhoe working from construction mats.

With winter construction, the pipe would be installed in wetlands under frozen conditions using methods like conventional upland construction. Because equipment is supported by frozen soil and ice, temporary mats would not be required. The success of winter construction depends on prolonged periods of subfreezing temperatures, which produce sufficient frost depth. Because these conditions are not always predictable, the ability to use the winter construction method is generally not assured.

Ice roads may also be used to decrease impacts. Ice roads are created by plowing the snow from the wetland surface and driving sequentially heavier pieces of equipment across the wetland surface to facilitate the penetration of the frost deeper in the ground, creating a stable working surface.

Revegetated areas would be monitored for invasive species through final stabilization or as stipulated in permit requirements. Actions would be taken to control and minimize the spread of invasive species where they occur within revegetated areas.

Temporarily disturbed wetlands would be restored by replacing the soil in kind and restoring the approximate former grades. Wetlands in roadway ROWs that had previously been maintained by mowing would be revegetated using a standard WDOT seed mix. Wetlands that were not in artificially constructed and maintained features, such as roadside ditches, would be reseeded using a mixture of native plants.

Open trench crossing method

For an open trench crossing, a trench would be excavated through the stream using draglines or backhoes operating from one or both banks. The potential impacts to a waterway and its biota from open trench construction are quite different if the trenching is done when the waterway has flowing water rather than when the stream is dry. The DNR typically limits open trench installation of the proposed pipelines to intermittent waterways with no flowing water at the time of construction. If there is flowing water, one of the other crossing methods would have to be used. This EIS assumes that open trench construction would be allowed only during times of no stream flow.

Restricting open trenching to times of no flow eliminates the direct construction impacts to the stream’s water column, avoiding the associated sedimentation of habitat for fish and aquatic invertebrates, water quality degradation, and reduced light for aquatic plants and algae.

No long-term impacts to streams would be expected if the contours of the streambed are restored to their pre-construction condition, as required by Chapter 30 permitting.

Dam and pump crossing method

The dam and pump stream crossing method is slower and more expensive than the open trench method, but generally reduces the water quality impacts caused by open trenching. It is also preferred for small streams that are sensitive to sediment loading.

This method involves damming the stream on either side of the construction area before trench excavation, using sand bags or other methods that greatly minimize the addition of sediment to the stream. Before the dams are installed, one or more water pumps would be placed on the upstream side of the proposed trench, so water can be pumped around to the downstream side of the construction area.

The placement and removal of the pumps and damming material would cause minor sediment suspension. Where the pump hose discharges downstream of the crossing, energy dissipation devices would be used as necessary to prevent scouring of the stream bed. Trenching, installation of the pipeline, and restoration of the banks and ROW would be completed in the same manner as described for the open trench method. However, because the stream flow is pumped around the construction area, instead of through it, only minimal sediments would be displaced by construction.

The use of bypass pumping to redirect stream water flow around the construction area would temporarily block the movement of fish and other aquatic organisms through the area.

Flume crossing method

The flume method is suitable for small to intermediate streams with straight channels at the crossing area, and that are sensitive to sediment loading.

Flumes made of large pipe sections would be aligned in the stream parallel to the water flow. The stream would then be dammed with a diversion bulkhead to direct stream flow through the flumes. A similar bulkhead would be installed at the downstream end of the flumes to prevent backwash from entering the construction area. Energy dissipation devices would be installed as needed to prevent scouring at the discharge location.

A trench would then be excavated underneath the flumes in the exposed section of stream bed. A section of pipeline long enough to span the stream would be welded together and pulled beneath the flume. The flumes would be removed after the installation of the pipeline. Backfilling and bank restoration would be completed as described for the open trench method.

Fluming, like the dam and pump method, isolates stream flow from the construction area and allows installation of the pipeline without significant displacement of sediments. The use of the flume to redirect stream water flow through the construction area would also temporarily prevent movement of fish and other aquatic organisms.

Horizontal directional drilling crossing method

Directional drilling minimizes the environmental effects of pipeline construction on a waterbody or waterway by going beneath its bed and avoiding direct disturbance of the bed and banks. This technique is especially useful for wide crossings, where navigation traffic is high, areas where bottom sediments are contaminated, or where there are sensitive habitats or cultural resources near the banks.

The HDD method involves using a special drill rig to drill a gently curved borehole below the surface of the ground and the bed of the waterway. After it exits on the opposite side of the stream, the drilling machine pulls a long, pre-welded pipeline section back through the drilled hole.

Temporary workspaces would be cleared for drilling equipment, measuring approximately 250 feet long by 50 feet wide on the entry side of the crossing. A slant drill unit would be placed on one bank and a small-diameter pilot hole would be drilled under the stream. After the pilot hole has been completed, it would be enlarged to accept the pipeline by pulling a barrel reamer back and forth through the bore hole. Drilling mud would be continuously pumped into the hole to remove cuttings and maintain the integrity of the enlarged hole. After the hole has been reamed, a prefabricated pipeline section long enough for the crossing would be pulled through the hole by the drilling rig.

An HDD crossing avoids most of the potential impacts that are a concern with pipeline crossings of waterways, as the pipeline is installed beneath the bed of the waterway. There is no disturbance or change to either the bed or water column. Many of the potential concerns described for other methods of crossing waterways, including sedimentation and turbidity, habitat alteration, disrupting breeding and movement patterns, and the introduction of pollutants into the water column, do not occur when the HDD method is properly used.

HDD construction uses a drill “mud” under pressure to lubricate the drill pipe, remove drill cuttings and maintain the integrity of the drill hole. The drilling mud is usually a water-based slurry of bentonite clay which may have an emulsifier added. Drilling mud and cuttings would also require disposal.

Pressurized drilling mud can leak to the surface, or “frac-out.” Such failures are not easily predicted; however, the impacts from failure can be reduced by monitoring mud pressure and drilling head location, inspecting the surface during the drill process, and by increasing the depth of the drill path below the bed of the river. In most cases the volume of sediment resulting from seepage of drilling mud would be far less than the amount produced by a conventional open-cut crossing.

During the crossing, drilling mud is stored away from the river in an earthen berm containment structure or fabricated containment tanks sized to accommodate the volume of mud necessary for the drill. Following completion of directional drilling, mud is disposed of in accordance with applicable state and local requirements. Where landowner permission is available, mud is typically land-spread in upland, agricultural fields. If landowner permission is not available or land-spreading is not appropriate for some other reason, drilling mud would be disposed of in a landfill or other authorized disposal site.

If an unanticipated frac-out were to occur in an upland location, the drilling mud would be contained to the extent possible with standard erosion control measures such as silt fences and/or hay bales, then disposed of properly by removing and spreading over an upland area or hauled off-site to an approved location.

A frac-out can occur in the bed of a waterbody or an adjacent wetland. If an in-stream frac-out occurred, the drilling would stop to develop an appropriate response. If proceeding with the HDD crossing would cause significant adverse impacts to waterbodies and fisheries resources, the HDD would stop, and an alternative crossing method would be used. For a wetland frac-out, the slurry at the surface would be isolated using silt fence and/or hay bales, then removed by vacuum truck, machinery, or by hand, and disposed of in an acceptable upland location.

Jack and bore crossing method

This method is used primarily to install pipe under a surface, or shallow obstructions such as roads, railroads and other existing utilities. In some instances, it may be used to install a pipeline under waterways. This method is also called auger boring or pipe jacking.

With this method, two construction pits are dug, a jacking pit and a receiving pit. The pits are typically about 15 feet wide and 35 feet long. A rotating boring machine is used to create a hole, starting from the jacking pit and ending in the receiving pit. A casing pipe, larger in diameter than the water pipe, is pushed into the hole following the boring machine. After the casing pipe has been installed between the jacking and receiving pits, the water pipe is slid into the casing pipe. The void area between the casing pipe and the bored soils is filled with grout and the area between the casing pipe and the water pipe is filled with pea gravel or sand.

There is little potential for a frac-out condition occurring during jack and bore installation, unlike that for a HDD installation, because the bentonite drilling slurry is not pressurized. The unpressurized drilling slurry would not have a force mechanism to push it far enough out of the drill hole to result in a frac-out release.

The use of this method to install a pipeline avoids most of the potential impacts that are a concern with pipeline crossings of waterways that place the pipe beneath the bed of the waterway. There is no disturbance or change to either the waterway's bed or water column.

Many of the potential impacts of some other methods of crossing waterways, including sedimentation and turbidity, habitat alteration, disrupting breeding and movement patterns, and the introduction of pollutants into the water column, do not occur when this method is used.

Operation and maintenance related impacts

Other than inspections from vehicles and routine removal of brush and trees, there should be little long-term disturbance of the corridor, and associated long-term effects on water quality due to operating and maintaining the proposed pipelines.

5.1.7.2 Summary of pipeline construction effects on waterways

For intermittent waterways, open trench crossings of these waterways would only be allowed at times of no flow. With this restriction, open cut trenching would not alter the streams' water quality or have any direct effect on aquatic life. With simple restoration efforts, using this method would also not substantially change either streambed configuration or flow characteristics.

For perennial waterways that would be crossed, the potential environmental consequences using HDD or jack and bore pipeline construction methods would be minimal, because those pipeline installation methods do not directly disturb the bed or water column of the waterway. The potential impacts to the perennial waterways crossed using a dam and pump or flume method, are also expected to be minor, with impacts primarily of temporarily inhibiting movements of fish and other aquatic organisms through the construction zone.

5.1.7.3 Pipeline construction effects on wetlands

The temporary removal of wetland vegetation is a primary impact of pipeline construction and right-of-way maintenance activities. Construction also would temporarily diminish the recreational and aesthetic value of the wetlands crossed. These effects would be greatest during and immediately following construction. In wet meadow/emergent wetlands, the impact of construction would be relatively brief, since herbaceous vegetation regenerates within one or two seasons. In forested and shrub-dominated wetlands, the impact would last longer due to the longer recovery period of these vegetation types. Long-term vegetation management over the pipeline to allow access and inspection would prevent regeneration of tree and shrub cover.

Clearing of wetland vegetation would also temporarily, or in some cases, permanently, remove or alter wetland wildlife habitat.

Trench excavation is a major disturbance of a wetland, but construction activities would also impact wetlands outside of the trench area. Compaction and rutting of wetland soils could result from the temporary stockpiling of soil and the movement of heavy machinery. Surface drainage patterns and hydrology could be temporarily altered, and there would be increased potential for the trench to act as a drainage channel. Trench breakers would be placed in the trench to prevent the flow of groundwater in the backfilled trench. Increased siltation in adjacent wetland areas could result from trenching activities. Disturbance of wetlands also could temporarily affect the wetland's capacity to reduce/moderate erosion and floods.

Construction through wetlands would comply, at a minimum, with conditions set in the state and federal permitting. The evaluation of potential impacts from crossing wetlands is based on DNR waterway and wetland permitting which requires the use of appropriate erosion control practices along with the restoration of the wetland contours to preconstruction conditions.

The following discussion summarizes the major components of proposed construction methods. Staging areas and extra workspace would be needed on both sides of larger wetlands. These areas would be located at least 50 feet away from the wetland boundaries, where topographic conditions permit, and would be limited to the minimum area needed for assembling the pipeline. Storage of hazardous materials, chemicals, fuels, and lubricating oils would generally be prohibited within 100 feet of wetland boundaries.

Temporary erosion control devices would be installed at the base of cleared slopes leading to wetlands. If there is no slope, erosion control devices would be installed as necessary to prevent exposed soils from flowing off the ROW into the wetland or to prevent sediment from flowing from adjacent uplands into the wetlands.

During clearing, woody wetland vegetation would be cut at ground level and removed from the wetland, leaving the root systems intact. In most areas, removal of stumps and roots would be limited to the area directly over the trench. Stumps from areas outside of the trench line would be removed, as necessary, to provide a safe work surface.

To facilitate revegetation of wetlands, topsoil would be stripped over the trench, except in areas where standing water or saturated soils make it impracticable, where no topsoil layer is evident, or where the topsoil layer exceeds the depth of the trench.

The use of either low ground-pressure equipment or standard construction equipment operating from timber pads would reduce disturbance of wetlands with saturated soils or standing water.

Imported rock, stumps, brush, or offsite soil would not be used as temporary or permanent fill in wetlands. Following construction, materials used in wetlands to provide stability for equipment access would be removed.

If the standard crossing method is not practical because of saturation or standing water, either a push/pull method or winter construction might be used. Use of the push/pull method is generally limited to large wetlands with standing water and/or saturated soils that have adequate access for pipeline assembly and equipment operation on either side of the wetland. If this method is used, a long section of pipeline would be assembled on an upland area of the ROW adjacent to the wetland. Usually this requires use of extra temporary workspace adjacent to the ROW. The trench would be dug by a backhoe supported on timber mats. The prefabricated section of pipeline would then be floated across the wetland. When the pipeline is in position, the floats would be removed, and the pipeline would sink into position. The trench would then be backfilled, and the original contours would be restored by a backhoe working from construction mats.

Under frozen conditions, the pipe would be installed in wetlands similar to conventional upland construction. Because equipment is supported by frozen soil and ice, temporary mats would not be required. The success of winter construction depends on prolonged periods of subfreezing temperatures, which produce sufficient frost depth. Because these conditions are not always predictable, the ability to use the winter construction method is generally not assured.

Ice roads could also be used to decrease impacts. Ice roads are created by plowing the snow off of the wetland surface and driving sequentially heavier pieces of equipment across the wetland surface to facilitate the penetration of the frost deeper in the ground, creating a stable working surface.

Following restoration of contours, wetlands would typically be seeded with annual ryegrass as a cover crop. Other measures such as replacement of the original surface soil, with its stock of roots and tubers can facilitate restoration. The wetland would either be seeded with an appropriate native wetland seed mix or allowed to re-vegetate naturally to preconstruction vegetative covers. No lime or fertilizer would be added to disturbed wetland areas, unless required in writing by the appropriate permitting agency. After a period of monitoring, wetlands that do not appear to be regenerating by this process may need to be seeded with an approved native seed mix.

Most of the wet meadow wetlands have, or are dominated by, reed canary grass, which is a very aggressive invasive plant. In wetlands that contain the grass, it is likely that, following construction, the ROW and workspace area would become dominated by the grass because of the disturbance and spreading of the plant rhizomes, which facilitate spread. A wetland free of reed canary grass should be protected from its introduction by construction mitigation techniques.

Operation of the pipelines would not require alteration of wetlands other than periodic brush and tree control in the pipeline’s permanent ROW. No permanent filling, dredging or other long-term wetland disturbance is anticipated.

5.1.8 Woodland effects

Some tree removal would be required at the proposed facility sites, including the WSPS, BPS, RFPS, and RFDS. These sites are predominately not forested.

Construction would be managed to minimize adverse impacts to forested land. Prior to beginning forest clearing activities, the construction boundaries (for example, workspace limits) would be clearly delineated. Any trees that are to be saved would be sufficiently marked (flagging, construction, and fencing) before clearing begins.

Erosion-control devices would be installed at all stream, wetland, and road crossings in forested areas before grading. The construction corridor would be cleared and graded to remove brush, trees, roots, and other obstructions such as large rocks and stumps. Trees and brush would be disposed of in accordance with local restrictions and/or applicable permit stipulations.

Rock construction entrances would be installed where required before or in association with grading.

Low-impact tree clearing would be the preferred method for clearing. This method incorporates a variety of approaches, techniques, and equipment to minimize site disturbance and to protect residual forests. The generally accepted tenets of low-impact tree clearing include:

- Employing directional tree felling—both hand felling and mechanical felling.
- Selecting tree-clearing contractors that are experienced in low-impact tree clearing.
- Using a variety of tree-clearing equipment to minimize impacts, such as forwarders, feller bunchers (cut to length systems), cable and grapple skidders, high-flotation tires, portable bridges, and temporary culverts. Equipment will be matched to specific site conditions.
- Removing all brush, cuttings, and tops from the construction area.

When pruning or side trimming is necessary, pruning cuts would be made to protect the health of the vegetation. This includes measures such as smooth cuts, and precutting large, heavy branches on the underside to prevent splitting or peeling of bark.

Timber cleared from the construction area may be stacked at the edge of the construction area, as requested by individual landowners and specified in landowner agreements. Where there is an agreement, the cut timber would be stacked in an already cleared upland area that would be accessible to the landowner without disturbing the restored areas. Timber would not be stacked in drainageways or left in wetlands.

Permanent conversion of forest to herbaceous cover would be required over the proposed pipeline for operation and maintenance of the pipeline. Long-term vegetation management would occur over the pipeline to allow access and prevent regeneration of tree and shrub cover that could damage the pipeline. Vegetation maintenance in forest areas could include herbicide/pesticide applications and mechanical methods such as cutting and mowing. Vegetation management would be performed in a way that minimizes disturbance to adjacent areas.

5.1.9 Air emission effects

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with the current proposal and alternatives. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

Odor associated with the return wastewater, which can carry a characteristic treatment plant smell, could persist for an unknown distance downstream of the proposed Root River outfall. Treatment plant odors on the Fox River can occasionally be discerned 8.4 miles downstream of the current Waukesha outfall as observed by DNR staff while collecting water quality data on the Fox River at the County Highway I location.

5.1.10 Land use effects

Land use changes associated with those proposed and alternative pipeline segments that are within existing road rights-of-way (ROW) would be minimal. Current land cover consists primarily of maintained turf or vegetated roadway buffer. After construction, the land within existing road ROW would continue to be maintained as turf or vegetated roadway buffer.

For those proposed and alternative water supply and return flow pipelines in new easements, current land use consists of agriculture, maintained lawns, driveways, and landscaping. After construction, the land cover in new ROW easement would be maintained vegetation that supports occasional access. Disturbed driveway or sidewalk pavement would be replaced in-kind.

The return flow pump station (RFPS) for the proposed project and alternatives would be part of the existing Waukesha WWTP. Current land use at the proposed RFPS consists of upland row crops, farmed and non-farmed wetland, paved access roads, maintained turf, and portions of the existing WWTP. After construction, the RFPS and additional paved access road would partially replace an estimated 1.81 acres including farmed wetland, maintained turf, existing paved access roads, and some trees.

The proposed access road at the proposed return flow discharge station (RFDS) would impact approximately 0.99 acres of farmed wetland. Farmed wetlands onsite would continue to be farmed for five or more years after the proposed construction. Within the next 10 years, the site is planned to be a naturally vegetated area, which would include enhancement of the existing farmed wetlands. The proposed booster pump station would also require the conversion of about 4.5 acres of agricultural land to industrial use.

Direct impacts to residential and commercial landowners could include temporary localized noise increases, construction equipment diesel emissions, disruption to property access, removal of vegetation, and soil disturbance which could lead to fugitive dust, soil tracking, soil compaction, and/or soil erosion. These potential impacts would be temporary, as construction would move sequentially along the proposed route. Pipeline construction duration is expected to be approximately 60 feet per day in urban areas and 80 feet per day in rural areas.

Indirect impacts to residential and commercial property owners could include additional road congestion and disruptions to normal traffic flow patterns. The potential for permanent visual impacts would be limited to areas where aboveground facilities are sited. The majority of the proposed infrastructure would be below the ground surface.

Vegetation along the proposed pipelines would be restored. A stormwater pollution prevention plan would be implemented to address stormwater management and erosion and sediment control issues. No significant erosion, tracking, or fugitive dust issues are expected.

5.1.10.1 Transportation land use effects

Most of the lengths of proposed and alternative pipeline alignments would be within existing road rights-of-way. The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed and alternative pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which could cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, could temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow could be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of the proposed project and alternatives. The Applicant is coordinating with WDOT and local municipalities for requirements for work within road rights-of-way and also to generate traffic detours where necessary to handle the diverted traffic during pipeline construction.

5.1.10.2 Agricultural land use effects

Potential adverse impacts to agricultural lands could include mixing of topsoil and subsoil, soil erosion and runoff, reduced productivity, damage to drain tile, crop loss, and loss of farming acreage.

Permanent loss of agricultural acreage would occur at the proposed BPS Facility site at the intersection of South Racine Avenue and South Swartz Road in Minooka Park where facilities are proposed.

The pipeline alternatives would result in loss of agricultural acreage at the RFDS where the proposed RFCB and outfall structures are proposed to be constructed. Agricultural lands enrolled in Farmland Preservation Programs would not be affected.

Impacts to agricultural lands would be minimized and mitigated as much as practicable. Construction site BMPs for agricultural lands would be implemented to minimize impacts and maintain agricultural productivity. Agricultural lands would be revegetated.

Construction on agricultural land that is not being transitioned to a new land use, would be carefully managed to minimize impacts to the productive capacity of the land after construction by using appropriate construction and restoration techniques. The following types of BMPs would be used during construction in agricultural areas, as appropriate, to minimize impacts and maintain agricultural productivity:

- Segregating topsoil by stripping it from the construction work area and storing it near the trench in a way that prevents it from becoming intermixed with subsoil materials.
- Storing subsoil materials separately and removing larger rocks that become exposed during excavation activities.
- Implementing soil erosion and sediment controls to minimize the transport of topsoil during disturbing conditions. These may include leaving crops such as small grains with limited biomass in place to minimize soil transport, minimizing the duration of disturbance, restoring the ROW to its preconstruction elevation, stabilizing exposed soils, and revegetating areas as soon as possible. Temporarily suspending construction during wet weather conditions to reduce the potential for soil compaction. Alternatively, corrective deep tillage measures may be used to restore the productivity of compacted soils.
- During backfilling, compact subsoil in the trench before placing the topsoil to prevent crowning.
- Removing construction debris to avoid it being dispersed into agricultural fields.
- If field drainage tiles are encountered during pipeline trench construction, they will be marked, and damaged tiles repaired by replacing damaged drain tile pipes with the same size replacement pipe prior to trench backfilling.
- Minimizing interruptions to field access during construction and restoring access areas between roads and fields that are disturbed during construction.

A Wisconsin DATCP AIS is required under Wisconsin Statute 32.035(4)(a) "if the project involves the actual or potential exercise of the powers of eminent domain and if any interest in more than 5 acres of any farm operation may be taken. DATCP may prepare an AIS on a project located entirely within the boundaries of a city, village, or town or involving any interest in five or fewer acres of any farm operation if the condemnation would have a significant effect on any farm operation as a whole." An AIS will not be required for the proposed project because it would not impact more than five acres of farm operations. Obtaining the areas currently farmed for use in pipeline easements and facility sites is not expected to require the use of eminent domain.

For the proposed pipelines and alternatives, no Farmland Preservation lands within Milwaukee County or Waukesha County will be impacted.

5.1.11 Cultural resource effects

The City has retained the services of a cultural resource management firm to aid in route impact analysis, and in anticipation of permit requirements at a state and federal level. The investigation was conducted in accordance with the Guidelines for Public Archeology in Wisconsin (Guide). A literature and archives review for historic structures, archaeological sites, and burial sites (i.e., cultural resources/historic properties) was conducted for all proposed routes and structures. The review describes where historic properties overlap the various route alternatives, provides relevant information on the importance of each site as it relates to the route(s), and recommends ways to minimize effects that planned construction may have on a historic property. In addition to the resources that overlap with corridors utilized by route alternatives, cultural resources within 50 feet of the right-of-way and 100 feet of the right-of-way were also reviewed. While these resources would not be affected by the proposed project as it is currently designed, future redesign of the proposed corridors and design of access roads may affect them. Field survey and reporting based on proposed final route alternatives is in progress to fulfill requirements pertaining to Section 106 of the National Historic Preservation Act. Section 106 is a federal process including opportunities for consultation with tribal interests and other stakeholders, as well as addressing mitigation measures for potential adverse effects to historic properties.

The U.S. Army Corps of Engineers is the lead federal agency in guiding the Section 106 process, and will coordinate reviews and guidance for potential mitigation measures with the Wisconsin State Historic Preservation Office.

5.1.11.1 Cultural resources review of proposed facilities sites

The location of proposed facilities associated with the Program were assessed separately from the overall pipeline alternatives (reference: 4-250 D1 Phase I Cultural Resources Survey Results).

Wastewater treatment plant and return flow pumping station

No previously recorded historic properties are coincident with the proposed wastewater treatment plant facilities and return flow pumping station. The footprint for these facilities was subjected to Phase I shovel testing, and no cultural material was identified.

Booster pumping station

No previously recorded historic properties are coincident with the proposed booster pumping station. The facility's footprint was subjected to Phase I shovel testing and surface collection, resulting in the identification of two new archaeological sites. The draft cultural resources report (4-250 D1 Phase I Cultural Resources Survey Results) identifies the sites as not eligible for the National Register of Historic Places, and no further testing was recommended.

Return flow discharge site

Two archaeological sites overlap the return flow discharge site (RFDS). Archaeological survey within the facility's footprint identified one new archaeological site and revised the location of a previously documented site based on the identification of a surface scatter of material in a plowed field. The draft cultural resources report (4-250 D1 Phase I Cultural Resources Survey Results) identifies the sites as not eligible for the National Register of Historic Places, and no further testing was recommended.

Water supply control buildings and water supply pumping stations

No previously recorded historic properties are coincident with the proposed water supply Control buildings and water supply pumping stations. The facility's footprint was subjected to Phase I shovel testing, and no cultural material was identified.

5.1.12 Population effects

All of the water supply alternatives are designed to meet the projected water demand of 8.2 MGD at build-out within the diversion area approved by the Compact Council (2016). This area corresponds approximately to the City of Waukesha's corporate boundaries plus internal "islands" of the Town of Waukesha. The Southeastern Wisconsin Regional Planning Commission (SEWRPC) projected that the population of this area, at build-out, will be 76,330 (CH2M Hill 2013, Vol. 2, Appendix C). The estimated population of the City of Waukesha in 2018 was 71,731 (Demographic Services Center 2019). There are no projections of how the proposed diversion might affect the rate of population growth within the diversion area – relative to the 'no action' alternative – or what if any impact the diversion could have on the population of surrounding communities outside of the diversion area. None of the alternative water supply or return flow routes would displace any residents.

5.1.13 Public water supply and use effects

No changes in water use sectors are expected with the currently proposed project. Water use by residential, commercial, and industrial sectors is not dependent upon water source. Instead, water use will change over time due to varying factors such regional economic conditions, impacts from water conservation, and climatic conditions.

5.1.14 Socioeconomic effects and environmental justice

Building the infrastructure for the current proposal would provide economic benefits to the pipeline construction industry. Operational costs to the Applicant and payments to the City of Milwaukee would increase incrementally as water volume use increases with increasing population and economic development in the City of Waukesha. The Applicant's projected average daily water demand of 8.2 MGD at build-out assumes strong economic conditions and industrial demand (CH2M Hill 2013, Vol. 2, Chapter 6). Construction and operational costs would be borne by Waukesha Water Utility rate payers.

The UW-Milwaukee's Center for Economic Development (CED) conducted a socioeconomic impact analysis of the regional water supply plan (RWSP) for Southeastern Wisconsin (Rast and Madison 2010). This analysis looked at the potential impacts of implementing the RWSP recommendation that nine communities, including the City of Waukesha, switch from relying on groundwater to relying on Lake Michigan.

CED's analysis relied on SEWRPC's Regional Land Use Plan (RLUP) and relevant local and countywide comprehensive plans, including planned land use. Plans were evaluated in order to understand how the recommendations set forth in the RWSP would impact development and land use. Existing and planned land uses for specific communities were examined in order to determine whether land use patterns in areas proposed for expansion or conversion under the RWSP could have an impact on environmental justice. Job projections and population projections by race, ethnicity, and disability for the year 2035 were also evaluated.

Over the past 50 years, there has been an outward migration of population and jobs from the large lakeshore manufacturing cities to the outlying counties and suburbs. The loss of an economy based on manufacturing and the movement of economic and development activity inland negatively impacted jobs and income in the central city areas. A substantial increase in the number and percent of people living at or below the poverty level has occurred in the Kenosha, Milwaukee, and Racine while it has declined in many suburban communities. Racial and ethnic minority and low-income populations have been disproportionately affected. These populations have become increasingly concentrated in Kenosha, Milwaukee, and Racine.

If trends continue, migration of the White Alone, Non-Hispanic populations from Milwaukee and Racine will continue to contribute to growth in suburban areas. White Alone populations in Kenosha and Waukesha are expected to decline in number and proportion while being offset by increases in minority populations that will result in the population growth of those cities.

USGS and SEWRPC studies indicate that groundwater issues are not currently a constraint on development in the region, and that the source of water would not have an impact on development.

CED's land use analysis found that the delineations of the existing and proposed utility service areas in the RLUP include lands that are mostly either currently developed or undevelopable. The land use analysis also found that most of the undeveloped land within the projected service areas is primarily infill development. Growth is limited under the RWSP to the existing development and infill developable areas within the proposed expanded water utility service areas. Therefore, it is not anticipated that projected population growth or the distribution of ethnic and racial minorities will be significantly affected by implementation of the recommendation to change sources of water supply.

Based on the land use findings, CED concluded that it is unlikely that a change in water source from groundwater to Lake Michigan water would yield any significant socio-economic imbalances through 2035 (Rast and Madison 2010).

A limitation of the socio-economic impact study conducted by Rast and Madison (2010) is that it did not consider environmental justice impacts associated with the return of treated wastewater to Lake Michigan via the Root River. While the principle benefits of the proposed diversion would accrue to the City of Waukesha and its residents, the potential environmental and human health impacts of returning treated wastewater via the Root River (detailed in Section 5.1.2.1) would disproportionately affect low-income and minority communities and individuals (e.g., people fishing and wading in the river at public parks) within the fiscally-constrained City of Racine.

5.2 Environmental effects of the proposed supply pipeline (M1-preferred)

5.2.1 Inland waterway effects of the proposed supply pipeline

The right-of-way of the proposed supply pipeline would cross seven navigable waterways, including the Root River, Honey Creek and five unnamed tributary streams. The proposed supply pipeline would not cross any outstanding or exceptional resource waters, trout streams, or wild or scenic rivers. Table 5-5 lists the waterbodies that would be crossed by the proposed supply pipeline construction corridor and the crossing methodology.

Table 5-5. Proposed supply pipeline (M1-preferred) waterway crossings and methodology

Total crossings	Ryan Creek	Mill Creek	Pebble Brook	Root River	Oak Creek	Honey Creek	Other unnamed crossings
7	--	--	--	1	--	1	5

Waterway Name	Location	Crossing Method
UNT to Poplar Creek	W. Coffee Road	HDD
UNT to Polar Creek	W. National Ave.	HDD
UNT to Root River	W. National Ave.	Trench under Culvert
UNT to Root River	National/Oklahoma Ave.	HDD
Root River	W. Oklahoma Ave.	HDD
UNT to Honey Creek	W. Oklahoma Ave.	Trench under Culvert
Honey Creek	W. Oklahoma Ave.	Jack and Bore

Source: Great Water Alliance via Jacobs Engineering Group (email June 12, 2019).

5.2.2 Endangered resources effects of the proposed supply pipeline

A desktop review of endangered biological resources was conducted by the Applicant. The desktop review included spatially locating the number of elemental occurrences (EOs) for terrestrial and wetland resources within one mile of each pipeline route, and aquatic resources within two miles of each pipeline route. EOs are defined as the rare, threatened, and endangered species and natural communities included in the State of Wisconsin's NHI database. EOs were further broken down into whether the EO would likely be impacted or not, and if impacted, if a measure is required or recommended to avoid, minimize or mitigate effects on the EO. Measures were classified as: required measures for state-listed endangered and threatened animal species, and recommended measures for state listed plant, natural communities, and state special concern special concern animals. Table 5-6 presents this information for the proposed supply pipeline.

Portions of this proposed pipeline also cross the federally-regulated Rusty-Patched Bumblebee High Potential Zone, and additional actions may be necessary if suitable habitat is present.

Table 5-6. Proposed supply pipeline (M1-preferred) endangered resources summary

Route	EOs[1] with no impact	EOs with required measures	EOs with recommended measures	Total EOs
M1-preferred	2	0	6	8

[1] Element occurrences.

5.2.3 Wetland effects of the proposed supply pipeline

Initially, the Applicant used the Wisconsin Wetland Classification System (WWI) and air photo interpretation to determine wetland effects. Wetlands were surveyed and field-verified by the Applicant prior to their submittal of the waterways and wetlands permit application.

The Water Supply Pipeline will temporarily impact 1.09 acres of wetland. This is a result of cutting a trench to install the pipeline, material staging, soils stockpiling and construction access. Temporary impacts to wetlands including Fresh (wet) Meadow, Deep and Shallow Marsh, and Wet to Wet-Mesic Prairie will be 1.04 acres. Temporary impacts that result in conversion from a shrub or forested wetland to an emergent-type wetland will be 0.05 acres. There is 9 square feet of permanent impact for the installation of a manhole and an air valve.

Table 5-7 lists numbers and acreage of affected wetlands field-verified by the Applicant. See also Section 5.1.6 and 5.1.10 for general wetland and land use impacts.

Table 5-7. Wetlands affected by the proposed water supply pipeline (M1-preferred)

	ROW			Easement		
Wetland	**Temporary Impact**	**Temporary Conversion**[1]	**Permanent Impact**	**Temporary Impact**	**Temporary Conversion**[2]	**Permanent Impact**
Number	7	2	1	0	0	0
Area (ac)	1.04	0.05	<0.01	0	0	0
Type (ac)						
EWM [2]	1.04	0	<0.01	0	0	0
Scrub/shrub	0.00	0.05	0.00	0	0	0
Forested	0	<0.01	0	0	0	0

[1] Conversion from a Shrub or Forested Wetland including Shrub-Carr, Floodplain Forest, and Hardwood Swamp, to an Emergent Type Wetland
[2] 'EMW' includes Fresh (wet) Meadow, Deep and Shallow Marsh, and Wet to Wet-Mesic Prairie.
Source: Great Water Alliance EIR, March 2018.

5.2.4 Woodland effects of the proposed supply pipeline

Table 5-8 includes information on woodlands that would be affected by the proposed water supply pipeline (M1-preferred).

No significant tracts of forested area are anticipated to be impacted by the proposed supply pipeline. Trees would be removed in the pipeline project footprint along existing road ROW.

See also Section 5.1.8 for woodland effects common to all proposed and alternative pipeline routes.

5.2.5 Upland grassland effects of the proposed supply pipeline

No known tracts of upland grassland area are anticipated to be impacted by the proposed supply pipeline.

5.2.6 Air emission effects of the proposed supply pipeline

The energy used for the proposed supply pipeline would release an estimated 4,300 tons/year (CO_2e) of annual greenhouse gas emissions (Jacobs Engineering Group, Feb. 2019). CO_2e emissions determined by using the value from eGRID2016 of 1251.5 lb. CO_2e /MWh for the Southeast Wisconsin region, which takes into account recent data for the regional electricity generation mix from coal, natural gas, renewables, etc. CO_2e (carbon dioxide equivalent emissions) are calculated based on the global warming potential of CO_2, CH_4, and N_2O. CO_2e emissions for water supply alternatives do not include emissions associated with the production and transportation of chemicals required for drinking water treatment since Milwaukee Water Supply is the same for the three supply route alternatives.

5.2.7 Land use effects of the proposed supply pipeline

The proposed supply pipeline would affect a total of 65.32 acres of land for pipeline construction (acres affected estimated by a 50-foot construction corridor). The land use construction and operation acreage effects of the proposed supply pipeline are listed in Table 5-8.

Table 5-8. Proposed supply pipeline (M1-preferred) ROW land use effects

Land use[1]	Area (ac)	Percent
Residential	2.33	3.56
Commercial & industrial	0.02	0.03
Transportation[2]	58.49	89.26
Utilities	0.04	0.06
Government & institutional	0.01	0.02
Recreation	0.00	0.00
Agricultural[2,3]	2.17	3.31
Open lands[4]	2.26	3.45
Woodlands[2, 5]	0.21	0.32
Totals[6]	65.53	100.00

[1] Represents the total that had a specific land use designation within the SEWRPC Digital Land Use Inventory for Waukesha and Milwaukee Counties.

[2] May include wetlands.

[3] Taken from Table G-3-1 Agricultural Evaluation Summary from GWA documents 4-170 D1 and 4-170 D2 Agricultural Impact Technical Memorandum.

[4] Includes SEWRPC land use categories of unused urban land, unused rural land and wetlands.

[5] Taken from Tables 4. WWI Wetlands Summary by Wetland Class and Table 5 Photo-Interpreted Potential Wetlands by Wetland Class from GWA document 4-130 D3 MKE Routes Wetland Technical Memorandum.

[6] Percentage total includes rounding errors.

5.2.7.1 Transportation land use effects of the proposed supply pipeline

Approximately 89.26 percent of the proposed supply pipeline alignment would be within existing road rights-of-way.

5.2.7.2 Agricultural land use effects of the proposed supply pipeline

Table 5-8 includes agricultural land that would be affected by the proposed supply pipeline. See Section 5.1.10.2 for agricultural land use effects common to all proposed and alternative pipeline routes. The proposed BPS Facility site at the intersection of South Racine Avenue and South Swartz Road in Minooka Park is currently used for row crop farming and would require the conversion of about 2.17 acres of agricultural land to industrial use.

5.2.7.3 Recreation and aesthetic resource effects of the proposed supply pipeline

Table 5-8 indicates no recreational land that would be affected by the proposed supply pipeline.

The proposed supply pipeline would not impact a Coastal Zone Management Area. Visual impacts from the proposed supply pipeline are expected to be minor.

5.2.8 Cultural resource effects of the proposed supply pipeline

Table 5-9 summarizes the results of this cultural resources analysis for the proposed supply pipeline.

Table 5-9. Proposed supply pipeline (M1) cultural resources summary[1]

No. of archaeological sites	No. of burial sites	No. of historic structures	No. NRHP listed
0	1	0	0

[1] Includes sites and structures that would be located within proposed pipeline ROW.

Source: 4-140 D4 MKE 3-Route Cultural Resources TM, June 14, 2018.

One cemetery would overlap the proposed supply pipeline corridor. There are no reported archaeological sites or historic structures that would be within 50 feet of the corridor; and one burial site/cemetery and six historical structures would be between 50 and 100-feet of the corridor. Archaeological survey of the proposed supply pipeline did not identify additional historic properties.

Impacts to cultural resources would be avoided or minimized through the pipeline detailed design process. If impacts cannot be avoided, resources would be treated per Section 106 of the NHPA and in coordination with the SHPO. Potential burial site disturbances must be approved by SHPO prior to the start of project activities.

5.2.9 Costs and energy effects of the proposed supply pipeline

Estimated construction and operational costs for the proposed supply pipeline and associated facilities are presented in Table 2-1 and Table 2-2. The proposed supply pipeline would require 6,900,000 kWh/yr of electrical energy for operation.[15] This estimate assumes future average day demand of 8.2 MGD for the water supply and booster pumping stations.

5.3 Environmental effects of the proposed return flow pipeline (OC3-preferred)

5.3.1 Inland waterway effects of the proposed return flow pipeline

The proposed return flow pipeline (OC3-preferred) would cross sixteen waterways, including: Ryan Creek, Pebble Brook at two locations, Muskego Creek, the Root River, and ten other unnamed tributaries. The non-right-of-way easement crosses one waterway at Ryan Creek. The pipeline impacts for waterways also include crossing the Root River at the proposed outfall site. The proposed return flow pipeline would not cross any outstanding or exceptional resource waters, trout streams, or wild or scenic rivers.

Table 5-10 lists the waterbodies that would be crossed by the proposed supply pipeline construction corridor and the crossing methodology.

[15] Source: Great Water Alliance, February 2019.

Table 5-10. Proposed return flow pipeline (OC3-preferred) waterway crossings and methodology

Total crossings	Ryan Creek	Muskego Creek	Pebble Brook	Root River	Oak Creek	Redwing Creek	Other unnamed crossings
16	1	1	2	2	-	-	10

Waterway Name	Location	Crossing Method	Area of Trenched Crossing
UNT to Pebble Brook	Hwy 59	Trench under culvert	--
Pebble Brook	Hwy 59	HDD	--
UNT to Pebble Brook	Hwy 59	HDD	--
Pebble Brook	Hwy 59	HDD	--
UNT to Muskego Creek	I-43	HDD	--
UNT to Muskego Creek	S Martin Road	Trench	345 sq ft.
Muskego Creek	I-43	HDD	--
Ryan Creek	Ryan Road	HDD	--
UNT to Ryan Creek	Ryan Road	HDD	--
UNT to Ryan Creek	Ryan Road	HDD	--
Root River	Ryan Road	HDD	--
UNT to Root River	Ryan Road	HDD	--
UNT to Root River	S 60th Street	Trench under culvert	--
UNT to Root River	S 60th Street	Trench	357 sq ft.
UNT to Muskego Creek	I-43	Trench	996 sq ft.
Root River[1]	Return Flow Discharge Site (RFDS)	Trench & Permanent Structure	2,349 sq ft.

[1]The Root River at the Return Flow Discharge Site will be impacted by the permanent placement of an outfall structure, grading, placement of a coffer dam, and temporary construction access.

Source: Great Water Alliance via Jacobs Engineering Group (email June 12, 2019).

5.3.2 Endangered resources effects of the proposed return flow pipeline

A desktop review of endangered biological resources was conducted by the Applicant. The desktop review included spatially locating the number of elemental occurrences (Eos) for terrestrial and wetland resources within one mile of each proposed pipeline route, and aquatic resources within two miles of each proposed pipeline route. Eos are defined as the rare, threatened, and endangered species and natural communities included in the State of Wisconsin's NHI database. Eos were further broken down into whether the EO would likely be impacted or not, and if impacted, if a measure is required or recommended to avoid, minimize or mitigate effects on the EO. Measures were classified as: required measures for state-listed endangered and threatened animal species, and recommended measures for state listed plant, natural communities, and state special concern animals. Table 5-11 presents this information for this alternative.

Table 5-11. Proposed return flow pipeline (OC3-preferred) endangered resources summary

Eos[1] with no impact	Eos with required measures	Eos with recommended measures	Total Eos
7	6	18	31

[1] Element occurrences.

Source: Great Water Alliance EIR, March 2018.

5.3.3 Wetland effects of the proposed return flow pipeline

Initially, the Applicant determined wetland effects using the Wisconsin Wetland Classification System (WWI) and air photo interpretation. The Applicant later surveyed and field-verified wetlands for their submittal of a waterways and wetlands permit application. The wetland effects described in this section are based on the latter survey and field verification.

The proposed return flow pipeline would temporarily impact 6.83 acres of wetlands and permanently impact less than 0.01 acres. These totals include the 0.94 acres of wetland impacts at the return flow discharge site (RFDS), as discussed in Section 5.1.6. Wetlands impacts would result from excavating a trench to install the pipeline, material staging, soil stockpiling, and construction access to the various workspaces. Table 5-12 lists the number and acreage of wetlands affected by the proposed return flow pipeline including the RFDS. Within the ROW, 0.51 acres of forested wetland and 0.18 acres of scrub/shrub wetlands would be temporarily converted to emergent wetlands, while an additional 0.08 acres of scrub/shrub wetlands would be converted within the easement.

Table 5-12. Wetlands affected by the proposed return flow pipeline

	ROW			Easement		
Wetland	Temporary Impact	Temporary Conversion[1]	Permanent Impact	Temporary Impact	Temporary Conversion	Permanent Impact
Number	69	19	1	8	1	0
Area (ac)	5.33	0.69	<0.01	0.72	0.08	0
Type (ac)						
EWM [2]	5.33	0	<0.01	0.72	0	0
Scrub/shrub	0	0.18	0	0.00	0.08	0
Forested	0	0.51	0	0	0	0

[1] Conversion from a Shrub or Forested Wetland including Shrub-Carr, Floodplain Forest, and Hardwood Swamp, to an Emergent Type Wetland

[2] Includes Fresh (wet) Meadow, Deep and Shallow Marsh, and Wet to Wet-Mesic Prairie

Source: Great Water Alliance EIR, March 2018.

5.3.4 Woodland effects of the proposed return flow pipeline

Table 5-13 includes information on woodlands that would be affected by the proposed return flow pipeline.

No significant tracts of forested area are anticipated to be impacted by the proposed return flow pipeline. Trees would be removed in the pipeline project footprint along existing road ROW.

Some tree removal would be required where the proposed return flow pipeline easements would be obtained, although the predominant land use in the easements is agricultural row crops. Some tree removal would be required for this alternative's pipeline easement near the I-43 crossing located on the easement 1,330 feet southwest of the intersection of West Small Road and South Westridge Drive, proposed easements east of the intersection of West Ryan Road and 112th Street, and the proposed easement 300 feet south of the intersection of West Salentine Drive and South Calhoun Road.

See also Section 5.1.8 for woodland effects common to all proposed and alternative pipeline routes.

5.3.5 Upland grassland effects of the proposed return flow pipeline

No known tracts of upland grassland area are anticipated to be impacted by the proposed return flow pipeline.

5.3.6 Air emission effects of the proposed return flow pipeline

The energy used for the proposed return flow route would release an estimated 2,300 tons/year (CO_2e) of annual greenhouse gas emissions (Jacobs Engineering Group, Feb. 2019). CO_2e emissions determined by using the value from eGRID2016 of 1251.5 lb. CO_2e /MWh for the Southeast Wisconsin region, which takes into account recent data for the regional electricity generation mix from coal, natural gas, renewables, etc. CO_2e (carbon dioxide equivalent emissions) are calculated based on the global warming potential of CO_2, CH_4, and N_2O.

5.3.7 Land use effects of the proposed return flow pipeline

The proposed return flow pipeline would affect a total of 132.42 acres of land for pipeline construction (acres affected estimated by a 50-foot construction corridor).

The land use construction and operation acreage effects of the proposed return flow pipeline are listed in Table 5-13.

Table 5-13. Proposed return flow pipeline (OC3-preferred) ROW land use effects

Land use[1]	Area (ac)	Percent
Residential	3.12	2.36
Commercial & industrial	0.59	0.45
Transportation[2]	121.69	91.90
Utilities	1.00	0.76
Government & institutional	0.26	0.20
Recreation	1.10	0.83
Agricultural[2,3]	0.00	0.00
Open lands[4]	4.14	3.13
Woodlands[2,5]	0.48	0.36
Totals[6]	132.42	100.02

[1] Represents the total that had a specific land use designation within the SEWRPC Digital Land Use Inventory for Waukesha and Milwaukee Counties.

[2] May include wetlands.

[3] Taken from Table G-3-1 Agricultural Evaluation Summary from GWA documents 4-170 D1 and 4-170 D2 Agricultural Impact Technical Memorandum.

[4] Includes SEWRPC land use categories of unused urban land, unused rural land and wetlands.

[5] Taken from Tables 4. WWI Wetlands Summary by Wetland Class and Table 5 Photo-Interpreted Potential Wetlands by Wetland Class from GWA document 4-130 D3 MKE Routes Wetland Technical Memorandum.

[6] Percentage total includes rounding errors.

Sources: Land use data: SEWRPC (2010). Analysis: Jacobs Engineering Group (email dated Nov. 1, 2018).

5.3.7.1 Transportation land use effects of the proposed return flow pipeline

Approximately 91.9 percent of the proposed return flow pipeline's proposed pipeline alignments would be within existing road rights-of-way.

The proposed return flow pipeline would require crossing three railroads (one active, two abandoned). One railroad is owned by CN and the crossing would be approximately 480 feet west of the intersection of South West Avenue and West Sunset Drive. The second railroad is abandoned, and the crossing would be approximately 390 feet north of the intersection of Chapman Drive and Sentry Drive. Both locations are within the City of Waukesha. The third railroad is also abandoned, and the crossing would be approximately 350 feet south of the intersection of Philip Drive and Sentry Drive. Applicable railroad crossing permits would be obtained by the City and construction activities would be coordinated with CN.

5.3.7.2 Agricultural land use effects of the proposed return flow pipeline

Table 5-13 includes agricultural land that would be affected by the proposed return flow pipeline. See Section 5.1.10.2 for agricultural land use effects common to all proposed and alternative pipeline routes.

The Applicant identified agricultural lands initially using aerial imagery. During construction, proposed easement sites east of the intersection of 112th Street and Ryan Road may experience crop loss and loss of agricultural acreage. Proposed construction may also temporarily impact drain tiles. Drain tiles have not been identified in the ROW area, but if affected, they would be replaced with similarly sized drain pipes.

Permanent loss of agricultural acreage would occur in the proposed easement near the I-43 crossing located 1,330 feet southwest of the intersection of West Small Road and South Westridge Drive. Row crop and forested land would be converted for pipeline access along these easements. The proposed RFDS at the intersection of South 60th Street and West Oakwood Road would impact row crop farming.

The proposed return flow pipeline would not intersect agricultural lands enrolled in Farmland Preservation Programs.

5.3.7.3 Recreation and aesthetic resource effects of the proposed return flow pipeline

Table 5-13 includes the 1.10 acres of recreational land that would be affected by the proposed return flow pipeline. Recreational lands include Minooka Park, Moorland Park, Muskego Recreational Trail and Valley Green Golf Course.

Minooka Park is a 579-acre recreational area maintained by the Waukesha County Park System located in the Cities of New Berlin and Waukesha in eastern Waukesha County. The park features a dog run, an archery range, a swimming beach, picnic areas, dog exercise areas, mountain bike trails, and a variety of sports fields.

Moorland park is a 37-acre recreational and conservation area maintained by the City of Muskego Parks and Recreation Department located in the city of Muskego in southeastern Waukesha County. The park includes soccer field, picnic areas, and walking trails as well as a small conservation area planted with prairie vegetation that provides opportunities for birding and nature watching.

The Muskego Recreation Trail is a 6.7-mile mixed use trail maintained running through a We Energies located in the City of Muskego corridor in south-eastern Waukesha County. The trail offers opportunities for birding, hiking, running, and biking.

Valley Green Golf Course is a private 12-acre property located along North Cape Road located in the City of Muskego in south-eastern Waukesha County. The property operates as a 9-hole par 3 golf course as well as a restaurant and tavern. The golf course is east of the proposed pipeline alignment.

All recreation effects are expected to be temporary during construction.

The proposed return flow pipeline would not impact a Coastal Zone Management Area. Visual impacts from the proposed return flow pipeline are expected to be minor.

5.3.8 Cultural resource effects of the proposed return flow pipeline

Table 5-14 summarizes the results of the cultural resources analysis for the proposed return flow pipeline.

Table 5-14. Proposed return flow pipeline (OC3-preferred) cultural resources summary[1]

No. of archaeological sites	No. of burial sites	No. of historic structures	No. NRHP listed
4	8	20	0

[1] Includes sites and structures that would be located within proposed pipeline ROW.

Source: Clean Water Alliance 4-140 D1 Cultural Resources, January 2018; 4-250 D1 Phase I cultural resources survey results.

Four archaeological sites, eight burial sites and twenty historic structures would overlap the proposed return flow pipeline corridor. One burial site, and 13 historic structures would be located within 50 feet of the route alternative corridor. Two archaeological sites and six historic structures would be between 50 feet and 100 feet of the proposed route. No cultural resources would overlap the proposed return flow pipeline easement corridor. Archaeological survey of the proposed return flow pipeline did not identify cultural material.

Impacts to cultural resources would be avoided or minimized through the pipeline detailed design process. If impacts cannot be avoided, resources would be treated per Section 106 of the NHPA and in coordination with the SHPO. Potential burial site disturbances must be approved by SHPO prior to the start of project activities.

5.3.9 Costs and energy effects of the proposed return flow pipeline

Estimated construction and operational costs for the proposed return flow pipeline route and associated facilities are presented in Table 2-1 and Table 2-2. The proposed return flow pipeline would require 3,700,000 kWh/yr of electrical energy for operation.[16] This estimate assumes an average return of up to 9.3 MGD, at build-out, for the return flow pump station.

5.4 Environmental effects of the alternative M2 supply pipeline

5.4.1 Inland waterway effects of the M2 supply pipeline

The right-of-way and proposed easements for Milwaukee supply route alternative M2 would cross nine waterways, including the Root River and seven unnamed tributary streams. There would be approximately 0.0.12 miles of waterway crossings within the supply pipeline right-of-way and 0.03 miles of waterway crossings in the proposed easements (Clean Water Alliance, PAA, January 2019).

[16] Source: Great Water Alliance, February 2019.

This alternative pipeline would not cross any outstanding or exceptional resource waters, trout streams, or wild or scenic rivers.

Table 5-15 lists the waterbodies that would be crossed by this alternative supply pipeline.

Table 5-15. Milwaukee supply route alternative M2 waterway crossings

Total crossings	Ryan Creek	Mill Creek	Pebble Brook	Root River	Oak Creek	Redwing Creek	Other unnamed crossings
8	--	--	--	1	--	--	7

Source: Great Water Alliance, WWIPA, PAA, January 2019.

Data based on NHD = U.S. Geological Survey – National Hydrography Dataset

5.4.2 Endangered resources effects of the M2 supply pipeline

A desktop review of endangered biological resources was conducted by the Applicant. The desktop review included spatially locating the number of elemental occurrences (Eos) for terrestrial and wetland resources within one mile of each pipeline route, and aquatic resources within two miles of each pipeline route. Eos are defined as the rare, threatened, and endangered species and natural communities included in the State of Wisconsin's NHI database. Eos were further broken down into whether the EO would likely be impacted or not, and if impacted, if a measure is required or recommended to avoid, minimize or mitigate effects on the EO. Measures were classified as: required measures for state-listed endangered and threatened animal species, and recommended measures for state listed plant, natural communities, and state special concern animals. Table 5-16 presents this information for the proposed supply pipeline.

Table 5-16. Milwaukee supply route alternative M2 endangered resources summary

Eos[1] with no impact	Eos with required measures	Eos with recommended measures	Total Eos
1	0	3	4

[1] Element occurrences.

Source: Great Water Alliance 4-130 D6 Endangered Resources TM 2018-02-02.

5.4.3 Wetland effects of the M2 supply pipeline

The Applicant used the Wisconsin Wetland Classification System (WWI) and air photo interpretation to determine wetland effects. Wetlands effects include the length of route alternative M2, which is 10.50 miles and excludes the Common Route corridor.

The right-of-way and easement for M2 contains a total of 70 potential wetlands based on 11 mapped WWI wetlands and 59 photo-interpreted wetlands. There are 0.23 acres of mapped wetlands per the WWI data, including the approximately 0.07-acre wetland in the proposed easements and an additional 1.14 acres of potential wetlands, based on desktop photo-interpretation. Of the mapped wetlands, approximately 83 percent are herbaceous plant-dominated wetlands and 17 percent are partially or fully forested or shrub-dominated wetlands (Clean Water Alliance, PAA, January 2019).

Impacts to wetland habitat used by state or federally designated threatened or endangered species could also occur. Both are a special natural resource according to Wis. Adm. Code Ch. NR 103.04. Thus, the proposed project may impact wetlands of special natural interest.

Table 5-17 lists numbers and acreage of wetlands that would be affected in the ROW and work buffer, as well as wetland acreage by wetland type for this alternative supply pipeline. Construction-related wetland impacts would likely be less. See also Section 5.1.6 and 5.1.10 for general wetland and land use impacts.

Table 5-17. Wetlands affected by Milwaukee supply route alternative M2 pipeline

	ROW[1]			Easement			Buffer[2]			Total all
Wetland	**WWI[3]**	**API[4]**	**Total**	**WWI**	**API**	**Total**	**WWI**	**API**	**Total**	
Number	10	59	69	1	0	1	16	39	55	125
Area (ac)	0.16	1.14	1.37	0.07	0.00	0.07	3.36	0.85	4.21	5.65
Type (ac)										
EWM[5]	0.08	0.98	1.07	0.07	0.00	0.07	0.55	0.54	1.04	2.18
Scrub/shrub	0.00	0.13	0.13	0.00	0.00	0.00	0.30	0.01	0.31	0.44
Forested	0.12	0.04	0.16	0.00	0.00	0.00	0.88	0.29	1.17	1.33
Open water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Other[6]	0.03	0.00	0.03	0.00	0.00	0.00	1.79	0.00	1.79	1.82

[1] Excludes common corridor. The construction corridor, 50 feet in width.
[2] Additional 50 feet of width beyond the ROW.
[3] Wisconsin Wetland Inventory.
[4] Air photo interpreted.
[5] Emergent/Wet Meadow.
[6] Combinations of wetland categories, flats and unvegetated wet soil, and filled wetland.
Source: Analysis: Jacobs, Email dated November 1, 2018.

5.4.4 Woodland effects of the M2 supply pipeline

Woodland effects of Milwaukee supply route alternative M2. Table 5-18 includes information on woodlands that would be affected by this alternative supply pipeline.

No significant tracts of forested area are anticipated to be impacted by this alternative supply pipeline. Trees would be removed in the proposed project footprint along existing road ROW.

Some tree removal would be required where pipeline easements would be obtained, although the predominant land use in the easements is agricultural row crops.

See also Section 5.1.8 for woodland effects common to all proposed and alternative pipeline routes.

5.4.5 Upland grassland effects of the M2 supply pipeline

No known tracts of upland grassland area are anticipated to be impacted by this alternative.

5.4.6 Air emission effects of the M2 supply pipeline

The energy used for the M2 pipeline would release an estimated 4,300 tons/year (CO_2e) of annual greenhouse gas emissions (Jacobs Engineering Group, Feb. 2019). CO_2e emissions determined by using the value from eGRID2016 of 1251.5 lb. CO_2e /MWh for the Southeast Wisconsin region, which takes into account recent data for the regional electricity generation mix from coal, natural gas, renewables, etc. CO_2e (carbon dioxide equivalent emissions) are calculated based on the global warming potential of CO_2, CH_4, and N_2O. CO_2e emissions for water supply alternatives do not include emissions associated with the production and transportation of chemicals required for drinking water treatment since M2 is the same for the three supply route alternatives.

5.4.7 Land use effects of the M2 supply pipeline

This alternative supply pipeline would affect a total of 62.97 acres of land for pipeline construction (acres affected estimated by a 50-foot construction corridor). The land use construction and operation acreage effects of this alternative are listed in Table 5-18.

Table 5-18. Milwaukee supply route alternative M2 ROW land use effects

Land use[1]	Area (ac)	Percent
Residential	1.30	1.63
Commercial & industrial	0.08	0.13
Transportation[2]	58.25	92.40
Utilities	0.00	0.00
Government & institutional	2.80	4.45
Recreation	0.00	0.00
Agricultural[2,3]	0.00	0.00
Open lands[4]	0.44	0.70
Woodlands[2,5]	0.16	0.25
Totals[6]	63.03	100.00

[1] Represents the total that had a specific land use designation within the SEWRPC Digital Land Use Inventory for Waukesha and Milwaukee Counties.

[2] May include wetlands.

[3] Taken from Table G-3-1 Agricultural Evaluation Summary from GWA documents 4-170 D1 and 4-170 D2 Agricultural Impact Technical Memorandum.

[4] Includes SEWRPC land use categories of unused urban land, unused rural land and wetlands.

[5] Taken from Tables 4. WWI Wetlands Summary by Wetland Class and Table 5 Photo-Interpreted Potential Wetlands by Wetland Class from GWA document 4-130 D3 MKE Routes Wetland Technical Memorandum.

[6] Percentage total includes rounding errors.

Sources: Land use data: SEWRPC (2010). Analysis: Jacobs Engineering Group (email dated November 1, 2018.)

5.4.7.1 Transportation land use effects of the M2 supply pipeline

Approximately 92.50 percent of this alternative's pipeline alignments would be within existing road rights-of-way.

5.4.7.2 Agricultural land use effects of the M2 supply pipeline

Table 5-18 includes agricultural land that would be affected by this alternative supply pipeline. Within the ROW, this pipeline would have no effects to agricultural land use. No permanent loss of agricultural acreage is expected. See Section 5.1.10.2 for agricultural land use effects common to all proposed and alternative pipeline routes.

5.4.7.3 Recreation and aesthetic resource effects of the M2 supply pipeline

No recreational lands would be impacted by M2. Recreation and aesthetic resource effects of Milwaukee Supply Route alternative M2 (Table 5-18).

This alternative would not impact a Coastal Zone Management Area. Visual impacts from the proposed supply and corresponding return flow alternative are expected to be minor.

5.4.8 Cultural resource effects of the M2 supply pipeline

Table 5-19 summarizes the results of this cultural resources analysis for this alternative.

Table 5-19. Milwaukee supply route alternative M2 cultural resources summary[1]

No. of archaeological sites	No. of burial sites	No. of historic structures	No. NRHP listed
0	2	0	0

[1] Includes sites and structures that would be located within proposed pipeline ROW.

Two burial sites would overlap M2, one historical structure would be within 50-feet of the pipeline corridor; and three historical structures would be between 50 and 100-feet of the corridor.

Impacts to cultural resources would be avoided or minimized through the pipeline detailed design process. If impacts cannot be avoided, resources would be treated per Section 106 of the NHPA and in coordination with the SHPO. Potential burial site disturbances must be approved by SHPO prior to the start of project activities. If the route is selected, Phase I cultural resources survey of the route would be required to comply with Section 106.

5.4.9 Costs and energy effects of the M2 supply pipeline

Estimated construction and operational costs for this alternative supply pipeline route and associated facilities are presented in Table 3-2.

The M2 supply pipeline alternative would require 6,900,000 kWh/yr of electrical energy for operation.[17] This estimate assumes future average day demand of 8.2 MGD for the water supply and booster pumping stations.

5.5 Environmental effects of the alternative M3 supply pipeline

5.5.1 Inland waterway effects of the M3 supply pipeline

The right-of-way and proposed easements for Milwaukee supply route alternative M3 would cross eight waterways, including the Root River and seven unnamed streams. There would be approximately 0.16 miles of waterway crossings within the supply pipeline right-of-way. There are no waterways within the proposed easements for this alternative (Clean Water Alliance, PAA, January 2019).

This alternative pipeline would not cross any outstanding or exceptional resource waters, trout streams, or wild or scenic rivers.

Table 5-20 lists the waterbodies that would be crossed by this alternative supply pipeline.

Table 5-20. Milwaukee supply route alternative M3 pipeline waterway crossings

Total Crossings	Ryan Creek	Mill Creek	Pebble Brook	Root River	Oak Creek	Redwing Creek	Other unnamed crossings
8	-	-	-	1	-	-	7

Source: Great Water Alliance EIR and WWIPA, January 2019. Data based on NHD = U.S. Geological Survey – National Hydrography Dataset.

5.5.2 Endangered resources effects of the M3 supply pipeline

A desktop review of endangered biological resources was conducted by the City. The desktop review included spatially locating the number of elemental occurrences (EOs) for terrestrial and wetland resources within one mile of each proposed pipeline route, and aquatic resources within

[17] Source: Great Water Alliance, February 2019.

two miles of each proposed pipeline route. EOs are defined as the rare, threatened, and endangered species and natural communities included in the State of Wisconsin's NHI database. EOs were further broken down into whether the EO would likely be impacted or not, and if impacted, if a measure is required or recommended to avoid, minimize or mitigate effects on the EO. Measures were classified as: required measures for state-listed endangered and threatened animal species, and recommended measures for state listed plant, natural communities, and state special concern animals. Table 5-21 presents this information for the proposed project.

Table 5-21. Milwaukee supply route alternative M3 endangered resources summary

EOs[1] with no impact	EOs with required measures	EOs with recommended measures	Total EOs
1	0	2	3

[1] Element occurrence.

Source: Great Water Alliance 4-130 D6 Endangered Resources TM 2018-02-02.

5.5.3 Wetland effects of the M3 supply pipeline

The Applicant used the Wisconsin Wetland Classification System (WWI) and air photo interpretation to determine wetland effects. Wetlands effects include the length of Route alternative M3 which is 11.50 miles and excludes the Common Route corridor, where the water supply pipeline is collated with the return flow pipeline.

The right-of-way and proposed easements for alternative M3 contains a total of 110 potential wetlands based on 15 mapped WWI wetlands and 95 photo-interpreted wetlands. There are 0.44 acres of mapped wetlands per the WWI data and an additional 2.45 acres of potential wetlands based on desktop photo-interpretation. Of the mapped wetlands, approximately 88 percent are herbaceous plant-dominated wetlands and 12 percent are partially or fully-forested or shrub-dominated wetlands. There are no mapped WWI or photo-interpreted wetlands within the proposed easements (Clean Water Alliance, PAA, January 2019).

Impacts to wetland habitat used by state or federally designated threatened or endangered species could also occur. Both are a special natural resource according to Wis. Adm. Code Ch. NR 103.04. Thus, the proposed project may impact wetlands of special natural interest.

Table 5-22 lists numbers and acreage of wetlands that would be affected in the ROW and work buffer, as well as wetland acreage by wetland type for this alternative supply pipeline. Construction-related wetland impacts would likely be less. See also Section 5.1.6 and 5.1.10 for general wetland and land use impacts.

Table 5-22. Wetlands affected by Milwaukee supply route alternative M3 pipeline

	ROW[1]			Easement			Buffer[2]			Total all
Wetland	**WWI[3]**	**API[4]**	**Total**	**WWI**	**API**	**Total**	**WWI**	**API**	**Total**	
Number	15	95	110	0	0	0	25	53	78	188
Area (ac)	0.44	2.45	2.89	0.00	0.00	0.00	4.40	1.46	5.86	8.75
Type (ac)										
EWM[5]	0.12	2.41	2.53	0.00	0.00	0.00	0.49	1.13	1.62	4.15
Scrub/shrub	0.01	0.00	<0.01	0.00	0.00	0.00	0.25	0.06	0.31	0.32
Forested	0.25	0.03	0.28	0.00	0.00	0.00	1.29	0.27	1.56	1.84
Open water	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.01	0.14	0.14
Other[6]	0.07	0.00	0.07	0.00	0.00	0.00	2.24	0.00	2.24	2.31

[1] The construction corridor, 50 feet in width.
[2] Additional 50 feet of width beyond the ROW.
[3] Wisconsin Wetland Inventory.
[4] Air photo interpreted.
[5] Emergent/Wet Meadow.
[6] Combinations of wetland categories, flats and unvegetated wet soil, and filled wetland.
Source: Analysis: Jacobs Engineering Group (email dated November 1, 2018).

5.5.4 Woodland effects of the M3 supply pipeline

Table 5-23 includes information on woodlands that would be affected by this alternative.

No significant tracts of forested area are anticipated to be impacted by this alternative supply pipeline. Trees would be removed in this alternative's project footprint along existing road ROW. Some tree removal would be required where pipeline easements would be obtained, although the predominant land use in the easements is agricultural row crops.

See also Section 5.1.8 for woodland effects common to all proposed and alternative pipeline routes.

5.5.5 Upland grassland effects of the M3 supply pipeline

No known tracts of upland grassland area are anticipated to be impacted by this alternative.

5.5.6 Air emission effects of the M3 supply pipeline

The energy used for the M3 pipeline would release an estimated 4,400 tons/year (CO_2e) of annual greenhouse gas emissions (Jacobs Engineering Group, Feb. 2019). CO_2e emissions determined by using the value from eGRID2016 of 1251.5 lb. CO_2e /MWh for the Southeast Wisconsin region, which takes into account recent data for the regional electricity generation mix from coal, natural gas, renewables, etc. CO_2e (carbon dioxide equivalent emissions) are calculated based on the global warming potential of CO_2, CH_4, and N_2O. CO_2e emissions for water supply alternatives do not include emissions associated with the production and transportation of chemicals required for drinking water treatment since Milwaukee Water Supply is the same for the three supply route alternatives.

5.5.7 Land use effects of the M3 supply pipeline

This alternative supply pipeline would affect a total of 68.62 acres of land for pipeline construction (acres affected estimated by a 50-foot construction corridor). The land use construction and operation acreage effects of this alternative are listed in Table 5-23.

Table 5-23. Milwaukee supply route alternative M3 ROW land use effects

Land use[1]	Area (ac)	Percent
Residential	1.74	2.53
Commercial & industrial	0.17	0.25
Transportation[2]	65.10	94.54
Utilities	0.00	0.00
Government & institutional	0.55	0.80
Recreation	0.00	0.00
Agricultural[2,3]	0.00	0.00
Open lands[4]	1.02	1.48
Woodlands[2,5]	0.28	0.41
Totals[6]	68.86	100.01

[1] Represents the total that had a specific land use designation within the SEWRPC Digital Land Use Inventory for Waukesha and Milwaukee Counties.

[2] May include wetlands.

[3] Taken from Table G-3-1 Agricultural Evaluation Summary from GWA documents 4-170 D1 and 4-170 D2 Agricultural Impact Technical Memorandum.

[4] Includes SEWRPC land use categories of unused urban land, unused rural land and wetlands.

[5]Taken from Tables 4. WWI Wetlands Summary by Wetland Class and Table 5 Photo-Interpreted Potential Wetlands by Wetland Class from GWA document 4-130 D3 MKE Routes Wetland Technical Memorandum.

[6] Percentage total includes rounding errors.

5.5.7.1 Transportation land use effects of the M3 supply route

Approximately 94.54 percent of this alternative's pipeline alignments would be within existing road rights-of-way (ROW).

5.5.7.2 Agricultural land use effects of the M3 supply route

Within the ROW, this alternative pipeline would have no effects to agricultural land use. No permanent loss of agricultural acreage is expected (Table 5-23). See Section 5.1.10.2 for agricultural land use effects common to all proposed and alternative pipeline routes.

5.5.7.3 Recreation and aesthetic resource effects of the M3 supply route

Table 5-23 includes recreational land that would be affected by this alternative.

Above ground construction-related impacts may also occur to state and local public or conservation land and natural, recreational, or scenic areas depending on the final project designs. No permanent aboveground structures are envisioned within such areas.

This alternative would not impact a Coastal Zone Management Area. Visual impacts from the proposed supply and corresponding return flow alternative are expected to be minor.

5.5.8 Cultural resource effects of the M3 supply pipeline

Table 5-24 summarizes the results of this cultural resources analysis for this alternative supply pipeline.

Table 5-24. Milwaukee supply route alternative M3 cultural resources summary[1]

No. of archaeological sites	No. of burial sites	No. of historic structures	No. NRHP listed
1	3	1	0

[1] Includes sites and structures that would be located within proposed pipeline ROW.

One archaeological site, three burial sites, and one historical structure would overlap M3, four historical structures would be within 50-feet of the corridor; and five historical structures would be between 50 and 100-feet of the corridor.

Impacts to cultural resources would be avoided or minimized through the pipeline detailed design process. If impacts cannot be avoided, resources would be treated per Section 106 of the NHPA and in coordination with the SHPO. Potential burial site disturbances must be approved by SHPO prior to the start of project activities. If the route is selected, Phase I cultural resources survey of the route would be required to comply with Section 106.

5.5.9 Costs and energy effects of the M3 supply pipeline

Estimated construction and operational costs for this alternative supply pipeline and associated facilities are presented in Table 3-2.

This alternative supply pipeline would require 7,100,000 kWh/yr of electrical energy for operation.[18] This estimate assumes future average day demand of 8.2 MGD for the water supply and booster pumping stations.

5.6 Environmental effects of the alternative OC2 return flow pipeline

5.6.1 Inland waterway effects of the OC2 return flow pipeline

The right-of-way of this alternative route would cross twelve waterways, including Ryan Creek, Pebble Brook at two locations, the Root River, Oak Creek, and seven other unnamed tributaries. The non-right-of-way easement crosses one waterway at Ryan Creek. Within the right-of-way, non-right-of-way easement, and 50-foot buffer, there are approximately 0.49, 0.01, and 0.61 miles of waterways, respectively (Great Water Alliance, Supplemental EIR, Section 4.1.2). This alternative's proposed pipeline would not cross any outstanding or exceptional resource waters, trout streams, or wild or scenic rivers.

Table 5-25 lists the waterbodies that would be crossed by this alternative's proposed pipeline construction corridor.

Table 5-25. Oak Creek Route Alternative OC2 return flow proposed pipeline waterway crossings

Total crossings	Ryan Creek	Mill Creek	Pebble Brook	Root River	Oak Creek	Redwing Creek	Other unnamed crossings
12	1	--	2	1	1	--	7

Source: 4-130 D1 Wetland and Waterway Technical Memorandum January 2018. Data based on NHD = U.S. Geological Survey – National Hydrography Dataset

5.6.2 Endangered resources effects of the OC2 return flow pipeline

A desktop review of endangered biological resources was conducted by the City. The desktop review included spatially locating the number of elemental occurrences (EOs) for terrestrial and

[18] Source: Great Water Alliance, February 2019.

wetland resources within one mile of each proposed pipeline route, and aquatic resources within two miles of each proposed pipeline route. EOs are defined as the rare, threatened, and endangered species and natural communities included in the State of Wisconsin's NHI database. EOs were further broken down into whether the EO would likely be impacted or not, and if impacted, if a measure is required or recommended to avoid, minimize or mitigate effects on the EO. Measures were classified as: required measures for state-listed endangered and threatened animal species, and recommended measures for state listed plant, natural communities, and state special concern animals. Table 5-26 presents this information for this alternative.

Table 5-26. Oak Creek route alternative OC2 return flow pipeline endangered resources summary

EOs[1] with no impact	EOs with required measures	EOs with recommended measures	Total EOs
11	6	17	34

[1] Element occurrences.

Source: Great Water Alliance EIR, March 2018

5.6.3 Wetland effects of the OC2 return flow pipeline

The Applicant identified affected wetlands based on the Wisconsin Wetland Classification System (WWI) and air photo interpretation. The right-of-way for this alternative return flow pipeline contains a total of 173 potential wetlands based on mapped WWI wetlands (72) and photo-interpreted wetlands (101). There are 13.27 acres of mapped wetlands per the WWI data and an additional 8.78 acres of potential wetlands, based on desktop photo-interpretation. Of these mapped wetland features, approximately 56% are herbaceous plant dominated wetlands, and 44% are partially or fully forested or shrub dominated.

The non-right-of-way easement for this alternative return flow pipeline contains a total of seven potential wetlands based on mapped WWI wetlands (4) and photo-interpreted wetlands (3). There are 0.94 acres of mapped wetlands per the WWI data and an additional 0.05 acres of potential wetlands, based on desktop photo-interpretation. Of these mapped wetland features, the amount of herbaceous plant dominated wetlands is comparable to partially or fully forested or shrub dominated wetlands.

Impacts to wetland habitat used by state or federally designated threatened or endangered species could also occur. Both are a special natural resource according to Wis. Adm. Code Ch. NR 103.04. Thus, the proposed project may impact wetlands of special natural interest.

Table 5-27 lists numbers and acreage of wetlands that would be affected in the ROW and work buffer, as well as wetland acreage by wetland type for this alternative supply pipeline. Construction-related wetland impacts would likely be less.

Table 5-27. Wetlands affected by Oak Creek route alternative OC2 return flow pipeline

	ROW[1]			Easement			Buffer[2]		
Wetland	**WWI[3]**	**API[4]**	**Total**	**WWI**	**API**	**Total**	**WWI**	**API**	**Total all**
Number	72	101	173	5	3	8	114	99	213
Area (ac)[5]	13.27	8.78	22.05	0.94	0.05	0.99	27.68	5.93	33.61
Type (ac)									
EWM[6]	3.65	8.74	12.39	0.00	0.04	0.04	7.88	5.14	13.02
Scrub/shrub	0.09	0.00	0.09	0.00	0.00	0.00	0.32	0.31	0.63
Forested	0.26	0.00	0.26	0.25	0.01	0.26	2.22	0.29	2.51
Open water	0.04	0.02	0.06	0.00	0.00	0.00	1.32	0.12	1.44
Other[7]	9.23	0.00	9.23	0.69	0.00	0.69	15.92	0.05	15.97
Totals[5]	13.27	8.76	22.03	0.94	0.05	0.99	27.66	5.91	33.57

[1] The construction corridor, 50 feet in width

[2] Additional 50 feet of width beyond the ROW.

[3] Wisconsin Wetland Inventory.

[4] Air-photo interpreted.

[5] Variances in acreage totals due to rounding errors.

[6] Emergent/Wet Meadow.

[7] Combinations of wetland categories, flats and unvegetated wet soil, and filled wetland.

Source: Analysis: Jacobs Engineering Group (email dated November 1, 2018).

5.6.4 Woodland effects of the OC2 return flow pipeline

Table 5-28 includes information on woodlands that would be affected by this alternative.

No significant tracts of forested area are anticipated to be impacted by this alternative return flow pipeline. Some trees would be removed in this alternative's footprint along existing road ROW.

5.6.5 Upland grassland effects of the OC2 return flow pipeline

No known tracts of upland grassland area are anticipated to be impacted by this alternative.

5.6.6 Air emission effects of the OC2 return flow pipeline

The energy used for Oak Creek route alternative OC2 would release an estimated 2,100 tons/year (CO_2e) of annual greenhouse gas emissions (Jacobs Engineering Group, Feb. 2019). CO_2e emissions determined by using the value from eGRID2016 of 1251.5 lb. CO_2e /MWh for the Southeast Wisconsin region, which takes into account recent data for the regional electricity generation mix from coal, natural gas, renewables, etc. CO_2e (carbon dioxide equivalent emissions) are calculated based on the global warming potential of CO_2, CH_4, and N_2O.

5.6.7 Land use effects of the OC2 return flow pipeline

This alternative return flow pipeline would affect a total of 124.49 acres of land for pipeline construction. The land use construction and operation acreage effects of the proposed project are listed in Table 5-28.

Table 5-28. Oak Creek route alternative OC2 return flow pipeline ROW land use effects

Land use[1]	Area (ac)	Percent
Residential	3.15	2.53
Commercial & industrial	0.66	0.53
Transportation[2]	113.78	91.40
Utilities	1.00	0.80
Government & institutional	0.26	0.21
Recreation	1.16	0.93
Agricultural[2,3]	0.00	0.00
Open lands[4]	3.65	2.93
Woodlands[2,5]	0.79	0.63
Surface Water[2]	0.04	0.03
Totals[6]	124.49	99.99

[1] Represents the total that had a specific land use designation within the SEWRPC Digital Land Use Inventory for Waukesha and Milwaukee Counties.

[2] May include wetlands.

[3] Taken from Table G-3-1 Agricultural Evaluation Summary from GWA documents 4-170 D1 and 4-170 D2 Agricultural Impact Technical Memorandum.

[4] Includes SEWRPC land use categories of unused urban land, unused rural land and wetlands.

[5] Taken from Tables 4. WWI Wetlands Summary by Wetland Class and Table 5 Photo-Interpreted Potential Wetlands by Wetland Class from GWA document 4-130 D3 MKE Routes Wetland Technical Memorandum.

[6] Percentage total includes rounding errors.

Sources: Land use data: SEWRPC (2010). Analysis: Jacobs Engineering Group (email dated November 1, 2018).

5.6.7.1 Transportation land use effects of the OC2 return flow pipeline

Approximately 91.4 percent of this alternative's pipeline alignments would be within existing road rights-of-way.

5.6.7.2 Agricultural land use effects of the OC2 return flow pipeline

As shown in Table 5-28, no agricultural land use would be affected by this return flow pipeline. See Section 5.1.10.2 for agricultural land use effects common to all proposed and alternative pipeline routes.

5.6.7.3 Recreation and aesthetic resource effects of the OC2 return flow pipeline

Table 5-28 includes 1.16 acres of recreational land that would be affected by this alternative.

Recreational lands include Calhoun Park, Minooka Park, Moorland Park, Muskego Recreational Trail and Valley Green Golf Course.

Calhoun Park is a 56-acre recreational area maintained by City of New Berlin Parks, Facilities, and Grounds Department located in the City of New Berlin in eastern Waukesha County. The park offers a variety of recreational opportunities through its fishing pier, sport fields, playground, picnic areas, a sled hill, and hiking trails.

Minooka Park is a 579-acre recreational area maintained by the Waukesha County Park System located in the Cities of New Berlin and Waukesha in eastern Waukesha County. The park features a dog run, an archery range, a swimming beach, picnic areas, dog exercise areas, mountain bike trails, and a variety of sports fields.

Moorland park is a 37-acre recreational and conservation area maintained by the City of Muskego Parks and Recreation Department located in the city of Muskego in south-eastern Waukesha County. The park includes soccer field, picnic areas, and walking trails as well as a small conservation area planted with prairie vegetation that provides opportunities for birding and nature watching.

The Muskego Recreation Trail is a 6.7-mile mixed use trail maintained running through a We Energies located in the City of Muskego corridor in south-eastern Waukesha County. The trail offers opportunities for birding, hiking, running, and biking.

Valley Green Golf Course is a private 12-acre property located along North Cape Road located in the City of Muskego in south-eastern Waukesha County. The property operates as a 9-hole par 3 golf course as well as a restaurant and tavern. The golf course is east of the proposed pipeline alignment.

All recreation effects are expected to be temporary during construction.

This alternative would not impact a Coastal Zone Management Area. Visual impacts from this alternative are expected to be minor.

5.6.8 Cultural resource effects of the OC2 return flow pipeline

Table 5-29 summarizes the results of the cultural resources analysis for this alternative.

Table 5-29. Oak Creek route alternative OC2 return flow pipeline cultural resources summary[1]

No. of archaeological sites	No. of burial sites	No. of historic structures	No. NRHP listed
5	8	6	1

[1] Includes sites and structures that would be located within proposed pipeline ROW.
Source: Clean Water Alliance 4-140 D1 Cultural Resources, January 2018

Five archaeological sites, eight burial sites and six historic structures would overlap this alternative route corridor. One burial site, and fourteen historic structures would be located within 50 feet of this alternative route corridor and two archaeological sites and six historic structures would be between 50 feet and 100 feet of this alternative route corridor.

One site that would overlap this alternative corridor is listed on the National Register of Historic Places, the Painesville Chapel (AHI 8710, NRHP #77000039) and Cemetery (BMI-0065). It is recommended that the final route avoid the site.

Impacts to cultural resources would be avoided or minimized through the pipeline detailed design process. If impacts cannot be avoided, resources would be treated per Section 106 of the NHPA and in coordination with the SHPO. Potential burial site disturbances must be approved by SHPO prior to the start of project activities. If the route is selected, Phase I cultural resources survey of the route would be required to comply with Section 106.

5.6.9 Costs and energy effects of the OC2 return flow pipeline

Estimated construction and operational costs for the alternative pipeline routes and associated facilities are presented in Table 3-2.

This alternative return flow pipeline would require 3,300,000 kWh/yr of electrical energy for operation.[19] This estimate assumes an average return of up to 9.3 MGD, at build-out, for the return flow pump station.

5.7 Environmental effects of the alternative OC4 return flow pipeline

5.7.1 Inland waterway effects of the OC4 return flow pipeline

The right-of-way of this alternative route would cross nineteen waterways, including Ryan Creek, Mill Creek, Pebble Brook at three locations, the Root River, Oak Creek, Redwing Creek and eleven other unnamed tributaries. The non-right-of-way easement crosses one waterway at Ryan Creek. The 50-foot buffer crosses the same waterways with one additional unnamed tributary and crosses the Root River twice. Within the right-of-way, non-right-of-way easement, and 50-foot buffer, there are approximately 0.77, 0.01, and 0.71 miles of waterways, respectively.

Table 5-30 lists the waterbodies that would be crossed by this alternative's proposed pipeline construction corridors.

Table 5-30. Oak Creek Route alternative OC4 return flow pipeline waterway crossings

Total crossings	Ryan Creek	Mill Creek	Pebble Brook	Root River	Oak Creek	Redwing Creek	Other unnamed crossings
19	1	1	3	1	1	1	11

Source: 4-130 D1 Wetland and Waterway Technical Memorandum January 2018. Data based on NHD = U.S. Geological Survey – National Hydrography Dataset.

5.7.2 Endangered resources effects of the OC4 return flow pipeline

A desktop review of endangered biological resources was conducted by the City. The desktop review included spatially locating the number of elemental occurrences (EOs) for terrestrial and wetland resources within one mile of each proposed pipeline route, and aquatic resources within two miles of each proposed pipeline route. EOs are defined as the rare, threatened, and endangered species and natural communities included in the State of Wisconsin's NHI database. EOs were further broken down into whether the EO would likely be impacted or not, and if impacted, if a measure is required or recommended to avoid, minimize or mitigate effects on the EO. Measures were classified as: required measures for state-listed endangered and threatened animal species, and recommended measures for state listed plant, natural communities, and state special concern animals. Table 5-31 presents this information for this alternative.

Portions of this alternative pipeline also cross the federally-regulated Rusty-Patched Bumblebee High Potential Zone, and additional actions may be necessary if suitable habitat is present.

[19] Source: Great Water Alliance, February 2019.

Table 5-31. Oak Creek route alternative OC4 return flow pipeline endangered resources summary

EOs[1] with no impact	EOs with required measures	EOs with recommended measures	Total EOs
10	8	23	41

[1] Element occurrences.

Source: Great Water Alliance EIR, March 2018.

5.7.3 Wetland effects of the OC4 return flow pipeline

Affected wetlands were identified using the Wisconsin Wetland Classification System (WWI) and air photo interpretation. The right-of-way for this alternative return flow pipeline contains a total of 167 potential wetlands based on mapped WWI wetlands (76) and photo-interpreted wetlands (91). There are 15.08 acres of mapped wetlands per the WWI data and an additional 10.14 acres of potential wetlands, based on desktop photo-interpretation. Of these mapped wetland features, approximately 57% are herbaceous plant dominated wetlands, and 43% are partially or fully forested or shrub dominated (Clean Water Alliance, PAA, January 2019).

The easement for this alternative return flow pipeline contains a total of 6 potential wetlands based on mapped WWI wetlands (3) and photo-interpreted wetlands (3). There are 0.55 acres of mapped wetlands per the WWI data and an additional 0.06 acres of potential wetlands, based on desktop photo-interpretation. Of these mapped wetland features, the amount of herbaceous plant dominated wetlands is comparable to partially or fully forested or shrub dominated wetlands.

In addition, the electrical transmission utility corridor for this alternative includes a total of 24 potential wetlands based on 7 WWI mapped wetlands (1.5 acres) and 17 photo-interpreted wetlands (2.20 acres). Of the mapped wetland features, herbaceous plant-dominated wetlands are greater than the partially or fully forested or shrub-dominated wetlands.

Impacts to wetland habitat used by state or federally designated threatened or endangered species could also occur. Both are a special natural resource according to Wis. Adm. Code Ch. NR 103.04. Thus, the proposed project may impact wetlands of special natural interest.

Table 5-32 lists numbers and acreage of wetlands that would be affected in the ROW and work buffer, as well as wetland acreage by wetland type for this alternative return flow pipeline. Construction-related wetland impacts would likely be less. See also Section 5.1.6 and 5.1.10 for general wetland and land use impacts.

Table 5-32. Wetlands affected by Oak Creek route alternative OC4 return flow pipeline

Wetland	ROW[1]			Buffer			Total all
	WWI[2]	API[3]	Total	WWI	API	Total	
Number	86	111	197	123	110	233	430
Area (ac)	17.13	12.4	29.53	37.35	5.48	42.83	71.36
Type (ac)							
EWM[4]	3.88	11.94	15.82	14.46	4.73	19.19	35.01
Scrub/shrub	0.13	0.01	0.14	0.71	0.31	1.02	1.16
Forested	0.31	0.03	0.34	2.57	0.19	2.76	3.10
Open water	0.04	0.04	0.08	0.62	0.06	0.68	0.76
Other[5]	12.76	0.36	13.12	18.76	0.17	18.93	32.05

[1] The construction corridor, 50 feet in width. Also includes Easement and Electrical Easement Corridor Data

[2] Wisconsin Wetland Inventory.

[3] Air photo interpreted.

[4] Emergent/Wet Meadow.

[5] Combinations of wetland categories, flats and unvegetated wet soil, and filled wetland.

Source: Analysis: Jacobs Engineering Group (email dated November 1, 2018).

5.7.4 Woodland effects of the OC4 return flow pipeline

Table 5-33 includes information on woodlands that would be affected by this alternative. No significant tracts of forested area are anticipated to be impacted by this alternative. Trees would be removed in this alternative's proposed footprint along existing road ROW. Some tree removal may be required where pipeline easements would be obtained.

See also Section 5.1.8 for woodland effects common to all proposed and alternative pipeline routes.

5.7.5 Upland grassland effects of the OC4 return flow pipeline

No known tracts of upland grassland area are anticipated to be impacted by this alternative.

5.7.6 Air emissions effects of the OC4 return flow pipeline

The energy used for OC4 would release an estimated 2,500 tons/year (CO_2e) of annual greenhouse gas emissions (Jacobs Engineering Group, Feb. 2019). CO_2e emissions determined by using the value from eGRID2016 of 1251.5 lb. CO_2e /MWh for the Southeast Wisconsin region, which takes into account recent data for the regional electricity generation mix from coal, natural gas, renewables, etc. CO_2e (carbon dioxide equivalent emissions) are calculated based on the global warming potential of CO_2, CH_4, and N_2O.

5.7.7 Land use effects of the OC4 return flow pipeline

This alternative return flow pipeline would affect a total of 127.3 acres of land for pipeline construction.

The land use construction and operation acreage effects of this alternative are listed in Table 5-33.

Table 5-33. Oak Creek route alternative OC4 return flow pipeline ROW land use effects

Land use[1]	Area (ac)	Percent
Residential	3.35	2.63
Commercial & industrial	0.76	0.60
Transportation[2]	104.07	81.75
Utilities	1.02	0.80
Government & institutional	0.26	0.20
Recreation	13.06	10.26
Agricultural[2,3]	0.00	0.00
Open lands[4]	3.83	3.01
Woodlands[2,5]	0.91	0.71
Totals[6]	127.30	99.99

[1] Represents the total that had a specific land use designation within the SEWRPC Digital Land Use Inventory for Waukesha and Milwaukee Counties. Wetland acreage differs from WWI data.

[2] May include wetlands.

[3] Taken from Table G-3-1 Agricultural Evaluation Summary from GWA documents 4-170 D1 and 4-170 D2 Agricultural Impact Technical Memorandum.

[4] Includes SEWRPC land use categories of unused urban land, unused rural land and wetlands.

[5] Taken from Tables 4. WWI Wetlands Summary by Wetland Class and Table 5 Photo-Interpreted Potential Wetlands by Wetland Class from GWA document 4-130 D3 MKE Routes Wetland Technical Memorandum.

[6] Percentage total includes rounding errors.

Sources: Land use data: SEWRPC (2010). Analysis: Jacobs Engineering Group (email dated Nov. 1, 2018.)

5.7.7.1 Transportation land use effects of the OC4 return flow pipeline

Approximately 81.75 percent of this alternative's pipeline alignments would be within existing road rights-of-way.

In addition, this alternative would require crossing three railroads. One railroad is owned by CN and the crossing would be approximately 480 feet west of the intersection of South West Avenue and West Sunset Drive. The second railroad is abandoned, and the crossing would be approximately 390 feet north of the intersection of Chapman Drive and Sentry Drive. Both locations are within the City of Waukesha. The third railroad is also abandoned, and the crossing would be approximately 350 feet south of the intersection of Philip Drive and Sentry Drive. Applicable railroad crossing permits would be obtained by the City and construction activities would be coordinated with CN.

5.7.7.2 Agricultural land use effects of the OC4 return flow pipeline

Table 5-33 includes agricultural land that would be affected by this alternative pipeline. See Section 5.1.10.2 for agricultural land use effects common to all proposed and alternative pipeline routes.

The Applicant identified agricultural lands initially using aerial imagery. This alternative may potentially affect row crops located in a proposed easement located between Guthrie Road and National Avenue.

During construction, proposed easement sites east of the intersection of 112th Street and Ryan Road may experience crop loss and loss of agricultural acreage. Proposed construction may also temporarily impact drain tiles. Drain tiles have not been identified in the ROW area, but if affected, they would be replaced with similarly sized drain pipes.

This alternative would not intersect agricultural lands enrolled in Farmland Preservation Programs.

5.7.7.3 Recreation and aesthetic resource effects of the OC4 return flow pipeline

Table 5-33 includes recreational land that would be affected by this alternative.

This alternative would not impact a Coastal Zone Management Area. Visual impacts from this alternative are expected to be minor.

There is one bike trail, owned and maintained by the City of Muskego that is parallel or overlapping the ROW along this alternative return flow pipeline route. The trail and pipeline alignments coincide on Durham Drive, which changes names to Moorland Road and continues for a total length of approximately 19,553 feet. The bike trail and proposed return flow pipeline route cross the roadway multiple times, resulting in them being on opposite sides of the road in some areas in and overlapping in others.

The bike trail could be affected by pipeline construction or disturbances where this alternative return flow pipeline route would be within 25 feet. This distance would account for any disturbance of grade, as well as any construction equipment necessary. Where the bike path and the alternative return flow pipeline route overlap, the bike path would be removed and replaced in-kind. This alternative return flow pipeline alignment would be less than 25 feet away from the bike path for approximately 12,350 feet.

Valley Green Golf Course is a private 12-acre property located along North Cape Road located in the City of Muskego in south-eastern Waukesha County. The property operates as a 9-hole par 3 golf course as well as a restaurant and tavern. The golf course is east of the proposed pipeline alignment. Recreational impacts would be minimal.

5.7.8 Cultural resource effects of the OC4 return flow pipeline

Table 5-34 summarizes the results of this cultural resources analysis for this alternative.

Table 5-34. Oak Creek route alternative OC4 return flow pipeline cultural resources summary[1]

No. of archaeological sites	No. of burial sites	No. of historic structures	No. of NRHP listed
5	5	4	1

[1] Includes sites and structures that would be located within proposed pipeline ROW.

Source: Clean Water Alliance 4-140 D4 Cultural Resources, June 2018.

Five archaeological sites, five burial sites, and four historic structures would overlap OC4; one burial site and 11 historic structures would be within 50 feet of the route alternative corridor, and two archaeological sites and three historic structures would be within 100 feet of the route alternative corridor. Two archaeological sites and three burial sites would overlap the electrical transmission utility corridor associated with OC4 (all five sites would also be overlapped by the corridor). No cultural resources would overlap the remaining two easement corridors associate with OC4.

One site that would overlap this alternative pipeline corridor is listed on the National Register of Historic Places, the Painesville Chapel (AHI 8710, NRHP #77000039) and Cemetery (BMI-0065). It is recommended that the final route avoid the site.

Impacts to cultural resources would be avoided or minimized through the pipeline detailed design process. If impacts cannot be avoided, resources would be treated per Section 106 of the NHPA and in coordination with the SHPO. Potential burial site disturbances must be approved by SHPO prior to the start of project activities. If the route is selected, Phase I cultural resources survey of the route would be required to comply with Section 106.

5.7.9 Costs and energy effects of the OC4 return flow pipeline

Estimated construction and operational costs for this alternative pipeline and associated facilities are presented in Table 3-2.

This alternative return flow pipeline would require 4,000,000 kWh/yr of electrical energy for operation.[20] This estimate assumes an average return of up to 9.3 MGD, at build-out, for the return flow pump station.

5.8 Environmental effects of the I-43 easement alternative

As described in Section 3.1.7, this alternative return flow route segment was developed to satisfy a Hardship Application to the FHWA for which the USACOE required a NEPA categorical exclusion (CE) analysis. Table 5-35 lists environmental resource categories and the likely effects of this alternative return flow route segment.

Table 5-35. I-43 Easement return flow alternative segment environmental effects summary

Resource category	Likely environmental effect
Business & economics	Temporary adverse effect on a produce farm and farm stand
Community	Temporary lane closures along Racine Ct. and Martin Rd.
Aesthetics	Minimal tree clearing
Agriculture	Temporary impacts
Indirect impacts	None
Cumulative impacts	None
Environmental justice	None
Historical & archaeological	None per the State Historical Preservation Officer, Sunny Side Cemetery not affected
Recreation properties	None
Wetlands	3.35 Acres of temporary wetland impacts
Rivers, streams & floodplains	Temporary effects only, HDD used to cross under Muskego Creek
Lakes or other open water	None, HDD used to cross under a pond
Groundwater, wells, & springs	Minor temporary dewatering, no impact expected on 1 private well, no springs inventoried
Unique wildlife & habitat	None identified
Coastal zones	None located within easement
Threatened/endangered species	None
Air quality	Temporary impacts only
Noise	3 residences within 100 ft. may experience temporary construction noise
Hazardous substances	None
Stormwater	None, BMPs to be employed
Erosion/sediment	None, BMPs to be employed

Source: GWA CE analysis for FHWA Hardship application. Based on field-verified data.

[20] Source: Great Water Alliance, February 2019.

5.9 Environmental effects of the No Action alternative

The ‘no action’ alternative could potentially have an adverse effect upon the health of City of Waukesha residents because the current water supply source is non-compliant for radium, a cancer-causing contaminant naturally occurring in the deep aquifer. The existing deep aquifer wells do not provide sufficient quality and quantity of water to meet the Applicant’s projected water supply needs.

The ‘no action’ alternative would continue use of the deep aquifer and shallow aquifer without additional treatment. Currently, 83 percent of the Applicant’s water supply comes from the deep aquifer and 17 percent comes from the shallow aquifer (2013 – 2017 water withdrawal data). As the Applicant’s water demand increases, the no action alternative would result in increased use of the deep aquifer as the shallow aquifer wells are currently pumped to maximum capacity (CH2M Hill 2013, Vol. 2). The no action alternative assumes 7.3 MGD from the deep aquifer and 1.2 MGD from the shallow aquifer under an 8.5 MGD average day demand. The approved diversion amount is 8.2 MGD and the groundwater flow modeling conducted to review the Mississippi River Basin alternatives used 8.5 MGD average day demand. A continued long-term water withdrawal from the deep aquifer would contribute to deep aquifer drawdown levels. This continued withdrawal would still contain concentrations of contaminants (including radium, gross alpha and TDS) in the water supply, as even as the deep aquifer rebounds, levels of these contaminants still exist above Safe Drinking Water Act standards.

Flow in the Fox River would continue as a result of deep aquifer water being withdrawn and discharged from the Applicant’s WWTP to the Fox River. Under this alternative, shallow aquifer pumping would continue at the same rate as used between 2010 and 2014. Since shallow aquifer pumping would remain the same no additional baseflow would be diverted from the Fox River.

The ‘no action’ alternative is not feasible. The Applicant must comply with drinking water quality standards and the deep aquifer water supply does not meet radium standards.

6 Comparison of alternatives

This section provides a brief summary and comparison of the various water supply and return flow alternatives analyzed for this EIS. Detailed reviews of each alternative can be found in the preceding sections of the EIS. Section 2 and 3 describe the current proposal and alternatives, including the 'no action' alternative. Section 4 describes the existing environment. Section 5 details potential environmental effects of the current proposal and the various alternatives for water supply and return flow pipelines. Potential cumulative effects are summarized in Section 7 along with a general evaluation of the proposal.

6.1 Comparison of water supply sources and pipelines

As detailed in Section 5, each of the three water supply pipeline alternatives (M1-preferred, M2, and M3) were analyzed for potential impacts on natural resources and the human environment. Section 5.1 describes potential impacts common to all of the pipeline routes. Sections 5.2, 5.4, and 5.5 describe potential effects unique to the different water supply alternatives.

Prior to the Compact Council Decision, the Applicant reviewed six water supply alternatives. Four of these considered withdrawals exclusively from the Mississippi River Basin, one from a combination of Mississippi River Basin and Lake Michigan sources, and one exclusively from Lake Michigan. Based on public comments, the DNR also modeled and reviewed an alternative scenario that included variations on well placement meant to minimize adverse environmental impacts. These alternatives were all reviewed in the DNR's Preliminary Final EIS (Appendix E).

After the Compact Council Decision, the Applicant considered only Lake Michigan water supply options from existing withdrawers – the City of Milwaukee and the City of Oak Creek (Great Water Alliance, Supplemental Environmental Impact). In 2018, the Applicant entered into an agreement to receive Great Lakes water from the City of Milwaukee.

Table 6-1 provides a summary of comparative environmental impacts across the three Milwaukee supply pipeline alternatives. Table 3-2 provides a comparison based on the cost of constructing and operating these alternatives.

As noted in Section 5.2, the Applicant field-verified waterway and wetland acreages for the proposed water supply route (M1-preferred) prior to its submittal of the waterways and wetlands permit application. For alternatives M2 and M3, the reported impacts are based on desktop analysis, and were not field-verified. As a result, the waterway and wetland impacts of the proposed water supply appear to be considerably less than those of the alternatives.

Table 6-1. Comparison of water supply pipeline alternatives

Parameter	Alternative		
	M1-preferred [1]	M2	M3
Pipeline length in miles	11.40	12.59	13.59
Percent in transportation or utility corridor	89.26	92.50	94.54
Number of waterways crossed	7 [2]	8	8
Endangered resources element occurrences near pipeline	8	4	3
Acres of wetlands affected	1.1 [2]	5.65	8.75
Acres of forested wetlands converted to emergent	< 0.01 [2]	0.16	0.28
Acres of woodland affected	0.21	0.16	0.28
Acres of open land affected	2.26 [3]	0.70 [3]	1.02 [3]
Acres recreation land near pipeline	0	0	0
Acres of residential land affected	2.33	1.30	1.74
Acres of commercial & industrial land affected	0.02	0.08	0.17
Acres of agricultural land affected	2.17	0	0
Acres of government & institutional land affected	0.01	4.45	0.80
Number cultural sites overlapping pipeline	1	2	5
Annual energy use in MWh	6,900	6,900	7,100

[1] Proposed project supply pipeline.

[2] Field-verified data provided by Jacobs Engineering Group (email dated June 12, 2019)
Note: Waterway and wetland impacts listed under alternatives M2 and M3 are based on desktop assessments.

[3] Includes SEWRPC land use categories of unused urban land, unused rural land and wetlands.

Of the three alternatives, the proposed supply pipeline (M1-preferred) would be least in length, percentage in the transportation corridor, number of waterways crossed, and affected commercial/industrial and government/institutional land. The proposed supply pipeline would be highest in number of nearby endangered resource elements and affected residential, agricultural, and open lands. The proposed supply pipeline would be the least costly to construct, but between the other two alternatives in terms of operating costs over a twenty-year span.

6.2 Comparison of return flow pipeline route alternatives

As detailed in Section 5, each of the three return flow pipeline alternatives (OC2, OC3-preferred, and OC4) were analyzed for potential impacts on natural resources and the human environment. Section 5.1 describes potential impacts common to all of the pipeline routes. Sections 5.3, 5.6, and 5.7 describe potential effects unique to the different return flow alternatives.

Table 6-2 provides a summary of comparative potential impacts across the different return flow pipeline route alternatives. Table 3-2 provides a comparison based on the cost of constructing and operating these alternatives.

As noted in Section 5.3, the Applicant field-verified waterway and wetland acreages for the proposed return flow route (OC3-preferred) prior to its submittal of the waterways and wetlands permit application. For alternatives OC2 and OC4, the reported impacts are based on desktop analysis, and were not field-verified. As a result, the waterway and wetland impacts of the proposed return flow route appear to be considerably less than those of the alternatives.

Return flow discharge impacts are consistent for each return flow pipeline alternative because the return flow outfall location is the same for each of the pipelines: the Root River at Oakwood and S. 60th St. Section 5.1 describes these effects.

All the return flow options have similar potential for impacts to natural resources features (Table 6-2). Natural resource features along any route will be affected during construction. Use of best management practices for protecting wetland and waterways and site restoration will be required to minimize the temporary impacts of the pipeline construction.

Table 6-2. Comparison of return flow pipeline alternatives

	Alternative		
Parameter	**OC2**	**OC3-preferred** [1]	**OC4**
Pipeline length in miles	19.9	20.5	23.2
Percent in transportation or utility corridor	91.40	91.90	81.75
Number of waterways crossed	12	16 [2]	19
Endangered resources element occurrences near pipeline	34	31	41
Acres of wetlands affected	33.61	6.83 [2]	71.36
Acres of forested wetlands converted to emergent	0.26	0.51 [2]	0.34
Acres of woodland affected	0.79	0.48	0.91
Acres of open land	3.65 [3]	4.14 [3]	3.83 [3]
Acres recreation land near pipeline	1.16	1.10	13.06
Acres of residential land affected	3.15	3.12	3.35
Acres of commercial & industrial land affected	0.66	0.59	0.76
Acres of agricultural land affected	0	0	0
Acres of government & institutional land affected	0.26	0.26	0.26
Number of cultural sites overlapping pipeline	19	32	14
Annual energy use in MWh	3,300	3,700	4,000

[1] Return flow pipeline for the proposed project.

[2] Field-verified data provided by Jacobs Engineering Group (email dated June 12, 2019).
Note: Waterway and wetland impacts listed under alternatives OC2 and OC4 are based on desktop assessments.

[3] Includes SEWRPC land use categories of unused urban land, unused rural land and wetlands.

Of the three alternatives, the proposed return flow pipeline (OC3-preferred) would be the shortest. It would also have the least endangered resource occurrences near the pipeline. The proposed pipeline would affect the least amount of woodlands, as well as recreational, residential, and commercial/industrial lands. The proposed pipeline would have the largest percentage in transportation corridors. It would also have the largest acreage of wooded wetland conversion and affect the greatest acreage of open lands. The proposed return flow pipeline would be between the other two routes in terms of the cost of construction and operation over a twenty-year span.

7 Cumulative effects and evaluation

7.1 Cumulative effects

The Applicant is without adequate supplies of potable water due to the presence of radium in its current groundwater water supply. The Applicant's current water supply, the deep sandstone aquifer, is derived from groundwater that is hydrologically interconnected to waters of the Lake Michigan basin. Groundwater pumping from the deep sandstone aquifer in southeast Wisconsin has changed the predevelopment groundwater flow direction from flowing towards Lake Michigan to flowing towards pumping centers. Currently the largest pumping center from the deep sandstone aquifer in southeast Wisconsin is in Waukesha County.

The proposed diversion would not result in significant adverse direct impacts or cumulative impacts to the quantity or quality of the waters of the Great Lakes basin or to water dependent natural resources, including cumulative impacts that might result due to any precedent-setting aspects of the proposed diversion. The proposed annual diversion represents 0.000238 percent of the volume of Lake Michigan and 0.000049 percent of the volume of the Great Lakes. These totals do not take into account any treated wastewater returned to the Lake Michigan basin. The Applicant proposes to return approximately 100% of the water withdrawn.

The proposed water supply pipeline route (M1-preferred) and the proposed Root River return flow pipeline (OC3-preferred), including the return flow discharge site, would impact a total of 7.92 wetland acres. The use of best management practices for protecting wetland and waterways and site restoration would be required to minimize the temporary impacts of the pipeline construction. The proposed booster pump station would also require the conversion of about 4.5 acres of agricultural land to industrial use. Other land use impacts would be temporary during construction.

For the Lake Michigan supply, and subsequent return flow to the Root River, there could be an approximate 10% decrease in flows to the Fox-Illinois River due to decreased daily discharge from the City's existing WWTP. This decrease would likely have minimal impacts to the water quality and flora and fauna using the Fox River. Eliminating the current shallow aquifer well pumping near the Fox River would minimally increase the baseflow of tributaries to the Fox River and to associated wetlands.

The Applicant would be required to meet all water quality based effluent limits as stated in a WPDES permit for return flow to the Root River. The proposed Root River return flow would not involve any construction activities in Lake Michigan.

7.1.1 Effects on scarce resources

Other than the permanent conversion of forested wetlands to emergent wetlands within proposed pipeline rights-of-way, effects on scarce resources, such as listed species and archeological/historic resources, are not anticipated. Should there be any impacts to listed species, the project would need to apply for an Incidental Take Permit/Authorization.

7.1.2 Unavoidable adverse effects

Proposed project pipelines are expected to result in a total permanent impact of less than 0.01 acres (102 sq. feet) of wetland and less than 0.01 (133 sq. feet) of the Root River, below the ordinary high water mark. Additional permitted pollutant loading to the Root River is expected.

Fox River flow immediately downstream of the Applicant's WWTP could decrease by an average of 10 percent, due to return flow to the Root River.

7.1.3 Consistency with plans

The proposed project is consistent with public plans and policies. The Applicant would be required to comply with all conditions of the Compact Council's diversion approval (Compact Council, 2016). The proposed diversion would be implemented to ensure that it is in compliance with all applicable municipal, state and federal laws as well as regional interstate and international agreements, including the Boundary Waters Treaty of 1909.

7.1.4 Short-term and long-term effects

Construction-related resource effects are anticipated to be short-term. Conversion of wooded to non-wooded areas would be a long-term effect as long as pipeline rights-of-way are maintained. Discharges to the Root River and reduced discharge to the Fox River would continue for the long-term. Energy and materials for construction and operation would be committed for the long-term. Long-term effects on Lake Michigan are not anticipated. A safe and sustainable public water supply for the Applicant is expected for the long-term.

7.1.5 Precedence

The proposed diversion was reviewed for precedent-setting impacts. While the Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement (Agreement) and the Great Lakes Compact prohibit diversions, they provide limited exceptions for a public water system in a "straddling community" or a "community within a straddling county" to apply subject to Agreement/Compact requirements. Every decision for individual diversion requests is unique and based on a different set of facts and circumstances. Both the DNR Technical Review and the Compact Council's Decision found that any precedent setting impacts will not adversely impact Lake Michigan or the Great Lakes.

7.1.6 Risk

There is little degree of risk or uncertainty in predicting environmental effects or effectively controlling potential deleterious environmental impacts, including those relating to public health or safety. The current proposal would utilize well-known technologies for water supply, treatment and return. Water returned to the Root River would be required to meet all state and federal permit requirements.

7.1.7 Controversy

This first-of-its-kind project has generated considerable public interest and controversy. The DNR has received many public comments throughout the review process and has responded to those comments throughout the Technical Review and EIS process. The project was reviewed by the Regional Body and Compact Council. Through that review the Regional Body and Compact Council received extensive public comment as well.

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Appendix A. Proposed pipeline routes

A.1. Proposed supply pipeline (M1-preferred) route description

The proposed water supply pipeline route (M1-preferred) is described below following the flow path beginning at the anticipated connection to the Milwaukee Water Works (MWW) distribution system in the City of Milwaukee and ending at the connection to the Waukesha Water Utility (WWU) distribution system in the City of Waukesha. The proposed water supply pipeline would be approximately 11.40 miles in length. The proposed pipeline would be installed using open trench construction except as otherwise indicated.

The proposed water supply pipeline would begin with a connection to the MWW distribution system near the intersection of West Oklahoma Avenue and South 74th Street. The proposed supply pipeline would then proceed west along Oklahoma Avenue.

A.1.1. Oklahoma Avenue segment

The proposed supply pipeline would initially follow West Oklahoma Avenue to the west. Oklahoma Avenue is four-lane, two-way road with a center median. Land use in this area is residential and light commercial.

Jack and bore construction would be used to cross under Honey Creek which flows through a concrete-lined channel in the area. South 76th Street would also be crossed using jack and bore construction.

East of South 84th Street, the pipeline would cross an unnamed stream flowing through a 60-inch culvert. The crossing would be done by excavating under the culvert.

South 84th Street would be crossed using jack and bore construction to install approximately 110 feet of pipe casing. West Beloit Road would also be crossed using HDD construction. South 92nd Street would be crossed using jack and bore construction for approximately 230 linear feet.

The proposed pipeline route would pass underneath the bridge of Interstate 894 over Oklahoma Avenue. Land use in this area is residential and commercial. Continuing west along Oklahoma Avenue, the proposed supply pipeline would cross under South 108th Street using 190 feet of jack and bore construction.

HDD construction would be used to install approximately 1,120 linear feet of the pipeline to cross under the Root River, Root River Parkway, an unnamed tributary to the Root River and South 119th Street. In this area, Oklahoma Avenue is a four-lane, two-way road with a center median and bike lanes. The land use in this area is primarily commercial, with residential areas.

Approximately 150 feet of pipe casing would be installed using jack and bore construction to cross under South 124th Street. At 124th Street Oklahoma Avenue becomes National Avenue. The proposed pipeline would then continue east and southeast on National Avenue.

A.1.2. National Avenue segment

National Avenue is a four-lane, two-way road with a center turning lane. The land use in this area is primarily residential and commercial. Just west of Highpointe Drive, an unnamed tributary to the Root River which flows through a culvert would be crossed by excavating under the culvert.

Approximately 170 feet of pipe casing would be installed using jack and bore construction to cross under and minimize traffic disruption on South Sunny Slope Road. HDD would be used to install approximately 300 linear feet of the proposed pipeline under South Acredale Drive and an unnamed tributary to Poplar Creek. At the intersection with West Coffee Road, the proposed supply pipeline corridor would turn east.

A.1.3. Coffee Road segment

Coffee Road is a two-lane, two-way road with bike lanes. The land use around the route in this area is primarily residential, with light commercial areas. Approximately 180 feet of pipe would be installed using jack and bore construction to cross under Moorland Road.

West of the intersection with West Saint Francis Drive and just east of South Calhoun Road, the proposed supply pipeline would pass adjacent to several small wetlands resulting in temporary impacts during construction.

As the road continues to the west, the land use along Coffee Road transitions to primarily agricultural, with residential areas. Jack and bore construction would be used to install approximately 220 feet of pipe casing under Calhoun Road. About 2,000 feet east of the intersection of Coffee Road and Woelfel Road, HDD would be used to install 376 linear feet of the pipeline to cross under an unnamed tributary to Poplar Creek. West of the waterway, a small wetland would be temporarily impacted during construction.

As Coffee Road continues to the east, the land use transitions back to more residential with some agricultural areas. Several small wetlands would be temporarily impacted between Woelfel Road and South Heide Lane, and west of Heide Lane. Just east of the intersection with South Johnson Road, another small wetland would be temporarily impacted during construction.

At the intersection with South Swartz Road, the proposed supply pipeline would turn to the south.

A.1.4. Swartz Road segment

Swartz Road is a two-lane, two-way road. The land use in this area is primarily agricultural with residential areas. North of the intersection with South Racine Avenue a small wetland would be affected. The proposed route would cross South Racine Avenueto reach the proposed booster pump station (BPS) in the southwest corner of the intersection of Swartz Road and Racine Avenue. Upon exiting the BPS, the proposed supply pipeline would converge with the proposed return flow pipeline in a common corridor and turn northeast to follow Racine Avenue. A small area of temporary wetland impacts would occur adjacent to the BPS.

A.1.5. Racine Avenue segment

Racine Avenue is a two-lane, two-way road. The land use in this area is residential. At the intersection with East Sunset Drive, the common pipeline corridor would turn east.

A.1.6. East Sunset Drive segment

The proposed common pipeline corridor would continue east along East Sunset Drive. Most of the pipeline length between Racine Avenue and Blackhawk Trail would result in temporary impacts to wetland during construction. The two pipelines would diverge slightly between Racine Avenue and Blackhawk Trail with the proposed supply pipeline following an easement on private land in order to avoid raised planting beds. Just east of the intersection with Les Paul Parkway (Wisconsin Highway 59) the proposed supply and return flow pipelines would diverge.

Jack and bore construction would be used to cross Les Paul Parkway. After this road crossing, the proposed water supply pipeline would connect to the water supply control building (WSCB) and the WWU water distribution system. The proposed return flow pipeline would turn southwest to follow Les Paul Parkway.

A connection to the WWU water distribution system would also proceed south from Sunset Drive along Guthrie Road to the Hunter Tower. The Hunter Tower interconnection at the water supply control building (WSCB) would provide an emergency pressure source for the booster pumping station (BPS) discharge pipeline. The WSCB would have a 12-inch pressure reducing valve (PRV) connection the highline booster pumping station/Hunter Tower to the BPS discharge pipeline. During normal operation the PRV would be set to maintain a BPS Discharge Pipeline pressure of 96 psi. If pressure in the BPS Discharge Pipeline would drop below 96 psi the PRV would open and the higher pressure at the highline booster pumping station/Hunter Tower would allow the BPS discharge pipeline to maintain minimum required pressures.

A.2. Proposed return flow pipeline (OC3-preferred) route description

Appendix A. A description of the proposed return flow pipeline alignment is presented below following the flow path from Waukesha to Milwaukee. The proposed return flow pipeline would be approximately 13.59 miles in length. The proposed pipeline would be installed using open trench construction except as otherwise indicated.

A.2.1. Sentry Drive segment

The proposed return flow pipeline would begin at Waukesha's WWTP at approximately 1,150 feet west of the intersection of Sentry Drive and the WWTP access drive. The proposed pipeline would run to the north along the west side of the WWTP property. Less than a hundredth of an acre of hardwood swamp and two hundredths of an acre of fresh wet meadow would be permanently filled for pipeline construction in this area. The proposed pipeline would then turn east on the WWTP property, cross a potentially abandoned rail line using jack and bore construction and proceed south along Sentry Drive. Sentry Drive is a four-lane, two-way roadway in an area that is urban, with municipal and industrial areas. The same potentially abandoned rail line would again be crossed using jack and bore construction along Sentry Drive. Approximately 450 feet to the north of the intersection of Chapman Drive and Sentry Drive, jack and bore construction would be used to install approximately 100 linear feet of pipe casing under abandoned railroad tracks.

A.2.2. West Sunset Drive segment

The proposed return flow pipeline would then proceed east along West Sunset Drive, which is a four-lane, two-way roadway in an area that is urban, with industrial, commercial, and residential land uses. Approximately 500 feet to the west of the intersection of Sunset Drive and South West Avenue, jack and bore construction would be used to install approximately 150 feet of pipe casing to cross under existing railroad tracks. From just east of the railroad tracks to West Avenue the proposed pipeline would be routed through an easement on private property adjacent to the south side of Sunset Avenue. This easement would allow work space for jack and bore construction under railroad tracks.

A.2.3. West Avenue segment

The proposed return flow pipeline would then proceed south along West Avenue which is a four-lane, two-way roadway in an area that is urban, with industrial, commercial, and residential land uses. Just north of the intersection with Wisconsin Highway 59 (Les Paul Parkway), an unnamed tributary to Pebble Brook that runs through a culvert would be crossed by trenching under the culvert.

A.2.4. Wisconsin 59 segment

The proposed return flow pipeline would then proceed east and north along Wisconsin 59 which is a four-lane, divided two-way roadway. The land use around the proposed route in this area is urban, with industrial, commercial, and residential areas. Temporary wetland impacts would occur at intervals along much of the route length along Wisconsin 59. Jack and bore construction would be used to install approximately 170 linear feet of pipe casing under South East Avenue to minimize traffic disruption. Approximately 1,600 feet northeast from the intersection of East Avenue and Wisconsin 59,350 linear feet of pipe casing would be installed using HDD to cross under a Pebble Brook. HDD would also be used to cross under an unnamed tributary to Pebble Brook, another crossing of Pebble Brook and to cross under Wisconsin 59 from the northwest side to the southeast side.

A.2.5. East Sunset Drive segment

At the southeast corner of the intersection of Sunset Drive and East Racine Avenue, the proposed return flow pipeline would converge with the proposed supply pipeline into a common pipeline corridor. The proposed common pipeline corridor would then proceed east along Sunset Drive which is a four-lane, two-way roadway. Most of the pipeline length between Blackhawk Trail and Racine Avenue would result in temporary impacts to wetland during construction. The land use around the proposed route in this area is primarily urban and residential areas.

A.2.6. Racine Avenue segment

The proposed common corridor pipelines would then proceed southeast and south along Racine Avenue, which is a two-way, two-lane road that predominantly runs through a rural agricultural area with some residential properties. Near the intersection with Swartz Road, a small area of temporary wetland impacts would occur adjacent to the proposed booster pump station.

The two proposed pipelines would diverge from the proposed common corridor at the intersection of Racine Avenue and Swartz Road. The proposed return flow pipeline would continue south along Racine Avenue while the proposed water supply pipeline would proceed north along Swartz Road.

Northwest of the intersection between Racine Avenue and South Racine Circle, and at that intersection, temporary wetland impacts would occur during construction. A small area of temporary wetland impacts would occur at the intersection with Observatory Road. South of the intersection with West Lawnsdale Road, HDD would be used to cross under a driveway. Between the intersections with West Highland Drive and with Interstate 43, several wetland areas would be temporarily impacted. Between Terrace Drive and South Racine Court, the proposed pipeline would cross Racine Avenue from the west side to the east side using HDD construction. The pipeline would then follow Racine Court until reaching the ROW of Interstate 43.

A.2.7. Interstate 43 segment

The proposed return flow pipeline would then proceed northeast along the northwest side of the I-43 ROW. The land use around the proposed route in this area is primarily rural and natural open areas.

A small section of floodplain forest and shrub carr wetland would be converted to open wetland between Racine Avenue and the first waterway crossing in this segment. Crossing an unnamed waterway would require about 17 feet of trenched construction. Temporary wetland impacts would occur after the stream crossing for a short distance. Following this, HDD construction would be used to cross under a forested wetland and an unnamed tributary of Muskego Creek. Most of the distance between this stream crossing and South Martin Road would require temporary wetland impacts during construction. Immediately east of Martin Road, another unnamed tributary to Muskego Creek would be crossed using 16 feet of trenched construction. East of this stream crossing, several areas of temporary wetland impacts would occur, as would the conversion from floodplain forest to open wetland in two small areas. HDD would then be used to install approximately 320 linear feet of pipe to minimize impacts to Muskego Creek and associated wetlands. Between this stream crossing and South Calhoun Road, several small wetland areas would have temporary impacts, while two small wetland areas would be converted from a forested to an open condition.

Northeast of Calhoun road, the proposed return flow pipeline would turn east to cross under I-43 using approximately 500 linear feet of jack and bore construction.

A.2.8. Parcel NBC 1286999002 segment

The proposed return flow pipeline corridor would proceed east and then south across private Parcel NBC 1286999002. The construction within this parcel would require a 50-foot permanent easement and a 15-foot temporary easement. The length of the proposed return flow pipeline across Parcel NBC 1286999002 would be approximately 2,230 feet. The proposed pipeline would then cross West Small Road.

A.2.9. Small Road segment

The proposed return flow pipeline corridor would then turn to the northeast and follow Small Road. Small Road is a two-lane, two-way roadway in an area of mixed rural, agricultural, commercial and residential land uses. The proposed pipeline would then cross South Westridge Drive.

A.2.10. Westridge Drive segment

The proposed return flow pipeline would then turn to the southeast and follow Westridge Drive which is a two-lane, two-way roadway in an area of mixed rural, agricultural, commercial and residential land uses.

A.2.11. Moorland Road segment

The proposed return flow pipeline would then turn south to follow Moorland Road. Moorland Road is a two-lane, two-way roadway that transitions to a four-lane, divided two-way roadway approximately 700 feet north of the intersection with College Avenue. The land use around the proposed route in this area is primarily agricultural with a few commercial and residential properties.

Temporary wetland impacts would occur during construction at several points between Westridge Drive and College Avenue.

At the northwest corner of the intersection with College Avenue, jack and bore construction would be used to install approximately 110 linear feet of pipe casing to cross College Avenue from south to north and to minimize traffic disruption at the surrounding intersection.

Temporary wetland impacts would occur during construction at several points between College Avenue and Janesville Road. Commerce Center Parkway would also be crossed using jack and bore construction.

Just north of Janesville Road, a small area of hardwood swamp would be converted to open wetland. HDD would be used to cross Janesville Road and Princeton Drive. Moorland Road transitions back to a two-lane, two-way roadway south of Janesville Road.

Temporary wetland impacts would also occur during construction at several points between Janesville Road and Durham Drive. Woods Road would be crossed using HDD.

A.2.12. Durham Drive segment

Mooreland Road becomes Durham Drive at the intersection with Woods Road. The proposed return flow pipeline would follow Durham Drive to the south and southeast. Durham Drive is a two-lane, two-way roadway. The land use around the proposed route in this area is primarily rural, with residential areas.

Very small areas of temporary wetland impact would occur immediately south of the intersection with Woods Road, and at the intersection with Pilgrim Drive, and between the intersection with Schultz Lane and HiView Drive. Another very small wetland would be temporarily impacted at the intersection with North Cape Road.

A.2.13. North Cape Road segment

The proposed return flow pipeline would then turn south to follow South North Cape Road. North Cape Road is a two-lane, two-way roadway with a large concrete shoulder. The land use around the proposed route in this area is primarily rural, with residential areas. Very small wetland areas at the intersection with Boxhorn Drive and north of the intersection with West Ryan Road would be temporarily impacted during construction. The proposed pipeline would cross Ryan Road and then turn east.

A.2.14. Ryan Road segment

The proposed return flow pipeline would then follow Ryan Road. Ryan Road is a two-lane, two-way roadway with a gravel shoulder in an area of primarily rural and agricultural land uses.

Several wetland areas would be temporarily impacted between North Cape Road and West Loomis Road. Loomis Road (U.S. Highway 45) would then be crossed using jack and bore construction to install 340 linear feet of pipe casing. Temporary wetland impacts would occur immediately east of this road crossing.

At the intersection of South 112th Street and Ryan Road, HDD would be used to install 800 linear feet of pipe casing to avoid impacts to Ryan Creek, wetlands and old trees through easements on private parcels. The proposed return flow pipeline would pass through a total of eight privately owned parcels for a total length of 3,100 feet along Ryan Road. Tax IDs for the parcels which the pipeline would pass through, from west to east are: 8929991000, 8929990000, 8929989002, 8929989003, 8929989001, 8939997001, 8939997002, and 8939995001. A 50-foot permanent easement spanning across the eight parcels would be required. A shrub-carr wetland would be converted to open wetland, and a very small wetland would also be temporarily impacted in the easement area.

Temporarily wetland impacts would also occur east of the easements, and some hardwood swamp would be converted to open wetland. The land use around the proposed route in this area is primarily rural and agricultural, with residential properties. A larger area of forested wetland would be crossed using HDD construction just west of the intersection with South 96th Street. Between 96th Street and South 94th Street, a very small area of shrub-carr wetland would be converted to open wetland.

Between South 92nd Street and West Saint Martin's Road, the proposed return flow pipeline would pass through another easement on private land. Within this easement, several small wetlands would be temporarily impacted, and an unnamed tributary to Ryan Creek would be crossed using HDD construction. East of the intersection with Saint Martin's Road, the proposed pipeline would cross to the north side of Ryan Road using jack and bore construction. Wetlands would be temporarily impacted over about half the distance between Saint Martins Road and South 76th Street.

At the intersection of Ryan Road and 76th Street, jack and bore construction would be used to install approximately 175 linear feet of pipe casing to cross under 76th Street. The land use around the proposed route in this area is primarily rural and agricultural, with some light industrial and commercial areas. East of the intersection with 76th Street, temporary wetland impacts would occur, and a very small shrub-carr area would be converted to open wetland. An unnamed tributary to the Root River and associated wetlands would be crossed using HDD construction. Temporary wetland impacts would occur during construction over most of the distance between 76th Street and the Root River.

Approximately 1,450 feet west of the intersection of Ryan Road and South 60th Street, HDD would be used to install approximately 1,400 feet of the pipeline underneath the Root River, an unnamed tributary to the Root River and associated wetlands. At the Ryan Road crossing of the Root River, the roadway transitions from a two-lane, two-way roadway to a four-lane, two-way roadway. The land use around the proposed route in this area is primarily rural, with agricultural, residential and commercial areas. East of the Root River, the proposed pipeline would cross to the south side of Ryan Road and then turn south to follow South 60th Street.

A.2.15. 60th Street segment

The proposed return flow pipeline would follow 60th Street, which is a four-lane, two-way roadway. The land use around the proposed route in this area is rural, with industrial areas. Between West Airways Avenue and West Franklin Drive, an unnamed tributary to the Root River, which flows through a culvert, would be crossed by trenching under the culvert. At the intersection with West Franklin Drive, 60th Street transitions to a two-lane, two-way roadway. South of the intersection with Franklin Drive, the pipeline would cross an unnamed tributary to the Root River using open trench construction. The crossing would be approximately 25 feet in length.

The proposed return flow pipeline corridor would cross West Oakwood Road and then follow Oakwood Road east for a short distance. The proposed return flow pipeline would then turn south to enter the proposed Root River outfall site in the southeast quadrant of the intersection of 60th Street and Oakwood Road. Temporary wetland impacts would occur over much of the crossing of the outfall site prior to reaching the discharge structure on the Root River.

Appendix B. Alternative pipeline routes

B.1. Milwaukee supply route alternative M1 pipeline description

Water supply route alternative M1 follows the same roadways as the proposed supply route (M1-preferred) with two exceptions. M1 has an additional section on the eastern end of the route making this alternative approximately 12.75 miles in length. For M1, the connection to Milwaukee would be at the intersection of West Morgan Avenue and 68th Street. The route would follow Morgan Avenue to the west until reaching South Honey Creek Drive. The route would then turn north to follow South Honey Creek Drive, and then follow West Honey Creek Drive to the west. At South 76th Street, the route would turn north along 76th Street before reaching West Oklahoma Avenue. The remainder of alternative supply route M1 would follow the same roadways as the route for M1-preferred but would not follow an easement along East Sunset Drive just west of Racine Avenue.

B.2. Milwaukee supply route alternative M2 pipeline description

A description of the alignment of Milwaukee Supply Route alternative M2 is presented below following the flow path, beginning at the Milwaukee Water Works (MWW) distribution system in the City of Milwaukee and ending at the connection to the Waukesha Water Utility (WWU) distribution system in the City of Waukesha. This alternative supply pipeline would be approximately 12.59 miles in length. The pipeline would be installed using open trench construction except as otherwise indicated.

B.2.1. Howard Avenue segment

This alternative supply pipeline would begin with a connection to the MWW distribution system at the intersection of West Howard Avenue and South 60th Street. The pipeline would proceed west along Howard Avenue which is a four-lane, two-way road. The land use around the route in this area is primarily residential and commercial.

B.2.2. Forest Home Avenue segment

At West Forest Home Avenue, this alternative pipeline would turn southwest. Forest Home Avenue is a four-lane, two-way road, with bike lanes and a center median. The land use in this area is primarily residential and commercial. Approximately 80 feet northeast of the intersection of Forest Home Avenue and 68th Street, jack and bore construction would be used to install approximately 240 feet of pipe casing under 68th Street.

B.2.3. Cold Spring Road segment

At the intersection of Forest Home Avenue and West Cold Spring Road, the pipeline would turn west to follow Cold Spring Road which is a four-lane, two-way road. Some portions of Cold Spring Road also have parking lanes or bike lanes. The land use in this area is primarily residential. Approximately 50 feet east of the intersection of Cold Spring Road and 76th Street, jack and bore construction would be used to install approximately 220 feet of pipe casing under 76th Street. At the intersection of Cold Spring Road and 92nd Street, 150 feet of jack and bore would be used to cross under 92nd Street.

Approximately 350 feet west of 99th Street, jack and bore would be used to cross underneath the bridge of Interstate 41 over Cold Spring Road. At the intersection of Cold Spring Road and 104th

Street, jack and bore construction would be used to cross under 104th Street. Approximately 300 feet west of the intersection of Cold Spring Road and 104th Street, 800 feet of HDD would be used to cross under the Root River and a tributary to the Root River. At the intersection of Cold Spring Road and 108th Street, 460 feet of HDD would be used to cross under 108th Street, a creek and a culvert.

Approximately 400 feet west of the intersection of Cold Spring Road and 116th Street, 450 feet of HDD would be used to cross under a creek and culvert. At the intersection of Cold Spring and Beloit Roads, 300 feet of jack and bore would be used to cross under Beloit Road. At the intersection of Cold Spring Road and 124th Street, 120 feet of jack and bore would be used to cross under 124th Street. At the intersection of Cold Spring and Sunny Slope Roads, 100 feet of jack and bore construction would be used to cross under Sunny Slope Road. Cold Spring Road ends at South Sunny Slope Road, but this alternative pipeline would continue to the west.

B.2.4. New Berlin Public Schools segment

This alternative supply pipeline would next use an easement to cross Parcel NBC 1241994 which is owned by New Berlin Public Schools. The pipeline easement would be near the northern boundary of the property and would make a slight jog to north to avoid an athletic field. About 130 feet west of the intersection of Cold Spring Road and Sunny Slope Road, HDD would be used to install approximately 350 linear feet of the pipeline under a waterway.

B.2.5. Fenway Drive segment

Alternative supply pipeline M2 would then proceed west along West Fenway Drive which is a two-lane, two-way road. The land use in this area is primarily residential. The alternative pipeline would jog to the north at South Regal Drive in order to continue on Fenway Drive. Regal Drive is a two-lane, two-way road.

B.2.6. Mayflower Drive segment

At the intersection of Fenway Drive and West Mayflower Drive, this alternative pipeline would turn north and then west. Mayflower Drive is a two-lane, two-way road in a residential area. At the intersection of Mayflower Drive and Moorland Road, 170 feet of jack and bore would be used to cross under Moorland Road. At the intersection with South Church Drive, the alternative supply pipeline would turn north.

B.2.7. Church Drive segment

Alternative supply pipeline M2 would follow Church Drive which is a two-lane, two-way road. At the intersection with West National Avenue, the pipeline would turn to the southwest.

B.2.8. National Avenue segment

National Avenue is a four-lane, two-way road in an area that is primarily residential and commercial. Initially this alternative pipeline would be on the southeast side of National Avenue. Approximately 1,000 feet northeast of the intersection of National Avenue and Observatory Road, 120 feet of jack and bore construction would be used to cross under National Avenue to the northwest side. At the intersection with West Observatory Road, the alternative supply pipeline would turn to the northwest.

B.2.9. Observatory Road segment

Observatory Road is a two-lane, two-way road in an area that is primarily residential and agricultural. Initially, Observatory Road heads northwest, but then turns west. At the intersection of Observatory Road and Calhoun Road, 100 feet of jack and bore construction would be used to cross under Calhoun Road. Approximately 30 feet east of the intersection of Observatory Road and Johns Drive, HDD would be used for approximately 260 feet of the pipeline to avoid impacts to a creek and culvert.

West of Woelfel Road, Observatory Road bends to the southwest before heading west again. At a point 1,500 feet west of the intersection of Observatory Road and Woelfel Road, approximately 350 feet of the pipeline would be installed using HDD to avoid impacts to a creek and culvert. South Racine Avenue would then be crossed using approximately 80 feet of jack and bore construction.

B.2.10. Racine Avenue segment

At the intersection of Observatory Road and Racine Avenue, this alternative supply pipeline would turn northwest. At this point, this alternative supply pipeline would join in a common corridor with either the proposed return flow pipeline or with the Oak Creek Route Alternative 2 return flow pipeline, if either of those were chosen. This alternative supply pipeline would then follow Racine Avenue to the north.

Racine Avenue is a two-lane, two-way roadway. The land use around the route alternative in this area is primarily residential and agricultural. The proposed booster pump station (BPS) would be located at the intersection of Racine Avenue and South Swartz Road, and this alternative supply pipeline would pass through the proposed BPS and then continue to follow Racine Avenue to the northwest. At East Sunset Drive, this alternative supply pipeline would turn west.

B.2.11. Sunset Drive segment

The common pipeline corridor would continue east along the south side of Sunset Drive. At Guthrie Road, one spur of this alternative supply pipeline would turn south and connect to the WWU distribution system at Hunter Tower. The common pipeline corridor would also continue west on Sunset Drive. Just east of the intersection with Les Paul Parkway (Wisconsin Highway 59) this alternative supply pipeline would diverge from the common pipeline corridor. Jack and bore construction would be used to install approximately 350 linear feet of water supply pipe casing to cross both Sunset Drive and Les Paul Parkway in a single trenchless crossing. After this road crossing, the proposed water supply pipeline would connect to the water supply control building (WSCB) and the WWU water distribution system. The proposed return flow pipeline would turn southwest to follow Les Paul Parkway.

B.3. Milwaukee supply route alternative M3 pipeline description

A description of the alignment of Milwaukee Supply Route alternative M3 is presented below following the flow path, beginning at the Milwaukee Water Works (MWW) distribution system in the City of Milwaukee and ending at the connection to the Waukesha Water Utility (WWU) distribution system in the City of Waukesha. This alternative supply pipeline would be approximately 13.59 miles in length. The pipeline would be installed using open trench construction except as otherwise indicated.

B.3.1. Howard Avenue segment

This alternative supply pipeline would begin with a connection to the MWW distribution system at the intersection of West Howard Avenue and South 60th Street. The pipeline would proceed west along Howard Avenue which is a four-lane, two-way road. The land use around the route in this area is primarily residential and commercial.

B.3.2. Forest Home Avenue segment

At West Forest Home Avenue, this alternative pipeline would turn southwest. Forest Home Avenue is a four-lane, two-way road, with bike lanes and a center median. The land use in this area is primarily residential and commercial. Approximately 80 feet northeast of the intersection of Forest Home Avenue and 68^{th} Street, jack and bore construction would be used to install approximately 240 feet of pipe casing under 68^{th} Street.

B.3.3. Cold Spring Road segment

At the intersection of Forest Home Avenue and West Cold Spring Road, the pipeline would turn west to follow Cold Spring Road which is a four-lane, two-way road. Some portions of Cold Spring Road also have parking lanes or bike lanes. The land use in this area is primarily residential. Approximately 50 feet east of the intersection of Cold Spring Road and 76^{th} Street, jack and bore construction would be used to install approximately 220 feet of pipe casing under 76^{th} Street. At the intersection of Cold Spring Road and 92^{nd} Street, 150 feet of jack and bore would be used to cross under 92^{nd} Street.

Approximately 350 feet west of 99^{th} Street, jack and bore would be used to cross underneath the bridge of Interstate 41 over Cold Spring Road. At the intersection of Cold Spring Road and 104^{th} Street, jack and bore construction would be used to cross under 104^{th} Street. Approximately 300 feet west of the intersection of Cold Spring Road and 104^{th} Street, 800 feet of HDD would be used to cross under the Root River and a tributary to the Root River. At the intersection of Cold Spring Road and 108^{th} Street, 460 feet of HDD would be used to cross under 108^{th} Street, a creek and a culvert.

Approximately 400 feet west of the intersection of Cold Spring Road and 116^{th} Street, 450 feet of HDD would be used to cross under a creek and culvert. At the intersection of Cold Spring Road and West Beloit Road, this alternative supply pipeline would turn to the southwest.

B.3.4. Beloit Road segment

Milwaukee Supply Route Alternative M3 would follow Beloit Road which is a two-lane, two-way road. The land use in this area is primarily residential. Approximately 60 feet northeast of the intersection of Beloit Road and 124^{th} Street, 160 feet of jack and bore construction would be used to cross under 124^{th} Street. Approximately 15 feet northeast of the intersection with West Armour Avenue, jack and bore construction would be used to install approximately 90 feet of pipe casing to minimize traffic disruption on Armour Avenue. About 50 feet northeast of the Interstate 43 underpass, HDD would be used to install approximately 790 linear feet of the pipeline.

Southeast of the I-43 underpass, Beloit Road curves to the west. Approximately 20 feet east of the intersection with South Sunny Slope Road, jack and bore would be used to install approximately 140 feet of pipe casing under Sunny Slope Road.

Beloit Road again crosses I-43 to the west of the intersection of Beloit Road and Sunny Slope Road. Beloit Road turns into a four-lane, two-way divided road west of this Interstate 43 underpass. About 50 feet east of the Interstate 43 underpass, jack and bore construction would be used to install approximately 290 feet of pipe casing as Beloit Road crosses under I-43.

Approximately 50 feet east of the intersection of Beloit Road and Moorland Road, jack and bore construction would be used to install approximately 200 feet of pipe casing under Moorland Road. West of Moorland Road, Beloit Road again curves to the southwest.

Approximately 300 feet east of South Towne Road, Beloit Road transitions to a two-lane, two-way road. The land use in this area is primarily industrial with light commercial and residential areas. Approximately 550 feet west of the intersection of Beloit Road and Moorland Road, HDD would be used to install approximately 410 linear feet of the pipeline to minimize impacts to a creek.

West of Emmer Drive, Beloit Road again curves to the west. The land use around the route in this area is primarily residential with agricultural areas. Approximately 960 feet east of the intersection of Beloit Road and Calhoun Road, HDD would be used to install approximately 370 feet of the pipeline to minimize impacts to a creek. Approximately 40 feet east of the intersection with South Calhoun Road, jack and bore construction would be used to install approximately 130 linear feet of pipe casing under Calhoun Road. About 430 feet west of the intersection with Calhoun Road, HDD would be used to install approximately 350 linear feet of the pipeline to minimize impacts to a creek and culvert.

At the intersection of Beloit Road and West National Avenue, this alternative supply pipeline (M3) would turn to the southwest.

B.3.5. National Avenue segment

Milwaukee Supply Route alternative M3 would follow National Avenue which is a two-lane, two-way road. The land use around the route in this area is primarily residential and agricultural. Approximately 810 feet southwest of the intersection of National Avenue and South Egofske Road, the pipeline would turn west across National Avenue to a private parcel.

B.3.6. Parcel NBC 1268960 segment

Approximately 100 feet of jack and bore construction would be used to cross under National Avenue to Parcel NBC 1268960. This private parcel would be crossed with a required minimum 50-foot permanent easement. At South Racine Avenue, jack and bore construction would also be used to cross under Racine Avenue.

B.3.7. Racine Avenue segment

At this point, this alternative supply pipeline would join in a common corridor with the proposed return flow pipeline, if it were chosen. This alternative supply pipeline would then follow Racine Avenue to the north. Racine Avenue is a two-lane, two-way road. The land use around the route in this area is primarily residential with agricultural areas and becomes more agricultural as it proceeds north. To the north of the intersection with West Observatory Road, Racine Avenue curves to the northwest.

The proposed booster pump station (BPS) would be located at the intersection of Racine Avenue and South Swartz Road, and this alternative supply pipeline would pass through the proposed

BPS and then continue to follow Racine Avenue to the northwest. At East Sunset Drive, this alternative supply pipeline would turn west.

B.3.8. Sunset Drive segment

The common pipeline corridor would continue east along the south side of Sunset Drive. At Guthrie Road, one spur of this alternative supply pipeline would turn south and connect to the WWU distribution system at Hunter Tower. The common pipeline corridor would also continue west on Sunset Drive. Just east of the intersection with Les Paul Parkway (Wisconsin Highway 59) this alternative supply pipeline would diverge from the common pipeline corridor. Jack and bore construction would be used to install approximately 350 linear feet of water supply pipe casing to cross both Sunset Drive and Les Paul Parkway in a single trenchless crossing. After this road crossing, the proposed water supply pipeline would connect to the water supply control building (WSCB) and the WWU water distribution system. The proposed return flow pipeline would turn southwest to follow Les Paul Parkway.

B.4. Oak Creek route alternative OC2 return flow pipeline description

A description of the alignment of Oak Creek Route Alternative 2 return flow pipeline is presented below following the flow path, beginning at the Waukesha WWTP and ending at the Root River discharge site. This alternative return flow pipeline would be approximately 25.69 miles in length. The pipeline would be installed using open trench construction except as otherwise indicated.

B.4.1. Sentry Drive segment

This alternative return flow pipeline would begin at Waukesha's WWTP at approximately 1,150 feet west of the intersection of Sentry Drive and the WWTP access drive. The alternative pipeline would run to the north along the west side of the WWTP property. The pipeline would then turn east on the WWTP property, cross a potentially abandoned rail line using jack and bore construction and proceed south along Sentry Drive. Sentry Drive is a four-lane, two-way roadway in an area that is urban, with municipal and industrial areas. The same potentially abandoned rail line would again be crossed using jack and bore construction along Sentry Drive. Approximately 450 feet to the north of the intersection of Chapman Drive and Sentry Drive, jack and bore construction would be used to install approximately 100 linear feet of pipe casing under abandoned railroad tracks.

B.4.2. West Sunset Drive segment

This alternative return flow pipeline would then proceed east along West Sunset Drive, which is a four-lane, two-way roadway in an area that is urban, with industrial, commercial and residential land uses. Approximately 500 feet to the west of the intersection of Sunset Drive and West Avenue, jack and bore construction would be used to install approximately 150 feet of pipe casing to cross under railroad tracks.

B.4.3. West Avenue segment

This alternative return flow pipeline would then proceed south along South West Avenue which is a four-lane, two-way roadway in an area that is urban, with industrial, commercial, and residential land uses.

B.4.4. Route 59 segment

This alternative return flow pipeline would then proceed east and north along Route 59 which is a four-lane, divided two-way roadway. The land use around the proposed route in this area is urban, with industrial, commercial, and residential areas. At South East Avenue, jack and bore construction would be used to install approximately 170 linear feet of pipe casing under East Avenue to minimize traffic disruption. Approximately 1,600 feet northeast from the intersection of East Avenue and Route 59, 350 linear feet of pipe casing would be installed using HDD to cross a creek.

B.4.5. East Sunset Drive segment

At the southwest corner of the intersection of Route 59 and East Sunset Drive, jack and bore construction would be used to install approximately 170 linear feet of pipe casing to cross Route 59. This alternative return flow pipeline would then proceed east along Sunset Drive which is a four-lane, two-way roadway. The land use around the route in this area is primarily urban and residential areas.

B.4.6. Racine Avenue segment

This alternative return flow pipeline would proceed southeast and south along East Racine Avenue, which is a two-way, two-lane road that predominantly runs through a rural agricultural area with some residential properties.

B.4.7. Lawnsdale Road segment

This alternative return flow pipeline corridor would then turn east to follow Lawnsdale Road which is a two-lane, two-way roadway. The land use in this area is primarily rural, with residential areas.

B.4.8. National Avenue segment

This alternative return flow pipeline corridor would then turn northeast to follow West National Avenue which is a two-way roadway. The land use in this area is primarily rural, with agricultural and residential areas.

B.4.9. Private parcels NBC 1236993 and NBC 1236995 segment

Southwest of the intersection of South Calhoun Road and National Avenue, this alternative return flow pipeline corridor would turn east and then south across two private parcels. The construction within Parcels NBC 1236993 and NBC 1236995 would require 50-foot permanent easements and a 15-foot temporary easement.

B.4.10. Calhoun Road segment

At Calhoun Road, this alternative return flow pipeline corridor would turn south. Calhoun Road is a two-lane, two-way roadway. The land use around in this area is primarily rural, with agricultural areas.

B.4.11. Private parcels NBC 1286999002 and NBC 1286999001 segment

At the intersection of Calhoun Road and West Beres Road, this alternative return flow pipeline corridor would turn east and then south for approximately 4,310 feet across two private parcels. The construction within Parcels NBC 1286999002 and NBC 1286999001 would require 50-foot permanent easements and 15-foot temporary easements. At the east side of Parcel NBC

1286999001, jack and bore construction would be used to install approximately 375 linear feet of pipe casing to cross under Interstate 43 to Parcel NBC 1286999002, avoiding traffic disruption along Interstate 43.

B.4.12. Small Road segment

This alternative return flow pipeline corridor would then turn northeast to follow West Small Road which is a two-lane, two-way roadway. The land use in this area is a primarily rural, with agricultural, commercial and residential areas.

B.4.13. Westridge Road segment

This alternative return flow pipeline corridor would follow South Westridge Drive which is a two-lane, two-way roadway. The land use in this area is a primarily rural, with agricultural, commercial and residential areas.

B.4.14. Moorland Road segment

This alternative return flow pipeline would then turn south to follow South Moorland Road. In this area, Moorland Road is a two-lane, two-way roadway. The land use in this area is primarily agricultural, with few commercial and residential properties. At the intersection with College Avenue, jack and bore construction would be used to install approximately 110 linear feet of pipe casing to cross under College Avenue.

Approximately 700 feet north of the intersection with College Avenue, Moorland road transitions to a four-lane, divided two-way roadway. The land use in this area is primarily rural, with residential, commercial, and agricultural areas. At the intersection with Janesville Road, jack and bore construction would be used to install approximately 160 linear feet of pipe casing to cross under Janesville Road. Just north of this intersection, 180 linear feet of pipe casing would be installed using jack and bore construction to cross under Moorland Road from east to west.

B.4.15. Durham Drive segment

Mooreland Road becomes Durham Drive at the intersection with Woods Road. This alternative return flow pipeline would then follow Durham Drive to the southeast. Durham Drive is a two-lane, two-way roadway. The land use in this area is primarily rural, with residential and agricultural areas. At the intersection with South North Cape Road, jack and bore construction would be used to install approximately 100 linear feet of pipe to cross under Cape Road. The pipeline would then follow Cape Road to the south.

B.4.16. North Cape Road segment

North Cape Road is a two-lane, two-way roadway with a large concrete shoulder. The land use in this area is primarily rural, with residential and agricultural areas. At West Ryan Road, this alternative return flow pipeline corridor would turn to the east.

B.4.17. Ryan Road segment

In this area, Ryan Road is a two-lane, two-way roadway with a gravel shoulder. The land use in this area is primarily rural and agricultural. Jack and bore construction would be used to install 340 linear feet of pipe casing to cross under Loomis Road (Wisconsin Highway 36). At the intersection with South 112th Street, HDD would be used to install 800 linear feet of pipe casing to avoid wetlands and old trees.

At 112th Street, this alternative return flow pipeline would pass through a total of eight privately owned parcels along Ryan Road for a total length of 3,100 feet. Tax IDs for the parcels which the pipelines pass through, from west to east are: 8929991000, 8929990000, 8929989002, 8929989003, 8929989001, 8939997001, 8939997002, and 8939995001. A 50-foot permanent easement spanning across the eight parcels would be required.

Just west of the intersection of Ryan Road and Saint Martins Road, HDD would be used to install a length of 350 feet of the pipeline below an concrete culvert. The land use in this area is primarily rural and agricultural, with residential properties. At the intersection with South 76th Street, jack and bore construction would be used to install approximately 175 linear feet of pipe casing under 76th Street.

At the proposed Ryan Road crossing of the Root River, the roadway transitions from a two-lane, two-way roadway to a four-lane, two-way roadway. HDD would be used to install approximately 1,400 feet of the pipeline underneath the Root River.

At South 60th Street, this alternative return flow pipeline would turn south.

B.4.18. 60th Street segment.

South 60th Street is a four-lane, two-way roadway. The land use around the route in this area is rural, with industrial areas. At the intersection with Franklin Drive, 60th Street transitions to a two-lane, two-way roadway.

This alternative return flow pipeline corridor would end at the proposed Root River outfall site in the southeast quadrant of the intersection of 60th Street and Oakwood Road.

B.5. Oak Creek route alternative OC3 return flow pipeline description

Return flow route alternative OC3 follows the same roadways as the proposed return flow route (OC3-preferred) except that OC3 does not follow Racine Court. OC3 also does not include an easement on private land along West Sunset Drive just west of West Avenue. The remainder of alternative return flow route OC3 would follow the same roadways as the route for OC3-preferred.

B.5.1. Oak Creek route alternative OC4 return flow pipeline description

A description of the alignment of Oak Creek Route Alternative 4 return flow pipeline is presented below following the flow path, beginning at the Waukesha WWTP and ending at the Root River discharge site. This alternative return flow pipeline would be approximately 26.54 miles in length. The pipeline would be installed using open trench construction except as otherwise indicated.

B.5.2. Sentry Drive segment

This alternative return flow pipeline would begin at Waukesha's WWTP at approximately 1,150 feet west of the intersection of Sentry Drive and the WWTP access drive. The alternative pipeline would run to the north along the west side of the WWTP property. The pipeline would then turn east on the WWTP property, cross a potentially abandoned rail line using jack and bore construction and proceed south along Sentry Drive. Sentry Drive is a four-lane, two-way roadway in an area that is urban, with municipal and industrial areas. The same potentially abandoned rail line would again be crossed using jack and bore construction along Sentry Drive. Approximately 450 feet to the north of the intersection of Chapman Drive and Sentry Drive, jack and bore construction would be used to install approximately 100 linear feet of pipe casing under abandoned railroad tracks.

B.5.3. West Sunset Drive segment

This alternative return flow pipeline would then proceed east along West Sunset Drive, which is a four-lane, two-way roadway in an area that is urban, with industrial, commercial and residential land uses. Approximately 500 feet to the west of the intersection of Sunset Drive and West Avenue, jack and bore construction would be used to install approximately 150 feet of pipe casing to cross under railroad tracks.

B.5.4. West Avenue segment

This alternative return flow pipeline would then proceed south along South West Avenue which is a four-lane, two-way roadway in an area that is urban, with industrial, commercial, and residential land uses.

B.5.5. Route 59 segment

This alternative return flow pipeline would then proceed east and north along Route 59 which is a four-lane, divided two-way roadway. The land use in this area is urban, with industrial, commercial, and residential areas.

B.5.6. Route 164 segment

At the southwest corner of the intersection of Route 164 and Route 59, jack and bore construction would be used to install approximately 220 linear feet of pipe casing to cross under Route 59. This alternative return flow pipeline would then proceed south along Route 164, which is a four-lane, divided two-way roadway. The land use in this area is agricultural and commercial, with residential areas. South of Glendale Road, the land use becomes rural, with agricultural and residential areas.

Approximately 3,160 feet south from the intersection of Route 164 and Route 59, HDD would be used to install approximately 360 linear feet of pipeline to cross under a creek. Approximately 1,350 feet south from the intersection of Route 164 and Lawnsdale Road, HDD would be used to install approximately 350 linear feet of pipeline to minimize impact to another creek.

B.5.7. Town Line Road segment

At the intersection of Town Line Road and Route 164, jack and bore construction would be used to install 150 linear feet of pipe casing to cross under Route 164. This alternative return flow pipeline corridor would then follow Town Line Road to the east. Town Line Road is a two-lane, two-way roadway. The land use in this area is primarily rural, with agricultural and residential areas.

B.5.8. Parcels NBC 2182999006, VNT 2017999, 2017998 and VNT 2017996 segment

At the intersection of Town Line Road and Guthrie Road, this alternative return flow pipeline corridor would continue east and then south across four private parcels to the intersection of Crowbar Avenue and National Avenue. The land use in this area is primarily rural, with agricultural and residential areas. The total length of the proposed common corridor across these four parcels would be approximately 3,640 feet.

B.5.9. Crowbar Drive segment

This alternative return flow pipeline corridor would continue south along Crowbar Drive which is a two-lane, two-way roadway. The land use in this area is rural and agricultural with residential. Jack and bore construction would be used to install approximately 630 linear feet of pipe casing to cross under Interstate 43.

B.5.10. Tans Drive segment

This alternative return flow pipeline corridor would then turn east on Tans Drive which is a two-lane, two-way roadway. The land use in this area is rural, with residential areas.

B.5.11. Racine Avenue segment

At Racine Avenue, this alternative return flow pipeline corridor would turn south and southeast. Racine Avenue is a four-lane, two-way roadway. The land use in this area is rural, with commercial and residential areas. Jack and bore construction would be used to install approximately 370 linear feet of casing under Janesville Road to minimize traffic disruption. This alternative pipeline corridor would follow Racine Avenue until the intersection with City of Muskego Recreational Trail.

B.5.12. City of Muskego Recreational Trail segment

This alternative return flow pipeline corridor would then turn northeast and east to follow the City of Muskego Recreational Trail until reaching Durham Drive. The land use in this area is primarily rural, with residential areas.

B.5.13. Durham Drive segment

This alternative return flow pipeline corridor would then follow Durham Drive to the south. Durham Drive is a two-lane, two-way roadway. The land use in this area is primarily rural, with residential and agricultural areas. At the southeast corner of the intersection of Durham Drive and North Cape Road, jack and bore construction would be used to install approximately 100 linear feet of pipe to cross under Cape Road. This alternative pipeline would then follow North Cape Road to the south.

B.5.14. North Cape Road segment

North Cape Road is a two-lane, two-way roadway with a large concrete shoulder. The land use in this area is primarily rural, with residential and agricultural areas. At West Ryan Road, this alternative return flow pipeline corridor would turn to the east.

B.5.15. Ryan Road segment

In this area, Ryan Road is a two-lane, two-way roadway with a gravel shoulder. The land use in this area is primarily rural and agricultural. Jack and bore construction would be used to install 340 linear feet of pipe casing to cross under Loomis Road (Wisconsin Highway 36). At the intersection with South 112th Street, HDD would be used to install 800 linear feet of pipe casing to avoid wetlands and old trees.

At 112th Street, this alternative return flow pipeline would pass through a total of eight privately owned parcels along Ryan Road for a total length of 3,100 feet. Tax IDs for the parcels which the pipelines pass through, from west to east are: 8929991000, 8929990000, 8929989002, 8929989003, 8929989001, 8939997001, 8939997002, and 8939995001. A 50-foot permanent easement spanning across the eight parcels identified would be required.

Just west of the intersection of Ryan Road and Saint Martins Road, HDD would be used to install a length of 350 feet of the pipeline below an concrete culvert. The land use in this area is primarily rural and agricultural, with residential properties. At the intersection with South 76th Street, jack and bore construction would be used to install approximately 175 linear feet of pipe casing under 76th Street.

At the proposed Ryan Road crossing of the Root River, the roadway transitions to a four-lane, two-way divided roadway. HDD would be used to install approximately 1,400 feet of the pipelines to bypass underneath the Root River.

At South 60th Street, this alternative return flow pipeline would turn south.

B.5.16. 60th Street segment

South 60th Street is a four-lane, two-way roadway. The land use around the route in this area is rural, with industrial areas. At the intersection with Franklin Drive, 60th Street transitions to a two-lane, two-way roadway.

This alternative return flow pipeline corridor would end at the proposed Root River outfall site in the southeast quadrant of the intersection of 60th Street and Oakwood Road.

Appendix C. Alternatives screening process

The following description is from the Applicant's supplemental environmental impact report and subsequent information submittals. The Applicant's review of alternatives took place in several stages. In late 2016, the Applicant identified six possible pipeline routes and facility locations in a screening-level analysis for a water supply from the City of Oak Creek with return flow to the Root River. In 2017, the Applicant accepted an offer from the City of Milwaukee to supply water. The Applicant then evaluated two Milwaukee route alternatives (an initial supply route alternative and a sub-alternative). In 2018, the Applicant replaced the initial two Milwaukee supply route alternatives with three other Milwaukee supply pipeline route alternatives (M1, M2, and M3). The three Oak Creek return flow alternatives were also retained for further evaluation. The Applicant chose M1 to be the preferred supply route alternative, and Oak Creek 3 to be the preferred return flow route alternative.

C.1. Evaluation factors for pipelines and facilities

Possible pipeline routes and facility locations for the City of Oak Creek alternatives were evaluated in a two-step process. In the first phase, screening level data were reviewed in the route study area to identify route alternatives between Oak Creek and Waukesha and between the Waukesha WWTP and the Root River discharge parcel. The second phase involved a more detailed evaluation of routes that remained after the phase one evaluation.

During the first phase, route alternatives were developed to limit overlapping corridors so that alternatives were distinctly different. Some potential corridors were eliminated to avoid new or planned regional transportation projects, areas in proximity of high risk contaminated sites (i.e. National Priorities List Superfund sites), and segments of routes with significant lengths outside of existing rights-of-way that would result in excessive impacts to the environment and wetland areas. These initial criteria reduced the potential environmental impacts associated with each of the routes being considered.

Potential water supply connection locations and route alternatives were discussed with WWU during a workshop. Following this workshop, an additional evaluation was conducted by gathering GIS data from communities where the route may pass, reviewing aerial surveys, and performing desktop evaluations. Six route alternatives between Oak Creek and Waukesha were identified, which were evaluated based on the following criteria:

- Opportunities with other planned projects
- Bike trails
- Open space
- Route length
- Hydraulic efficiency
- Cost, restoration, and staging
- Operation and maintenance access
- Difficult construction crossings
- Compatibility with long-range planning

After further analysis and discussions with municipalities, potential corridors were eliminated to avoid new or planned construction projects to the extent possible. The original proposal of an

Oak Creek water supply pipeline route included in the Lake Michigan Application was removed from evaluation as it included corridors identified with new or planned roadway construction. After the analysis, six route alternatives remained for further consideration. In each case, the requirements for associated facilities were the same. Consequently, facilities did not become a distinguishing factor between alternative routes.

To reduce the number of route alternatives from six to three, each route was evaluated and compared based on economic and non-economic criteria.

Capital cost opinions were developed to provide a means for comparing route alternatives on an economic basis. These costs were prepared in accordance with the AACE International's Recommended Practice No. 18R-97 for a Class 5 Opinion of Probable Construction Cost with an accuracy of -50 to +100 percent and contingency of 30 percent. The Preliminary Alternatives Report Workshop (W-01) was held with WWU on February 2, 2017 and the cost opinions for the six route alternatives were reviewed. The cost difference between route alternatives was within the 30 percent contingency and within the accuracy of the AACE International's Class 5 Opinion of Probable Construction Cost of -50 to +100 percent.

Route alternatives were also compared using non-economic criteria. Non-economic criteria address characteristics or special requirements associated with each route alternative and consider factors of importance for each route alternative. The non-economic criteria evaluated are presented in Table C-1 and include infrastructure, hydraulics and energy, accessibility, and environmental (as measured by desktop analysis) factors. These factors were further detailed through specific criteria. For example, infrastructure criteria included pipeline length, effects of special crossings, and traffic and roadway conditions.

Table C-1. Non-economic criteria and weighting to evaluate six routes

Criteria	Weighting	Impacts
Infrastructure criteria		
Pipeline length	5	Length of pipe. Duration of construction; date of initial operation; duration of public inconvenience. Number of pipe joints and potential latent defects (e.g. future leaks). Number of appurtenances requiring operations and maintenance.
Special crossings	3	Length of crossing. Duration of construction. Time and risk of potential problems.
Traffic and roadway conditions	3	Pavement condition. Traffic count. Time and risk of potential problems.
Hydraulics and energy criteria		
Energy usage	4	Power required to deliver flow and operational costs.
Topographic considerations	1	Additional infrastructure required. Duration of construction. Additional maintenance requirements.
Hydraulic considerations	1	Pressure considerations. Material availability. Risk of ruptures from hydraulic transients.
Accessibility criteria		
Accessibility	5	Accessibility for emergency vehicles. Accessibility for maintenance. Proximity to major highways. Overhead clearance. Site congestion.
Public impact during construction	3	Community relations. Business operations and profits. Tranquility of life (e.g. noise, dust, vibration). Traffic backups; public and business commuting time and cost.
Opportunities with other planned projects	3	Cooperative efforts with municipalities. Use of identified lands or properties. Synergy with other planned projects.
Environmental (desktop assessment) criteria		
Contaminated materials	2	High risk sites. Risk of construction delays. Risk of additional costs during construction.
Protected resources	3	Historic preservation districts. Construction delays.
Wetlands	3	Potential disturbance and mitigation. Design and construction complexity. Quality of environment, flora, and fauna.
River and floodplain	3	Number of potential crossings. Complexity of design. Construction related risks. Government and public perception.

The criteria were applied to the six routes through a two-step process. WWU assigned weighting to the criteria based on their criticality to the proposed project. Proposed project team members then reviewed route alternatives for each non-economic criterion and scored the route alternatives based on each team member's expertise in the collaborative team environment. The scoring also considered whether the given route alternative would require additional facilities such as pumping stations, that could result in larger capital costs or greater environmental impacts. WWU also weighted the non-economic criteria during the meeting based on their vision for how they wish to operate their new water supply. Weighting ranged from one (least importance to the proposed project) to five (greatest importance to the proposed project). Route scores were presented to WWU in a workshop. The resulting products of the weighting and scores were compiled to produce a total score for each route. The route with the lowest total score represented the least favorable combination of criteria weighting and alternative scoring. The route with the highest total score represented the most favorable combination of criteria weighting and alternative scoring.

The findings from the economic and non-economic evaluation were reviewed with WWU as part of the Preliminary Route Alternatives Report Workshop held on February 2, 2017. Based on the economic and non-economic evaluation, Oak Creek Route Alternatives 2, 3, and 4 were selected for further evaluation during the Route Study in the second phase of the analysis.

C.2. Comparison of Oak Creek Route Alternatives OC2, OC3, and OC4

Oak Creek route alternatives 2, 3, and 4 were further refined in several east-west portions of the corridors to minimize pipeline length, public impact, and easement requirements, as well as to improve accessibility and avoid wetlands and areas of suspected high-risk contaminated material sites. These included study areas between Moorland Road and Racine Avenue for Oak Creek Route Alternatives 2 and 3 and between Racine Avenue and Route 164 for Oak Creek Route Alternative 4. Route sub-alternatives were identified in each study area and evaluated based on economic and non-economic criteria. Findings from the economic and non-economic evaluation were reviewed with WWU and preferred route sub-alternatives were selected as part of the Route Study – Alternative Routes Review Meeting (Task 4-100 M-01) held on March 2, 2017.

An array of economic and non-economic criteria was developed specifically for this phase of the analysis to compare Oak Creek Route Alternatives 2, 3, and 4. Using the criteria, the alternatives were evaluated based on desktop assessments, field reconnaissance, and public open house meetings in which the public provided input on route alternatives. Preliminary horizontal alignments, trenchless requirements, and steady state hydraulics were developed to compare the route alternatives. The non-economic and economic criteria included the following items.

- Hydraulic analysis
- Total pipeline length
- Trenchless requirements
- Geotechnical conditions
- Contaminated materials
- Maintenance of traffic requirements
- Wetlands
- Waterways
- Floodplain encroachment
- Special habitats
- Protected resources
- Agricultural resources
- Energy consumption
- Stakeholder feedback
- Real property and easement requirements
- Constructability

- Conceptual opinion of probable construction costs

As in the earlier phase, economic and non-economic criteria were used to develop route scoring to identify a preferred route. The evaluation process was guided by the Envision Rating System for Sustainable Infrastructure (Institute for Sustainable Infrastructure 2017). Key Performance Indicators (KPIs) were developed to integrate WWU's values into the design process and provide a basis for developing metrics to evaluate and compare route alternatives. KPIs are criteria that remain constant, but the alternatives and the metrics for each KPI change based on the decision that is being evaluated. Although they are not all assigned a cost value, the KPIs are of critical importance in determining the preferred route alternative.

Table C-2 presents the KPI definitions using language from the Envision Rating System for Sustainable Infrastructure. The KPI definitions were developed to be broad enough to apply to all aspects of the project and act as universal weighing criteria. The metrics delineated into KPIs are listed in Table C-3.

Table C-2. Definitions of key performance indicators

Key performance indicator	Definition	Weight
System reliability	Using robust design strategies, preventive maintenance and intuitive configurations, project elements are dependable and resilient.	19.0
Life cycle cost	Pursue strategies that reduce long-term operational and maintenance costs.	15.5
Schedule	Complete the project in a timeframe that mitigates negative impacts on the community's quality of life.	14.0
Ease of construction	Avoid sites that require intensive efforts to preserve or restore, integrate infrastructure, or access with construction equipment.	11.0
Public acceptability	The project vision and goals align with those of the affected communities, and the implementation of the project expands the skills, capacity, mobility, and health of a community while mitigating negative impacts.	6.5
Capital cost	Minimize financial impact on the community with consideration of factors such as resource conservation, ease of infrastructure integration, and avoiding site development that requires additional efforts to preserve.	6.0
Effects on ability to finance	Through triple-bottom line analysis, project elements have been de-risked and future-proofed, helping attract infrastructure investment.	6.0
Future expansion	Implement designs and other measures that allow for the expansion of the project to incorporate future connections and increased flow.	6.0
Operational flexibility	Reduce vulnerabilities by creating an adaptable design that can function in a variety of social, economic, and environmental conditions with monitored systems that allow ease and consistency of operation.	6.0
Environmental impact	Measures are taken to preserve the natural world through avoidance, monitoring, restoration, and negative impact mitigation; resources are conserved during the construction and operation of the project; there is a concerted effort to preserve the ambient conditions that affect quality of life of the community like noise, light, and air quality.	5.0
Cost sharing potential	Thorough infrastructure integration and commitment to synergistic opportunities, the cost of project elements is shared by a broader community.	5.0

Table C-3. Key performance indicator metrics

Key performance indicator	Metrics
System reliability	Length of pipe (linear feet), accessibility (number of special crossings, number of easements), maximum pressure (pounds per square inch [psi])
Life cycle cost	Capital cost ($), energy cost (U.S. dollars)
Schedule	Days (determined by linear feet of pipe / day)
Ease of construction	Depth to bedrock (linear feet of pipe < 50 feet deep), dense soils (linear feet of pipe), organic soils (linear feet of pipe), shallow groundwater, soils corrosive to steel/ductile iron (linear feet of pipe), soils corrosive to Portland cement concrete pipe (linear feet of pipe), contaminated materials (total ranking score on each route)
Public acceptability	Protected resources (no. of archaeological, burial, and historic sites), transportation (linear feet of roadway impacts, square footage of pavement area, additional driving hours), number of easements, agriculture (acreage in the easements), coordination with planned regional transportation projects
Capital cost	Capital cost ($)
Effects on ability to finance	Envision score
Future expansion	Number of municipalities traversed, ADD of municipalities traversed (mgd)
Operational flexibility	Number of pressure sustaining valves, number of connections to the distribution system, distribution system pressure (psi)
Environmental impact	Acreage of WWI mapped and photo-interpreted wetlands, number of waterways crossed
Cost sharing potential	Number of municipalities traversed, simultaneous planned regional transportation projects

Waukesha Water Utility staff independently weighted the KPIs from 1 (to represent a less significant or lower perceived impact to the project) to 10 (to represent a more significant or higher perceived impact to the project). The weights were linearly scaled such that the sum of all weights totaled 100. This resulted in some criteria having weights greater than 10. After weighting was complete, project team members performed desktop analyses and compared route alternatives for the non-economic criteria within their discipline or area of expertise. These comparisons were used to develop route scoring.

Results from the non-economic evaluation and a hydraulics analysis were used to support development of Conceptual Opinions of Probable Construction Cost for comparing route alternatives on an economic basis. The costs were prepared in accordance with the AACE International's Recommended Practice No. 18R-97 for a Class 4 Opinion of Probable Construction Cost with an accuracy of -20 to +50 percent of cost. A contingency of 25 percent was also used per a Class 4 Opinion of Probable Construction Costs. Opinion of Probable Construction Costs were developed per Division at an Engineering News-Record Construction Cost Indices value of 10,942. The cost differences between route alternatives are within the 25 percent contingency and -20 to +50 percent accuracy of the AACE International's Class 4 Opinion of Probable Construction Cost. As a result, the preferred route alternative was identified based on predominantly non-economic considerations.

C.3. Milwaukee supply route alternatives development

With the City of Milwaukee's offer to supply water, the route analysis also initially considered two Milwaukee Supply Route Alternatives, called the Milwaukee Supply Route Alternative and Milwaukee Supply Route Sub-Alternative.

These initial Milwaukee Supply Route alternatives were developed to limit duplication of overlapping corridors and to minimize pipeline length, public impact, and easement requirements. Potential corridors were eliminated to avoid new or planned regional transportation projects to the extent feasible. Several of the potential corridors were also eliminated due to less preferable environmental crossings associated with the Root River, special crossings associated with interstates, and dense urban developments in Milwaukee.

The Milwaukee Sub-Alternative water supply route would follow an existing electrical transmission utility corridor that could be used to avoid construction beneath roads and minimize traffic disturbance for a portion of the overall water supply pipeline route. The Milwaukee Supply Route Sub-Alternative was reviewed with WWU and discussed with the City of Milwaukee. After receiving confirmation of the route for evaluation, preliminary horizontal alignments for the Milwaukee Supply Route Alternative and the Milwaukee Supply Route Sub-Alternative were developed.

A hydraulic analysis was conducted to identify necessary infrastructure and confirm operating conditions. Opinions of probable cost were generated and were similar for both original Milwaukee supply route alternatives.

The initial two Milwaukee supply route alternatives were also evaluated based on non-economic criteria. The non-economic criteria were kept consistent with those utilized in evaluating the six Oak Creek route alternatives. The purpose of the non-economic scores was to assist in identifying a preferable route between Milwaukee and Waukesha. Route scores were developed with the highest total score represents the more favorable combination of criteria weighting and alternative scoring.

The Milwaukee Supply Route Sub-Alternative was preferred on a non-economic basis due to lower public impact and improved accessibility through the electrical transmission utility corridor. However, discussions with the electrical utility indicated that an easement through that corridor may be difficult to obtain. For this reason, the Milwaukee Supply Route Sub-Alternative was eliminated from consideration.

Following evaluation, the two initial Milwaukee supply route alternatives were replaced with three other Milwaukee supply route alternatives (M1, M2 and M3). These three were then evaluated using the same process along with the three Oak Creek return flow alternative routes.

C.4. Current alternatives evaluation process

The three Milwaukee supply and three Oak Creek return flow route alternatives were screened in more detail for the following resources.

- Wetlands and waterways
- Archaeological resources
- Agricultural resources
- Wisconsin Natural Heritage Inventory (NHI)

C.4.1. Current alternatives wetland evaluation process

A desktop evaluation of wetlands and waterways was conducted for the three Milwaukee supply and three Oak Creek return flow alternatives. The evaluation was conducted by reviewing maps and aerial imagery including DNR WWI maps, USGS topographic maps, Natural Resources Conservation Service soils maps and recent and historical aerial photographs. Potential wetlands and waterways were identified, classified, and mapped on recent aerial photographs. The study area included the road ROW for each of the proposed pipeline routes, several easements outside the ROW, and a We Energies corridor. This summary described the amount of wetland acreage associated with WWI-mapped and additional photo-interpreted wetlands for ROW and non-ROW easements, and the number of waterway crossings in the ROW.

C.4.2. Current alternatives cultural resource evaluation process

As part of the pipeline route alternative analysis and selection process, a literature and archives review of cultural resources was conducted. Literature and archives research included the following sources: the Wisconsin Historic Preservation Database, the Archaeological Report Inventory, the Archaeological Site Inventory, the Architecture History Inventory, the C.E. Brown Atlas, the C.E. Brown Manuscripts, county historical society publications, county site files, 1937-38 aerial photographs, old topographic maps, the General Land Office survey maps, the Wisconsin Land Economic Inventory maps, the National Register of Historic Places (NRHP), and public and university libraries.

The evaluation described where cultural sites would be overlapped by the alternative corridors, provided relevant information on the importance of each site, and recommended ways to minimize effects that planned construction could have on cultural resource sites. In addition to the resources that would overlap the proposed alternative corridors, cultural resources within 50 feet and 100 feet of the corridors, and proposed easements were also reviewed. While these resources would not be affected by the footprint of proposed alternatives, adjustments of the preliminary alternative corridors and design of access roads could affect them. A Phase I survey of the proposed project is required and is being undertaken to comply with Section 106 of the National Historic Preservation Act.

Resource impacts of the proposed project would be avoided and minimized through the pipeline detailed design process. Where avoiding an impact is not practical, the resources would be treated consistent with the requirements contained within Section 106 of the National Historic Preservation Act and would be followed in coordination with the Wisconsin State Historic Preservation Office.

C.4.3. Current alternatives agricultural resources evaluation process

As part of the pipeline route alternative analysis and selection process, a desktop review of agricultural resources was conducted. The desktop review included the locations and quantity of agricultural lands using the following sources: Waukesha County Open Data Portal Website (Land Use 2010), the Milwaukee County Land Information Office Geospatial data (Land Use 2010), the U.S. Department of Agriculture Organic Integrity Database, and the Organic Agriculture in Wisconsin 2017 Status Report and 2015 Status Report. The evaluation described where agricultural sites overlap existing ROWs, a We Energies Corridor (Oak Creek Route Alternative 4 only), a 50-foot buffer beyond the edge of those features, and project-related easements for the routes.

C.4.4. Current alternatives endangered resources evaluation process

As part of the pipeline route alternative analysis and selection process, a desktop review of endangered biological resources was conducted. The desktop review included spatially locating the number of element occurrences (EOs) for terrestrial resources within one mile of each pipeline route and aquatic resources within two miles of each pipeline route. EOs are defined as the rare, threatened, and endangered species and natural communities included in the State of

Wisconsin's NHI database. EOs were further broken down into those likely to be impacted or not, and if impacted, whether a measure would be required or recommended to avoid, minimize or mitigate effects on the EO. Measures were classified as: required measures for state-listed endangered and threatened animal species, and recommended measures for state listed plant, natural communities, and state special concern animals.

The desktop review also included review of the USFWS's IPaC database, which tracks federal threatened and endangered species, critical habitats, migratory birds, federal wildlife management facilities (e.g. wildlife refuges, fish hatcheries), and wetlands in the National Wetland Inventory.

C.5. Issues and concerns raised with state agency staff

A PSC and DNR Pre-Application Meeting was held on January 24, 2017. The intended project was introduced and review coordination and schedules between the agencies was discussed.

A workshop was held with PSC and DNR on June 5, 2017 to discuss organization and the required construction permit considerations. PSC and DNR recommended that impacts to forested wetlands be minimized.

A meeting was held with WDOT on July 20, 2017. An exception will be needed to use the WDOT Interstate 43 ROW.

C.6. Contacts and consultations with government entities, landowners, and interested parties

C.6.1. Consultations with the City of Franklin

On June 27, 2017, an open house meeting was held to acquire stakeholder feedback. The open house occurred at the Hunger Task Force Farm in Franklin. The open house allowed GWA representatives to meet with the public, residents, business owners and landowners. The feedback helped identify public perception of the pipeline route alternative alignments.

On August 23, 2017, representatives from the GWA met with staff members from the City of Franklin to discuss permits required of the project from the City of Franklin.

The staff of the City of Franklin voiced several concerns with the pipeline route alternatives proposed by GWA.

The Franklin Department of Public Works Facility is located at 7979 Ryan Road and includes public access from waste disposal as well as the fueling station for city vehicles. The City of Franklin would like trenchless construction considered for this area. The Applicant is considering trenchless construction in this area.

60th Street was reconstructed in 2016. The City would like to restrict construction access along the roadway or they would like trenchless construction to be considered, and the Applicant is considering trenchless construction in this area.

Franklin Business Park near 51st and Ryan Road has many businesses that run multiple shifts. Traffic impact in the area should be minimized. The Applicant is considering options to minimize traffic impact to these businesses.

C.6.2. Consultations with the City of New Berlin

On June 29, 2017, an open house meeting was held to acquire stakeholder feedback. The open house occurred at the New Berlin Public Library. The open house allowed GWA representatives to meet with the public, residents, business owners, and landowners. The feedback helped identify public perception of the route alignments.

On July 18, 2017, representatives from the GWA met with staff members from the City of New Berlin to review local permitting requirements for the construction of the water transmission main and return flow line.

The staff of the City of New Berlin voiced concerns that the proposed pipeline route would interfere with their future road improvement projects on Moorland and Calhoun roads scheduled for construction in 2019. Moorland Road will be widened to four lanes from the current two, and Calhoun Road will be reconstructed to lower an existing hill north of Beloit. In addition, there will be ongoing construction of two subdivisions along Moorland Road. The Calhoun Road reconstruction was included in the factors that led to the selection of the proposed Route Alternative 3 (Oak Creek) instead of Route Alternative 2 (Oak Creek).

Representatives from the GWA and staff members from the City of New Berlin met again on August 30, 2017 to continue discussions on the City's concerns with the pipeline construction interfering with their future Moorland Road and Calhoun Road improvement projects. Changes to the horizontal alignment and construction methods of the pipe on Moorland are being considered by the Applicant.

C.6.3. Consultations with the City of Muskego

On June 28, 2017, an open house meeting was held to acquire stakeholder feedback. The open house occurred at the Muskego High School. The open house allowed GWA representatives to meet with the public, residents, business owners and landowners. The feedback helped identify public perception of the route alignments.

On August 24, 2017, representatives from the GWA met with staff members from the City of Muskego to review the anticipated permits required of the Applicant from the City of Muskego.

The staff of the City of Muskego raised the issue that North Cape Road is the main hauling route for two large waste landfills located along 124th Street. Extensive construction along the roadway could be intrusive to the waste hauling operations. The Applicant is considering options to minimize impact to the hauling routes.

C.6.4. Consultations with the City of Greenfield and City of Milwaukee

Open house meetings will likely be held in the City of Greenfield and the City of Milwaukee to acquire stakeholder feedback.

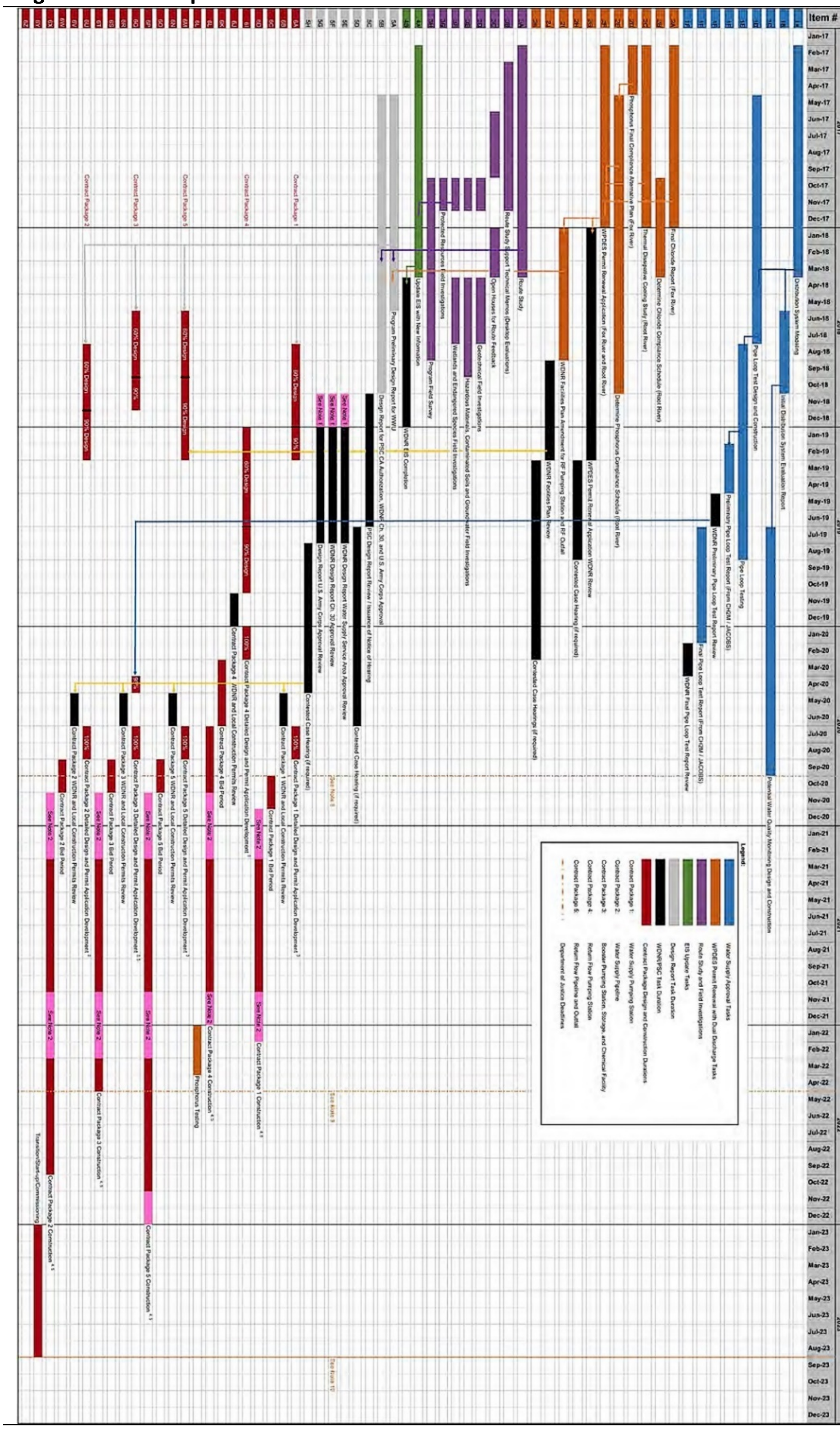
C.6.5. Consultations with the USACE

On June 23, 2017, representatives of GWA met with staff from U.S. Army Corps of Engineers (USACE), DNR, and PSC to introduce the intended project to USACE and obtain initial feedback of their concerns, permitting strategy, and schedule.

The staff from DNR commented that the project team should take advantage of opportunities to enhance wetlands where practicable due to the high public profile of the project.

Appendix D. Proposed project schedule

Figure D-1. Anticipated construction schedule



Source: Great Water Alliance.

Appendix E. Preliminary Final EIS

January 2016

City of Waukesha
Proposed Great Lakes Diversion

PRELIMINARY FINAL
ENVIRONMENTAL IMPACT STATEMENT

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

To the Reader

In October 2013, the City of Waukesha (Applicant) submitted a revised *Application for a Lake Michigan Diversion with Return Flow* (Application) to the Wisconsin Department of Natural Resources (department), updating the original version of the Application submitted in May 2010. The Application contained five Volumes (Vol.):

Vol. 1 – Application Summary
Vol. 2 – City of Waukesha Water Supply Service Area Plan
Vol. 3 – City of Waukesha Water Conservation Plan
Vol. 4 – City of Waukesha Return Flow Plan
Vol. 5 – City of Waukesha Environmental Report for Water Supply Alternatives

Because the City of Waukesha lies within a county that straddles the Great Lakes surface water divide, it is eligible to seek an exception from the prohibition of diversions under the Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement (Agreement) and Great Lakes—St. Lawrence River Basin Water Resources Compact (Compact). The Agreement is a good faith agreement between the Great Lake States and Provinces to manage water quantity in the Great Lakes Basin. The Agreement is implemented in the United States through the Compact—a legally binding contract among the eight Great Lakes States. The Applicant seeks to obtain a Lake Michigan water supply as a solution to its current water supply problems that include elevated levels of radium in the drinking water supply above the drinking water standard. The Applicant is currently under a state court order to meet the state and federal radium drinking water standard by 2018.

This document is a preliminary final Environmental Impact Statement (EIS), prepared by the Wisconsin Department of Natural Resources (department) in compliance with ch. NR 150, Wisconsin Administrative Code, and s. 1.11 Wisconsin Statutes. The purpose of an EIS is to inform decision-makers and the public of the anticipated effects on the quality of the human environment of a proposed action or project and alternatives to the proposed action or project. The EIS is an informational tool—it is not a decision document.

The department also prepared a draft version of the EIS. The public was invited to provide comments on the scope of the analysis between February 5, 2010 and August 13, 2011, and three public scoping meetings were held on July 26, 27 and 28 in 2011 at Pewaukee, Wauwatosa and Sturtevant. The department received 102 public scoping comments. The department then prepared the draft EIS and invited the public to comment on it between June 25 to August 28, 2015. The department received 3,634 written comments from individuals and groups. Additionally, comments were received at three public hearings on August 17 and 18, 2015 at Waukesha, Milwaukee and Racine. Of the 404 people who registered at the hearings, 128 provided oral testimony.

This preliminary final EIS explains the Applicant's proposal to use water from Lake Michigan (in order to meet its water supply needs) and return wastewater to the Lake Michigan basin as required by the Agreement and Compact. The preliminary final EIS analyzes potential impacts of alternative water supplies and return flow options, including analysis of an additional alternative, and other analyses not presented in the draft EIS. Also included in this preliminary final EIS is the department's response to public comments on the draft EIS.

In addition, the department has prepared a Technical Review, a requirement of Article 201 of the Agreement, section 4.9 of the Compact, and Wisconsin's Compact implementing legislation (s. 281.346(4)(e)1.f., Wis. Stats.). The Technical Review outlines the department's findings related to the Agreement, Compact and Wisconsin's Compact implementing statutes.

The department will forward the preliminary final EIS, Technical Review and Application to the Great Lakes States, and Quebec and Ontario through the Regional Body and Compact Council for review and decision as required by the Agreement and Compact. The Regional Body is the governing body of the Agreement and includes the Great Lakes premiers and governors. The Compact Council is the governing body of the Compact and includes the Great Lakes governors. Throughout this process, Great Lakes Tribes and First Nations will also be informed of the proposal and provided opportunities to comment.

Once the Compact Council and Regional Body make a determination that the diversion is approved, and before any specific permits are issued, the department will issue a final EIS including any comments and decisions from the Regional Body and a WEPA compliance determination. The Applicant would need to acquire all permits and approvals for the divers from the State of Wisconsin before the department would approve the diversion.

The department maintains a website with information related to the Applicant's diversion application, including the public participation process, communications with the Applicant, and other supporting materials.

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Acronyms and Abbreviations

ADD	average day demand
Agreement	Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement
Applicant	City of Waukesha
Application	*City of Waukesha Application for a Lake Michigan Diversion with Return Flow*
AWE	Alliance for Water Efficiency
AWWA	American Water Works Association
CEM	conservation and efficiency measure
CFS	cubic feet per second
CMOM	Capacity, Management, Operations and Maintenance
Compact	Great Lakes—St. Lawrence River Basin Water Resources Compact
department	Wisconsin Department of Natural Resources
EIS	Environmental Impact Statement
ER	Environmental Report
EPA	United States Environmental Protection Agency
GLB	Great Lakes basin
GMA	Groundwater Management Area
GPCD	gallons per capita per day
GPD	gallons per day
I/I	infiltration and inflow
MCL	maximum contaminant level
MDD	maximum day demand
MG	million gallons
mg/L	milligrams per liter
MGD	million gallons per day
MGY	million gallons per year
MMSD	Milwaukee Metropolitan Sewerage District
MRB	Mississippi River basin
MWWAT	Michigan Water Withdrawal Assessment Tool
PCB	polychlorinated biphenyl
piC/L	picocuries per liter
PRESTO	Pollutant load Ratio Estimation Tool (DNR model)
WPSC	Public Service Commission of Wisconsin
SDWA	Safe Drinking Water Act
SEWRPC	Southeastern Wisconsin Regional Planning Commission
SPARROW	Spatially-referenced Regression on Watershed Attributes (model)
TDS	total dissolved solids
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
ug/L	micrograms per liter
USGS	United States Geological Survey
WBR	Winter Base-Rate

WDNR	Wisconsin Department of Natural Resources
WEPA	Wisconsin Environmental Policy Act
WGNHS	Wisconsin Geological and Natural History Survey
WPDES	Wisconsin Pollutant Discharge Elimination System
WPSC	Wisconsin Public Service Commission
WQBEL	Water quality based effluent limits
WWTP	wastewater treatment plant

Section 1 Introduction and Project Summary

1 Proposed Project

1.1 Process Summary

The City of Waukesha, Wisconsin, located in southeast Wisconsin, 17 miles west of Lake Michigan, seeks an exception from the prohibition of diversions under the Great Lakes—St. Lawrence River Basin Water Resources Compact (Compact) and Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement (Agreement). The Compact prohibits diversions of Great Lakes water, with limited exceptions. One exception allows a "community within a straddling county," such as Waukesha, to apply for a diversion of Great Lakes water.

Figure 1-1 Location of City of Waukesha and Great Lakes Water Basin

The Wisconsin Department of Natural Resources has been reviewing the City of Waukesha's (Applicant) diversion application since the City first applied in May 2010. The City submitted its latest revised *Application for a Lake Michigan Diversion with Return Flow* (Application) to the Wisconsin Department of Natural Resources (department) in October 2013. As part of this process, the Applicant prepared Volume 5 (Vol.5) *City of Waukesha Environmental Report for Water Supply Alternatives*. The department has completed both a draft and a preliminary final Environmental Impact Statement (EIS) under Wisconsin's Environmental Policy Act (s.1.11, Wis. Stats.) and the department procedures for environmental analysis and review (ch. NR 150, Wis. Admin. Code).

This preliminary final EIS evaluates the preferred and proposed alternatives for both water supply and return flow. This EIS contains 6 sections:

- Section 1: Introduction and Project Summary – An overview of the project.
- Section 2: Project Alternatives – A summary of the alternatives reviewed by the department including water supply alternatives and proposed pipeline routes.
- Section 3: Affected Environment – The existing natural resources that are in the region that may be impacted by this project.
- Section 4: Environmental Effects of the Proposed Project – A synopsis of the potential impacts that may result from the project alternatives.
- Section 5: Comparison of Alternatives.
- Section 6: Cumulative Effects and Evaluation.

The Wisconsin Department of Natural Resources maintains a website on the Waukesha diversion application at http://dnr.wi.gov/topic/WaterUse/WaukeshaDiversionApp.html.

1.2 Purpose and need for proposed project

The Applicant asserts that it needs a new source of water to address water quantity and quality concerns. The Applicant has long relied on a deep aquifer groundwater supply, but depressed water levels in the deep aquifer have compounded a problem of high radium concentration (a naturally occurring carcinogen) in the groundwater. The public supply is supplemented by water from the shallow aquifer. In 2014, the Applicant served a population of 70,850 people and used 6.6 million gallons of water per day. The Applicant is under a 2009 Wisconsin court judgment to develop a permanent solution to the radium contamination problem by 2018.

Figure 1-2 Location of water supply and wastewater return flow routes

1.3 Water Supply Service Area

The Applicant had its water supply service area delineated by the Southeastern Wisconsin Regional Plan Commission (SEWRPC) in accordance with Wis. Stat. 281.348. The delineated service area includes the City of Waukesha and portions of the City of Pewaukee, and portions of the Towns of Delafield, Genesee, and Waukesha. Inclusion in the water supply service area is based on several factors including future land use plans, sanitary sewer area plans, and historic private well contamination. The delineated water supply service area sets the outer boundary of municipal water supply service expansion, and is designed to promote the orderly management of growth within a community.

1.4 Water supply for proposed project

The Applicant proposes to divert from the Great Lakes basin up to an annual average of 10.1 million gallons per day and a daily maximum of 16.7 million gallons based upon a final water supply service area build-out for a population of 97,400 (approximately the year 2050).

Under the proposed diversion, the Applicant would receive treated water from the City of Oak Creek Water Utility, which is located in the Great Lakes basin and withdraws surface water from Lake Michigan. The water would be transported to Waukesha through a 19.4 mile pipeline and distributed to customers (see Section 2 of the EIS for details).

1.5 Return flow for proposed project

As required by the Compact, the Applicant proposes that, after consumptive use, remaining water will be treated at the existing Waukesha wastewater treatment plant (WWTP) before it is piped via Root River Alignment 2 and discharged to the Root River, a tributary to Lake Michigan. The pipeline would follow major roads and corridors to minimize environmental impacts. In total, this alternative would require approximately 20.2 miles of 30-inch pipe. The Applicant intends to keep some wells as an emergency back-up supply. Emergency wells are required to meet the requirements of NR 810.22.

1.6 Authorities and approvals for proposed project

Table 1-1 lists the various permits and approvals that will be or may be required for construction, operation and maintenance of the proposed project.

Table 1-1. Permit and Approvals

Permit, Approval or Evaluation	Statute or Regulation	Administering and Enforcing Agency
FEDERAL		
Great Lakes—St. Lawrence River Basin Water Resources Compact	Public Law 110-342	Great Lakes---St. Lawrence River Basin Water Resources Council
Endangered Species Act Section 7 Consultation	16 U.S.C. s. 1531 et. seq. (Endangered Species Act)	U.S. Fish and Wildlife Service (Green Bay ES Field Office)
Clean Water Act Section 404 Dredge and Fill Permit	33 U.S.C. s. 1344 (Clean Water Act)	U.S. Army Corps of Engineers (St. Paul District and Detroit District)
Section 10 Navigable Waters Permit	33 U.S.C. s. 403 (Rivers and Harbors Act of 1899)	U.S. Army Corps of Engineers (St. Paul District)
STATE		
Stream Crossings of Navigable Waters	Wis. Stats. ch. 30, Wis. Adm. Code. NR 102, 320, 329, 341, 345	WDNR
WPDES Stormwater Discharge Permit	Wis. Stats. s. 283.33, Wis. Adm. Code. NR 216	WDNR

Wetland Permit	Wis. Stats s. 281.36, Wis. Adm. Code NR 103	WDNR
Pit/trench Dewatering General Permit	Wis. Stats. ch. 283, Wis. Adm. Code 216	WDNR
Wastewater Facilities Plan Review	Wis. Adm. Code NR 110	WDNR
Control of Particulate Emission - Fugitive Dust	Wis. Adm. Code NR 415.035, 415.04	WDNR
Wisconsin Floodplain Management Program including local floodplain zoning ordinances	Wis. Adm. Code NR 116	WDNR
Incidental Take Permit	Wis. Stats. s. 29.604 (6m)	WDNR
Water Quality Antidegradation evaluation	Wis. Adm. Code NR 207	WDNR
Wisconsin Pollutant Discharge Elimination System Permit	Wis. Stats. ch. 283, Wis. Adm. Code NR 217	WDNR
Water Supply Service Area Plan	Wis. Stats. ss. 281.346 and 281.348	WDNR
Wastewater systems construction plan review	Wis. Stats. s. 281.41, Wis. Adm. Code NR 108	WDNR
Water systems construction plan review	Wis. Adm. Code NR 108	WDNR
Cultural Resources Review	Wis. Stats. ss. 44.40 and 157.70	Wisconsin State Historic Preservation Office
Agricultural Impact Statement	Wis. Stats. s. 32.035	Wisconsin Department of Agriculture, Trade, and Consumer Protection
Certificate of Public Convenience and Necessity	Wis. Stats. s.196.491	Public Service Commission of Wisconsin
LOCAL		
General types include (but are not limited to): construction permits, public utility laws, navigable waters, land use regulations, zoning laws and designations, stormwater management plans, erosion and sediment control, floodplain and wetland ordinances	varies	county/municipality

At least 3 different counties(Milwaukee, Racine and Waukesha) and approximately 20 municipalities (Brookfield (City), Caledonia (Village), Cudahy (City), Franklin (City), Greendale (Village), Greenfield (City), Hales Corners (Village), Milwaukee (City), Mount Pleasant (Village), Muskego (City), New Berlin (City), Norway (Town), Oak Creek (City), Raymond (Town) , St. Francis (City), Waukesha(City and Town), West Allis (City)) could be affected by the construction, operation and maintenance of the proposed diversion project or its alternatives. Each of these counties and municipalities has ordinances that constitute local laws that the Applicant must comply with. These ordinances cover a variety of topics but generally include: construction laws and permits needed (especially in streets and sidewalks), public utility laws, laws governing navigable waters, land use regulations, zoning laws and designations, stormwater management plans, erosion and sediment control, and floodplain and wetland ordinances.

The department has made a determination that the Applicant's proposed diversion is in compliance with the Boundary Waters Treaty of 1909. The treaty states, in relevant part: "[other than as previously stated] no further or other uses or obstructions or diversions… affecting the natural level or flow of boundary waters on the other side of the line shall be made [except with approval of the International Joint Commission]" (Boundary Waters Treaty of 1909; art. 3). The Applicant's proposed diversion will not trigger this section of the treaty because the Applicant will be returning all water withdrawn less an allowance for consumptive use. The diversion will not alter the flows or levels of the Great Lakes.

Section 2 Project Alternatives

2 Project Alternatives

The City of Waukesha (Applicant) first applied for a Lake Michigan diversion in May 2010 and submitted an updated *Application for a Lake Michigan Diversion with Return Flow* (Application) to the Wisconsin Department of Natural Resources (department) in October 2013.

As part of the Application, Volume 5 (Vol. 5), the Applicant prepared an environmental report which considers the preferred alternative (Lake Michigan Supply – City of Oak Creek, with return flow to the Root River) among various alternatives for water supply options in the Mississippi River basin, the Lake Michigan basin and a combination of both basins. Any Lake Michigan Basin alternative under a diversion approval would need to return the water withdrawn, less an amount for consumptive use, back to the Lake Michigan basin.

For purposes of this environmental impact statement (EIS), the department reviewed the following water supply and return flow alternatives after considering analysis completed by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and potentially feasible alternatives identified by the City:

Water supply alternatives:

- Deep and shallow aquifers – Mississippi River basin
- Shallow aquifer – Mississippi River basin
- City of Milwaukee - from Lake Michigan
- City of Oak Creek (alignment 2) – from Lake Michigan
- City of Racine – from Lake Michigan

Return flow alternatives:

- Fox River – Mississippi River basin
- Root River (alignment 2) - to Lake Michigan
- MMSD South Shore Outfall - to Lake Michigan
- Direct to Lake Michigan (near Milwaukee and Oak Creek)

The ‘no action’ alternative was also included for purposes of comparison. The ‘zero demand increase alternative’ was also included in response to comments on the draft EIS. The department has analyzed the potential environmental effects of these water supply and return flow alternatives in Section 4 of this EIS. Below is a general description of each alternative.

2.1 No Action Alternative

The Applicant’s public water supply system is comprised of groundwater supply (wells), treatment, storage and conveyance assets. The water system consists of ten active wells: seven deep wells and three shallow wells, three water treatment plants for radium and iron/manganese removal, twelve storage tanks, nine booster pump stations, and approximately 326 miles of transmission and distribution water mains.

The ‘no action’ alternative would continue to use the current public water supply system, with no modifications to the current wells. The deep sandstone aquifer provides approximately 80% of the Applicant’s current water supply. The deep wells contain radium, a known carcinogen, at concentrations above the federal and state drinking water standard. Although the Applicant maintains radium treatment to reduce the amount of radium in its drinking water, the water system is not in compliance with state regulations that require less than 5 picocuries per liter (pCi/L) radium 226 and radium 228 at each entry point of the distribution system (see the department’s Technical Review S1). The no action alternative assumes 7.3 MGD from the deep aquifer and 1.2 MGD from the shallow aquifer under an 8.5 MGD average day demand. Note that the Applicant’s request is for 10.1 MGD average day demand; however, the groundwater flow modeling conducted to review the Mississippi River Basin alternatives used 8.5 MGD average day demand. The no action alternative is not a feasible option, as the Applicant must comply with drinking water quality standards and deep aquifer water supply does not meet radium standards.

The ‘no action’ alternative is further explained in Section 4.

2.2 Zero demand increase alternative

Multiple comments on the draft EIS supported the alternative put forth by the Compact Implementation Coalition (CIC) – a group of environmental and conservation organizations. The alternative was developed through CIC contracts with GZA GeoEnvironmental Inc., and Mead and Hunt (GZA GeoEnvironmental, Inc. 2015; Mead and Hunt, 2015). The CIC and others expressed the opinion that this alternative demonstrates that the Applicant does not need another water source and therefore does not meet the Agreement/Compact requirements. The following is a description of this alternative, as understood by the department. The potential effects of this alternative are also discussed in section 4.

This alternative assumes that average day demand (ADD) will not increase above 6.7 MGD and an 11.1 MGD maximum day demand (MDD).The alternative was developed by consultants for a group of non-governmental organizations and submitted to the department as part of the comments for the draft EIS. The ADD for this alternative is calculated assuming the full build-out of the existing service area assuming the 2008-2012 average per capita per day demand of 89.1 gallons, 8% unaccounted for water, and 10% demand reduction for water conservation. Details on this alternative can be found in the report “Non-Diversion Alternative Using Existing Water Supply with Treatment City of Waukesha Water Supply, Waukesha Wisconsin.” (GZA GeoEnvironmental, Inc. 2015) This ADD does not consider the Applicant’s delineated water supply service area for calculating demand projections and uses alternative assumptions for calculating demand than the assumptions used by the Applicant. The department does not consider this alternative viable because it does not meet the Agreement/Compact criteria to meet all applicable state laws. State law requires the Applicant to consider the delineated water supply service area in developing a projected water demand. This alternative only considers the existing service area not the delineated service area (see Technical Review S3 for additional information). In addition, the department determined that the proposed infrastructure does not have the firm capacity to supply the 11.1 MGD projected MDD, as requires under S. NR 811.26 Wis. Adm. Code.

For this alternative, the Applicant would use the existing deep and shallow aquifer wells; add reverse osmosis (RO) treatment to three deep wells; maintain hydrous manganese oxide (HMO) treatment on one deep well; and pump water from all of the wells to the Hillcrest reservoir for blending and then distribution to the system. This alternative would not add any additional wells. Additional infrastructure would be required to pump water from all wells to the Hillcrest Reservoir prior to delivery to the water supply system. See Table 2-1 below for well treatment and capacity summary.

Table 2-1- Applicant well capaccities with proposed zero demand increase alternative. (Duchniak, 2015)

Well	*Aquifer Depth*	*Treatment*	*24-hr Firm Pump Capacity (MGD)*	*24-hr Firm Well Capacity (with Treatment)[1] (MGD)*	*12-hr Firm Well Capacity (with Treatment)[1] (MGD)*	*18-hr Firm Well Capacity (with Treatment)[1] (MGD)*
3	Deep	HMO	1.1	1.1	0.6	0.8
5	Deep	(None)	1.4	1.4	0.7	1.1
6	Deep	Add RO	2.7	2.2	1.1	1.6
7	Deep	(None)	0.9	0.9	0.5	0.7
8	Deep	Add RO	2.4	1.9	1.0	1.4
9	-- Abandon[2] --		0.0	0.0	0.0	0.0
10	Deep	Add RO	3.8	3.0	1.5	2.3
11	Shallow	(None)	0.2	0.2	0.1	0.2
12	Shallow	(None)	0.7	0.7	0.4	0.5
13	Shallow	(None)	0.9	0.9	0.5	0.7
	Firm Capacity[3]:		**10.3**	**9.3**	**4.6**	**7.0**

[1] Reverse Osmosis treatment results in reject water. Reject water is brine that is discharged to the sanitary sewer. A 20% reject water volume is calculated for Reverse Osmosis treatment technology at Wells No. 6, 8 and 10.
[2] Well 9 is proposed to be is abandoned in this review due to poor water quality, and limited well house footprint, preventing addition of treatment facilities. The abandonment of Well 9 was not included in the GZA report.
[3]Firm capacity is the system capacity with the largest well out of service. In the Applicant's system this is Well No. 10.

As discussed for this alternative, treatment would be installed at the three largest deep wells (No. 6, 8, and 10) to reduce total dissolved solids and radium. Since the deep wells are on small lots, adjacent residential property would need to be purchased for the additional treatment facilities. The Applicant has stated that each of these wells would need to have its own treatment facility, and that water from the remaining deep wells and shallow wells would be blended at the Hillcrest reservoir.

Water treatment solids (sludge) generated as part of the treatment process would require a new sludge pipeline from the water treatment plant. This pipeline would parallel the treated water pipeline to minimize construction impacts and costs.

2.3 Water Supply alternatives

2.3.1 Mississippi River basin supply alternatives

There are two Mississippi basin supply alternatives evaluated in this document. The alternatives are: the deep and shallow aquifers supply alternative, and the shallow aquifer supply alternative. If either of these alternatives were chosen, the return flow would be through the City's wastewater treatment plant with discharge to the Fox River.

2.3.1.1 Deep and shallow aquifers supply alternatives

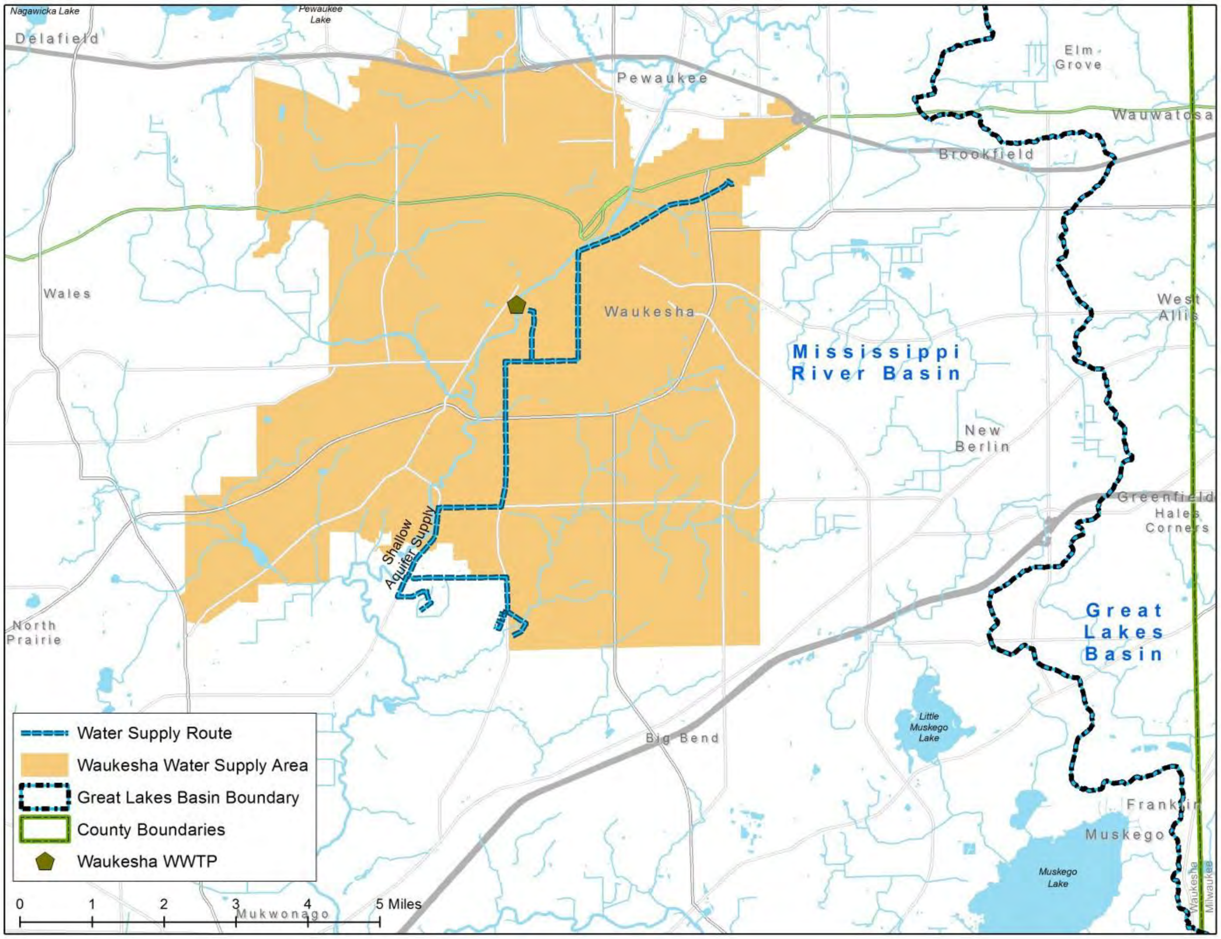
With this alternative the Applicant would continue use of the deep aquifer (St. Peter sandstone) and shallow aquifer south of the City of Waukesha with additional treatment facilities and wells for the deep and shallow aquifer supply alternative (Figure 2-1).

The proposed infrastructure includes 7.6 million gallons per day (MGD) capacity from the existing deep wells and 1.2 MGD from the existing shallow wells. This alternative includes an additional 7.9 MGD capacity from 12 new shallow wells south of Waukesha, near the Vernon Marsh Wildlife Area, in the shallow sand and gravel aquifer (Figure 2-2).

All water in this alternative would require new pipelines to allow water to be blended at the Hillcrest reservoir.

The proposed new shallow aquifer wells would need new pipes to connect the wells with the new water treatment plant needed for this alternative. These pipes would cross the Fox River, Pebble Brook and wetlands adjacent to the Vernon Marsh Wildlife Area between the wells and the water treatment plant. From the water treatment plant, a new pipe would follow existing roads to convey the treated water to the Hillcrest reservoir and Applicant's distribution system.

Figure 2-1 Deep and Shallow aquifer water supply potential pipeline infrastructure



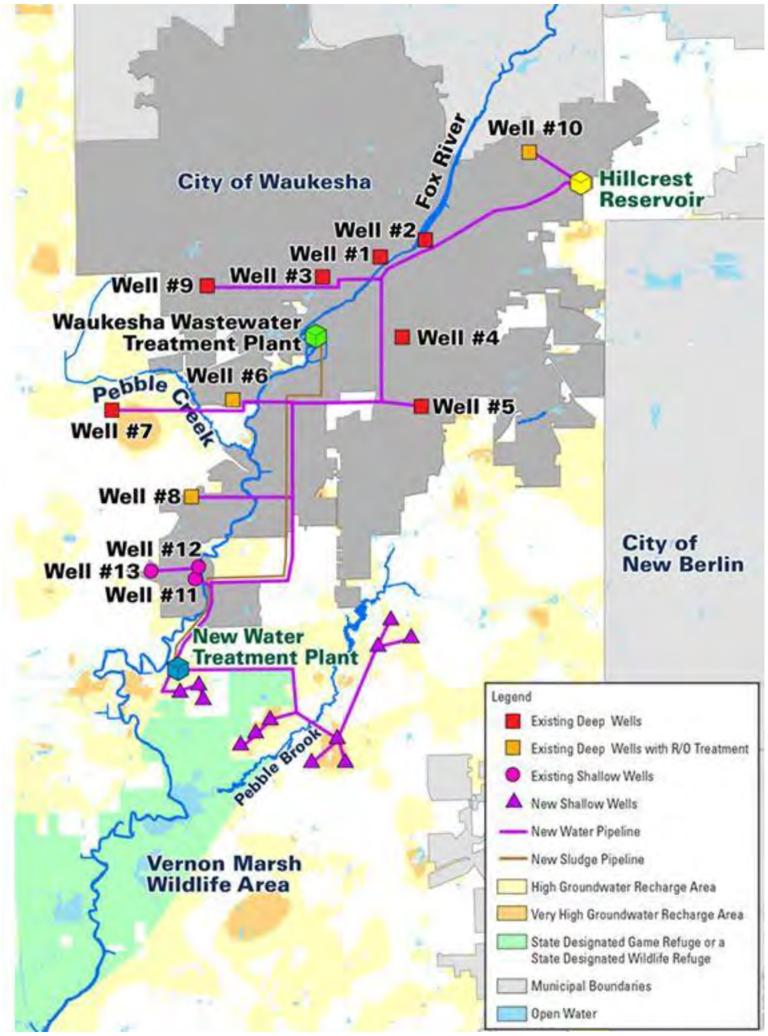
For this alternative, treatment would be installed at the three largest deep wells (No. 6, 8, and 10) to reduce TDS and radium. Since the deep wells are on small lots, adjacent residential property would need to be purchased for the additional treatment facilities. The Applicant assumes wells No. 6, 8, and 10, would each have its own treatment facility, and that water from the remaining deep wells and shallow wells would be blended at the Hillcrest reservoir. Additionally, arsenic treatment may be needed in the shallow wells (test wells identified slightly elevated arsenic levels), as well as iron, manganese and microorganism removal. The shallow well water would be pumped from the wells to a new water treatment plant. A new pump station and 30-inch diameter pipeline would convey treated water to the City of Waukesha and connect with the water distribution system and Hillcrest reservoir.

Water treatment solids (sludge) generated as part of the treatment process would require a new sludge pipeline from the water treatment plant. This pipeline would parallel the treated water pipeline to minimize construction impacts and costs.

In total, this alternative would require approximately 13.9 miles of 8- to 30-inch diameter pipeline.

The department also reviewed a variation on this alternative that would eliminate the shallow wells along Pebble Brook and added River Bank Inducement wells along the Fox River.

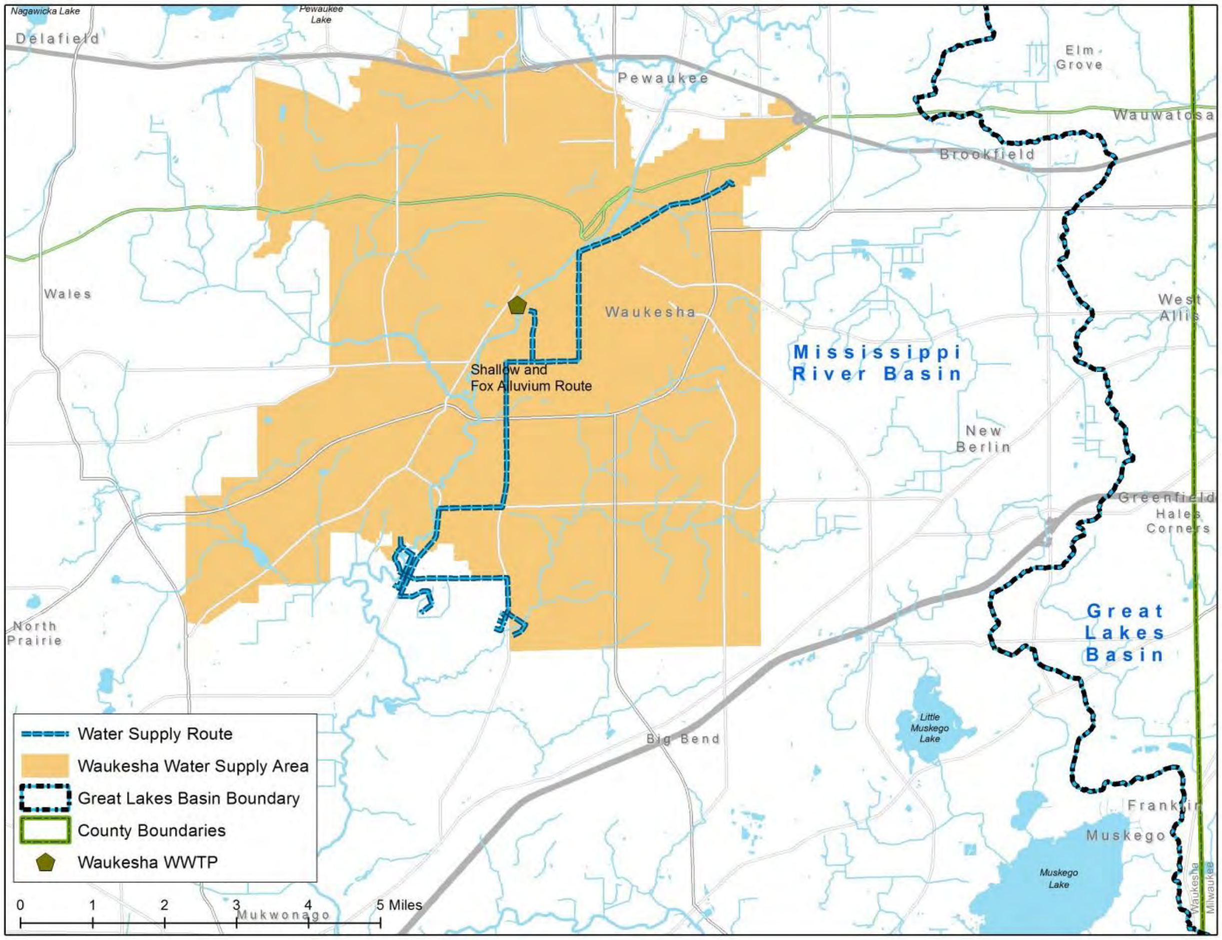
Figure 2-2 Deep and shallow aquifers water supply alternative as proposed by the Applicant (Vol. 1, Exhibit 4-3)



2.3.1.2 Shallow aquifer supply alternatives

In this alternative the Applicant would use the shallow sand and gravel aquifer south of the City of Waukesha (Figure 2-3).

Figure 2-3. Shallow aquifer (Fox River alluvium) water supply potential pipeline infrastructure



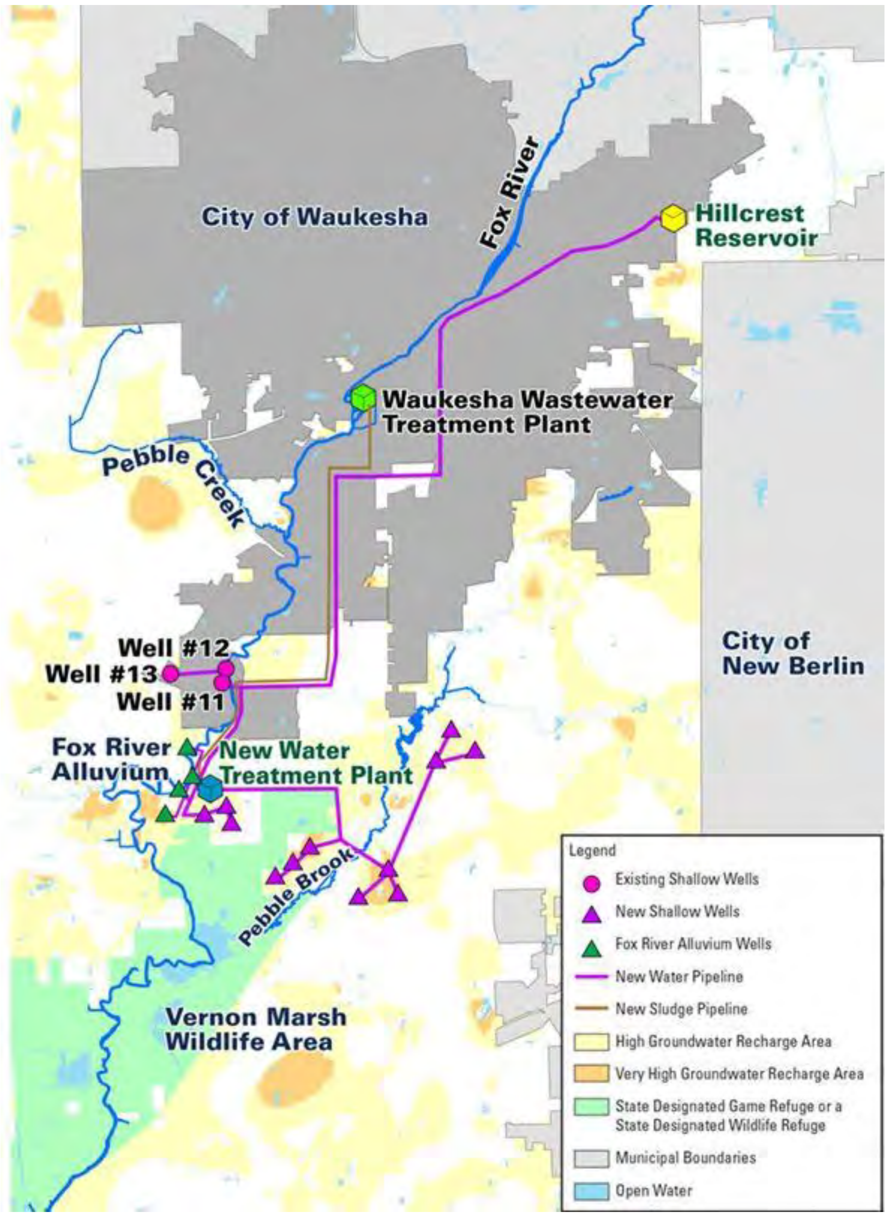
This alternative's proposed infrastructure includes 4.5 MGD capacity through four new wells along the Fox River south of the City of Waukesha, 1.2 MGD from the existing shallow wells, and an additional 11.0 MGD capacity from 12 new shallow wells south of the City of Waukesha near the Vernon Marsh Wildlife Area in the shallow sand and gravel aquifer (Figure 2-4).

For this alternative, the shallow aquifer wells would pump water, through new supply pipes, to a new water treatment plant south of the City of Waukesha. The water would be treated for iron, manganese, microorganism removal and possibly arsenic. The proposed pipes would cross the Fox River, Pebble Brook and wetlands adjacent to the Vernon Marsh Wildlife Area. From the water treatment plant, a new pump station and 30 inch diameter pipeline would follow existing roads to convey the treated water to the Applicant's distribution system and to the Hillcrest reservoir.

Water treatment solids (sludge) generated as part of the treatment process would require a new sludge pipeline from the water treatment plant. This pipeline would parallel the treated water pipeline to minimize construction impacts and costs.

In total, this alternative would require approximately 14.7 miles of 8- to 30-inch diameter pipeline

Figure 2-4. Shallow aquifer water supply alternative as proposed by the Applicant (Vol. 1, Exhibit 4-9)



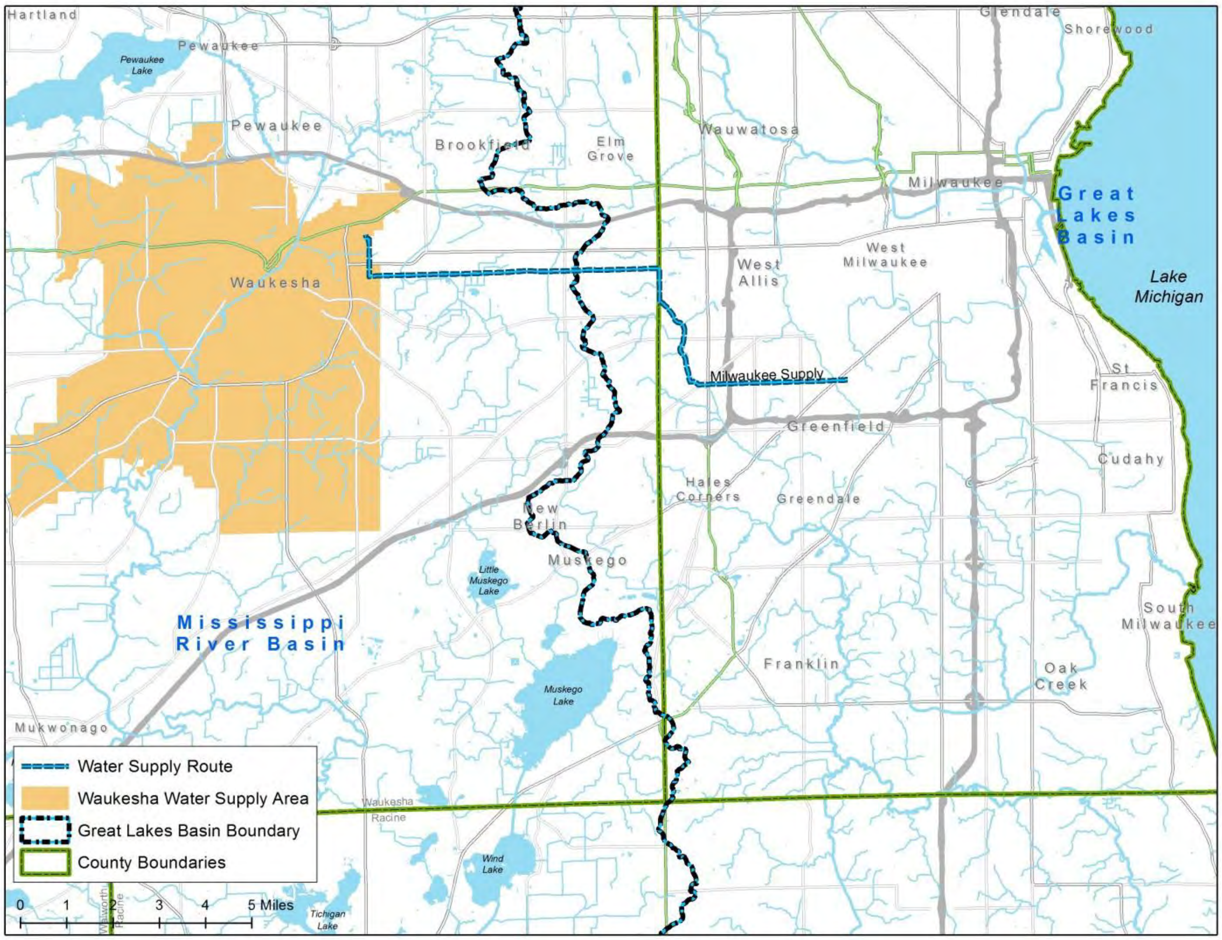
2.3.2 Lake Michigan supply alternatives

There are three Lake Michigan basin supply alternatives evaluated in this EIS. The alternatives are: the City of Milwaukee supply alternative, the City of Oak Creek supply alternative, and the City of Racine supply alternative. If any of these alternatives were chosen, the return flow would be to Lake Michigan

2.3.2.1 Milwaukee supply alternative

Under this alternative, Lake Michigan water would be purchased from the City of Milwaukee, obtained by connecting to the City of Milwaukee's existing distribution system on the west side of Milwaukee. This alternative would utilize treatment from the City of Milwaukee's two existing drinking water treatment plants (Figure 2-5).

Figure 2-5. Lake Michigan - City of Milwaukee water supply potential pipeline infrastructure

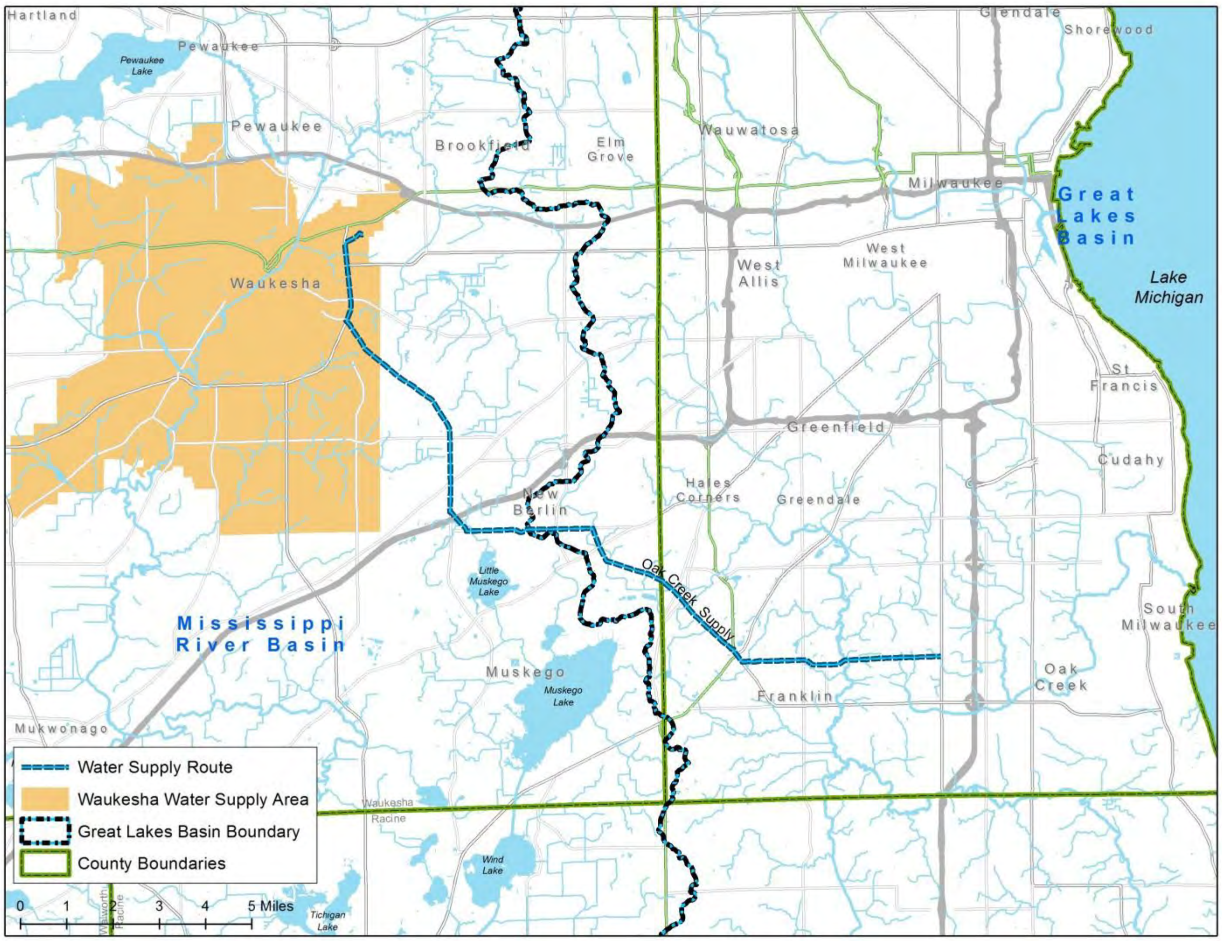


For this alternative, a new pipeline and booster pump station would be constructed. The connection to the City of Milwaukee's distribution system would be near 60th Street and Howard Avenue. The Applicant assumed this location because there is a large transmission main nearby. From this connection, a 30-inch supply pipeline would head west and follow City and Milwaukee County streets for about 6 miles. Along this segment the booster pump station is proposed to be constructed. From the booster pump station, the pipeline would continue west for about 6 miles along a utility corridor. The last segment of pipe (about 1 mile) would continue on City streets and lightly developed areas with a connection at the Hillcrest reservoir. In total, this alternative would require approximately 15 miles of pipeline.

2.3.2.2 Oak Creek supply alternative

The Applicant's preferred water supply alternative would be to obtain Lake Michigan surface water from the Oak Creek Water Utility, utilizing treatment from the City of Oak Creek's existing drinking water treatment plant located in the Great Lakes basin (Oak Creek Alignment 2, Figure 2-6).

Figure 2-6. Lake Michigan - City of Oak Creek water supply potential pipeline infrastructure

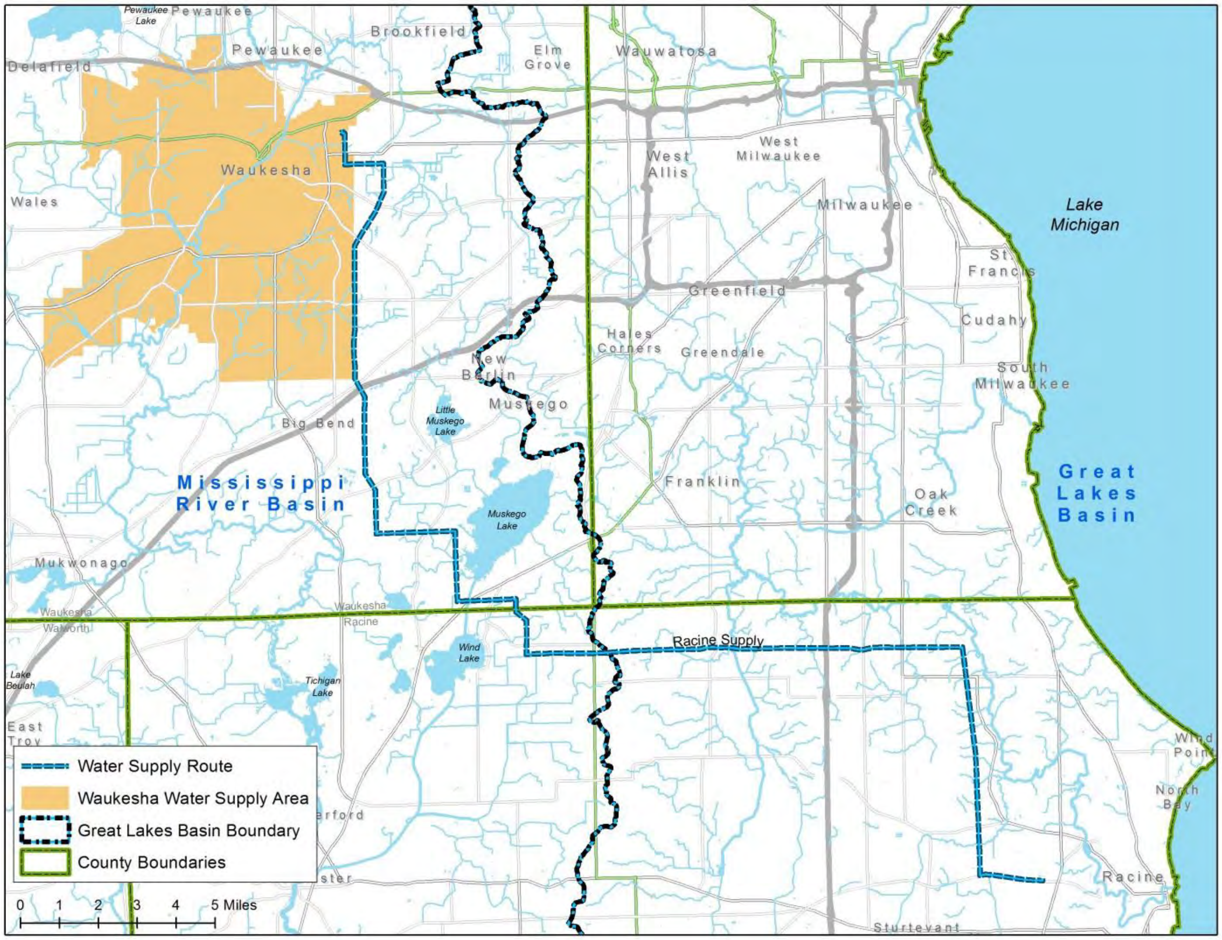


Lake Michigan water would be obtained by connecting to the City of Oak Creek's existing distribution system near 27th Street and Puetz Road. A booster pump station would be required at the point of connection to the existing distribution system. From this station, a 30-inch pipeline would be constructed northwest through the City of Franklin, City of Muskego, City of New Berlin, Town of Waukesha and the City of Waukesha. The approximately 19.4 mile-long pipeline would follow transportation corridors and rights-of-way to minimize environmental impacts. The supply pipeline would terminate at the Hillcrest reservoir in the City of Waukesha.

2.3.2.3 Racine Supply alternative

Under this alternative, Lake Michigan water would be obtained by purchasing water from the City of Racine and connecting to the existing distribution system on the west side of the City of Racine (Figure 2-7).

Figure 2-7. Lake Michigan - City of Racine water supply potential pipeline infrastructure



For this alternative, a new pipeline and booster pump station would be constructed. This alternative would utilize the City of Racine's existing drinking water treatment plant and connect to the City of Racine's distribution system near Highway C and Newman Road. A pump station would be constructed at the connection point to the City of Racine because there is an existing water reservoir nearby. From this connection, a 30-inch pipeline would head west and follow city, state and county roads, and utility corridors for the entire distance. A booster pump station would be constructed along the alignment. The last 2 miles of the alignment are the same as for the Milwaukee and Oak Creek alignments following a utility corridor for about 1 mile and city streets and lightly developed areas for the final mile before its connection at the Hillcrest reservoir. In total, this alternative would require approximately 38 miles of pipeline.

2.4 Return flow Alternatives

2.4.1 Mississippi River basin wastewater discharge alternatives

2.4.1.1 Fox River wastewater discharge alternative

Currently, the Applicant's wastewater treatment plant (WWTP) discharges to the Fox- Illinois River. This alternative considers *all* continued discharge of treated effluent to the Fox-Illinois River for the Mississippi River basin water supply alternatives only.

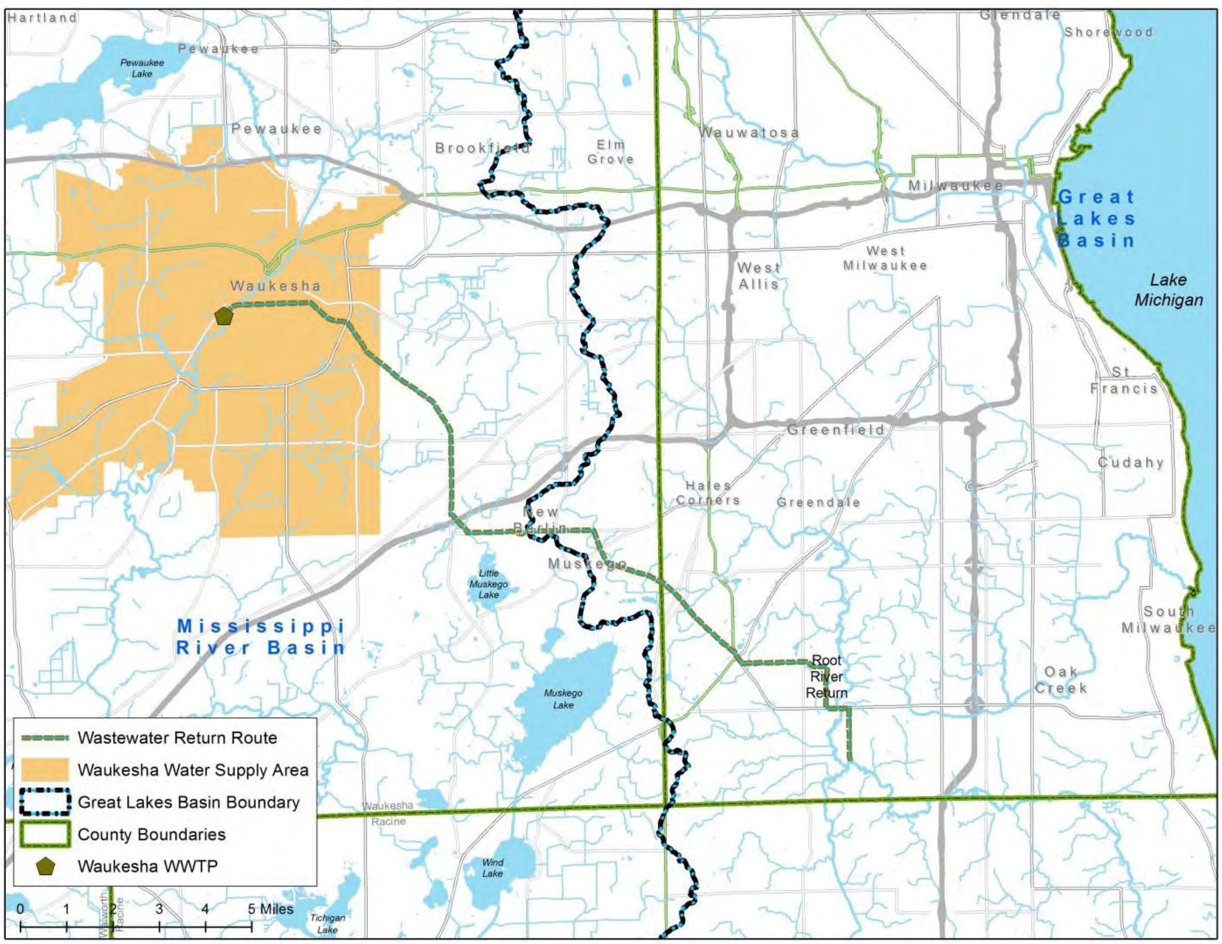
2.4.2 Lake Michigan return flow alternatives

If a Lake Michigan water supply is granted to the Applicant, all water withdrawn, less an amount for consumptive use, would be returned to Lake Michigan. Any additional flow than what is required under the return flow management plan would continue to be discharged to the Fox River. The following options explore the required return flow to the Lake Michigan Basin.

2.4.2.1 Root River return flow alternative

The Applicant's preferred return flow location is the Root River (Root River Alignment 2, Figure 2-8).

Figure 2-8. Root River return flow potential pipeline infrastructure

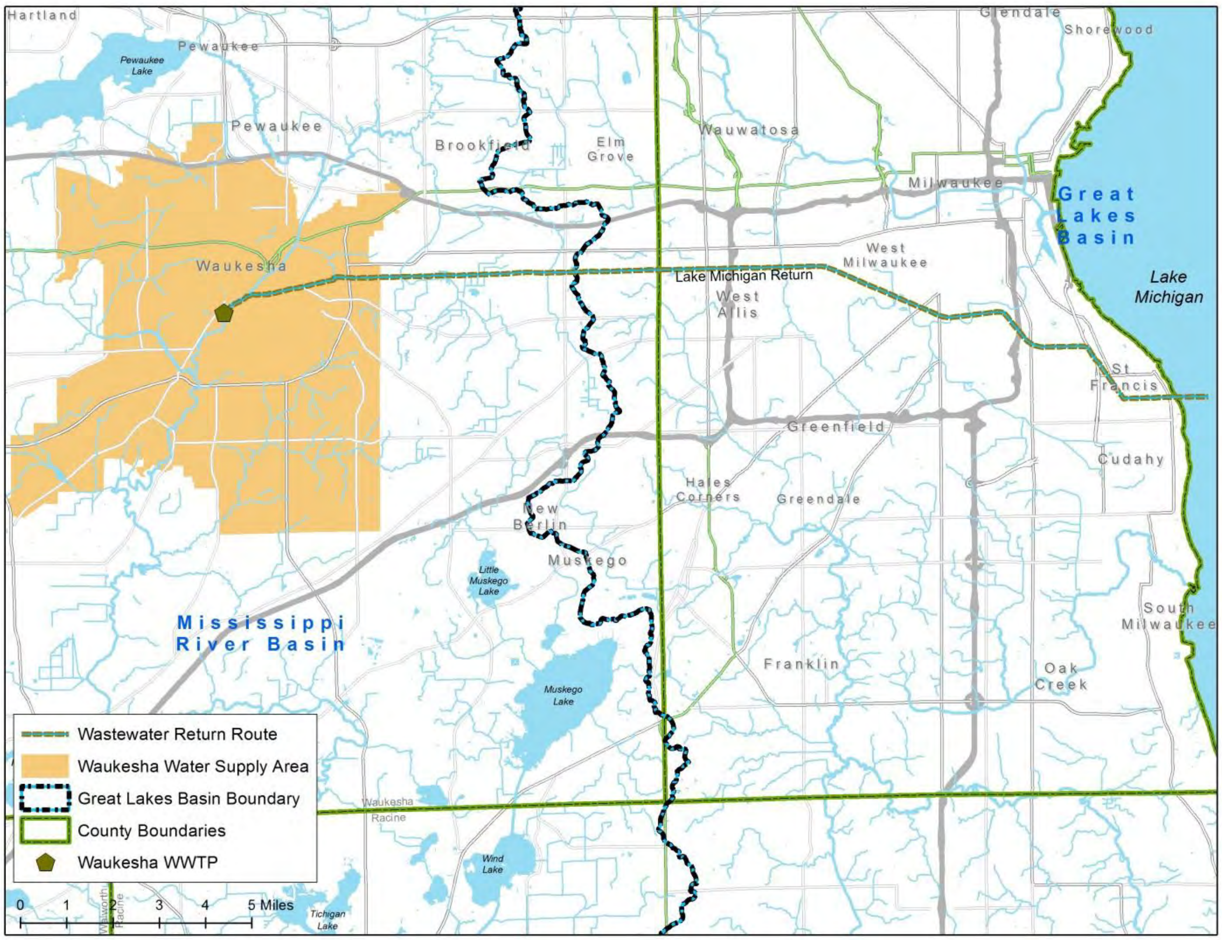


The Applicant proposed a pipeline for return flow to the Root River (Alignment 2, Figure 2-8). Wastewater would be treated at the Applicant's wastewater treatment plant (WWTP). The alignment would begin at the Applicant's WWTP and proceed southeast through the Cities of New Berlin, Muskego and Franklin. The pipeline would follow major roads, listed in Table 2-1 below, to minimize environmental impacts. In total, this alternative would require approximately 20.2 miles of 30- to 36-inch pipe.

2.4.2.2 Direct to Lake Michigan return flow alternative

The Applicant's alternative of returning flow directly to Lake Michigan (near Milwaukee and Oak Creek) would be accomplished by a pipeline constructed from the Applicant's WWTP to Lake Michigan (Figure 2-9).

Figure 2-9. Direct to Lake Michigan return flow potential pipeline infrastructure



This pipeline alignment would parallel the Root River for about 9.6 miles. Where the two pipeline alternatives diverge, the Lake Michigan alignment would continue east for about 11.2 miles parallel to a railroad corridor. As the alignment nears Lake Michigan it would continue east about 1.2 miles along a city street where it would intersect with the lake. The pipeline would extend into Lake Michigan about 0.5 miles to provide an offshore outfall. In total, this alternative would require approximately 22.5 miles of pipeline.

2.4.2.3 MMSD return flow alternatives

The Milwaukee Metropolitan Sewerage District (MMSD) operates regional sewage collection and water reclamation systems for most communities within the Lake Michigan Basin in the Milwaukee metropolitan area. The City included four (MMSD) return flow alternatives in the Application (Vol. 4, Attachment A-2, and CH2MHill Memo, March 10, 2015):

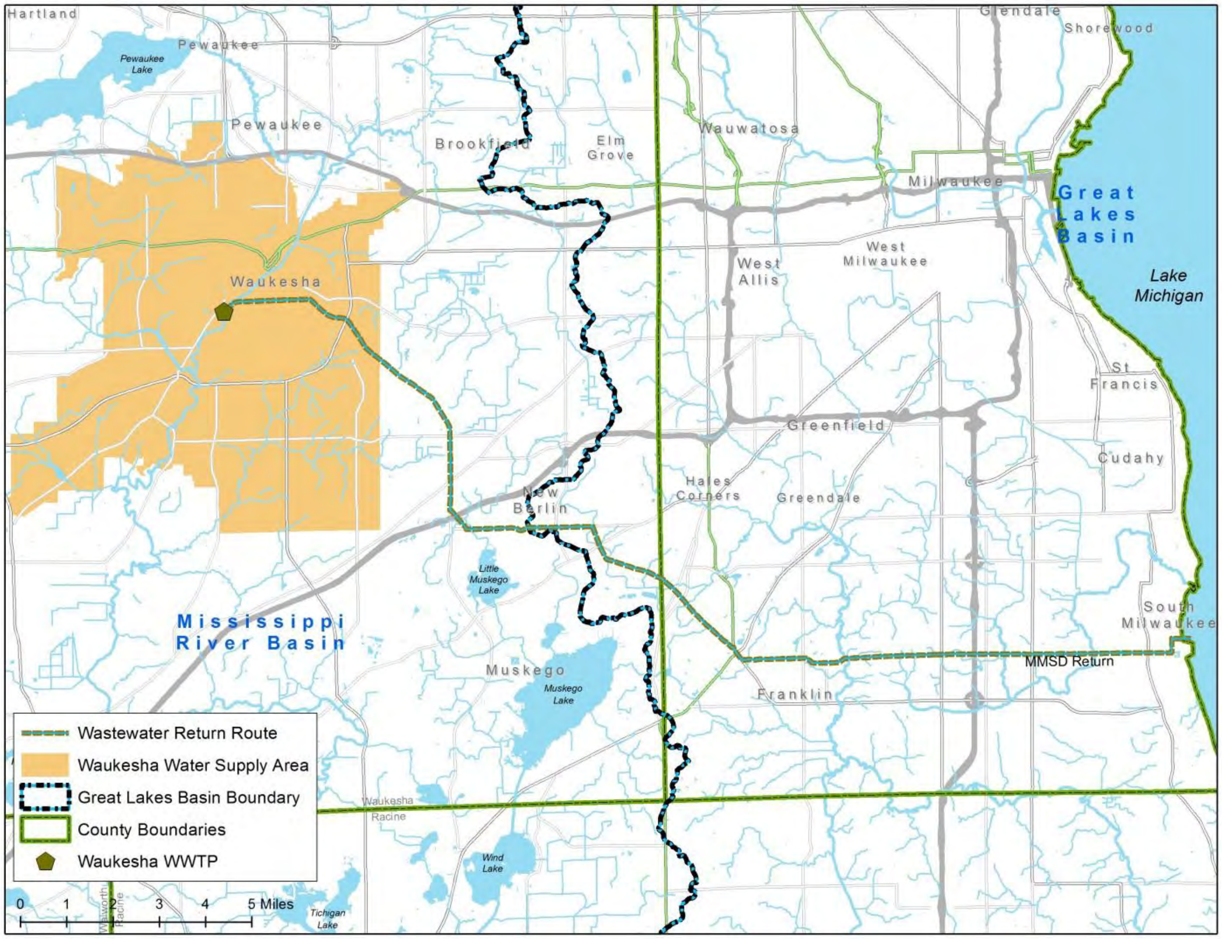
- Alternative 1: Wet Weather Equalization and Pipeline to MMSD South Shore
- Alternative 2: Wet Weather Equalization and Pipeline to MMSD Interceptor near Greenfield Park Pump Station
- Alternative 3: Pipeline to MMSD South Shore and Biological High Rate Treatment Facility at South Shore
- Alternative 4: Pipeline of Treated Wastewater Effluent to MMSD South Shore Outfall

For Alternatives 1-3, the Applicant would decommission its current WWTP. Wastewater from the approved sanitary sewer service area would be conveyed to MMSD for treatment and discharge to Lake Michigan. In these alternatives all the water, including infiltration and inflow from the Mississippi River basin (18 to 45%), would be returned to the Lake Michigan basin (up to 169% of the withdrawal). For these alternatives, improvements to the MMSD collection system and treatment plants would likely be required. The MMSD system is capacity-limited during wet weather, so any flow returned to MMSD would likely require additional conveyance and treatment capacity equivalent to the return flow, or storage to temporarily hold the water until treatment capacity is available.

The SEWRPC regional water supply study included MMSD return flow in its evaluation of return flow alternatives, but did not recommended this option because the cost exceeded that of either return flow directly to Lake Michigan or to a Lake Michigan tributary (SEWRPC, 2010a, Chapter 9, page 631). The MMSD alternative evaluation in the Return Flow Plan (Application, Vol. 4) confirms the high-cost of the MMSD alternative. Consequently, utilizing MMSD infrastructure for conveyance and treatment (MMSD alternatives 1-3) are not evaluated further.

For MMSD Alternative 4, the City would utilize the outfall to Lake Michigan at the MMSD South Shore Water Reclamation Facility (South Shore, Figure 2-10). The Applicant would send treated effluent from its current WWTP and would be required to meet all water quality discharge permit limits. The MMSD Alternative 4, utilizing the existing South Shore outfall, is further evaluated in this document.

Figure 2-10. MMSD return flow alternative 4 potential pipeline infrastructure



The pipeline alignment would be the same as for the Root River alignment (see Figure 2-8 above) for 17.6 miles from the Applicant's WWTP to Puetz Road and 68th Street in Franklin (see Table 2-1). The pipeline would continue east along Puetz Road towards the lake instead of turning southward toward the Root River. At 5th Avenue near Lake Michigan, the alignment would turn north for approximately 0.3 miles to enter MMSD's South Shore Water Reclamation Facility and another 0.5 miles where the return flow would be discharged to Lake Michigan through the MMSD outfall.

2.4.3 Other alternatives not considered in detail

Extensive studies have investigated various water supply alternatives for the Applicant (CH2M HILL and Ruekert & Mielke, 2002, SEWRPC, 2010a, Cherkauer, 2009, CH2M HILL, 2010). The City also looked in detail at alternative pipeline routes and an alternative return flow to Underwood Creek that are not evaluated in detail in this EIS. In March 2002, the Applicant completed a future water supply study. Stakeholders in this study included representatives from the department, the Waukesha Water Utility, the City of Waukesha, Southeastern Wisconsin Regional Planning Commission (SEWRPC), U.S. Geological Survey (USGS), Wisconsin Geological and Natural History Survey, and the University of Wisconsin–Madison. The study looked at the following 14 water supply sources and combinations of them.

- Deep (confined) aquifer near Waukesha
- Deep (unconfined) aquifer west of Waukesha
- Shallow groundwater south of Waukesha (including riverbank inducement along the Fox River)
- Shallow groundwater west of Waukesha
- Shallow aquifer, Silurian dolomite
- Fox River
- Rock River
- Lake Michigan
- Fox or Rock River Dam
- Waukesha quarry
- Waukesha springs
- Pewaukee Lake
- Milwaukee River
- Wastewater reuse

More options for water supply alternatives are reviewed in the department's Technical Review S2 for this project.

The Applicant had also proposed a return flow alternative to Underwood Creek. The department determined that an Underwood Creek return flow is not a viable option at this time due to difficulty in obtaining the required permits. This alternative is not evaluated further in this EIS. A return flow Direct to Lake Michigan near Racine was also not considered for this EIS because it was similar to other direct to Lake Michigan options but had greater costs and impacts due to its larger pipeline.

The Applicant also proposed an alternative water supply pipeline route known as Oak Creek supply alignment 1, and an alternative return flow pipeline route known as Root River return flow alignment 1. There are minimal differences between these alternative routes and the Applicant's preferred routes, so neither is evaluated in this EIS, only the Applicant's preferred options (Oak Creek Alignment 2, Root River Alignment 2) were reviewed.

Table 2-2. Road corridors of potential pipelines for alternatives (Source: Vol. 5, Table 3-4 Supplement)

Alternative	Direction	Length (miles)	Route	City
Deep and Shallow Aquifers	W	1.2	Offroad east to wells	Waukesha
Deep and Shallow Aquifers	W	0.5	Oakdale Road	Waukesha
Deep and Shallow Aquifers	E	2.2	Offroad west to wells	Waukesha
Deep and Shallow Aquifers	NE	1.3	River Drive	Waukesha
Deep and Shallow Aquifers	E	0.9	Lawnsdale Road	Waukesha
Deep and Shallow Aquifers	N	2.0	Oakdale Road	Waukesha
Deep and Shallow Aquifers	N	0.8	Sentry Drive	Waukesha
Deep and Shallow Aquifers	E	1.0	W Sunset Drive	Waukesha
Deep and Shallow Aquifers	N	1.5	S West Avenue	Waukesha
Deep and Shallow Aquifers	NE	2.3	E Main Street	Waukesha
Deep and Shallow Aquifers	SE	0.1	Offroad	Waukesha
Shallow Aquifer	Multi	2.7	Offroad east to wells	Waukesha
Shallow Aquifer	W	0.5	Oakdale Road	Waukesha
Shallow Aquifer	E	2.2	Offroad west to wells	Waukesha
Shallow Aquifer	NE	1.3	River Drive	Waukesha
Shallow Aquifer	E	0.9	Lawnsdale Road	Waukesha
Shallow Aquifer	N	2.0	Oakdale Road	Waukesha
Shallow Aquifer	N	0.8	Sentry Drive	Waukesha
Shallow Aquifer	E	1.0	W Sunset Drive	Waukesha
Shallow Aquifer	N	1.5	S West Avenue	Waukesha
Shallow Aquifer	NE	2.3	E Main Street	Waukesha
Shallow Aquifer	SE	0.1	Offroad	Waukesha
Lake Michigan Supply - Milwaukee	W	3.1	W Howard Avenue	Greenfield/Milwaukee
Lake Michigan Supply - Milwaukee	W	0.2	Offroad	Greenfield
Lake Michigan Supply - Milwaukee	NW	2.2	S Root River Parkway	West Allis/Greenfield
Lake Michigan Supply - Milwaukee	N	0.7	124th Street	Waukesha/West Allis
Lake Michigan Supply - Milwaukee	W	6.3	New Berlin Recreation Trail/Utility Corridor	Waukesha/New Berlin
Lake Michigan Supply - Milwaukee	N	1.0	Offroad	Waukesha
Lake Michigan Supply - Oak Creek	W	4.4	W Puetz Road	Franklin
Lake Michigan Supply - Oak Creek	NW	2.5	W Martins Road	Franklin
Lake Michigan Supply - Oak Creek	NW	2.0	Tess Corners Drive	Muskego
Lake Michigan Supply - Oak Creek	W	2.7	W College Avenue	New Berlin/Muskego
Lake Michigan Supply - Oak Creek	NW	0.5	Minor Roads	New Berlin
Lake Michigan Supply - Oak Creek	NW	5.0	S Racine Avenue	Waukesha/New Berlin
Lake Michigan Supply - Oak Creek	NE	1.7	W 164 Street	Waukesha
Lake Michigan Supply - Oak Creek	NE	0.4	E Main Street	Waukesha
Lake Michigan Supply - Oak Creek	SE	0.1	Offroad	Waukesha

Lake Michigan Supply - Racine	W	1.7	Spring Street	Mount Pleasant
Lake Michigan Supply - Racine	N	5.9	Offroad/Utility Corridor	Caledonia/Mount Pleasant
Lake Michigan Supply - Racine	W	11.3	Offroad/Utility Corridor	Norway/Raymond/Caledonia
Lake Michigan Supply - Racine	NW	1.6	Offroad/Utility Corridor	Norway/Muskego
Lake Michigan Supply - Racine	W	1.5	Offroad/Utility Corridor	Muskego
Lake Michigan Supply - Racine	N	1.8	Offroad/Utility Corridor	Muskego
Lake Michigan Supply - Racine	W	2.0	Offroad/Utility Corridor	Muskego
Lake Michigan Supply - Racine	N	7.6	Offroad/Utility Corridor	New Berlin/Muskego
Lake Michigan Supply - Racine	NE	2.3	Offroad/Utility Corridor	New Berlin
Lake Michigan Supply - Racine	W	1.0	Offroad/Utility Corridor	New Berlin/Waukesha
Lake Michigan Supply - Racine	NW	1.0	Offroad	Waukesha/Brookfield
Root River Return Flow	NE	0.4	Offroad	Waukesha
Root River Return Flow	E	1.6	College Avenue	Waukesha
Root River Return Flow	SE	6.0	Racine Avenue	Waukesha/New Berlin
Root River Return Flow	SE	0.5	Minor Roads	New Berlin
Root River Return Flow	E	2.7	W College Avenue	New Berlin/Muskego
Root River Return Flow	SE	2.0	Tess Corners Drive	Muskego
Root River Return Flow	SE	2.5	Martins Road	Franklin
Root River Return Flow	E	1.9	Puetz Road	Franklin
Root River Return Flow	S	0.9	S 68th Street	Franklin
Root River Return Flow	E	0.5	W Ryan Road	Franklin
Root River Return Flow	S	1.2	S 60th Street	Franklin
Direct to Lake Michigan	NE	2.6	Offroad	Waukesha
Direct to Lake Michigan	E	7.1	New Berlin Recreation Trail/Utility Corridor	Waukesha/New Berlin
Direct to Lake Michigan	E	3.5	Offroad/Railroad Corridor	West Allis
Direct to Lake Michigan	SE	7.7	Offroad/Railroad Corridor	West Allis/Milwaukee/St Francis
Direct to Lake Michigan	E	1.0	E Lunham Avenue	St Francis/Cudahy
Direct to Lake Michigan	E	0.8	Offroad/Lake Michigan	St Francis/Cudahy
MMSD Alternative 4	NE	0.4	Off Road	Waukesha
MMSD Alternative 4	E	1.6	College Avenue	Waukesha
MMSD Alternative 4	SE	6	Racine Avenue	Waukesha/New Berlin
MMSD Alternative 4	SE	0.5	Minor Roads	New Berlin
MMSD Alternative 4	E	2.7	W. College Avenue	New Berlin/Muskego
MMSD Alternative 4	SE	2	Tess Corners Drive	Muskego
MMSD Alternative 4	SE	2.5	Martins Road	Franklin
MMSD Alternative 4	E	1.9	W. Puetz Road/68th Street	Franklin
MMSD Alternative 4	E	7.5	Puetz Road	Franklin/Oak Creek
MMSD Alternative 4	N	0.3	5th Avenue	Oak Creek
MMSD Alternative 4	E	0.5	Off Road	Oak Creek

Section 3 Affected Environment

3 Affected Environment

3.1 Geology and Soils

3.1.1 Surficial and bedrock geology

The bedrock geology of Southeastern Wisconsin consists of Paleozoic sedimentary units, generally thickening to the east. In most places, Pleistocene deposits of till, sand and gravel, cover the bedrock units making bedrock outcrops rare. The basic geology framework of the region is in Table 3.1 below (maps available in CH2MHill, 2013, Vol. 5, Appendix 6-8).

SURFICIAL GEOLOGY
The Pleistocene deposits in the Region consist of a complex sequence of deposits differing in origin, age, lithology, thickness, and areal extent. Mickelson and others (1984) recognized five lithostratigraphic units in Southeastern Wisconsin: Kewaunee, Horicon, Oak Creek, New Berlin, and Zenda Formations.

The inland portion of Waukesha county is covered with glacial deposits of the Green Bay Lobe (Horicon Formation) and early advances of the Lake Michigan Lobe (New Berlin and Zenda Formations) that occurred about 15,000 to 35,000 years ago (Clayton et al., 2001; Mickelson and Syverson, 1997). These earlier ice advances till units tend to be more sandy and more permeable than the younger tills to the east. The till of the Zenda Formation is older, pink, and medium-grained, and only rarely occurs at the surface. The younger Horicon and New Berlin Formations contain yellowish-brown and coarse-grained tills; the New Berlin Formation usually overlies the Zenda Formation (Mickelson and others, 1984). The Kettle Moraine, formed along the junction of these two ice lobes, is a hummocky upland consisting mainly of outwash sediment that collapsed when underlying or adjacent ice melted.

The lakeshore counties of Milwaukee and Racine also contain sandy till units (Horicon and New Berlin Formations) left by earlier advances, but these are mostly buried by younger silty deposits (Kewaunee and Oak Creek Formations) from later advances of the Lake Michigan Lobe.

There are three known major advances of the Lake Michigan Lobe, each of which laid down a distinctive type of till. The first advance of the Lake Michigan Lobe occurred about 15,000 to 35,000 years ago and deposited the sandy tills of the Zenda and New Berlin Formations. During the second major advance of the Lake Michigan Lobe about 13,000 to 14,500 years ago, a gray silty till of the Oak Creek Formation (Mickelson and others, 1984) was deposited, in three major morainic belts: the Valparaiso, Tinley and Lake Border systems, formed roughly parallel to the shoreline (Brown, 1990, Schneider, 1983; Simpkins, 1989). This silty, clayey till has a very low permeability, but contains lenses of gravelly outwash and sandy lake deposits. The third major advance of the Lake Michigan Lobe occurred from about 13,000 to 11,000 years ago, and deposited a reddish silty till (of the Kewaunee Formation) in a narrow band along the lakeshore north of Milwaukee and into Ozaukee County (Mickelson and others, 1984; Mickelson and Syverson, 1997). This till overlies the earlier gray clayey till and is also of very low permeability (Table 3.1).

Table 3-1. Geologic column for bedrock and glacial deposits in southeastern Wisconsin (University of Wisconsin - Extension, Wisconsin Geological Natural History Survey)

Geologic Time	Rock		Lithologic
QUATERNARY			
Recent	Undifferentiated		Soil, muck, peat, alluvium, colluvium, beach sediment
Pleistocene *(all units include lake and stream sediment in addition to*	Kewaunee Formation		Brown to reddish-brown, silty and clayey till
	Horicon Formation		Coarser, brown, sandy till with associated sand and gravel
	Oak Creek Formation		Fine-textured, gray clayey till; lacustrine clay, silt, and sand
	New Berlin Formation		Upper: medium-textured. gravelly sandy till; Lower: outwash sand
	Zenda Formation		Medium-textured, pink, sandy till; limited distribution
PALEOZOIC			
Devonian	Antrim Formation		Gray, silty shale; thin; limited distribution
	Milwaukee Formation		Shaly dolomite and dolomitic siltstone
	Thiensville Formation		Dolomite and shaly dolomite
Upper Silurian	Waubakee Formation		Dense, thin-bedded, gray, slightly shaly dolomite
	Racine Formation		Finely crystalline dolomite; locally shaly beds and dolomite reefs
	Waukesha Formation		Cherty, white to buff, medium bedded, shaly dolomite
	Brandon Bridge beds		Pink to green shaly dolomite with shaly beds
	Lower Silurian beds (undifferentiated)		Dolomite and shaly dolomite
Ordovician	Neda Formation		Brown hematitic shale and oolite; occurs sporadically
	Maquoketa Formation		Green to gray dolomitic shale; locally layers of dolomite,
	Sinnipee Group	Galena Formation	Cherty dolomite with shaly dolomite at the base
		Decorah Formation	Shaly dolomite with fossils; thin or absent
		Platteville Formation	Dolomite and shaly dolomite
	Ancell Group	Glenwood Formation	Blue to green shale or sandy dolomite; thin or absent
		St. Peter Formation	Predominantly medium-grained quartz sandstone
	Prairie du Chien Group	Shakopee Formation	Light gray to tan dolomite or dolomitic sandstone; locally absent
		Oneota Formation	Massive, light gray to tan, cherty, sandy dolomite; locally absent
Cambrian	Trempealeau Group	Jordan Formation	Fine- to medium-grained quartz sandstone; locally absent
		St. Lawrence Formation	Tan to pink silty dolomite; locally absent
	Tunnel City Group		Fine- to medium-grained sandstone and dolomitic sandstone; locally
	Elk Mound Group	Wonewoc Formation	Medium- to coarse-grained, tan to white, quartz sandstone
		Eau Claire Formation	Fine- to medium-grained sandstone; local beds of green shale
		Mt. Simon Formation	Coarse- to medium-grained sandstone; lower beds very coarse and
PRECAMBRIAN	Undifferentiated		Granite or quartzite

BEDROCK GEOLOGY

The bedrock of Southeastern Wisconsin is separated into two major divisions: 1) younger, relatively flat-lying sedimentary rocks of the Paleozoic Era (younger than 570 million years), and 2) older Precambrian predominantly crystalline rocks.

The Paleozoic rocks form the major aquifers of Waukesha, Milwaukee and Racine counties and consist of sedimentary rocks—dolomite, shale, and sandstone—that range from Cambrian to Devonian in age. The Paleozoic rocks are nearly flat-lying, but dip gently to the east from the

Wisconsin Arch into the Michigan Basin, and thicken significantly from west to east (Figure 3.1). An older crystalline basement of Precambrian crystalline rock, primarily granite and quartzite, underlies the Paleozoic sedimentary sequence.

Devonian strata, the youngest Paleozoic rock in Wisconsin, are present only along a narrow band parallel to the Lake Michigan shoreline from Milwaukee to the north. They constitute the westernmost occurrence of Devonian strata in the Michigan Basin. The Silurian dolomites are at the bedrock surface throughout most of the Region. The Ordovician-age Maquoketa Formation (shale) and Sinnipee Group (dolomite) underlie the western edge of the Region. The remaining Ordovician rock units, the St. Peter formation and the Prairie du Chien Group, and the Cambrian sandstone sequence are not exposed at the bedrock surface, but are encountered in deep wells throughout the Region.

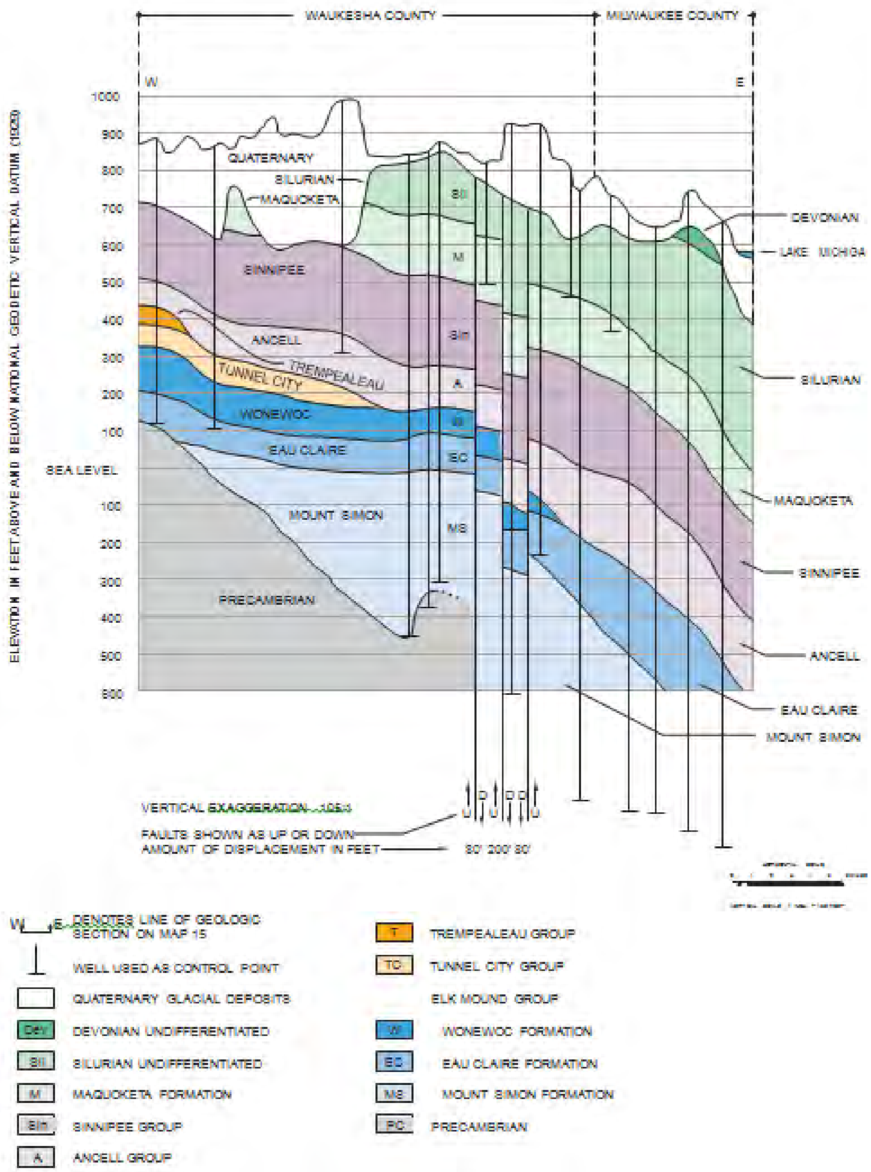
The youngest rocks in the three county area discussed are the Devonian limestone, dolomite, and shale. Because of the eastward regional dip of the beds, Devonian rocks are exposed only in a small area in eastern Milwaukee County. The Devonian consists, from the top, of the Antrim Shale, the Milwaukee Formation, and the Thiensville Formation. The Thiensville Formation ranges from 55 to 75 feet in thickness and grades from shaly dolomite at the base to clean dolomite at the top. The Milwaukee Formation consists of about 60 feet of shaly dolomite and dolomitic siltstone, and locally in eastern Milwaukee County it is overlain by up to 13 feet of a gray, silty mudstone of the Antrim Formation (formerly Kenwood Shale).

The Silurian section of Waukesha, Racine and Milwaukee counties consists of up to 600 feet of dolomite, subdivided into five formations. These are, from the top, the Waubakee Formation, the Racine Formation, the Waukesha Formation, the Brandon Bridge beds, and the undifferentiated "lower Silurian beds" (Table 3.1). The Waubakee Formation consists of dense, laminated to thin-bedded, slightly shaly, gray dolomite and is present only in Ozaukee and eastern Milwaukee County. It varies from 60 to 100 feet in thickness, and is unconformably overlain by the Devonian Thiensville Formation. Locally, reefs developed in the underlying Racine Formation project through the Waubakee Formation and are overlain directly by the Thiensville Formation.

The Racine formation is on average about 170 feet thick in the Milwaukee area, but can reach as much as 290 feet where reefs are developed. The nonreef facies of the Racine Formation is well-bedded, finely crystalline, light olive-gray dolomite, with some shaly beds. Reefs occur locally within the Racine Formation, and consist of massive, coarsely crystalline, porous, fossiliferous, mottled gray to brownish-gray dolomite (Mikulic and Kluessendorf, 1988). The reefs are up to 100 feet thick and over 990 feet in diameter, and grade laterally into typical nonreef Racine dolomite. The contact between the non-reef Racine facies and the overlying Waubakee Formation is gradational.

The Waukesha Formation consists of locally cherty, white to buff-colored, medium-bedded, shaly dolomite. In the southern part of the Region, at Racine and Burlington, the Brandon Bridge beds consist of light pink to green shaly dolomite interbedded with maroon shaly beds in the lower half. The Brandon Bridge beds thin to the north and are not present north of Waukesha (Mikulic, 1977). In Milwaukee County, the Brandon Bridge beds and the Waukesha Formation combined, range in thickness from 45 to 80 feet. These two units are sometimes called in the literature the Manistique Formation.

Figure 3-1. Geologic cross section of Southeastern Wisconsin, west - east (Source: SEWRPC, 2002)
The lower part of the Silurian section is not exposed in Southeastern Wisconsin and has not been extensively studied because few rock cores exist. The "lower Silurian beds" are approximately 175 feet thick in Milwaukee County. The beds consist of dolomite similar to that of other Silurian formations and are probably equivalent to the Byron and Mayville Formations of northeastern Wisconsin. The upper unit, the Byron Formation, is described as a fine-grained mudstone and the lower unit, the Mayville Formation, as a coarser- textured packstone.



The Ordovician rocks of the three county area discussed consist from, from the top, of the Neda Formation (shale), the Maquoketa Formation (shale and dolomite), the Sinnipee Group (dolomite), the Ancell Group (sandstone), and the Prairie du Chien Group (dolomite). The Ancell and Prairie du Chien Groups are not exposed at the bedrock surface, and are known only from well cuttings and logs.

Neda Formation

The upper Ordovician Neda Formation is a layer of brown hematitic shale and oolite, which occurs sporadically at the Ordovician-Silurian boundary in eastern Wisconsin and is conformable and gradational with the underlying Maquoketa Formation. Where present, the Neda Formation can be up to 50 feet thick.

Maquoketa Formation

The Maquoketa Formation underlies the Silurian dolomite and is exposed at the bedrock surface in the western part of Waukesha County. It consists predominantly of green to gray shale, dolomitic shale, and dolomite. It is approximately 150 feet thick in Racine County and thickens to the north and east. The Fort Atkinson Member is a continuous dolomite unit consisting of coarse, dark brown to brown, shaly dolomite up to 50 feet thick in the middle of the Maquoketa Formation, between the Brainard and Scales Members, which are predominantly shale.

Sinnipee Group

The Sinnipee Group consists of dolomite, shaly dolomite, and minor shale, and is divided into three formations (Table 3.1). The uppermost one, the Galena Formation, consists of cherty dolomite with 15 to 20 feet of shaly dolomite at the base. The middle unit, the Decorah Formation, is thin or locally absent in Southeastern Wisconsin, represented by five or less feet of shaly dolomite in Waukesha County (Choi, 1995). The lower formation of the Sinnipee Group, the Platteville Formation, consists of dolomite and shaly dolomite, and reaches a thickness of 85 feet in Racine County.

Ancell Group

The Ancell Group includes the Glenwood and St. Peter Formations (Table 3.1). The Glenwood Formation consists of 20 feet or less of dolomitic sandstone, blue-green shale, or sandy dolomite. The Glenwood Formation is locally variable in thickness and lithology and is not always present in Southeastern Wisconsin (Mai and Dott, 1985). The St. Peter Formation is present throughout the three counties, and is subdivided into two members. The upper Tonti Member is a pure quartz sandstone, ranging in thickness from less than 50 feet to locally greater than 250 feet. The lower Readstown Member is variable in character, consisting of white to red sandstone, conglomerate (consisting of shale, chert, sandstone, and/or dolomite clasts), red to brown shale, or any combination of these rock types, in a matrix of fine to coarse sand or clay. The Readstown Member is not continuous, and is best developed in areas where maximum erosion of the underlying formations took place prior to Ancell Group deposition.

Prairie du Chien Group

The Prairie du Chien Group is subdivided into two formations (Table 3.1). The upper Shakopee Formation, consists of light gray to tan sandy dolomite (the Willow River Member) and a thin (15 feet or less) discontinuous dolomitic sandstone (the New Richmond Member). The New Richmond Member is not always recognizable in well cuttings, and is not well defined. The lower formation, the Oneota Formation, consists of massive, light gray to tan, commonly cherty dolomite. The base of the Oneota Formation becomes sandy and is gradational with the underlying Coon Valley Member of the Cambrian Jordan Formation. The Prairie du Chien Group is not exposed at the bedrock surface in Southeastern Wisconsin, and is known in the subsurface in parts of Racine County, having been removed by pre- St. Peter erosion to the north. Where present, the Prairie du Chien Group is generally less than 70 feet thick (Mai and Dott, 1985).

The Cambrian rocks of the three county area discussed, are primarily sandstone, with some dolomite and shale. These rocks have not been adequately studied due to the scarcity of good samples. Their stratigraphy is not known in detail. The Cambrian is subdivided into three major divisions, the Trempealeau Group, the Tunnel City Group, and the Elk Mound Group (Table 3.1). The Cambrian section thickens from northwest to southeast, ranging in thickness from around 700 feet in western Waukesha County to around 2,400 feet near Zion, Illinois, south of Kenosha.

Trempealeau Group

The Trempealeau Group consists of the Jordan and St. Lawrence Formations. The Trempealeau Group is eroded by the pre-St. Peter unconformity in much of Southeastern Wisconsin. Where not eroded, the Trempealeau Group varies from 70 to 150 feet in total thickness. In its outcrop area of western Wisconsin, the Jordan Formation can be subdivided into five members on the basis of grain size and composition. These members are not easily recognized in the subsurface. The Jordan Formation is predominantly fine- to medium-grained quartz sandstone, commonly with some dolomitic cement. The Coon Valley Member at the top of the Jordan Formation is a sandy dolomite that grades into the overlying Oneota Formation. The St. Lawrence Formation is tan to pink sandy or silty dolomite, becoming more dolomitic to the south, where it is known as the Potosi Dolomite in Illinois (Buschbach, 1964).

Tunnel City Group

The Tunnel City Group consists of fine- to medium-grained sandstone and dolomitic sandstone, which varies in color from light brown to green, depending on glauconite content. In its outcrop area of western Wisconsin, the Tunnel City group is divided into the Lone Rock and Mazomanie Formations. In Southeastern Wisconsin these formations are not easily recognized in well cuttings, and the Tunnel City Group is treated as a single unit varying from 50 to 80 feet in thickness. It is equivalent to the Franconia Formation of northern Illinois (Buschbach, 1964). The Tunnel City Group is not present in Milwaukee County due to erosion.

Elk Mound Group

The Elk Mound Group is the lowermost division of the Paleozoic sedimentary section. It is divided into the Wonewoc, Eau Claire, and Mount Simon Formations (Table 3.1). The lowest one, the Mount Simon sandstone, directly overlies the Precambrian crystalline rock basement.

Wonewoc Formation

The formation is a medium- to coarse-grained, tan to white quartz sandstone. It is generally poorly cemented, but may be locally cemented by dolomite or silica. Where present, the Wonewoc Formation is easily distinguished from the overlying Tunnel City Group and the underlying Eau Claire Formation by coarser grain size, color, and absence of glauconite. The lower contact of the Wonewoc Formation is an erosional surface that locally cuts into the underlying Eau Claire Formation. Total thickness of the Wonewoc and Eau Claire Formations together varies from 160 to 200 feet from north to south across the Region.

Eau Claire Formation

This formation consists of fine- to medium-grained sandstone with local beds of green to black shale and dolomite. Dolomite cement, pyrite, and fossils are commonly present. The Eau Claire Formation thickens to the south into northern Illinois, and shale and dolomite content increases to the south as well (Buschbach, 1964). It is easily distinguished from the overlying Wonewoc and underlying Mount Simon Formations by finer grain size and glauconite content.

Mount Simon Formation

The Mount Simon Formation consists predominantly of coarse- to medium-grained sandstone, with coarser layers commonly containing pebbles. It is generally poorly cemented, but locally may be cemented by dolomite or silica. In Milwaukee and Racine Counties red, black or green shale beds can be present within the Mount Simon Formation. The lower beds are commonly very coarse and pebbly, locally becoming conglomerate near the Precambrian contact. The Mount Simon Formation thickens to the south and east. The maximum complete section penetrated in Southeastern Wisconsin is 1,306 feet in Waukesha County.

The Precambrian crystalline basement of the three counties discussed is poorly known. Limited wells have reached the Precambrian and recovered identifiable samples. The most common recovered rock types, presumably 1,760 million years old or younger, are granitic and quartzite resembling the Waterloo and Baraboo quartzites exposed to the west (Smith, 1978). The Precambrian is encountered at a depth of 77 feet in western Waukesha County, and dips to the south and east (Figure 3.a), reaching a depth of 3,460 feet in the Zion, Illinois well. The Precambrian basement forms the lower boundary of the lower Paleozoic sandstone aquifer.

STRUCTURAL GEOLOGY

The three county area of Southeastern Wisconsin has largely remained tectonically inactive for approximately one billion years and the structural deformations are minimal there. The cross-section in Figure 3.1 shows diagrammatically the stratigraphic formations and their dip, and the dip of the Precambrian surface across Waukesha County and Milwaukee County. Faults shown on the cross-sections are inferred from the differences in elevation of formation boundaries, both in wells shown on the sections and by comparison with wells located within the several miles of the sections. There are no wells shown on the sections that actually cross a fault trace. Because most large faults in Southeastern Wisconsin are nearly vertical, it is rare that a well will cross a fault trace. There is only one well (in the City of Waukesha) supported by drill cuttings that is known to be drilled through a fault trace.

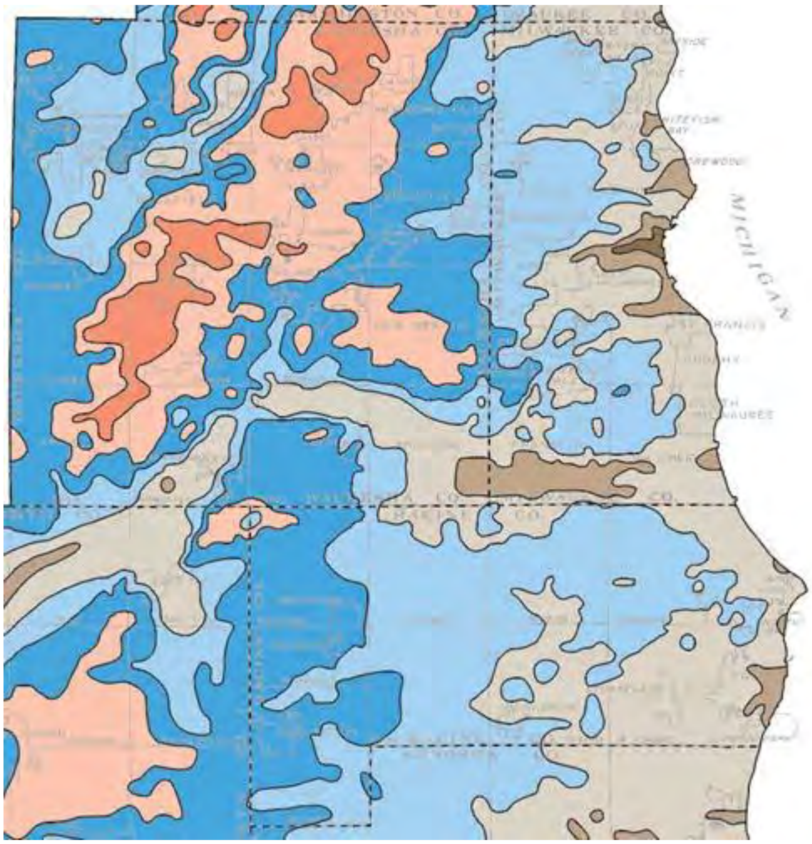
The west-east section (Figure 3.1) crosses a major fault zone, the Waukesha Fault, which passes through Waukesha County and trends northeastward into Lake Michigan. The Waukesha Fault is a potentially important hydrologic feature because it offsets major formation and aquifer boundaries, and may significantly influence deep groundwater flow systems. Although the existence of the Waukesha Fault in Southeastern Wisconsin has been recognized for some time (Foley and others, 1953), its location and linear extent have been, until recently, poorly defined due to limited data from bedrock wells and only one significant exposure. Sverdrup and others (1997) used gravity data from geophysical surveys conducted in the early 1980s to trace the Waukesha Fault from the Waukesha-Walworth county line to Port Washington in Ozaukee County.

BEDROCK ELEVATION AND BEDROCK VALLEYS

Figure 3.2 shows the approximate bedrock elevations in Waukesha, Milwaukee and Racine counties, which broadly resembles depth to bedrock in these counties. Areas located over the deep bedrock valleys are where the bedrock is farthest from the land surface. The northern valley extends from northeastern Washington County southwest through northwestern Waukesha County to southern Jefferson County. In the southern half of the Region, a long valley curves from southern Milwaukee and Waukesha Counties south through Walworth County into Illinois. Thicknesses of glacial materials in these buried valleys range from 250 feet to more than 450 feet.

The areas where bedrock is closest to the land surface trend from northeast to southwest, from southeastern Washington County through northeastern Waukesha, bedrock generally is found there at depths less than 25 feet. Numerous outcrops and large quarries are found in the Silurian dolomite, which is the uppermost bedrock formation. Elsewhere along the same general trend, bedrock lies at depths of less than 50 feet; for example, at the Kettle Moraine in Waukesha County. In most of the rest of Southeastern Wisconsin, depth to bedrock ranges between 50 and 250 feet. This wide range of depth to bedrock is, in large part, caused by end moraines deposited during the last glacial period and the erosion of river valleys since then. For example, there are only a few outcrops or areas where bedrock is less than 50 feet deep in Racine County because of the thickness of glacial deposits. But numerous outcrops are in Milwaukee County, where the Milwaukee, Menomonee, and Root Rivers and their tributaries have formed deep valleys in these same glacial deposits. In some cases, isolated outcrops have been reported in areas where overall bedrock surface is more than 25 feet deep.

Figure 3-2. Bedrock elevation in Milwaukee, Racine and Waukesha Counties (Wisconsin GHNHS)



3.1.2 Soils

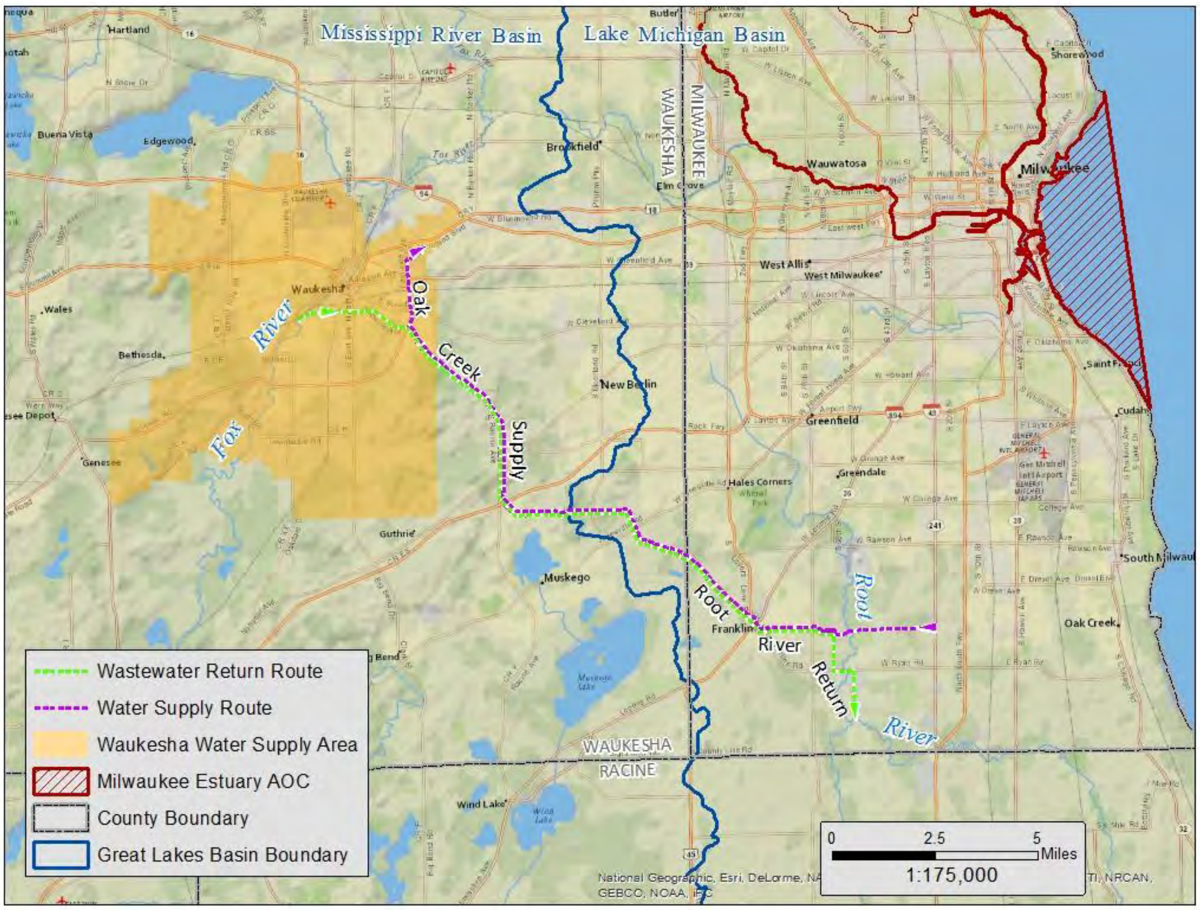
The soils along the near-shore areas of Lake Michigan are within the southern Lake Michigan coastal ecological landscape and are characteristic mainly of glacial lake influence, along with ridge and swale topography, clay bluffs, and lake plains. Ground moraine inland from the lakeshore is the dominant landform, with soils generally consisting of silt-loam surface overlying loamy and clayey tills.

3.2 Lake Michigan

3.2.1 Physical description and floodplain of Lake Michigan

Lake Michigan is bordered by four states and has the second largest volume of any of the Great Lakes. It is the only Great Lake located entirely within the borders of the United States. Lake Michigan is 307 miles long, up to 118 miles wide, and up to 925 feet deep. It has a surface area of 22,300 square miles, an average depth of 279 feet, a volume of 1,180 cubic miles (1,300 trillion gallons) and a retention time of 99 years (USEPA and Environment Canada, 2012).

Figure 3-3. Lake Michigan Shoreline and Area of Concern and Project Area Overview



3.2.2 Water quality of Lake Michigan

Southeastern Wisconsin's Lake Michigan shoreline water quality has been influenced by nonpoint and point source pollution, as well as changes caused by invasive species, most notably zebra mussels (*Dreissena polymorpha)* and quagga mussels (*Dreissena rostriformis bugensis)*. Nonpoint source pollution to the shoreline includes impervious and pervious surface runoff, boating wastes, bacterial transport in shoreline algae accumulation, and direct input from animals, such as seagulls. Point source pollution generally results from combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), or from stormwater outfalls (Kinzelman, 2007).

In recent decades invasive dreissenid mussels which have covered the lake bottom have resulted in clearer water which in turn has led to algae growth, including the spread of *Cladophora* at deeper water levels than prior to mussel colonization. Research at the Great Lakes Water Institute and elsewhere continues on the interaction between invasive mussels, nutrient cycling in Lake Michigan, and the growth of *Cladophora* (Bootsma, 2009).

Milwaukee Harbor Area of Concern

The Milwaukee Harbor estuary is designated a Great Lakes Area of Concern (AOC) because of the presence of legacy contaminants (PCBs, PAHs, heavy metals, etc.) and other impairments. The harbor suffers from urban stresses similar to those experienced in other highly urban areas at the other 42 AOCs throughout the Great Lakes. Priorities for the Milwaukee AOC include remediation of contaminated sediments in tributaries and nearshore waters of Lake Michigan, prevention of eutrophication, nonpoint source pollution control, improvement of beach water quality, enhancement of fish and wildlife populations, and habitat restoration (EPA, 03/2010).

Lake Michigan water quality data – MMSD, UW-Milwaukee, and SEWRPC

SEWRPC and the Milwaukee Metropolitan Sewerage District (MMSD) have been measuring water quality in the Greater Milwaukee area since the 1960s (SEWRPC, 2007, p. 149). Notable water quality improvements have been documented since the MMSD's deep tunnel system came online in 1994 to reduce the number of combined sewer overflows (CSOs). Water quality trends at sampling stations in the Milwaukee outer harbor and nearshore Lake Michigan areas over this historical monitoring period have indicated (SEWRPC, 2007, p. 155):

- Fecal coliform concentration has trended down.
- Biological oxygen demand has trended down.
- Dissolved oxygen concentration has stayed the same or trended down and generally meets standards.
- Total suspended solids concentration trends varied with some stations increasing and others staying the same.

Potential discharge locations for the Applicant's return flow have been identified near the lakeshore cities of Oak Creek (directly to Lake Michigan) and Racine (Root River). A summary of nearshore average water quality data for nearshore samples collected from Lake Michigan near these cities is provided in Vol. 5 (CH2MHill, 2013, see Table 3-1).

Total phosphorus concentration has trended down in the outer harbor and up in the nearshore area. Since 1986, average annual concentrations have been less than 0.1 mg/L, except for 1 year. The phosphorous standard for the near shore and open waters of Lake Michigan is 0.007 mg/L (NR 102.06(5) (b), Wis. Admin. Code), however, an interim effluent limit for discharge to Lake Michigan has been set at 0.6 mg/L (NR 217.13(4), Wis. Admin. Code), for all dischargers until a nearshore model can be developed to determine site specific standards. Nearshore phosphorus water quality data ranged from 0.011to 0.014 mg/L TP (Figure 3.4 below: 1979-2010 data, stations NS-01, NS-02, NS-03 and NS-10).

Data collected closest to the Milwaukee Metropolitan Sewerage District (MMSD) South Shore water reclamation facility measurements are closer to the submerged treatment plant outfall. Nearshore data is expected to be more characteristic of overall Lake Michigan water quality than

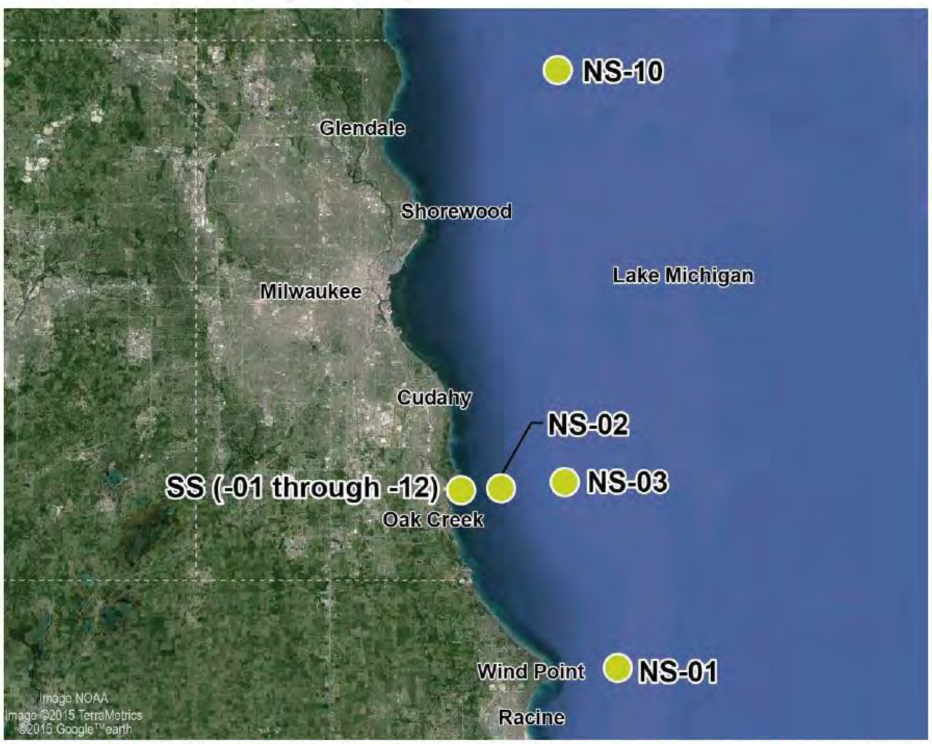
South Shore data because it is further away from a discharge location. South Shore concentrations for TP ranged from 0.015 to 0.111 mg/L (1979-2010 data, stations SS-01 through SS-12).

Figure 3.4 shows the locations of nearshore and South Shore area sampling sites near the cities of Oak Creek and Racine. Nearshore sampling point NS-10 is located north of the Menomonee River. Along the western shoreline of Lake Michigan currents predominantly follow a north-to-south direction (or lake-wide, a counterclockwise rotation). NS-10 is therefore expected to represent water quality without the immediate effects of various discharges to the lake south of the City of Milwaukee. These discharges may include the Kinickinick, Menomonee, Milwaukee, and Root Rivers, the MMSD Jones Island and South Shore water reclamation facilities, the Oak Creek power plant, and various stormwater outfalls and direct runoff.

Figure 3-4. WATERBase Water Quality Data Sampling Locations

Water Quality Data Collection Locations [a]

Locations near Oak Creek, WI, and Racine, WI



[a] Screenshot of WATERBase interface. Nearshore sample locations are individually identified as NS-01, NS-02, NS-03 and NS-10. Clustered samples taken close to the South Shore (SS) Water Reclamation Facility are also indicated.

Lake Michigan water quality data near City of Racine

Racine is a coastal community located on the southwestern shore of Lake Michigan. Over the past decade and a half, research has been conducted at the two primary public beaches, Zoo Beach and North Beach (just north of the mouth of the Root River). Between the years 2000-2004, elevated levels of *Escherichia. coli (E. coli)* caused poor recreational water quality an average of 25 days for North Beach and an average 32 days for Zoo Beach (Kinzelman and McLellan, 2009). The City initiated strategies to determine the sources of pollution, and in turn, mitigation and remediation techniques. Several mitigation measures have been implemented at the two beaches in the past decade such as: beach grooming, slope improvements, specialized infiltration basins and constructed dune systems to reduce stormwater runoff, and planting beach grasses to reduce overland sheet flow. From 2005-2014, the average advisory or closure (per Wisconsin's implementation of the federal BEACH Act) was only 4 days per season, with a range of 1-8 days.

Although beach conditions have improved, algae along the Lake Michigan shoreline can harbor elevated concentration of bacterial indicators. Stranded algal mats are typically found along the water's edge at Lake Michigan beaches, where nearshore recreational activities occur. Stranded mats have higher concentrations of bacterial indicators than submerged mats. Average concentrations of *E. coli* measured in June 2004 ranged from 333 to 25,000 CFU/gram for stranded mats versus 400 to 1,700 CFU/gram for submerged mats (Kinzelman, 2005). The presence of *Cladophora* along the shoreline has been augmented from a variety of environmental factors, including nutrient loading and greater sunlight penetration due to the improved water clarity from the filter feeding by invasive zebra and quagga mussels (Bootsma, 2009)

The Root River itself can be a source of bacteria to the City of Racine beaches and Lake Michigan. Microbiological quality has been studied along the Root River. Between 1975-2004 fecal coliform concentrations commonly exceeded state water quality standards (SEWRPC,2007). Historical fecal coliform data have decreased along the mainstem from upstream to downstream (SEWRPC, 2007). More recently, levels of *E. coli* have been monitored along the Root River in order to compare Root River watershed concentrations to the coastal recreational waters of Lake Michigan (Koski et. al, 2014).

3.2.3 Geomorphology and sediment of Lake Michigan

The geology of Lake Michigan developed during the Pleistocene Epoch as continental glaciers repeatedly advanced across the Great Lakes region and Lake Michigan. Glacial movements deepened and enlarged the basins of the Great Lakes (USEPA and Environment Canada, 2012). Near Milwaukee, the near-shore geomorphology is varied. Example lakebed substrates include: rock, cobble and sand, sand, and clay outcrops (WPSC, 2003).

Groundwater flow into Lake Michigan is a significant component of overall flow. Direct and indirect groundwater inflow contributes 33.8 percent of Lake Michigan water (USGS, 2000).

Sediment quality was reviewed in the vicinity of the Wisconsin Electric Power Company (WEPCO, or We Energies) Oak Creek, Wisconsin power plant. Two sediment quality studies were undertaken to investigate lakebed sediment on behalf of We Energies as a requirement for dredging operations. The first study, conducted in 1998, reported low to undetectable amounts of chlorinated organic compounds, such as polychlorinated biphenyls (PCBs) and pesticides. Metals, which are naturally present at trace levels in Lake Michigan sediment, were also present at or below mean concentrations at other locations on Lake Michigan (WDNR, 2003). The second study, conducted in 2002, detected no PCBs at the selected sample sites, and metals were again detected at or below mean background concentrations. Polycyclic aromatic hydrocarbons (PAHs), which are compounds resulting primarily from industrial oil and coal activities, were detected at three of eleven sample locations at concentrations high enough to negatively affect benthic macroinvertebrates. However, elevated levels were expected based on close proximity to the power plant's coal dock. Locations elsewhere in the lake would be expected to vary in sediment quality.

3.2.4 Flora and fauna (including T/E/SC) of Lake Michigan

Most of the near-shore areas along Lake Michigan are dominated by agriculture and urban development although considerable acreage along Lake Michigan in Milwaukee County is in parkland as well as the Schlitz Audubon Nature Center. Very few forested areas exist, but the remaining stands are dominated by maple and beech trees and also contain oak, hickory, and lowland hardwood species. There are also areas of wet-mesic and wet prairie, but they are limited and occur only in small preserves because of the landscape being heavily disturbed and fragmented. Because of fragmentation and significant disturbance, non-native plants are abundant in those areas. There are no aquatic plant threatened species, endangered species or species of concern within Lake Michigan.

3.2.4.1 Macrophytes of Lake Michigan

The primary aquatic macrophytes found in Lake Michigan include Sago Pondweed (*Stuckenia pectinata*), Coontail (*Ceratophyllum demersum*), Eurasian Watermilfoil (*Myriophyllum spicatum*), Elodea (*Elodea canadensis*), and Curly-leaf Pondweed (*Potamogeton crispus*). These plants are found in harbors and protected areas along the coast.

3.2.4.2 Benthic invertebrates of Lake Michigan

Free-floating or planktonic algae are present in Lake Michigan, dominated by the diatoms (represented by *Synedra, Fragilaria, Tabellaria, Asterionella, Melosira, Cyclotella* and *Rhizosolenia)*, among others. Concentrations of free-floating algae fluctuate during the year, subject to the availability of sunlight, water temperatures, and in the cases of diatoms, bioavailability of silicon (WPSC, 2003). Algae typically found attached to substrate are also present in Lake Michigan. These include *Cladophora, Ulothrix, Tetraspora, Stigeoclonium,* and red algae *Asterocytis.*

In recent years, nuisance algae (genus *Cladophora*) growth has been observed along the Lake Michigan shoreline. The algae grow underwater attached to rocks, are dislodged by waves, and then washed up on shore. The decaying algae create nuisance odors. Similar algae growths were observed in the mid-1950s and again during the 1960s and 1970s, before this most recent occurrence. The cause of this latest resurgence in algae growth is uncertain, but it may be due in part to changes in water clarity and phosphorous availability brought on by the prevalence of invasive zebra and quagga mussels.

3.2.4.3 Benthic invertabrates of Lake Michigan

A survey of the Great Lakes in 1998 identified 20 taxa of benthic macroinvertebrates in Lake Michigan with an average of about seven taxa per sampling site (Barbiero et al., 2000). The amphipod *Diporeia* (formerly *Pontoporeia)*, tubificid oligochaetes, and sphaeriid snails dominated the Lake Michigan benthic macroinvertebrate community. However, in near-shore areas, oligochaetes were the dominant taxonomic group. The density of benthic

macroinvertebrates typically ranged from 1,500 to 6,500 organisms per square meter. Surveys performed in 2002 near the Great Lakes Water Institute in Milwaukee revealed that oligochaetes and chironomidae are present, as are freshwater sponges, *Ectoprocta,* mayflies, leeches, isopods, and amphipods.
Since 1988, the southern basin of Lake Michigan has had zebra and quagga mussels and undergone major changes in nutrient cycling. Dreissenid mussel infestations have been confirmed on most suitable habitat (USGS, 2011).

Changes in nutrient cycling due to dreissenid mussels have repartitioned the productivity of the lake and reduced the density of benthic macroinvertebrate fauna, particularly oligochaetes and snails, observed between 1980 and 1987 (Nalepa et al., 1998). A decline in the abundance of an important amphipod (*Diporeia)* also began in 1988. Filter feeding by zebra mussels in near-shore waters was thought to have decreased the amount of food available to the amphipod (Nalepa et al., 1998). The declining abundance of *Diporeia*, which have been nearly extirpated from Lake Michigan, coincides with the expansion of the dreissenid mussels (Nalepa et al. 2009).

3.2.4.4 Fish of Lake Michigan

Lake Michigan is primarily cold water and relatively infertile. Historically, the fishery consisted mostly of lake trout, burbot, Coregonid fishes, whitefish and sculpins. An introduction of sea lamprey and over-fishing led to declines in the numbers of native piscivorous fish. Alewife populations grew and lake trout, lake herring, lake whitefish, bloater chubs and yellow perch populations declined. Control of invasives, along with a fish stocking program have increased predation and native fish numbers and have assisted in stabilizing alewife numbers. Today, the Lake Michigan fishery consists of nearly 100 species. Table 3.2 below summarizes some of the predominant fish species of the near-shore waters of Lake Michigan (WPSC, 2003). Annual stocking of native lake trout, along with the introduction of Chinook and Coho Salmon, Brown trout and Steelhead has helped develop Lake Michigan into a popular sport fishery.

Both Lake sturgeon and American eel, also nearshore species, are listed as special concern species and skipjack herring is endangered in Wisconsin. The non-native listed in Table 3.2 include: alewife, Chinook salmon, coho salmon, rainbow trout, brown trout, rainbow smelt, gizzard shad, common carp, round goby, three spine stickleback and sea lamprey.

Even though the Milwaukee Harbor estuary has these stresses, the fishery is reported to contain a high abundance and diversity of species, because the fishery is connected to the rest of Lake Michigan and to parts of the Milwaukee, Menomonee, and Kinnickinnic Rivers that achieve full fish and aquatic life standards (SEWRPC, 2007, p. 205).

Table 3-2. Predominant fish species found nearshore in Lake Michigan (WDNR data)

Lake Michigan (nearshore) Fish Species			
Alewife	Emerald shiner	Longnose sucker	Sea Lamprey
Bloater	Fathead minnow	Muskellunge	Slimy sculpin
Bluntnose minnow	Freshwater drum	Nine spine stickleback	Smallmouth bass
Bowfin	Gizzard shad	Northern pike	Spottail shiner
Brook stickleback	Johnny darter	Pumpkinseed	Three spine stickleback
Brook trout	Lake chub	Rainbow smelt	Trout perch
Brown trout	Lake sturgeon	Rainbow trout	Walleye
Burbot	Lake trout	Rock bass	White bass
Chinook salmon	Lake whitefish	Round goby	White sucker
Cisco	Largemouth bass	Round whitefish	Yellow perch
Common carp	Longnose dace	Sand shiner	

3.2.4.5 Herptiles, Birds and Mammals of Lake Michigan

Herptiles of Lake Michigan

The common mudpuppy (*Necturus maculosus*) is a Wisconsin special concern species found near shoals and is a Species of Greatest Conservation Need that is significantly associated with the Lake Michigan natural community per the Wildlife Action Plan (search 'Wildlife Action Plan at dnr.wi.gov).

Birds of Lake Michigan

The Caspian tern (Endangered), common tern (Endangered), Forster's Tern (Endangered), black tern (Endangered) and horned grebe (Special Concern) are all Species of Greatest Conservation Need that are significantly associated with the Lake Michigan natural community per the Wildlife Action Plan.

3.3 Fox River

3.3.1 Physical description of floodplain of the Fox River

The Fox River's headwaters originate near Colgate, Wisconsin and the river flows 202 miles to Ottawa, Illinois, where it empties into the Illinois River. The total watershed area is nearly 2,700 square miles. Eighty four miles of the River are within Wisconsin. The upper part of the Fox River, 35% of the basin, flows through the City of Waukesha and is the current discharge location for treated effluent from the City's wastewater treatment plant (WWTP).

3.3.2 Flow and flooding in the Fox River

The Fox River flow gage (USGS stream gage 05543830) is located in the City of Waukesha and has a contributing drainage area of 124 square miles. The average annual stream flow (flow period 1963 to 2013) is 113 cfs at the Fox River in the City of Waukesha. The gage has been in operation since 1963 and has recorded major flood events in 1965, 1973, 1974 and 1979. Frequencies for these floods were set at once every 5, 20, 6 and 5 years respectively (Waukesha County Flood Insurance Study (FEMA), 2014)

The history of flooding on the streams within the City of Waukesha indicates that flooding may occur during any season of the year. The majority of major floods on the Fox River have occurred in the early spring and are usually the result of spring rains and/or snowmelt. The most recent flooding within the City of Waukesha occurred in March, 1960 and April, 1973. A peak discharge of 2160 CFS was recorded at the USGS gage for the 1973 flood, which would have an expected frequency of once every 25 years. Highwater marks from this flood were used to verify the hydraulic model used in this study (FEMA, 2014).

The Fox River floodplain model was not updated as part of the updated Flood Insurance Study. The current effective profiles and flows for the Fox River are listed in the Waukesha County Flood Insurance Study. Note: A new floodplain study, to be funded by the Federal Emergency Management Agency (FEMA), is in the process of being developed for the Fox River Watershed, which includes new hydrology and hydraulics for the Fox River. The effective date of this study is dependent on the availability of funding.

3.3.3 Water quality of the Fox River

In Wisconsin, the Fox River is designated a Warm Water Sport Fishery with the following uses: fish and aquatic life, recreation, public health and welfare, and fish consumption. Downstream in Illinois, the Fox River is designated as 'general use water,' which includes primary contact uses, and 'public and food water supply standards. The entire Fox River (miles 113.24 – 196.64) is on Wisconsin's §303(d) impaired waters list for PCBs, sediment/TSS and total phosphorus exceedances. Downstream impairments include aquatic toxicity due to PCBs and degraded biological communities due to phosphorus and sediment (Table 3.3).

Table 3-3. Wisconsin's §303 (d) pollutants and impairments for the Fox River - Illinois

Fox River (river miles)	Pollutant	Impairment
113.24 to 196.64	PCBs	Contaminated Fish Tissue
113.24 to 187.16	Total Phosphorus	Degraded Biological Community, Low Dissolved Oxygen, Unknown
171.45 to 187.16	Sediment/Total Suspended Solids	Degraded Habitat, Low Dissolved Oxygen

Water quality information has been gathered by a number of organizations in the Fox River watershed including the WDNR, USGS and SEWRPC. Long-term water quality trend data are gathered by the WDNR about 7 miles downstream of the Waukesha WWTP at County Highway I. Parameters collected include: total suspended solids, alkalinity, dissolved oxygen, pH, total phosphorus, dissolved orthophosphorus, chlorophyll a, nitrogen series and *E. coli*. Several biological indices have been developed for three stream reaches along the Fox River. These indices use benthic macroinvertebrate and fish as indicators of water quality and physical conditions present within the stream (see section on macroinvertebrates below).

The Applicant's WWTP currently discharges to the Fox River (CH2MHill, 2013, Vol. 4, Appendix H for more WWTP information and historical effluent data).

3.3.4 Geomorphology and sediments of the Fox River

Near the City of Waukesha, the Fox River has natural channel reaches with minimal modifications, while other reaches have been significantly altered by development. Within the City center, upstream of the City's WWTP, the Fox River is dammed to create the Barstow Impoundment. River banks in the impoundment consist of sheetpile, concrete, rock reinforcements, and vegetation. Upstream of the dam, large sediment depositions are reported to include pollutants that may cause human and aquatic health concerns.

Further upstream, the Fox River meanders through developed landscapes including residential, golf course, commercial and transportation development. In this segment the river has primarily vegetated banks, with erosion and bank failures common to urban areas. The river generally has a wide floodplain with connected wetlands and some encroachments from development. The river is generally low gradient and primarily consists of pools and glides. The sediments are primarily silts and sands in the pools and sand and gravel in glides.

Downstream of the Barstow Impoundment, the river is confined by development. The river banks are primarily rock riprap and concrete retaining walls. The river is typically narrow and has a higher gradient than upstream reaches. Nearing the WWTP, the river returns to a low gradient meandering stream. Similar to the upstream reaches, the banks are mostly vegetated with some erosion and bank failures (typical in developing watersheds). Continuing downstream, the river has a fairly low gradient, with sediments consisting primarily of silt and sand in pools, and sand in the glides. Occasional areas of gravel are also present. In the downstream reaches, sand point bars have formed due to an increased bedload from agricultural runoff.

3.3.5 Flora and Fauna of the Fox River

The riparian vegetation communities of the Fox River at proposed pipeline intersections are typical of higher-order waterways in the Midwest. The floodplains at County Highway H and State Highway 59 are dominated by reed-canary grass and stinging nettle adjacent to the river; and mature woody trees such as box elder, silver maple, willows, and eastern cottonwood farther from the river. Few other herbaceous or shrub species are present. Four natural communities have been documented adjacent to the river. In addition, six rare plants, including two that are state-listed, are known to occur within the near vicinity of the Fox River.

3.3.5.1 *Macrophytes* of the Fox River

The Fox River does not have complete documentation of aquatic macrophytes. Observations of aquatic invasive species such as Eurasian water milfoil, curly leaf pondweed, reed canary grass and purple loosestrife have been identified in and adjacent to the Fox River.

3.3.5.2 Algae of the Fox River

The Fox River does not have recorded documentation of aquatic periphyton and algal species, however, populations of both have been observed in the Fox River.

3.3.5.3 Benthic invertebrates of the Fox River

Aquatic macroinvertebrates have been collected at multiple locations on the Fox River in 1999, 2000, 2002 and 2007. The MIBI (benthic macroinvertebrate index) was developed for this stream reach of the Fox River and samples ranged from 4.62 to 6.58, generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a good to fair water quality. Sampling in the Fox River resulted in the identification of over 90 macroinvertebrate taxa being identified in these samples. Some taxa were identified at a species level, while others were identified to genus, subfamily, or family levels. Insects were the most identified taxa, including: true flies, beetles, caddisflies, mayflies, true bugs, dragonflies, damselflies, dobsenflies. Other groups found included amphipods, crayfish, isopods, annelid worms, nematode worms and turbellarian worms. The most commonly identified organisms were caddisflies, midges, worms of the family Tricladida.

Surveys for mussels were conducted in the Illinois Fox River watershed and its tributaries from 1997-2001 in Wisconsin and Illinois. 96 main stem and tributary stations were sampled. A total of 27 species were identified of which 23 were live specimens. Three rare mussel species and one caddisfly species are known or have been known to occur within this stretch of the Fox River. An additional 2 introduced bivalve species (zebra mussels and Asian clam) were also found in the Fox River watershed (Schanzle, 2004).

Aquatic invasive species such as zebra mussels, rusty crayfish, banded mystery snails and asian clam have also been identified in segments of the Fox River and its tributaries.

3.3.5.4 Fish of the Fox River

Fox River fisheries data have been collected six miles downstream of the WWTP, between County Highway I and the confluence of Genesee Creek in 1999, 2000, 2003, 2004, and 2006 (Table 3.4). The surveys identified 38 species of fish (Table 3.4). The most abundant species collected were golden redhorse, common carp, bluegill, channel catfish, largemouth bass, white bass, northern pike, rock bass, common shiner, sand shiner, bluntnose minnow, emerald shiner, longnose garb white sucker, and creek chub. Most are considered warm water species, although they may also be found in cool water habitats. Several coldwater species (brook and brown trout) were noted at the confluence of Genesee Creek (a cold water fishery) and the Fox River but were only present in small numbers. The common carp is an invasive species that has also been identified in the Fox River and its tributaries.

A separate fish survey was conducted at the confluence of the Fox River and Pebble Creek, 1.65 miles downstream of the Waukesha WWTP (Waukesha County and SEWRPC, 2008). Many species were the same as those collected in the WDNR surveys, but species not found farther downstream in the Fox River were collected. These were brook stickleback (a cool water species), and the spottail shiner, golden shiner, orange-spotted sunfish, and tadpole madtom, all warm water species. In addition, one endangered, one threatened, and one special concern species were collected. Outside of these surveys, there are two additional rare fish species that may be present in this stretch of the Fox River.

Table 3-4. Fish Species in Fox River found donwstream of Waukesha's Wastewater Treatment Plant

Fox River Species	
Bigmouth shiner	Green Sunfish
Black bullhead	Honeyhead chub
Black crappie	Johnny darter
Blackstripe topminnow	Largemouth bass
Bluegill	Longnose gar
Bluntnose minnow	Mottled sculpin
Bowfin	Northern pike
Brook silverside	Pumpkinseed
Brook trout	Quilback
Brown trout	Rock bass
Central mudminnow	Sand shiner
Central stoneroller	Spotfin shiner
Channel catfish	Stonecat
Common carp	Walleye
Creek chub	White bass
Emerald shiner	White sucker
Golden redhorse	Yellow bass
Grass pickerel	Yellow bullhead
Greater redhorse	Yellow perch

3.3.5.5 Herptiles, Birds and Mammals of the Fox River

Herptiles of the Fox River

One state endangered and two special concern herptile species have been known to use the Fox River and its adjacent wetlands as habitat. However, the endangered herptile is thought to be extirpated from this area.

Birds of the Fox River

One state endangered and three special concern bird species are known to use the Fox River and its adjacent habitat for nesting.

Mammals of the Fox River

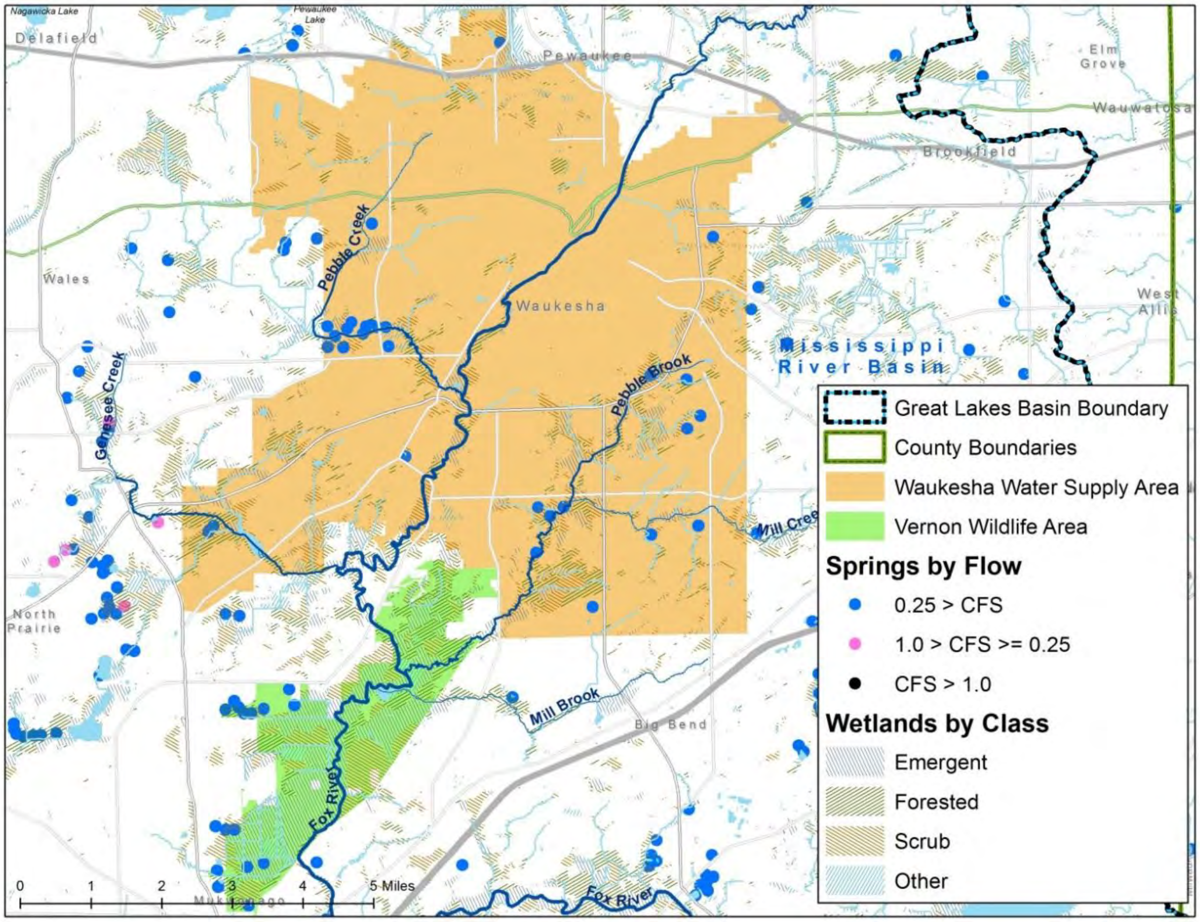
The Fox River also provides habitat for a variety of mammals, mostly furbearers. Muskrats, mink, otter, and beaver thrive in the marsh habitat. Other mammals including opossum, shrews, moles, bats, chipmunk, voles, mice, fox, raccoon, weasels, and skunk are numerous as well. White-tailed deer, eastern gray and fox squirrels, eastern cottontails, and coyotes are popular game species and receive moderate to heavy hunting pressure.

There are two rare mammals, including one that is state threatened, that are known to use the Fox River and/or its adjacent habitats. Fox River Tributaries

3.3.6 Physical description and floodplains of Fox River Tributaries

Pebble Brook, Pebble Creek, Mill Brook, Genesee Creek and Mill Creek all are smaller-order streams that empty into the Fox River in the vicinity of the City of Waukesha (Figure 3.5). All of these waterways are listed as Areas of Special Natural Resource Interest (ASNRI) because they have been designated as trout streams or contain state-listed endangered or threatened species. The riparian vegetation located adjacent to these waterways is often dominated by invasive species due to watershed disturbances (development). Even though the watershed is primarily urban, public parkways often buffer these waterways.

Figure 3-5. Map of Fox-Illinois River and tributary streams and local springs



Pebble Brook description

Pebble Brook is a narrow nine-mile long tributary to the Fox River south of the City of Waukesha. Pebble Brook is classified as a Cool-Warm Mainstem near the convergence with the Fox River and a Cool-Warm Headwater in the upper portions of the watershed.

Pebble Creek description

Pebble Creek is a narrow, six-mile long perennial trout stream in southeastern Waukesha County. It is a tributary to the Fox River south of the City of Waukesha, with a watershed size of 18 square miles. Pebble Creek is classified as a Cool-Cold Headwater stream. Cold water fisheries are surface waters capable of supporting a community of cold water fish and other aquatic life or serving as a spawning area for cold water fish species. Cold water streams often receive much of their flow from groundwater entering the stream which enables their temperature to remain cold. Pebble Creek is listed as a Class II Wisconsin trout stream (Class II is described as having some natural reproduction but not enough to fully utilize available food and space). The main tributary to Pebble Creek is Brandy Brook, a Class I Trout Stream. SEWRPC has created Watershed Protection Plans for Pebble Creek (SEWRPC, 2008).

Mill Creek description

Mill Creek is a four-mile tributary stream that flows west from the City of New Berlin for four miles past two private dams before entering Pebble Brook. The watershed is approximately seven square miles. Mill Creek is classified as a Cool (Warm Transition) Headwater.

Genesee Creek description

Genesee Creek is a five mile long tributary that reaches its mouth at the Fox River about a mile west of Waukesha. From its mouth to three and a half miles upstream Genesee Creek is classified as a Class II Trout water, and the remainder of the creek is a Class I Trout stream and an Exceptional Resource Water. Class I trout streams are high quality trout waters that have sufficient natural reproduction to sustain populations of wild trout, at or near carry capacity

Mill Brook description

Mill Brook is a narrow, five mile long perennial trout stream within an eight square mile watershed in southeastern Waukesha County. It is a tributary to the Fox River south of the City of Waukesha. Mill Brook is classified as a Cool-Warm to Cool–Cold Headwater stream. The headwaters of Mill Brook is listed as a Class I Trout Stream then further downstream as it flows into Vernon Marsh is listed as a Class II Trout Stream.

3.3.7 Flow and flooding in Fox River tributaries

There are no USGS flow gages located on the Fox River tributaries of Pebble Brook, Pebble Creek, Mill Creek, Genesee Creek and Mill Brook. The current effective Flood Insurance Study for these streams is dated November 5, 2014. The floodplain studies for these streams were not updated during this process. The profiles and flows can be found in the Waukesha County Flood Insurance Study. The modeled median low flows for August are: Pebble Brook (5.95 cfs), Pebble Creek (5.56 cfs), Mill Brook (2.34 cfs), Genesee Creek (9.62 cfs) and Mill Creek (2.25 cfs.).

3.3.8 Water quality of Fox River tributaries

Pebble Brook water quality

Water quality data was collected on Pebble Brook in August 2013 for a natural community assessment at WDNR station number 683232. Instantaneous measurements of dissolved oxygen (8.84mg/L, 89.5%), water temperature (15.95°C), specific conductivity (1040 umhos/cm) and pH (7.94) were taken at Pebble Creek for that assessment. A grab sample for total phosphorous was also collected. The result of that grab sample was 0.0604 mg/L which is lower than the phosphorus water quality standard. Pebble Brook is not listed impaired water on Wisconsin's Impaired Waters §303(d) list.

Aquatic macroinvertebrates have been collected at multiple locations on Pebble Brook in 1997, 2000, 2002 and 2013.The MIBI for stream segments of the Pebble Brook samples sites ranged from 4.21-5.57, generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken in the Pebble Brook Watershed.

Pebble Creek water quality

Pebble Creek is not listed as impaired on Wisconsin's §303(d) List; however two unnamed tributaries to Pebble Creek are listed. Unnamed - Perennial Stream D (Pb016) and Unnamed - Perennial Stream C (Pb108) are both listed as having impairments of degraded habitat and elevated water temperature due to total suspended solids. Nonpoint source runoff, sedimentation, and beaver dams often result in a loss of habitat, water temperature fluctuations, and water quality impacts in Pebble Creek.

Water quality data was gathered at WDNR station number 683458 on Pebble Creek at Hwy D in August 2011 and at WDNR station number 10037393 downstream of Kame Terrace in August 2012. Instantaneous measurements of dissolved oxygen (9.03 and 6.39 mg/L), water temperature (16.25 and 20.96^{o}C), specific conductivity (893.1 and 1632 umhos/cm) and pH (7.77 and 7.51), respectively, were taken with an MS5 Hydrolab on Pebble Creek. A grab sample for total phosphorous was also collected at each site. The result of that grab sample at Kame Terrace was 0.107 mg/L which exceeds the new phosphorus water quality standard. The sample at Hwy D was 0.034mg/L which is lower than the water quality standard.

Aquatic macroinvertebrate have been collected at multiple locations on Pebble Creek in 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The MIBI for stream segments of the Pebble Creek and Brandy Brook watershed samples ranged from 2.7-6.1506 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken on Pebble Creek and Brandy Brook.

Mill Creek water quality

No water chemistry data is available for Mill Creek. Aquatic macroinvertebrates have been collected at a few locations on Mill Creek in spring and fall of 1980, 1997, 2000, and 2002. The MIBI for stream segments of the Mill Creek samples sites ranged from 3.28-5.89 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken on Mill Creek. Mill Creek is not listed as impaired water on Wisconsin's Impaired Waters §303(d) list.

Genesee Creek water quality

Genesee Creek is not listed as impaired on Wisconsin's §303(d) list. Aquatic macroinvertebrates have been collected at multiple locations on Genesee Creek in 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The MIBI for stream segments of Genesee Creek samples ranged from 4.24-7.36 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a good water quality for samples taken on Genesee Creek. Genesee Creek is also listed as an Exceptional Water Resource with excellent biodiversity and water quality. In 2005 the Genesee Roller Mill Dam was removed, however two dams lower in the watershed remain in place and are having thermal impacts on the lower portions of the watershed.

Mill Brook water quality

No water chemistry data is available for Mill Brook. Aquatic macroinvertebrates have been collected at a few locations on Mill Brook in spring and fall of 1980 and 2004. The MIBI for a stream segment of the Mill Brook ranged from 3.58-4.73 generally indicating that the diversity and abundance of macroinvertebrate species are indicative of fair water quality for samples taken on Mill Brook. Construction erosion, nonpoint source contamination, sedimentation, stream realignment, manmade dams and ponds and beaver dams are all minor stressors in the watershed, that result in the loss of habitat and cause water temperature fluctuations and impacts on water quality in Mill Brook. Mill Brook is not listed as impaired water on Wisconsin's Impaired Waters §303(d) list.

3.3.9 Geomorphology and sediments of Fox River tributaries

Pebble Creek geomorphology

The 18 square mile Pebble Creek watershed contains three main reaches, Brandy Brook and Upper and Lower Pebble Creek. The Brandy Brook and Upper Pebble Creek subwatersheds lie west of the City of Waukesha. The confluence of Upper Pebble Creek and Brandy Brook form Lower Pebble Creek, which then flows into the Fox River within the Fox River Parkway in the southwestern part of the City of Waukesha. Flow data in the watershed is unavailable because it does not have a flow measurement gage. Over half of the reaches within the watershed show evidence of channelization, some of which were widened. Most channelization occurred between the 1940s and 1970s as part of the accepted agricultural practices of the time. Within the Pebble Creek watershed, bank erosion is more common in channelized reaches than in natural reaches. Upper Pebble Creek is the most urbanized and channelized subwatershed and has the most eroding banks (Waukesha County and SEWRPC, 2008, p. 82).

Lower Pebble Creek is a non-channelized stream. Its meandering, highly sinuous pattern is indicative of low gradient (less than one percent) natural streams in the area. Most of the Pebble Creek watershed streams are low gradient sand and gravel systems. High quality riffles occur frequently in Lower Pebble Creek. Brandy Brook's headwaters, which is a moderately sloped (1.4 percent) system, and Upper Pebble Creek's 2.2 percent sloped headwater stream, are exceptions to the low gradient prevalent within the watershed (Waukesha County and SEWRPC, 2008, p. 78). These higher gradient reaches have predominantly gravel, cobble, and boulder substrates.

All streams within the watershed are dominated by pool and riffle habitat. Most of the streams within Pebble Creek watershed have riparian buffers that exceed 75 feet (Waukesha County and SEWRPC, 2008, p. 130). Many reaches are within forested riparian corridors, with a good amount of in-stream cover including large woody debris and undercut banks. Occasionally, the abundant woody debris jams (sometimes with the help from beavers), forming obstructions to flow. Within channelized and incised reaches, these jams exacerbate bank erosion and cause blowouts during storm events.

Pebble Brook and Mill Creek geomorphology

The Pebble Brook and Mill Creek watersheds include residential, some agricultural, commercial, and industrial land uses. They are mostly undeveloped where Pebble and Mill Brook have wide floodplains with large wetland areas bordering the channels. The channels have been straightened in some areas to accommodate road crossings, a railroad, and agricultural developments, but the vast majority of the channel length is natural and highly sinuous with tortuous bends. The channels are low energy systems that include pool-riffle and pool-glide sequences, with few areas of point bar formations. The pools are generally sandy with some silt and organics. The glides and riffles are generally sand and gravel and the point bars are generally gravel.

The channel banks are nearly all earthen with dense vegetation that provides bank stability. Some erosion and bank failures are present that are typical of developing watersheds, but the channel banks are low and the channels have access to their floodplain during high flow events. The banks are undercut in many areas, with exposed root masses and overhanging vegetation. These portions of the channels are still very stable, however, due to the accessible floodplain and because the channels are low energy and the roots provide adequate bank strength.

Mill Brook geomorphology

Mill Brook is approximately 8.5 miles in length with a gradient of 9.4 feet per mile and flows into the Fox River. Construction erosion, nonpoint source contamination, sedimentation, stream realignment, manmade dams and ponds and beaver dams are all minor stressors in the watershed.

Genesee Creek geomorphology

The twenty-four square mile Genesee Creek watershed contains three main reaches, Spring Brook, North Branch of Genesee Creek and Genesee Creek. The North Branch of Genesee Creek, Spring Brook and a majority of Genesee Creek subwatersheds flow southeast through the Town of Genesee and a small section of the Town of Waukesha before converging with the Fox River. Flow data in the watershed is limited because it does not have a flow measurement gage in the watershed.

The headwater portions of Genesee Creek watershed have wide floodplains with large wetland areas bordering the channels. The channels have been straightened in some areas to accommodate road crossings, multiple railroad crossings, and a large area of agricultural development, but a good portion of the channel length is still natural with a high gradient. These higher gradient reaches have predominantly gravel, cobble, and rubble substrate. In 2005, the Roller Mill Dam was removed, however two dams lower in the watershed still remain.

3.3.10 Flora and fauna of Fox River tributaries

Pebble Brook flora and fauna

Pebble Brook has a riparian plant community typical of southeast Wisconsin. At County Highway XX, near where the pipeline crosses Pebble Brook, the surrounding watershed is less-disturbed relative to the other waterways. Tree species such as hackberry, silver maple, box elder, and several willow species are present. Though the herbaceous layer is dominated by weedy species such as reed canary grass and goldenrod, native sedges, rushes, and grasses are also present in some sections. Gray dogwood is a common shrub located in the floodplain; riverbank grape is also widespread.

Four natural communities and two animal concentration sites have been documented adjacent to or within the near vicinity of Pebble Brook. In addition, four rare plants, including two that are state-threatened, are known to occur within the vicinity of this brook.

Pebble Creek flora and fauna

The riparian vegetation along Pebble Creek is similar to the riparian community of Pebble Brook and the Fox River, which Pebble Creek empties into. Willows and maples are dominant woody species. They are located at the outer edge of the creek's floodplain. Closer to the waterway, reed-canary grass and stinging nettles dominate. Large populations of cattail are also present along Pebble Creek near Genesee Road.

Two natural communities have been documented adjacent to the creek. In addition, five rare plants, including three that are state-threatened, are known to occur within the near vicinity of the Pebble Creek.

Mill Brook flora and fauna

Mill Brook empties into the Fox River just south of where Pebble Brook does. Mill Brook riparian vegetation is similar to the other low-order streams in the area. It is dominated by both herbaceous and woody weedy species. Silver maple, green ash, and eastern cottonwood are located frequently along the waterway. Shrubs such as smooth sumac and gray dogwood are also common. Herbaceous species present include common weedy species such as reed-canary grass, goldenrod, stinging nettle, and yarrow.

Two natural communities and one animal concentration site has been documented adjacent to or within the near vicinity of Mill Brook. In addition, four rare plants, including one that is state-threatened, are known to occur within the vicinity of this brook.

Genesee Creek flora and fauna

Genesee Creek has seven natural communities that have been documented nearby. The rare plant diversity is also quite high with ten plant species, six of which are threatened, recorded within the vicinity including a couple that are directly associated with the creek.

Mill Creek flora and fauna

Mill Creek is located south of the City of Waukesha in both rural and residential areas. In the areas of lesser disturbance, a relatively diverse riparian plant community is present, consisting of wet meadows species such as sedges, grasses, and forbs. But stretches of Mill Creek are located adjacent to residential areas where reed-canary grass and mowed turfgrass dominate.

Two natural communities and one animal concentration site have been documented adjacent to or within the near vicinity of Mill Creek. In addition, one special concern plant is known to occur within the vicinity of this creek.

3.3.10.1 Macrophytes of Fox River tributaries

Pebble Brook macrophytes

The department has observed aquatic invasive species such as curly leaf pondweed, reed canary grass and purple loosestrife in or around Pebble Brook.

Pebble Creek macrophytes

SEWRPC's watershed plan lists examples of typical macrophytes observed such as elodea and curly leaf pondweed. The department has observed other aquatic invasive species, such as purple loosestrife and reed canary grass, in or adjacent to Pebble Creek.

Mill Creek macrophytes

The department has observed aquatic invasive species such as Eurasian water milfoil and red canary grass in or around Mill Creek.

Genesee Creek macrophytes

The department has observed macrophytes in or around Genesee Creek such as curly leaf pondweed, reed canary grass and purple loosestrife (all aquatic invasive species). New native species were planted as invasive species management after the removal of the Genesee Roller Mill Dam in 2005. Carroll University staff and students conduct extensive monitoring and projects within the riparian area of Genesee Creek and other information may be available.

Mill Brook macrophytes

The department has observed aquatic invasive species such as Eurasian water milfoil and red canary grass in or around Mill Brook.

3.3.10.2 Algae of Fox River tributaries

The department has observed aquatic periphyton and algal species in all of the Fox River tributaries; however this data is not formally documented.

3.3.10.3 Benthic invertebrates of Fox River tributaries

Pebble Brook invertebrates

Aquatic macroinvertebrates have been collected at multiple locations on Pebble Brook in 1997, 2000, 2002 and 2013. The MIBI for stream segments of the Pebble Brook samples sites ranged from 4.21-5.57 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken in the Pebble Brook Watershed. In addition, three rare mussel species and a rare caddisfly are known to be present within Pebble Brook or within connecting waterbodies to Pebble Brook.

Pebble Creek invertebrates

Aquatic macroinvertebrates have been collected at multiple locations on Pebble Creek in the years: 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The MIBI for stream segments of the Pebble Creek and Brandy Brook watershed samples ranged from 2.7-6.1506 generally indicating that the diversity and abundance of macroinvertebrate species are indicative of a fair to good water quality. In addition, two rare mussel species are known to be present within connecting waterbodies to Pebble Creek.

Mill Creek invertebrates

Aquatic macroinvertebrates have been collected at a few locations on Mill Creek in spring and fall of 1980, 1997, 2000, and 2002. The MIBI for stream segments of the Mill Creek samples sites ranged from 3.28-5.89 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality. In addition, three rare mussel species are known to be present within connecting waterbodies to Mill Creek.

Genesee Creek invertebrates

Aquatic macroinvertebrates have been collected at multiple locations on Genesee Creek in 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The MIBI for stream segments of the Genesee Creek samples ranged from 4.24-7.36 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a good water quality. Two rare mussel species (one is classified as threatened) and a caddisfly species are known to be present within connecting waterbodies to Genesee Creek.

Mill Brook invertebrates

Aquatic macroinvertebrates have been collected at a few locations on Mill Brook in spring and fall in 1980 and 2004. The MIBI for a stream segment of the Mill Brook ranged from 3.58-4.73 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of fair water quality. In addition, two rare mussel species and a caddisfly species are known to be present within connecting waterbodies to Mill Brook.

3.3.10.4 Fix of Fox River tributaries

Pebble Brook fish

Pebble Brook is classified as a Cool-Warm Mainstem near the convergence with the Fox River and a Cool-Warm Headwater in the upper portions of the watershed. Fish Surveys were conducted in 2000, 2002 and 2013. The surveys identified species such as bigmouth shiner, black bullhead, blackside darter, blackstripe topminnow, bluegill, bluntnose minnow, bowfin, central mudminnows, creek chub, common carp, common shiner, green sunfish, johnny darter, largemouth bass, northern pike, rock bass, white sucker and yellow bullhead. Most of these species are considered warm water species but several can be found in cool water habitats. Outside of these surveys, four other rare fish species are known to be present within Pebble Brook or within connecting waterbodies to Pebble Brook.

Pebble Creek fish

Brandy Brook and Pebble Creek upstream of County Trunk Highway (CTH) D supports a cold water fish community. Pebble Creek downstream of CTH D is designated a warm water sport fishery. SEWRPC's report, Community Assistance Planning Report No. 284, Pebble Creek Watershed Protection Plan (2008) documents the presence of a state threatened species and the cold water brown trout (*Salmo trutta*) and mottled sculpin (*Cottus bairdi)*) in 1999–2005 surveys in Pebble Creek. In addition, a special concern species was found in Pebble Creek, at the confluence with the Fox River.

Fish surveys were conducted on Pebble Creek and/or at the confluence with the Fox River 1990, 1995, 1999 and extensive surveying completed in 2004-2005. The fish species found during these surveys included brown trout (cold water species), mottled sculpin (cold water species), blacknose dace, brook stickleback, central mudminnow, fathead minnow, johnny darter, northern pike, rock bass, spottail shiner, white sucker, black bullhead, black crappie, blacknose shiner, blackside darter, blackstripe topminnow, bluegill, bluntnose minnow, bowfin, brook silverside, common carp, central stoneroller, channel catfish, common shiner, grass pickerel, green sunfish, hornyhead chub, largemouth bass, largescale stoneroller, longnose dace, mimic shiner, pumpkinseed, orangespotted sunfish, sand shiner, spotfin shiner, smallmouth bass, one threatened species and one special concern species. Additional species were found during WDNR fisheries surveys in 2005-2014 including creek chub, emerald shiner, golden shiner, rainbow darter and yellow perch. Most of these species are considered warm water species but several can be found in cool water habitats. Outside of these surveys, two other rare fish species are known to be present within connecting waters to Pebble Creek.

Mill Creek fish

Mill Creek is four mile tributary stream that flows west from the town of New Berlin past two private dams before entering Pebble Brook. Mill Creek is classified as a Cool (Warm Transition) Headwater.

Fish surveys were conducted on Mill Creek in 1997, 2000, 2002, 2008 and 2013. The fish species found during surveys included banded darter, black bullhead, black crappie, blackside darter, bluegill, bluntnose minnow, bowfin, brook stickleback, central mudminnow, central stoneroller, common shiner, creek chub, fathead minnow, golden shiner, green sunfish, hornyhead chub, johnny darter, largemouth bass, longnose dace, mottled sculpin (cold water species), pumpkinseed X bluegill, rainbow darter, rock bass, western blacknose dace, white sucker and yellow bullhead. Outside of these surveys, three rare fish species have also been documented within Mill Creek or nearby in connecting waterbodies.

Genesee Creek fish

Genesee Creek is a 5 mile tributary stream to the Fox River that flows east with a dam at Saylesville Millpond. Genesee Creek is listed as a partially Class I and Class II trout stream (Class I waters are high quality and support natural reproduction of wild trout, at or near carrying capacity. Class II waters have some natural reproduction, but not enough to fully utilize available food and space). The upper portion of Genesee Creek is also an Exceptional Resource Water (ERW). Genesee Creek is a Cool-Cold Headwater upstream of the confluence with Spring Brook and a Cool-Warm Mainstem downstream. Fish surveys from 2007 and 2014 found shorthead redhorse, walleye, golden redhorse, rainbow darter, banded darter, stonecat, rock bass, logperch, common shiner, johnny darter, white sucker, bluegill largemouth bass, northern pike, pumpkinseed, black bullhead, bluntnose minnow, common carp, fathead minnow, green sunfish, potfin shiner, yellow bullhead, black crappie, bowfin, channel catfish, tadpole madtom, blackside darter, blackstripe topminnow, brown trout (coldwater species), central mudminnow, creek chub, fantail darter, grass pickerel, longear sunfish, mottled sculpin (coldwater species), northern redbelly dace, sand shiner, slender madtom, southern redbelly dace, suckermouth minnow, warmouth, western blacknose dace. Outside of these surveys, three rare fish species have also been documented within Genesee Creek or nearby in connecting waterbodies.

Mill Brook fish

Mill Brook is listed in the Wisconsin classified trout streams as a partially Class I and Class II trout stream (Class I waters are high quality and support natural reproduction of wild trout, at or near carrying capacity; Class II waters have some natural reproduction, but not enough to fully

utilize available food and space). Mill Brook is also considered a Cool-Warm to Cool-Cold Headwater stream.
Fish surveys were conducted on Mill Brook in 2004 and 2009. The fish species found during those surveys included mottled sculpin (cold water species), brook stickleback, black bullhead, bluegill, central mudminnow, creek chub, largemouth bass, pumpkinseed, green sunfish, grass pickerel, johnny darter and white sucker. Outside of these surveys, three other rare fish species are known to be present within connecting waterbodies to Mill Brook.

3.3.10.5 Herptiles, Birds and Mammals of Fox River tributaries

Herptiles of Fox River Tributaries

One state endangered and two special concern herptile species are known or have been known to use the Fox River tributaries and their adjacent wetlands as habitat. Unfortunately, the state endangered herptile is considered extirpated in this area of Wisconsin.

Birds of Fox River Tributaries

Four rare bird species, including one that is state-endangered, are known to nest within the vicinity of the Fox River tributaries.

Mammals of Fox River Tributaries

These tributaries provide habitat for several species of mammals, mostly furbearers. Muskrats, mink, otter, and beaver thrive in the marsh habitat. Other mammals including opossum, shrews, moles, bats, chipmunk, voles, mice, fox, raccoon, weasels, and skunk are numerous as well. White-tailed deer, eastern gray and fox squirrels, eastern cottontails, and coyotes are popular game species and receive moderate to heavy hunting pressure. There are two state-threatened and one special concern mammal that are known to use the Fox River tributaries and their adjacent habitats.

3.4 Root River

3.4.1 Physical description and floodplains of the Root River

The Root River watershed covers 126,484 acres (about 198 square miles) in Waukesha, Milwaukee, Kenosha and Racine counties. The Root River flows 44 miles south and east from the City of New Berlin (Waukesha County) and empties into Lake Michigan at Racine (Racine County, Figure 3.6). The Root River watershed is within the Lake Michigan Basin.

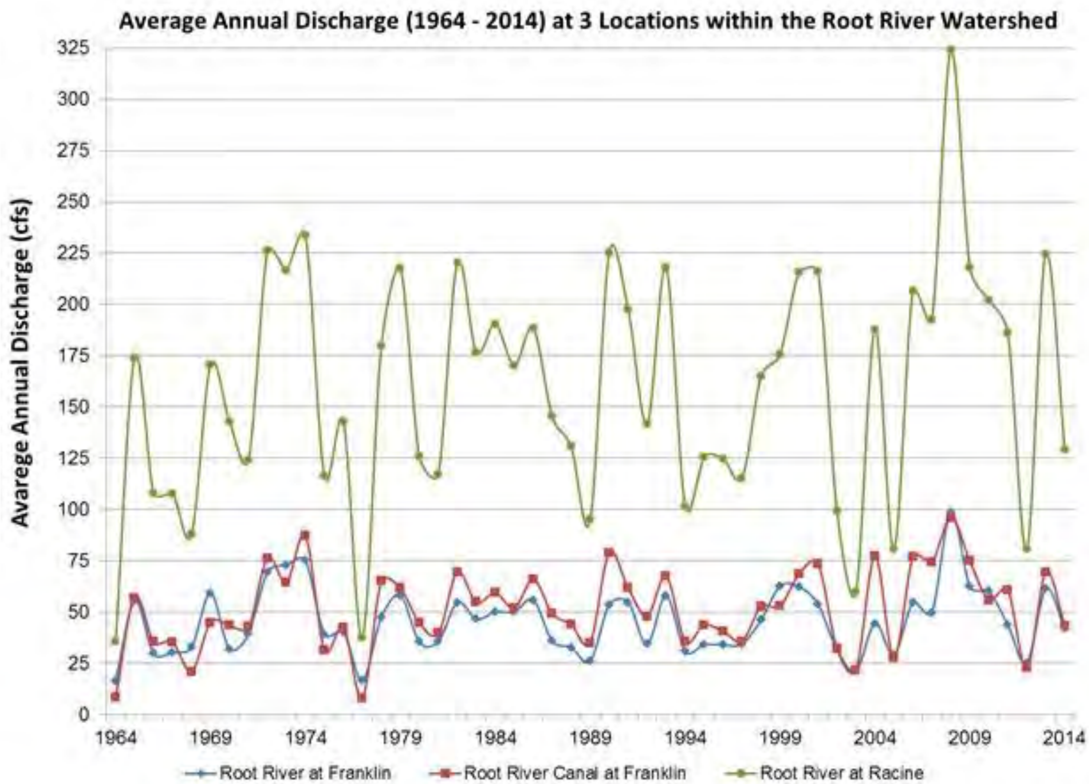
The headwaters of the Root River are heavily urbanized, the middle reaches are primarily agricultural and lower density development, and the lower parts of the watershed near Lake Michigan are heavily urbanized. The river has primarily natural bottom substrate and vegetated river banks and land uses are mixed between its headwaters and Lake Michigan. The principal tributary, near the Milwaukee/Racine County line, is the Root River Canal, coming from the south and joining up with the Root River southwest of Oakwood Road and 60th Street. The Horlick dam, constructed in 1834, is located in the City of Racine just upstream of the STH 38 crossing of the Root River (Figure 3.6). The dam is 19 feet high and impounds a surface area of about 60 acres.

Figure 3-6. Map of Root River Watershed

3.4.2 Flow and flooding in the Root River

At USGS Root River stream gage (04087220) near the City of Franklin, about two miles upstream of the proposed project return flow location, the average annual stream flow is 45.5 cfs (USGS flow data 1964 to 2014). From 1964 to 2014, the minimum daily mean flow recorded was 0.44 cfs, and the maximum daily mean flow was 4340 cfs. The average annual minimum flow is 12.7 cfs and the average annual max. flow is 93.9 cfs. At USGS Root River stream gage (04087240) in the City of Racine, approximately 20 miles downstream of the proposed project return flow location at Horlick Dam, the average annual stream flow is 158.71 cfs (USGS flow data 1964 to 2014, Figure 3.7).

Figure 3-7. Average Annual Discharge at 3 USGS gage sites in the Root River Watershed



3.4.3 Water quality of the Root River

The upper section of the Root River, the Root River Canal and the West Branch of the Root River Canal, are considered impaired because excessive phosphorus and total suspended solids loading that leads to dissolved oxygen levels below what is necessary to support fish and other aquatic organisms. The entire Root River (miles 0 – 43.95) is listed on Wisconsin's Impaired Waters §303(d) list. The harbor is also listed due to unspecified metals. There are no approved Total Maximum Daily Loads (TMDLs) for the Root River. The assessment units and corresponding pollutants and impairments are shown in Table 3.5.

Table 3-5. Root River Mainstem §303 (d) Pollutants and Impairments

Rock River (river miles)	**Pollutant**	**Impairment**
0 to 5.82	PCBs, Total Phosphorus	Contaminated Fish Tissues, Unknown
5.82 to 20.48	Total Phosphorus	Degraded Biological Community
20.48 to 25.8	Total Phosphorus, Sediment/TSS	Degraded Biological Community, Low Dissolved Oxygen
25.8 to 43.69	Chlorides, Total Phosphorus, Sediment/TSS	Acute Aquatic Toxicity, Degraded Biological Community, Low Dissolved Oxygen

The department, USGS, MMSD, the City of Racine Health Department, and citizen volunteers have gathered water quality data in the Root River watershed. SEWRPC has done extensive water quality modeling of the watersheds and has finalized the 2014 Root River Watershed

Restoration Plan: (http://www.sewrpc.org/SEWRPCFiles/Publications/CAPR/capr-316-root-river-restoration-plan-part-I.pdf). In support of this plan, additional monitoring was completed between 2011 and 2013 by the City of Racine and the department and is summarized in a comprehensive report (Koski et. al, 2014). Results from this recent monitoring support the impairment status for phosphorus, total suspended solids and fish consumption advisories in the Root River.

Several biological indices have been developed for three stream reaches along the Root River. These indices use benthic macroinvertebrates and fish as indicators of water quality and physical conditions present within the stream. The MIBI (benthic macroinvertebrate index), the HBI (Hilsenhoff Biotic Index, and warm and coolwater fish IBIs (fish indexes) were developed within each of three stream reaches of the Root River. In general the MIBI, HBI, and IBI for the lower reach of the Root River (river miles 0 to 5.82) suggests fair to good water quality and physical habitat condition. The middle reach (river miles 5.82 to 20.48) scores range from poor to good quality, with most of the data suggesting fair conditions. The upper reach (river miles 20.48 to 43.95) also ranges from poor to good quality. Overall, these data suggest some limitations in water quality and physical habitat for the middle and upper reaches. The Root River Watershed Restoration Plan includes a complete map of recent fisheries IBI scores and HBI macroinvertebrate sampling locations and scores (SEWRPC, 2014, p. 270).

3.4.4 Geomorphology of the Root River

The headwaters of the Root River begin near the City of New Berlin, on a glacial ridge. Glaciers shaped the drainage area of the Root River, creating clay bluffs, lake plains, ground moraines and ridge and swales on top of the Niagara Dolomite. The soils are comprised mostly of silt- loams overlying loamy and clay–like tills, which are commonly poorly drained. About 72 percent of the Root River watershed has poorly drained soils with low permeability with moderate to low groundwater recharge potential (SEWRPC, 2014).

MMSD completed a comprehensive study of the portions of the Root River that are within their jurisdiction in 2007 – the data is only available for the portion of the Root River in Milwaukee County and generally consists of data upstream of the proposed return flow location. The purpose of the study was to document existing channel stability in the North Branch of the river and to provide hydrologic, hydraulic and sediment transport predictions on the vertical and lateral stability of the river and tributary channels (MMSD, 2007). The river has a mixture of gradients, with low-gradient reaches dominated by pools and glides with sand, silt, organic and glacial till bottom and bank sediments. Other reaches are higher- gradient with pool and riffle sequences with gravel, cobble and bedrock substrates. The banks of the river are mostly earthen, with vegetation providing bank stability, but there are some areas of erosion and bank failures typical of urbanizing watersheds. The lower reaches of the river in the highly urbanized area of the City of Racine have sheetpile banks.

3.4.5 Flora and fauna of the Root River

The riparian vegetation of the Root River is composed of a variety of woody and herbaceous species. In the agricultural land use portions of the stream, there are often thin strips of non-crop vegetation present. Middle-aged silver maples, eastern cottonwood, and willow trees are scattered along the river. Both forbs and grasses, including reed-canary grass, are also present, with few shrubs intermixed throughout. There are 11 documented natural community types within the near vicinity of the Root River. The most common of these natural communities is the Southern Mesic Forest and Southern Dry-mesic Forest. There are also 18 known rare plant species (four listed as state endangered, four as state threatened, and 10 as special concern) within the near vicinity of the Root River.

3.4.5.1 Macrophytes of the Root River

Aquatic macrophytes found in the Root River include Sago pondweed (*Stuckenia pectinata*), Coontail (*Ceratophyllum demersum*), Eurasian Watermilfoil (*Myriophyllum spicatum*), Elodea (*Elodea canadensis*), Curly-leaf pondweed (*Potamogeton crispus*), and Bur-reed (*Sparganiumsp*).

3.4.5.2 Algae of the Root River

The department does not have formal documentation of algae on the Root River, however, an algae survey was completed by USGS and is summarized in "Biological Water-Quality Assessment of Selected Streams in the Milwaukee Metropolitan Sewerage District Planning Area of Wisconsin, 2007" (USGS, 2010).

3.4.5.3 Benthic invertebrates of the Root River

Macroinvertebrate sampling (2000-2011) within the Root River watershed is summarized in *A Restoration Plan for the Root River Watershed* (SEWRPC, 2014). This report shows water quality improvement over time for some areas of the river and decreases elsewhere. Macroinvertebrate HBIs scores indicate fairly poor to poor water quality near the proposed outfall location. There is positive water quality improvement shown at a site on the mainstem of the river, at Johnson Park near Racine, WI (Fig.41, SEWRPC, 2014).

Sampling in the Root River resulted in the identification of 384 macroinvertebrate taxa. Some taxa were identified at a species level, while others were identified to genus, subfamily, or family levels. Insects were the most identified taxa, including: true flies, beetles, caddisflies, mayflies, true bugs, dragonflies (including a special concern species), and damselflies. Other groups found included amphipods, crayfish (including a special concern species), isopods, annelid worms, nematode worms, turbellarian worms and snails. The most commonly identified organisms were isopods, caddisflies, midges, worms of the family Tubificidae, and caddisflys. Surveys for mussels in 1977 identified three species: giant floater, lilliput, and white heelsplitter. Additional mussel survey work in 2012 found live mussels from seven native species and dead shells from four additional native species. Most common were creeper, fat mucket, giant floater, and white heelsplitter. Fragile papershells, three ridges, and wabash pigtoes were also found. Nonnative zebra mussels were also found. The rusty crayfish has been identified as an invasive invertebrate species in the Root River.There are no known endangered, threatened, or special concern mussel species within the Root River.

3.4.5.4 Fish of the Root River

The Root River is classified for WDNR fish and aquatic life standards and supports a WWSF community. The Root River is a warm-water habitat. There are areas of good quality within parts of the Root River watershed, but also areas of impairment due to agricultural and urban impacts. The Root River watershed has relatively few streambed and bank modifications, with less than one percent of the stream channel being in conduit and none lined with concrete. Fish IBI ratings range from very poor to fair near the outfall location and downstream (Fig.41, SEWRPC, 2014).

Downstream from the Horlick Dam the river supports a stocked trout and salmon fishery. Upstream from the dam, the river supports a poor quality fishery with relatively few species. This section of the stream is dominated by species tolerant of poor water quality, with few top predators (SEWRPC, 2014).

Fishery data for in the Root River watershed shows that 10 new species have been identified, but 10 of 64 recorded species have not been observed since 1986 (SEWRPC, 2007, pp. 100–14). The most recent fishery surveys by USGS conducted in 2004, 2007 and 2010 identified 19 species in the Root River near the proposed return flow location (USGS, 2013). There are five rare fish species (two of which are listed as state threatened) that have at one time been known to be present within the Root River; however, none of these fish species were observed during these surveys. Table 3.6 lists the fish species found at the USGS locations upstream of the proposed return flow location for Alignment 2. Common carp and goldfish have been identified as invasive fish species in the Root River.

Table 3-6. Root River Fish Species at USGS Gage Station (04087214) and (04087220)- 2004,2007,2010

Root River Fish Species (Upstream of Proposed Outfall)	
Black bullhead	Johnny darter
Blacknose dace	Largemouth bass
Blackslide darter	Longnose dace
Bluegill	Northern pike
Bluntnose minnow	Orangespotted sunfish
Brook stickleback	Pumpkinseed
Central mudminnow	Sand shiner
Creek chub	White sucker
Fathead minnow	Yellow perch
Green sunfish	

3.4.5.5 Herptiles, Birds and Mammals of the Root River

Herptiles of the Root River Watershed

Many reptiles and amphibians are known to exist in the Root River watershed. These include mudpuppy and other newts and salamanders, American toad and a variety of frogs (including an endangered species which is thought to be extirpated from this area), turtles (including one special concern species) and a number of snake species (including two special concern and one state-endangered species).

Birds of the Root River Watershed

As many as 283 bird species are known or have been known to exist in the Root River watershed, including: loons, grebes, cormorant, bitterns, herons (including a special concern species), turkey vulture, ducks, eagle, hawks (including a state-threatened species), a state-endangered falcon, grouse, partridge, bobwhite, pheasant, turkey, coot, rail, crane, plovers, woodcock, sandpipers (including a state-threatened species), snipe, terns, gulls, mourning dove, pigeon, cuckoos, owls, nighthawk, woodpeckers, flycatchers, wrens, robin, thrush, vireos, warblers, tanagers, and sparrows. In addition, there is a Migratory Bird Concentration Site that is adjacent to portions of the Root River.

Mammals of the Root River Watershed

A variety of mammals occur in the Root River watershed, including: muskrat, white-tailed deer, gray squirrels, rabbits, opossum, shrews, moles, bats, chipmunk, beaver, voles, mice, coyote, fox, raccoon, weasels otter, and skunk. There are no known endangered, threatened, or special concern mammals within the near vicinity of the Root River.

3.5 Groundwater

3.5.1 Aquifers

The major aquifers in counties of Waukesha and Milwaukee are the Quaternary and Late Tertiary unconsolidated sand and gravel aquifer, the Silurian dolomite aquifer and the Cambrian-Ordovician sandstone aquifer. The unconsolidated sand and gravel aquifer is connected hydrogeologically to the Silurian dolomite aquifer where both are present. The combination of the two is generally considered to be the shallow aquifer in Milwaukee County and the eastern portion of Waukesha County. The shallow aquifer is unconfined in these areas whereas the deep Cambrian-Ordovician sandstone aquifer is confined due to the overlying Maquoketa Shale.

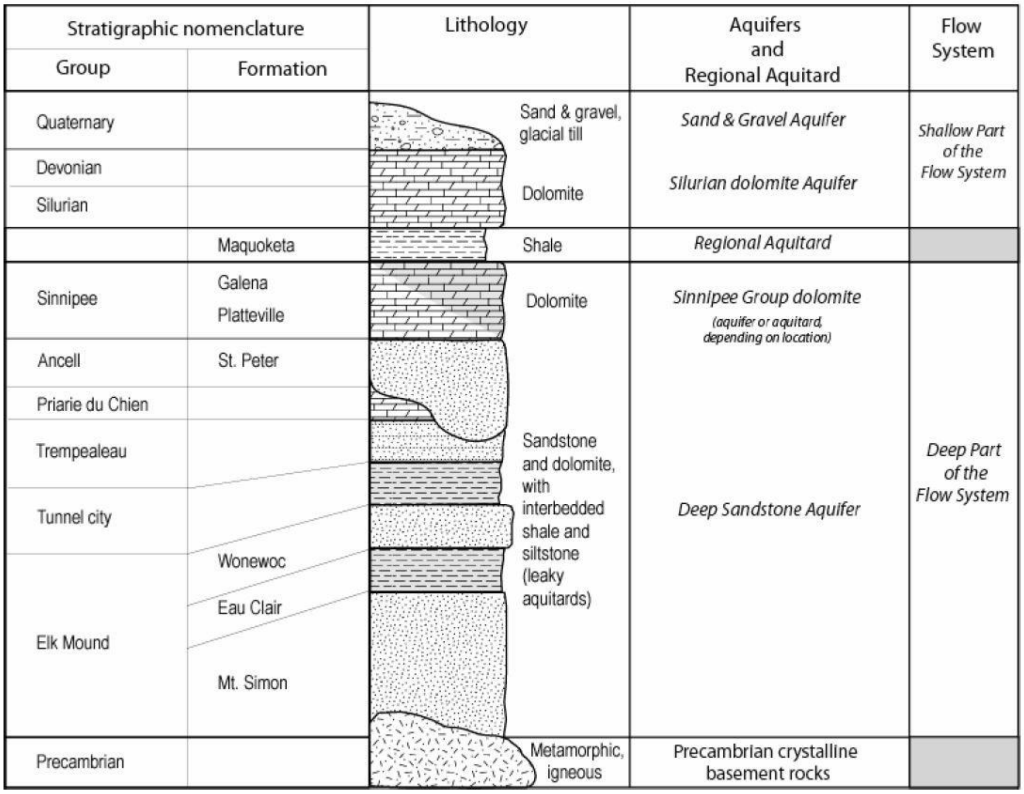
The aquifers extend to great depths, reaching a thickness in excess of 1,500 feet in the eastern parts of Milwaukee and Racine. The aquifers are, in descending order, the Quaternary sand and gravel, Silurian dolomite, Galena-Platteville, upper sandstone, and lower sandstone (see Figure 3.8). The confining beds are the Maquoketa Formation and the Precambrian crystalline rock. The shaly Antrim Formation and siltstone and shaly dolomite of the Milwaukee Formation constitute the uppermost semi- confining bed; and silty dolomite and fine-grained dolomitic sandstone of the St. Lawrence Formation/Tunnel City Group, the lower semi-confining bed in parts of the Region.

Regional Aquifers

The aquifer systems in the counties discussed can be divided into two types: unconfined water table aquifers and semi-confined or confined deep bedrock aquifers. Water-table conditions generally prevail in the Quaternary deposits and Silurian dolomite aquifer above the Maquoketa Formation and in the Galena-Platteville aquifer west of the Maquoketa Formation (Figure Xb). These shallow aquifers provide water for most private domestic wells and some municipal wells.

In the deep sandstone aquifer beneath the Maquoketa Formation, the water can be under artesian pressure. Heavy pumping of deep aquifer high-capacity wells has caused the gradual, steady decline in the artesian pressure and a reversal of the predevelopment, upward flow of groundwater. Flowing wells, common within the Region in the late 1880s, ceased flowing at the beginning of the 1900s, and the potentiometric surface of the sandstone aquifer has been gradually declining and is now lower than the water table throughout most of the Region. On average, water levels in deep observation wells have been declining at the rate of four feet per year in the Milwaukee-Racine area and five feet per year around the City of Waukesha since the beginning of record in the late 1940s (SEWRPC, 2002).

Figure 3-8. Hydrostratigraphic sequence for southeastern Wisconsin lithologic column Stratigraphic nomenclature (after Ostrom, 1962) and lithologic column



Shallow aquifer

The aquifers in the counties discussed are divided into shallow and deep. The shallow aquifer system comprises two or three aquifers, depending on its location relative to the Maquoketa shale (Figure 3.8). Where the Maquoketa formation is present, the shallow aquifer system consists of the Silurian dolomite aquifer and the overlying sand and gravel aquifer. There, the Maquoketa Formation is the lower limit of the shallow aquifer system. In the westernmost parts of Waukesha County where the Maquoketa Formation is not present, the shallow aquifer system consists of the sand and gravel aquifer, Galena-Platteville aquifer, and upper sandstone aquifer, and its lower boundary, the St. Lawrence semi-confining unit.

The sand and gravel aquifer consists primarily of layers or lenses within alluvial and glacial deposits and is extremely variable in thickness. It is not as continuous as the bedrock aquifers. The sand and gravel aquifer occurs as broad outwash deposits, isolated lenses within less permeable deposits, stream terraces, valley fill directly overlying bedrock, and other materials deposited by water or glacier (Kammerer, 1995). Important features are highly productive layers of sand and gravel in segments of buried bedrock valleys in Waukesha County which can yield large amounts of water to wells.

In Waukesha County, shallow groundwater west of the major groundwater divide discharges to large nearby lakes and their outlet the Oconomowoc River, or to the Bark and Scuppernong Rivers. East of the major water table divide, shallow groundwater discharges to Pewaukee Lake and the Fox River; east of the secondary groundwater divide, it discharges to Muskego Lake and flows into Milwaukee County. Locally, large, deep pits and quarries divert groundwater flow from its original direction. For example, a gravel pit just north of the City of Waukesha captures groundwater that would otherwise discharge into the Fox River.

In Milwaukee and Racine counties, the prevalent direction of groundwater flow is to the east, toward Lake Michigan, which is the major regional discharge area. In Milwaukee County, some shallow groundwater locally discharges into Lincoln Creek, Menomonee River, and Root River. In Racine County, the direction of flow depends on the position of the secondary divide running north-south through the counties. West of the secondary groundwater divide, groundwater flows toward the Fox River and its tributaries Honey Creek, New Munster Creek, Peterson Creek, and Basset Creek. East of the secondary divide, groundwater discharges into the Root River Canal in Racine County. In the easternmost tier of townships, the direction of groundwater flow is to the east, towards Lake Michigan (SEWRPC, 2002).

The extent to which the sand and gravel aquifer is used for water supply depends upon the quality and availability of groundwater from underlying or adjacent aquifers. The aquifer is mostly unconfined and its yields vary widely. The sand and gravel aquifer is extensively used in Waukesha County where properly constructed wells finished in this aquifer can produce from 100 to more than 1,000 gallons per minute (gpm).The shallow aquifer is the primary source for domestic wells in the area and is also a source of water supply for the Villages of Mukwonago and East Troy, and the Cities of Waukesha and Muskego.

The aquifer is hydraulically connected to sensitive environmental resources, including the Vernon Wildlife Area, Pebble Brook (a Class II trout stream), Genesee Creek, Mill Brook and Mill Creek and Pebble Creek. The Applicant currently obtains approximately 20 percent of its annual water supply from this aquifer.

Deep sandstone aquifer

The sandstone aquifer consists of alternating sequences of Cambrian and Ordovician age sandstone and dolomite, along with some shale. In the eastern half of Waukesha County the sandstone aquifer underlies a low permeability layer called the Maquoketa shale. Due to the thickness of the sandstone aquifer, large water quantities can be produced from wells within the aquifer.

The deep sandstone aquifer, corresponding to Cambrian-Ordovician units, rests on the Precambrian crystalline basement rocks which transmit little water and form the bottom boundary to the aquifer system. In ascending order, the major water-producing units of the deep part of the flow system are sandstones of the Mt. Simon Formation, the Wonewoc Formation and the St. Peter Formation.

Between the Mt. Simon Formation and the Wonewoc Formation lies the Eau Claire Formation, composed of shale and sandstone. A laterally extensive shaly zone within the Eau Claire Formation forms an important aquitard, the Eau Claire aquitard, over much of southern Wisconsin. Rocks of the Trempealeau and Tunnel City Groups, between the Wonewoc and St. Peter Formations, also form a leaky aquitard made up of interbedded sandstone, shale, siltstone and dolomite. Overlying the St. Peter Formation, dolomite of the Sinnipee Group and shale of the Maquoketa Formation together make up a major regional aquitard between deep and shallow aquifers. The Sinnipee Group dolomite at the top of the deep part of the flow system was of particular interest in our hydrostratigraphic conceptualization because its hydraulic properties depend on whether it is overlain by the Maquoketa shale. Where the Maquoketa is present, the Sinnipee Group dolomite acts as an aquitard that limits flow to the underlying deep sandstone aquifer. Where the Maquoketa is absent, the Sinnipee dolomite, constituting the uppermost bedrock unit, is highly weathered, relatively permeable, and is considered an aquifer.

Groundwater in the lower sandstone aquifer generally moves eastward from the regional potentiometric divide, paralleling the regional eastward dip of the Paleozoic rocks, and is confined under the Maquoketa Formation. Cones of depression on the potentiometric surface, caused by pumping from high-capacity wells in eastern Waukesha and western Milwaukee Counties and in the metropolitan areas of Racine, divert and capture groundwater from great distances and change the original direction of regional groundwater flow (SEWRPC, 2002).

The City's deep aquifer wells are constructed to depths greater than 2,100 feet. Since the nineteenth century (SEWRPC, 2010a, pp. 108–9), the deep aquifer has been drawn down more than 500 feet. More recently, water levels in this aquifer have begun to rise. The USGS groundwater monitoring network well located in the City of Waukesha shows the aquifer is still drawn down, but approximately 100 feet higher than levels observed in a nearby observation well in 1998. The deep aquifer currently supplies approximately 80 percent of annual water supply for the Applicant.

Near Waukesha, recharge to the deep aquifer occurs further west where the Maquoketa shale is not present. Figures 3.9, 3.10 and 3.11 illustrate the constraints limiting recharge of the deep aquifer near the City of Waukesha.

In the western part of Waukesha County, the deep sandstone aquifer is unconfined with permeable sand and gravel deposits in direct contact with the sandstone aquifer and acts as a major recharge source for the deep sandstone aquifer in Waukesha County. As the aquifer is unconfined in this portion of Waukesha County, it has not experienced the same drawdown and water quality issues found in the confined portion. This portion of the aquifer is a water supply source for the cities of Oconomowoc and Delafield, and Village of Dousman.

Precambrian Basement

Precambrian crystalline rock, mostly granite, underlies the Cambrian sedimentary sequence. Its characteristics are poorly known because only a very few wells reach the Precambrian surface in Southeastern Wisconsin. The Precambrian basement is not a source of water supply in the Region. It is assumed to have a very, low permeability and forms the lower boundary of the important lower sandstone aquifer (SEWRPC, 2002).

Groundwater Divides

The major groundwater divide is about 10 to 20 miles west of the subcontinental surface water divide. In Waukesha County, the major groundwater divide follows the trend of the Kettle Moraine topographic high, which corresponds to a secondary surface-water divide between the Fox River and the Rock River. Shallow groundwater east of the major groundwater divide in Waukesha County and west of the subcontinental surface-water divide in Racine County, generally discharges to the Fox River, which in turn eventually empties into the Mississippi River.

In addition to the major water table divide, there are several secondary groundwater divides wherever there are high areas in the water table. For example, secondary groundwater divides are found in southeastern Waukesha County and in western Racine County to the east of the Fox River. Other secondary groundwater divides traverse western Waukesha (SEWRPC, 2002).

The groundwater level in the deep sandstone aquifer increases toward the western edge of Waukesha County. The area just west of Waukesha County has the highest heads in the sandstone aquifer and forms the potentiometric divide (deep aquifer groundwater divide). Historical water-level data collected are not adequate to characterize the exact location of this regional divide, nor whether the divide has moved since pre-development time. Nevertheless, the USGS/WGHNS regional model for southeastern Wisconsin published by SEWRPC uses mathematical and calibration constraints to reproduce the behavior of this divide through time. Simulations using the regional model show that the divide has moved west on the order of 10 miles since pre-development times.[1]

Another west-east regional potentiometric divide exists between the Chicago metropolitan area cone of depression and the Waukesha-Milwaukee cone of depression. The exact location of this divide cannot be confirmed without field measurements of current water levels in wells open to the lower sandstone aquifer. Concentrated pumpage in Waukesha-Milwaukee and Chicago areas has created deep cones of depression, and the Chicago cone of depression probably diverts some groundwater from the north, possibly west-east through the middle of Racine County.

3.5.2 Groundwater quality

Shallow aquifer water quality

Groundwater from the shallow aquifer may require treatment to meet secondary drinking water standards, related to cosmetic or aesthetic quality of drinking water, of 0.3 mg/L for iron, 0.05 mg/L for manganese, and a primary standard of 10 ppb for arsenic. To remove these contaminants from the shallow aquifer supply and meet applicable drinking water standards, conventional groundwater treatment, including coagulation, flocculation, sedimentation, filtration and disinfection is needed (CH2MHill, 2013, Vol. 2).

Deep sandstone aquifer water quality

The Applicant's groundwater supply from the deep aquifer has radium levels up to three times the USEPA's drinking water maximum contaminant level (MCL) of 5 picocuries per liter (piC/L). Radium is a known carcinogen. The naturally occurring radioactive isotopes radium 226 and radium 228 are present in the aquifer because of parent elements in the sandstone. The concentration of radium in the City's groundwater supply is as high as 15 piC/L, one of the highest concentrations of radium in the country for a potable water supply.

The Applicant's deep wells have observed high total dissolved solids (TDS). The secondary drinking water standard is 500 mg/L. One well had TDS concentrations greater than 1,000 mg/L and was rehabilitated by blocking part of the well hole to reduce TDS, but in doing so well capacity was reduced more than 35 percent.

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[1] See the USGS website http://wi.water.usgs.gov/glpf/ under the Implications section for a map showing the simulated movement of the deep divide.

Groundwater contaminant sites

Areas in Wisconsin where groundwater is most susceptible to contamination are those where most of the groundwater is stored in shallow aquifers (Schmidt, 1987). Milwaukee County has approximately 5,468 environmental repair (ERP) and leaking underground storage tank (LUST) sites, Racine County has approximately 826 ERP and LUST sites, and Waukesha County has approximately 1,717 ERP and LUST sites.

Figure 3-9. Flow of groundwater in the St. Peter Sandstone deep aquifer

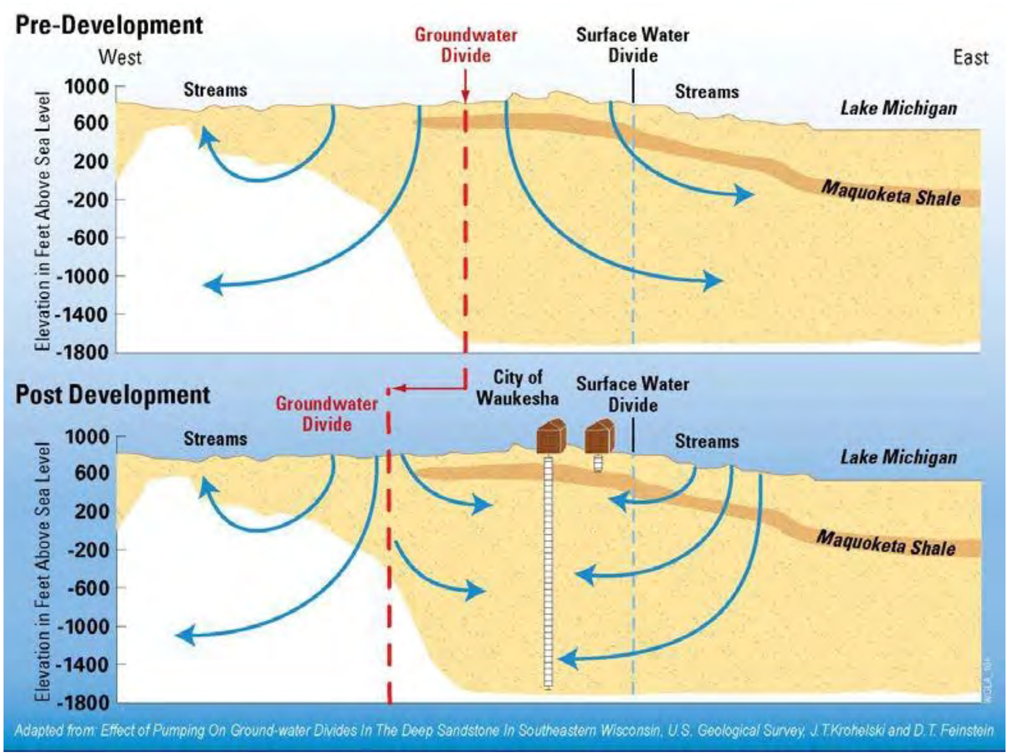
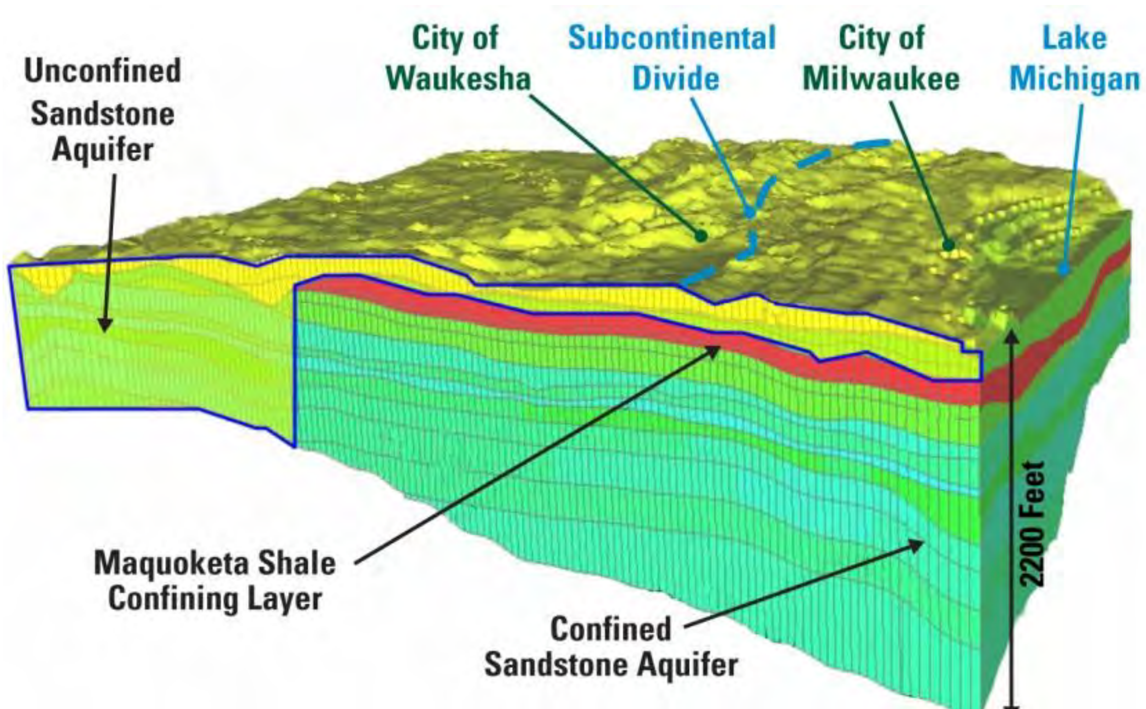
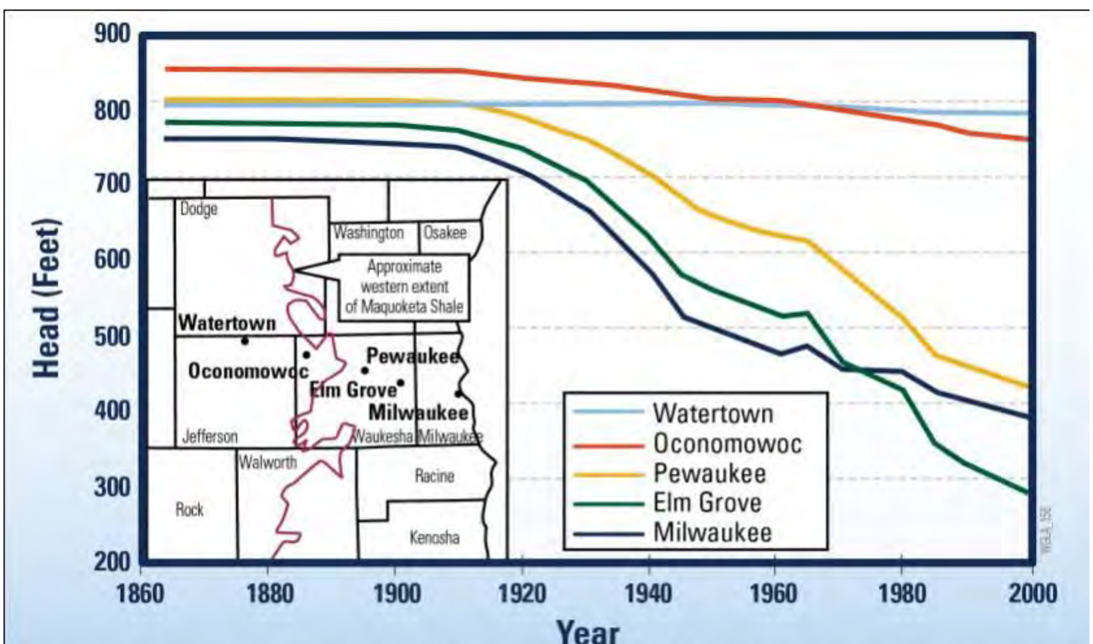


Figure 3-10. Hydrogeology of southeastern Wisconsin



Source: Adapted from Ken Bradbury, Wisconsin Geological and Natural History Survey

Figure 3-11. Deep aquifer groundwater levels in several locations



Water levels in the deep sandstone aquifer at selected locations. Curves represent simulated hydraulic heads (in feet above sea level) near the top of the deep aquifer (St. Peter Formation).
Source: SEWRPC Regional Water Supply Study

3.5.3 Springs

Springs are areas where groundwater discharges from an aquifer to the surface and may occur at the land surface or in a pool, pond, lake, or stream. Springs often provide a positive impact on habitat in surface waters by providing cool, oxygen-rich water. Trout streams, fen-meadows and other wetlands, and numerous sensitive species of plants and animals may be dependent upon spring discharges.

Historically, the Waukesha area had hundreds of springs and was renowned for its many spring spas and resorts in the early 20th century. Since that time, many springs in the area have been lost. Human activities such as dewatering and filling of wetlands, drain tile installation and ditching practices, and high-capacity well pumping may all lower groundwater levels and affect springs (Macholl, 2007). In Waukesha County, much of the land that historically contained springs has been developed for residential or commercial purposes (Swanson, 2007).

The Wisconsin Geological and Natural History Survey maintains an inventory of springs. Multiple springs exist near the groundwater alternatives area (WGNHS, 2010).

3.6 Vernon Marsh

3.6.1 Physical description and floodplain of Vernon Marsh

Vernon Marsh is a 4,655-acre state wildlife area in eastern Waukesha County consisting of wetlands and flowages associated with the Fox River. It is more than five miles long and one mile wide in some sections. Vernon Marsh is primarily located in the floodplain on both sides of the Fox River; the river winds north to south through the marsh. Main tributary streams include Pebble and Mill Brooks, both of which are impounded to form flowages on the property before draining into the Fox River. Vernon Marsh was designated a primary environmental corridor by the Southeastern Wisconsin Regional Planning Commission (SEWRPC, 1997).

Broadly, the marsh is dominated by open wetlands. A variety of open wetland types such as wet meadow, shallow and deep marsh, and open water wetland compose most of the Vernon Marsh floodplain. Less abundant wetland types such as scrub/shrub wetlands, forested wetlands, and calcareous fen (at the southern end of the marsh) are also present. Adjacent uplands are dominated by grassland habitats with interspersed hardwood forest. The property provides significant wildlife habitat, especially for migrating and nesting waterfowl (http://dnr.wi.gov/topic/lands/WildlifeAreas/vernon.html).

3.6.2 Geomorphology and depth of to groundwater of Vernon Marsh

In southeast Wisconsin, after the Wisconsin Glaciation, broad glacial lakes formed behind the glacier's retreat. Over time, these lakes receded. In the remaining low areas of these glacial plains, wetlands formed, including Vernon Marsh. The retreating glaciers left sand and gravel deposits, which hold groundwater in the form of aquifers (SEWRPC, 2002). In southeast Wisconsin, depths to groundwater vary. In wetlands, and specifically Vernon Marsh, groundwater levels are at or near the ground surface for much of the year.

3.6.3 Flora and Fauna (including T/ESC)

Vernon Marsh consists of wetland and upland communities, and flowages associated with the Fox River. The most common wetland communities include wet meadow, shallow marsh, deep marsh, and open water wetland. Less common wetland community types include scrub/shrub wetland, forested wetland and calcareous fen. Adjacent uplands are dominated by grassland habitats with interspersed areas of limited hardwoods. The property provides significant wildlife habitat, especially for migrating and nesting waterfowl. Many state threatened, endangered, and special concern species are present on the property including five plants, two herptiles, three invertebrates, four birds, four fish, and three mussel species.

3.6.3.1 Flora of Vernon Marsh

Vernon Marsh contains a variety of wetland and upland communities. The most common wetland plant communities include wet meadow, shallow marsh, deep marsh, and open water wetlands. Less common wetland plant community types present include scrub/shrub wetland, forested wetland, and calcareous fen.

Open water wetland communities are common throughout the marsh. Five flowages are managed by water control structures and greatly influence vegetation. Herbaceous species present in this open water community include submergent and floating-leaved aquatics such as water lilies, pondweeds, milfoils, coontail, and duckweed. These open water communities differ from deep and shallow marsh because open water complexes rarely have exposed soil, so emergent aquatic vegetation cannot establish.

The next-driest wetland plant community present at Vernon Marsh is marsh. Marsh wetland communities can be divided into deep and shallow marsh, but because vegetation is often similar between the two, they are combined for purposes of this discussion. In general, marsh communities are seasonally inundated; emergent vegetation is able to establish when bare soil is exposed and seeds can germinate. Cattail, composed of up to three very similar species, is ubiquitous in marsh communities at Vernon Marsh. It is also abundant in other nutrient-rich marsh systems throughout the Midwest. Cattail is the most dominant plant species in Vernon Marsh and is considered an invasive species. Other invasive species present in this wetland community in Vernon Marsh include purple loosestrife and giant reed. There are small areas of native marsh community; these contain various species of bulrush, bur reed, and sedges, but the invasive species limit the cover of these native species.

The final dominant wetland community at Vernon Marsh is wet meadow. This wetland community contains saturated soils which are typically only inundated in the spring. At Vernon Marsh, wet meadow primarily consists of monotypic stands of reed canary grass, another invasive species. Similar to cattail, reed canary grass thrives in nutrient-rich environments present in floodplain wetlands like Vernon Marsh. Smaller areas of wet meadow contain native species, including a more diverse assemblages of sedges, rushes, grasses, and forbs. Other common wet meadow species include tall goldenrod, tussock sedge, bluejoint grass, and woolgrass. State-listed species are also present in wet meadows at Vernon Marsh.

Other wetland communities are present, but less frequent. Both scrub/shrub and forested wetland communities exist, both dominated by shrubs and trees. Pockets of scrub/shrub containing several willow species are scattered throughout the marsh. Forested wetlands, composed of box elder, ash, willows, and some tamarack, also occur sporadically throughout.

Finally, though small in size, a calcareous fen is located at the southern end of Vernon Marsh. A fen is fed by mineral-rich groundwater and is composed of peat soils. Fens are the rarest wetland plant community in Wisconsin (Eggers and Reed, 1997). The Vernon Marsh fen is located just uphill from groundwater springs at the base of a moderate slope. This fen is densely vegetated with a sparse shrub layer of glossy buckthorn (an invasive species) and shrubby cinquefoil (native) that gives way to an herbaceous-dominated plant community. Signature fen species here include two species of beak-rush (one is state-listed), several forbs including Joe-pye-weed, and several species of spikerush. Two additional state-listed plants (both threatened) are present in this fen.

Small areas of uplands also occur at Vernon Marsh State Wildlife Area. There are several small dry-mesic forests containing canopy species such as red oaks, white ash, black cherry, and sugar maple. Also scattered throughout the site are old fields containing pasture grasses and occasional prairie plantings.

Vegetation at Vernon Marsh is dominated by reed canary grass, monotypic cattail and lowland brush. Small pockets of high quality sedges remain. Some acreage is forested including northern hardwoods, oak woodlots and lowland hardwoods. Upland prairies consist of warm season grasses such as big bluestem, indiangrass, and switchgrass, cool season grasses such as bromegrass and a variety of forbs but dominated by goldenrods and asters.

3.6.3.2 Herptiles, Birds and Mammals

Herptiles of Vernon Marsh

A robust herptile community composed of reptiles and amphibians including two special concern species consistent with open water and marsh is present at Vernon Marsh. Many other turtles, snakes, and frog species occur here.

Common reptiles and amphibians at Vernon Marsh include painted and snapping turtles, common garter snakes, western fox snakes, eastern milk snakes, brown snakes, northern redbelly and northern water snakes, American toads, spring peepers, Eastern gray tree frogs, Copes gray tree frogs, Northern leopard frogs, wood frogs, green frogs, bullfrogs, eastern tiger salamanders and mudpuppies. Other reptile and amphibian species are likely to be present. Vernon Marsh has the best potential for conserving herptiles of any state wildlife area in Waukesha County.

Birds of Vernon Marsh

Vernon Marsh, including five flowages, is managed for hunting a variety of species, including waterfowl, deer, and upland game birds. The flowages are managed to consist of 50% emergent marsh and 50% open water, specifically for waterfowl. Also, during migration, at least one flowage is drawn down and maintained as mud flats for migrating shorebirds. The large amount of marsh and open water habitat present at Vernon Marsh provides habitat for a variety of shorebirds, wading, birds, and ducks. Dabbling ducks, cranes, pelicans, herons, and egrets all use the marsh. Three state-listed species all nest on-site. Uplands act as hunting areas for turkey and ring-necked pheasant as well.

Common birds at Vernon Marsh include: Canada geese, mallards, wood ducks, blue-winged teal, American coots, belted kingfishers, herring gulls, ring-bill gull, great blue herons and great egrets. Other waterfowl which use the area as a spring or fall migratory stop-over include widgeon, green-winged teal, northern pintail, gadwall, northern shoveler, bufflehead, common goldeneye, and ringnecked duck. Birds found on the surrounding wetlands and uplands include sandhill cranes, woodcock, owls (great horned, screech and barred), hawks (red-tailed, Coopers, sharp-shinned and American kestrel), wild turkeys and a large variety of songbirds and shorebirds. Vernon is one of two wildlife areas in Waukesha County identified as having the best potential for conserving marsh birds, colonial waterbirds and waterfowl.

Mammals of Vernon Marsh

Vernon Marsh provides habitat for several species of mammals. Mammals using the wetlands and riparian areas in Vernon include muskrats, mink, beaver, raccoons, and several bat species. Other mammals on the surrounding uplands include gray and fox squirrels, cottontail rabbits, red and gray fox, coyotes, skunks, opossums, woodchucks, eastern chipmunks, thirteen-lined ground squirrels, white-tailed deer, and various species of shrews, moles, mice, voles and weasels. White-tailed deer, eastern gray and fox squirrels, eastern cottontails, and coyotes are common in the marsh and receive moderate to heavy hunting pressure. There are no known endangered, threatened, or special concern mammals that reside in Vernon Marsh.

3.6.4 Functional values of Vernon Marsh

The Vernon Marsh wetlands (as well as vegetated uplands located adjacent to the marsh), provide many functional values to humans and the environment. Because there are a variety of habitats present, Vernon Marsh provides a wide array of ecosystem functions. The open water and marsh communities are important habitat for waterfowl and furbearers, especially in drought years when more shallow wetlands dry up first. These deeper marsh habitats can also act as spawning grounds for some species of fish. Wildlife heavily use open water and marshes during migration when they feed on submergent vegetation and aquatic invertebrates. The Marsh provides significant opportunities for wetland, bird and herptile conservation.

In addition to wildlife habitat, Vernon Marsh filters runoff and holds flood water. Wetlands in general, and especially riparian wetlands like Vernon Marsh, can trap sediment and take up nutrients, improving water quality. Riparian wetlands can also retain large amounts of floodwater, reducing the risk of flooding to other areas downstream.

Finally, wetlands and open space in general, provide an intrinsic value to humans. Aesthetically, wetlands provide a pleasing environment in addition to their recreational value for hunting, trapping, fishing, and other recreation. Vegetated uplands also add to their aesthetic value and help to buffer the wetlands from runoff and other human-caused impacts.

3.7 Forested and scrub/shrub wetlands

In southeast Wisconsin, forested wetlands are typically dominated by mature deciduous tree species. Forested wetlands are often associated with glacial lake basins or river systems and have seasonally high water tables. Conversely, scrub/shrub wetlands are dominated by woody vegetation less than 20 feet in height. Scrub/shrub wetlands often occur as a transition between open and forested wetlands, both spatially and temporally. They can be located on the landscape spatially in between open and forested wetlands. Scrub/shrub wetlands can also occur in the same location as an open wetland as it transitions to forested wetland over time. This can happen in the absence of disturbance over many years.

Forested wetlands can consist of deciduous or coniferous tree species. Forested wetlands dominated by hardwood species often occur in the floodplains of rivers in southern Wisconsin, but can also occur in ancient lake basins (Eggers and Reed, 1997). Forested wetlands dominated by conifers are more common in the northern part of the state where they grow on organic soils with wide ranges of acidity. Forested wetlands are found in the project area.

Scrub/shrub wetlands typically occur on seasonally-saturated soils that are either organic (pear/muck) or mineral (alluvial) (Eggers and Reed, 1997). They can be located in bands around lakes or ponds, on the margins of floodplains, or more extensively, in glacial lake beds. These communities can persist for very long periods of time if the appropriate hydrologic conditions persist. Scrub/shrub wetlands are less common in southeast Wisconsin, though they are present in the project area.

3.7.1 Flora and fauna (including T/ESC)

3.7.1.1 Flora of forested and scrub/shrub wetlands

Forested wetlands are typically grouped based on the dominant tree species present, either deciduous hardwoods or conifers. Hardwood forested wetlands are typically dominated by black ash, red maple, and yellow birch in northern Wisconsin and silver maple, green ash, and eastern cottonwood, in southern Wisconsin.Coniferous forested wetlands are dominated by different species depending on the pH and water source of the wetland (Eggers and Reed, 1997). Northern white cedars dominate where soils are fertile and have an alkaline to neutral pH. Tamarack and black spruce dominate in nutrient-poor acidic soils, though tamarack can also grow in more basic soils.

A variety of herbaceous species can occur in the understory of all forested wetland types. In the understory of floodplain forests, jewelweed and nettles can be common, though the scouring action of flooding can limit any understory. In coniferous swamps and bogs, sedges, ferns, and forbs dominate. The extent of herbaceous understory also depends on the understory species' tolerance of shade.

Scrub/shrub wetlands are dominated by deciduous shrubs such as red-osier dogwood, gray dogwood, meadowsweet, and several species of willow. Native herbaceous species present in the understory include Canada bluejoint, tussock sedge, joe-pye weed, giant goldenrod, and other species common to sedge meadows. In disturbed scrub/shrub wetlands, reed canary grass can dominate the understory.

3.7.1.2 Herptiles, Birds and Mammals

Herptiles of forested and scrub/shrub wetlands

A variety of herptiles use scrub/shrub wetlands including frogs, snakes, turtles, and salamanders. The woody vegetation that characterizes forested and scrub/shrub wetlands provide needed cover and habitat for some species. Herptiles ranked as Species of Greatest Conservation Need (SGCN) by the Wisconsin DNR associated with forested and scrub/shrub wetlands include the four-toed salamander, and pickerel frog.

Birds of forested and scrub/shrub wetlands

Forested and scrub/shrub wetlands also provide important habitat to many species of birds. Forested wetlands can contain tree species not common elsewhere, providing unique habitat for birds. Further, trees can be stunted due to saturation and soil conditions, providing even more unique habitat. Numerous passerines, shorebirds, waterfowl, and raptors ranked as SGCNs are associated with forested wetlands.

Because scrub/shrub wetlands can act as a transition between open, herbaceous wetlands and forested wetlands, a wide variety of birds also use this community type. SGCNs such as the American woodcock, black-billed cuckoo, golden-winged warbler, veery, and willow flycatcher all rely on scrub/shrub wetlands for habitat.

Mammals of forested and scrub/shrub wetlands

Again, similarly to herptiles and birds, a variety of mammals use these community types because of their increased cover due to being dominated by woody vegetation. Many species of rodents and furbearers inhabit these wetlands types as they can receive additional protection from predators. In the winter, scrub/shrub wetlands can be important habitat for eastern cottontails and white-tailed deer. Scrub/shrub wetlands may also be used by Franklin's Ground Squirrel, a species of special concern.

3.7.2 Functional values of forested and scrub/shrub wetlands

As previously mentioned, scrub/shrub wetlands can act as a transition zone between open wetlands and forested wetlands. Scrub/shrub wetlands can provide additional habitat to species that normally concentrate in either of these other wetland types (forested or open wetlands). Depending on the location and size of the scrub/shrub wetland, it can provide flood attenuation and water quality improvement to the entire watershed. The same is true for forested wetlands. The tree canopy can provide an added layer of wildlife habitat not found in other wetland types and can help reduce runoff and flooding by intercepting and slowing rainfall.

3.8 Open wetlands (including calcareous fens)

Open wetlands are any wetlands dominated by herbaceous plant species. A variety of wetland communities make up open wetlands. They can be differentiated by vegetation, water chemistry, and water level. Open wetland types include open water, emergent marsh, and southern sedge meadow. Less common wetland types include wet prairies and calcareous fens.

Sedge meadows and wet prairies are dominated by grasses and sedges. Fens support grasses, sedges, and a diversity of other herbaceous plants. Emergent marshes occur along the edges of lakes and streams, and are characterized by emergent and submergent vegetation.

3.8.1 Description and locations of open wetlands

Wet meadows are nutrient rich systems dominated by a variety of herbaceous species (wet meadows and sedge meadows are similar, for the department's purposes of this EIS, they are referred to as wet meadows). Calcareous fens are fed by nutrient-rich groundwater while bogs are fed by nutrient poor rainwater. Both are dominated by gramminoids and forbs. Emergent marsh and open water wetlands are wetter, often containing standing water up to six feet with higher level of nutrients. They are dominated by submergent and emergent vegetation. Wet meadows, fens, and open bogs, are often located in depressions with less standing water.

3.8.2 Flora and fauna of open wetlands

3.8.2.1 Flora of open wetlands

The flora of open wetlands can be separated by plant species' nutrient and water level tolerance. Southern sedge meadows are dominated by terrestrial to emergent gramminoids (grasses, sedges, and rushes) and forbs that can tolerate moderate to high nutrient inputs. Tussock sedge, Canada bluejoint grass, and joe-pye weed are all common wet meadow species.

Fens also contain both gramminoids and forbs, typically terrestrial species, but these species must be able to tolerate low nutrients and high mineral levels. This is due to the fen's primary water source being groundwater-fed springs which contain high levels of calcium and magnesium. Because of this uncommon water source, fens are the rarest wetland type in Wisconsin. Typical calciphiles (calcium-tolerant plants) that thrive in fens include sterile sedge, Ohio goldenrod, and lesser fringed gentian.

Bogs receive their water input mostly via rain, which also contains low nutrients, leading to species that again must tolerate low nutrients and alkaline conditions. Sphagnum moss often dominates the saturated surface of bogs. Other representative species include cottongrass, sundew, pitcher plants, and a variety of ericaceous shrubs.

Emergent and open water wetlands contain grasses and forbs, which can tolerate higher water levels. Both submergent species, which live under water, and emergent species, which root in the bed of waterways but can grow out of the water. Common submergent plants include pondweeds, milfoils, coontail. Typical emergent plants include cattail, bulrushes, giant reed, and bur reed.

3.8.2.2 Herptiles, Birds and Mammals of open wetlands

Herptiles of open wetlands

Open wetlands act as habitat for a variety of reptiles and amphibians. Open wetlands, and wetlands in general, act as an interface between drier habitats and open water. These ecotones provide both wetland and upland habitat needs for these species that use both. Many species of frogs, snakes, and salamanders use open wetlands. Species of greatest conservation need (SGCN) with an affinity for a variety of open wetlands include four-toed salamander, pickerel frog, chorus frog, and Blanchard's cricket frog.

Birds of open wetlands

Many species of birds use open wetlands because they include both terrestrial and aquatic habitats. For emergent and open water wetlands, waterfowl, shorebirds, wading birds, and raptors all use these habitats. SGCNs with an affinity for emergent and open water wetlands include great egrets, whooping cranes, trumpeter swans, and bald eagles. In drier open wetlands, many raptors, wading birds, and shorebirds all utilize these systems. SGCNs that use southern sedge meadows include black rail, American bittern, and northern harrier.

Mammals of open wetlands

Similarly to other taxa previously mentioned, many mammal species also utilize open wetlands. Furbearers such as beaver, otter, mink, almost exclusively use open wetlands, while many rodents, ungulates, and larger mammals use wet meadow wetlands, especially in winter.

3.8.3 Functional values of open wetlands

Open wetlands provide a wide range of functions such as wildlife habitat, water quality improvement, flood abatement. Because of the wide-range of water levels contained in open wetlands, their functional values are widespread. Open wetlands adjacent to waterways provide water quality treatment by trapping sediments, nutrients, and toxins, cleaning water as it flows downstream. Similarly, riparian wetlands hold pulses of floodwater, lessening the threat of flooding downstream. Riparian open-water and emergent open wetlands provide wildlife habitat, for many species of birds and mammals. Finally, drier open wetlands, such as wet meadows, fens, and bogs, also provide similar ecosystem functions.

3.9 Upland Forests

3.9.1 Description and locations of upland forests

The project area and greater Southeast Glacial Plains Ecological Landscape is known to support bur oak openings of global significance (Wildlife Action Plan 2005-2015).

Wisconsin's southern forest communities occur south and west of the climatic Tension Zone - the approximate area where vegetative communities change from the prairie, savanna, oak and mixed hardwood forests of the south to the mixed deciduous-coniferous forests of the north. Common upland forest communities south of the Tension Zone and which have been documented in this study area include southern dry forest, southern dry-mesic forest, and southern mesic forest. Less common upland forest communities include oak openings.

Southern Wisconsin's landscapes have changed greatly during the past 150 years. The loss of forested land has been widespread in areas suitable for agriculture and residential development. Another major change occurred as the open landscapes of prairie and savanna succeeded to closed canopy forest following the exclusion of periodic fires. In many areas, canopy composition is now shifting from oak dominance to shade-tolerant mesic hardwoods, primarily due to the absence of fire disturbances. Land use and ownership patterns have resulted in significant forest fragmentation throughout southern Wisconsin, highlighting the ecological significance of the few remaining large forested blocks, particularly those along major river corridors.

Southern Dry Forest

Oaks are the dominant species in this upland forest community of dry sites. White oak and black oak are dominant, often with admixtures of northern red and bur oaks and black cherry. In the well-developed shrub layer, brambles (Rubus spp.), gray dogwood, and American hazelnut are common. The most important sites exist in the Kettle Moraine State Forest and vicinity.

Southern Dry-mesic Forest

Red oak is a common dominant tree of this upland forest community type. White oak, basswood, sugar and red maples, white ash, shagbark hickory, and black cherry are also important. The herbaceous understory flora is diverse and includes many species listed under southern dry forest. Significant patches of the community type exist in the Southern (Walworth, Jefferson, and Waukesha Counties) Unit of the Kettle Moraine State Forest. Examples of this community type are found at Cudahy Woods State Natural Area and Fall Park Woods (Milwaukee County), Bishop's Woods and Muskego Park Hardwoods (Waukesha County), Silver Lake Bog State Natural Area (Kenosha County), and Sander's Park Hardwoods State Natural Area (Racine County). River corridors offer the best opportunities to develop forest connectivity.

Southern Mesic Forest

This upland forest community occurs on rich, well-drained loamy soils, mostly on glacial till plains or loess-capped sites south of the tension zone. The dominant tree species is sugar maple, but basswood, and near Lake Michigan, American beech may be co-dominant. Many other trees are found in these forests, including those of the walnut family, ironwood, red oak, red maple, white ash, and slippery elm. The understory is typically open, or sometimes brushy. Historically, southern mesic forests were quite common throughout southern Wisconsin. This type has been severely reduced from its past extent.

Oak Opening

This is an oak-dominated savanna community in which there is less than 50% tree canopy coverage. Historically, oak openings were very abundant and occurred on wet-mesic to dry sites. Today, very few examples of this type exist. The few extant remnants are mostly on drier sites, with the mesic and wet-mesic oak openings almost totally destroyed by conversion to agricultural or residential uses, and by the encroachment of other woody plants due to fire suppression. The Southern Unit of the Kettle Moraine State Forest offers some of the best management and restoration opportunities in the upper Midwest, including Eagle Oak Opening (Waukesha County). Other good examples occur at Lulu Lake State Natural Area (Walworth County).

3.9.2 Flora and fauna (including T/E/SC) of upland forests

3.9.2.1 Flora of upland forests

Upland forests, much like forested wetlands, are typically grouped based on the dominant tree species present, and in southern Wisconsin are dominated by hardwoods. Upland forests in the study area represent a transition from drier, oak dominated sites to more mesic uplands where more mesophytic tree species (central and northern hardwood types) become more prevalent. Drier sites are typically dominated by bur, white and black oaks with scattered shagbark hickory, northern red oak and black cherry. As sites become more mesic, northern red oak is a common dominant tree species, with white oak, basswood, sugar and red maples, white ash, shagbark hickory and black cherry also important. On the mesic end of the spectrum the dominant tree species shifts to sugar maple, with basswood also important, and near Lake Michigan American beech may also be co-dominant. Other trees common in mesic upland forests include walnuts, ironwood, northern red oak, red maple, white ash and slippery elm.

A variety of herbaceous species can occur in the understory of upland forest types. The understory of oak openings commonly feature grasses, legumes, composites and other forbs that are best adapted to light conditions of high filtered shade. Southern dry forests tend to have a more well-developed shrub layer of *Rubus* spp. and gray dogwood while frequent herbaceous species include wild geranium, false Solomon's-seal and rough-leaved sunflower. As sites become more mesic the understory flora is diverse with a mixture of species found on both drier and more moist sites such as jack-in-the-pulpit, large-flowered bellwort, lady fern and tick-trefoils. Mesic sites support fine spring ephemeral displays of trout-lilies, trilliums, violets, bloodroot, blue cohosh and mayapple.

3.9.2.2 Herptiles, Birds and Mammals of upland forests

Herptiles of Upland Forests

A variety of herptiles use upland forests, including snakes, frogs and salamanders. The woody vegetation that characterizes upland forests provides needed cover and habitat for some species. Herptiles ranked as Species of Greatest Conservation Need (SGCN) by the department associated with upland forest types include the four-toed salamander and pickerel frog.

Birds of Upland Forests

Upland forests also provide important habitat to many bird species. Upland forests contain a wide spectrum of tree species across the moisture and shade gradient, thus providing habitat diversity for birds for both migration and breeding purposes. Numerous passerines ranked as SGCNs are associated with upland forests.

Because of the unique transition of forested uplands across drier to more mesic sites, a wide variety of birds use these community types. SGCNs such as brown thrasher, red-headed woodpecker, whip-poor-will, blue-winged warbler, American woodcock, wood thrush, and Acadian flycatcher all rely on forested uplands for habitat.

Mammals of Upland Forests

A variety of mammals use upland forests because of their varied structure and plant diversity, primarily species of woody vegetation. Mammals may rely on woody browse, mast, or the herbaceous understory for food, while others seek cover from forest structure. Many species, including opossum, shrews, moles, bats, chipmunk, voles, mice, fox, coyote, raccoon, weasels, skunks, white-tailed deer, eastern gray and fox squirrels, and eastern cottontails may use upland forests during all or a portion of their life cycle.

3.10 Upland grasslands

3.10.1 Description and locations of upland grasslands

Grasslands are characterized by a lack of trees and tall shrubs and are dominated by grasses, sedges and forbs. Grasslands occur on a wide variety of topography, soil types and moisture regimes - from water-covered peat to the driest sandy soils. The term grassland often refers collectively to several native vegetation community types known as prairie and bracken grassland.

Prairies are located mostly in the southern and western parts of the state and in addition to playing host to more than 400 species of native vascular plants. Prairies have a diverse and specialized fauna, especially among prairie invertebrates, prairie and grassland herptiles and grassland birds.

Tallgrass prairies are among the most decimated and threatened natural communities in the Midwest and the world. Most native prairies found today in Wisconsin are small remnants that are less than 10 acres in size. Very few exceed 50 acres, too small to support a full complement of species that typically inhabit a native prairie ecosystem. Most of the prairies left today are either of the wet or dry types. Mesic prairie, which was the most common type in pre-settlement days, is almost gone now, with only about 100 acres known to exist today. The greater Southeast Glacial Plains and Southern Lake Michigan Coastal Ecological Landscapes are known to support extensive grassland communities of state significance (Wildlife Action Plan 2005-2015).

3.10.2 Flora and fauna (including T/E/SC) of upland grasslands

3.10.2.1 Flora of upland grasslands

The flora of upland grasslands vary dependent on the soil's moisture gradient, but also by composition of grass versus forbs (herbaceous plants). Dry-mesic prairies, for example, are typically found on drier, sandy or loamy soils and are dominated by taller grass species such as big bluestem and Indian grass. As soils become richer, additional grass species appear including little bluestem, needle grass, prairie dropseed and switch grass. As sites grade into more wetland-type soils, grass species such as Canada bluejoint grass and cordgrass along with sedges begin appearing.

The herbaceous component can be quite diverse throughout the spectrum of grassland community types. On dry-mesic prairie sites there are often species that occur in both dry and mesic prairie, including legumes, rattlesnake-master and flowering spurge. More mesic sites can have a stronger percentage of forbs overall, but with many of the same species represented. Common species found in mesic prairies include prairie dock, lead plant, asters, prairie coreopsis, monarda and spiderwort. A wet-mesic prairie tends to be a much more herbaceous dominated grassland community. Including aster and sunflower species, shooting-star, goldenrod species, and culver's root; this community can occur in large wetland complexes with wet prairie, southern sedge meadow, calcareous fend and emergent marsh (i.e., open wetland) communities.

3.10.2.2 Herptiles, Birds and Mammals of upland grasslands

Upland grasslands act as habitat for a variety of herptiles, particularly where one type grades into another to provide a variety of habitats. Many frog, snake, and turtle species use upland grasslands. Species of greatest conservation need (SGCN) that may occur in upland grasslands include pickerel frog and Butler's gartersnake.

Birds

Over 40 grassland bird species breed in Wisconsin. In the last 30 years this group of birds has declined more than any other in North America (UW-Extension 2000). The shrinking populations of grassland birds can be traced primarily to the loss of grassland habitat as row crop acreage has increased. Additionally, the timing and frequency of hay harvesting can impact nesting efforts, destroying nests before the young birds have fledged.

Passerines, waterfowl, shorebirds, wading birds, and raptors all use upland grassland habitats. SGCNs with an affinity for grassland sites across the spectrum include bobolink, Henslow's sparrow, upland sandpiper, and short-eared owl. Other important grassland bird species include Eastern meadowlark, dickcissel, grasshopper sparrow, vesper sparrow, swamp sparrow, and Northern harrier.

Mammals

A variety of mammals use upland grasslands during all or a portion of their life cycle. Many species, including shrews, moles, thirteen-lined ground squirrels, voles, mice, fox, coyote, skunks, and white-tailed deer may be found in upland grasslands. One species of special concern, Franklin's Ground Squirrel, also uses prairie edges.

3.11 Air Quality

The proposed project area is currently in attainment with all National Ambient Air Quality Standards (ozone, $PM_{2.5}$, PM_{10}, sulfur dioxide, nitrogen dioxide, carbon monoxide and lead).

3.12 Census data

3.12.1 Population of data and trends

Waukesha county population more than doubled between 1960 and 2007. This growth is much greater than that in the seven county SEWRPC planning region as a whole. Whereas Waukesha County accounted for only 10 percent of the regional population in 1960, it now represents almost 20 percent (CH2MHill, 2013, Vol. 5). The City of Waukesha has experienced a similar population growth, increasing from 30,000 in 1960 to more than 64,000 in 2000. The rate of growth in the City is expected to decline over the next 25 years, reaching a projected total of 88,500 in 2035 (36 percent increase). Changes in population are based on three variables: birth and death rates, migration into and out of the community, and the ability of a community/town to annex neighboring lands, which increases the size and population. The birth and death rate, or the balance between births and deaths in a given area, is considered a population's "natural increase." According to SEWRPC, the region experienced a population increase of 120,800 people between 1990 and 2000. It is estimated that, of the 120,800 people, 116,900 were attributed to natural increase (SEWRPC, 2004).

Based on *The Economic State of Milwaukee's Inner City: 2006* (Levine and Williams) and numerous SEWRPC technical reports, the general trend over the past 50 years has been an outward population and job migration from larger cities along the lakeshore to outlying towns and counties (SEWRPC, 2004). The reduction in manufacturing jobs in the historically larger cities and the increased economic development within inland areas has reduced jobs in the large lakeshore cities and increased jobs in inland areas.

It is possible for population growth to be constrained by the unavailability of adjacent land for development. Unless a community has the capability to annex adjacent, developable land, it may experience "build-out" or near build-out conditions. Milwaukee, which is bordered by Lake Michigan, is an example of a community facing build-out conditions. Milwaukee has exhibited a population decline, partially because of the lack of available adjacent developable land. On the contrary, the City of Waukesha has developable land that will support population growth.

3.12.2 Age data

Based on the results of the 2010 census, the median age in Waukesha County is 42 (USCB, 2010a). Table 3.7 summarizes age statistics for the state, Waukesha County, and the City of Waukesha.

Table 3-7. Waukesha and Southeastern Wisconsin regional population age statistics for 2010 (Source: USCB 2010a)

Age Group	State of Wisconsin % of Total	Waukesha County % of Total	City of Waukesha % of Total
Under 5 years	6.3	5.5	7.1
5 to 9 years	6.5	6.7	6.8
10 to 14 years	6.6	7.2	6.1
15 to 19 years	7.0	6.8	6.7
20 to 24 years	6.8	4.7	7.8
25 to 29 years	6.5	5.1	8.6
30 to 34 years	6.1	5.2	8.1
35 to 39 years	6.1	6.0	7.0
40 to 44 years	*6.7*	*7.3*	6.7
45 to 49 years	7.7	8.8	7.0
50 to 54 years	7.7	8.8	6.8
55 to 59 years	6.8	7.5	5.8
60 to 64 years	5.5	6.1	5.1
65 to 69 years	4.0	4.2	3.2
70 to 74 years	3.1	3.1	2.2
75 to 79 years	2.5	2.7	1.9
80 to 84 years	2.1	2.2	1.6
85 and over	2.1	2.0	1.7
Median age	**38.5**	**42.0**	**34.2**

3.12.3 Racial data

The UW-Milwaukee's Center for Economic Development (CED) (Rast and Madison, 2010) made a detailed study of socioeconomic factors for SEWRPC's Regional Water Supply Plan. Current data and trends from that study are summarized here.

Within the Southeast Wisconsin region, the number and proportion of non-white has grown over the past five decades. Census data for 1960 indicates that whites constituted about 95 percent of the regional population. By 2007, racial minority populations increased, from less than five percent to nearly 23 percent in the region.

Table 3-7a shows the change in minority populations in the region between 1960 and 2007. In 1960, nearly 91 percent of racial minorities in the region lived in Milwaukee County. Racine and Kenosha counties had 7.6 percent and 1.4 percent of regional minority populations, respectively, while the other counties in the region totaled less than one percent of Non-White population. The Waukesha County Non-White population is projected to almost double by 2035, to almost 17 percent of the total population.

Table 3-7a: Racial Minority Distribution for Southeastern Wisconsin

County	1960				2007			
	Total Population	Non-White Population			Total Population	Non-White Population		
	Number	Number	Percent	Percent[a]	Number	Number	Percent	Percent[a]
Kenosha	100,615	1,090	1.1	1.4	161,254	22,745	14.1	5.0
Milwaukee	1,036,041	66,777	6.4	90.6	951,026	359,791	37.8	79.3
Ozaukee	38,441	46	0.1	<0.1	85,345	3,503	4.1	0.8
Racine	141,781	5,459	3.9	7.6	194,522	34,664	17.8	7.6
Walworth	52,368	230	0.4	0.2	100,140	6,912	6.9	1.5
Washington	46,119	59	0.1	<0.1	126,636	4,089	3.2	0.9
Waukesha	158,249	290	0.2	0.2	376,978	21,854	5.8	4.8
Region	1,573,614	73,951	4.7	100.0	1,995,901	453,558	22.7	100.0

Source: US Census Bureau and American Community Survey for the Year 2007, as reported by UWM 2010
[a] Percent of Regional Non-White Population

As shown in Table 3-7b, the City of Waukesha is predominately White, but racial diversity has risen since 1960. The percent of Non-Whites increased from 0.5 percent in 1960 to almost nine percent in 2000. More than 5,500 Non-White residents moved into the City over the period. The percent increase in Non-Whites is similar to that in other communities in the southeastern Wisconsin region.

Table 3-7b: Racial Minority Distribution for Southeastern Wisconsin in 1960 and 2000 for Selected Communities in Southeastern Wisconsin

Community	1960				2000			
	Total Population	Non-White Population			Total Population	Non-White Population		
	Number	Number	Percent	Percent	Number	Number	Percent	Percent
Kenosha	67,899	1,015	1.5	1.4	90,352	14,786	16.4	3.7
Milwaukee	741,324	65,752	8.9	88.9	596,974	298,595	50.0	74.9
Oak Creek	2,549	7	0.3	0.0	28,456	2,287	8.0	0.6
Port Washington	5,984	8	0.1	0.0	10,467	317	3.0	0.1
Racine	89,144	4,812	5.4	6.5	81,855	25,447	31.1	6.4
Brookfield	19,812	18	0.1	<0.1	38,649	2,242	5.8	0.6
Cedarburg	5,191	2	<0.1	<0.1	10,908	200	1.8	0.1
Elm Grove	4,994	4	0.1	<0.1	6,249	179	2.9	0.0
Germantown	622	0	0	0	18,260	762	4.2	0.2
Grafton	3,748	3	0.1	<0.1	10,312	235	2.3	0.1
Muskego[a]	--	--	--	--	21,397	405	1.9	0.1
New Berlin	15,788	14	0.1	<0.1	38,220	1,589	4.2	0.4
Saukville	1,038	0	0	0	4,068	105	2.6	0.0
Waukesha	30,004	141	0.5	0.2	64,825	5,692	8.8	1.4

Source: US Census Bureau, as reported by UWM 2010
[a]The Village of Muskego was incorporated in 1964.

The City of Milwaukee‘s White population declined by about 56 percent between 1960 and 2000 largely because of Whites moving to suburban communities. The City of Racine likewise experienced a 33 percent decline in its White population. Racine, Milwaukee and Kenosha had the most significant increases in minority populations during this time period. Table 3-7c shows the difference and percent change in racial distributions between 1960 and 2000 for selected communities in the region. Little of the growth in minority populations in suburban areas has been by growth in African-American populations.

Table 3-7c: Difference and Percent Change in Racial Distribution between 1960 to 2000 for Selected Communities in Southeastern Wisconsin

County	Total		White		Black or African American		Other Non-White	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Kenosha	22,769	100	9,075	39.9	5,770	25.3	7,924	34.8
Milwaukee	-144,368	100	-375,387	-260.0	158,312	109.7	72,707	50.4
Oak Creek	19,084	100	16,826	88.2	651	3.4	1,607	8.4
Port Washington	4,380	100	4,027	91.9	46	1.1	307	7.0
Racine	-7,317	100	-27,833	-380.4	11,627	158.9	8,889	121.5
Brookfield	18,995	100	16,927	89.1	258	1.4	1,810	9.5
Cedarburg	5,584	100	5,451	97.6	20	0.4	113	2.0
Elm Grove	1,282	100	1,158	90.3	9	0.7	115	9.0
Germantown	17,638	100	16,876	95.7	247	1.4	515	2.9
Grafton	6,571	100	6,329	96.3	15	0.2	226	3.4
Muskego[a]	--	--	--	--	--	--	--	--
New Berlin	22,574	100	20,930	92.7	189	0.8	1,455	6.5
Saukville	3,116	100	2,940	94.4	50	1.6	124	4.0
Waukesha	34,368	100	29,180	84.9	639	1.9	4,549	13.2

Source: US Census Bureau as reported by UWM 2010
[a] The Village of Muskego was incorporated in 1964.

CED projects that between 2000 and 2035, the regional population will continue to grow by about 18.5 percent (see Table 3-7d). All counties in the region are expected to increase in population and proportions of minority populations are also expected to continue to increase. By 2035, CED estimates that the minority population in the region will increase from 23.5 to about 36.8 percent of the total population due to mostly by increases in the Hispanic population.

Table 3-7d: Year 2035 Population Projections by Race and Ethnicity Within the Region

County	Total Population	Non-Hispanic Population								Hispanic Population[b]	
		White Alone		Black Alone		Asian Alone		Other[a]			
	Number	Number	%	Number	%	Number	%	Number	%	Number	%
Kenosha	213,886	146,646	68.6	18,611	8.7	5,374	2.5	4,351	2.0	38,904	18.2
Milwaukee	1,012,538	442,183	43.7	268,916	26.6	47,201	4.7	32,534	3.2	221,703	21.9
Ozaukee	98,922	86,238	87.2	2,543	2.6	2,958	3.0	2,374	2.4	4,809	4.9
Racine	234,467	159,866	68.2	21,289	9.1	3,152	1.3	6,668	2.8	43,492	18.5
Walworth	122,275	97,398	79.7	1,110	0.9	2,063	1.7	2,900	2.4	18,805	15.4
Washington	162,462	145,711	89.7	3,019	1.9	2,551	1.6	3,547	2.2	7,634	4.7
Waukesha	445,569	370,199	83.1	14,465	3.2	19,727	4.4	7,440	1.7	33,737	7.6
Region	2,290,118	1,448,240	63.2	329,954	14.4	83,026	3.6	59,814	2.6	369,084	16.1

Source: US Census Bureau and CED
[a] "Other" represents the aggregated Census data from the following populations; American Indian or Alaska Native Alone, Native Hawaiian and Pacific Islander, Some Other Race Alone, Two or More Races.
[b] Hispanics may be of any race.

CED projects that by 2035 Waukesha County will have the largest total population gain in the region and increase of 23.5 percent over the 2000 level. Racial and Hispanic population growth will amount to 64.3 percent of this projected growth. The total minority population of Waukesha County is expected to increase to 16.9 percent of population in 2035. The population of Milwaukee County is anticipated to net the second greatest population gain, an increase of

72,374 people, or about 7.7 percent. CED's analysis is that the White Alone, Non-Hispanic population in Milwaukee County will decline by 24 percent. This is the only projected net loss in any racial or ethnic population group within the region.

Selected communities within southeastern Wisconsin were analyzed by CED, and most are expected to increase in population between 2000 and 2035. CED's projection indicates that the population of Non-White Alone racial and ethnic minorities will increase in each of the selected communities. They further predict that the percent of each minority population will continue to increase relative to the White Alone populations over the 35-year period. Hispanic populations are expected to have the most significant increases in each of the selected communities.

As shown in Table 3-7e, CED's model projects that the total population of the City of Waukesha will increase by a little over 25 percent between 2000 and 2035, from 64,825 to about 81,186 people. The greatest portion of this increase is anticipated to be the Hispanic population. The White Alone, Non-Hispanic population is projected to continue to decline, which would be a new pattern since this group has not experienced a decline over the past 50 years.

The combined minority population is projected by CED to account for all of the population growth in Waukesha. Non-White, Non-Hispanic racial minorities are expected to increase from 1.2 to 5.7 percent of the City's population, the Asian population increasing from 2.1 to 7.5 percent, and the aggregated "Other"‖ population increasing from 1.4 to 2.8 percent. The greatest increase will be in the Hispanic population with an increase, from 8.6 to 26.6 percent of the population.

Table 3-7e: Population by Race and Ethnicity for the City of Waukesha

Population by Race and Ethnicity	2000		Projected 2035		Change		Percent of Change
	Number	Percent	Number	Percent	Number	Percent	
Total Population	64,825	100.0	81,186	100.0	16,361	25.2	100.0
Non-Hispanic Population	59,262	91.4	59,618	73.4	356	0.6	2.2
White Alone	56,191	86.7	46,539	57.3	-9,652	-17.2	-59.0
Black Alone	797	1.2	4,644	5.7	3,847	482.7	23.5
Asian Alone	1,389	2.1	6,127	7.5	4,738	341.1	29.0
Other[a]	885	1.4	2,308	2.8	1,423	160.7	8.7
Hispanic Population[b]	5,563	8.6	21,568	26.6	16,005	287.7	97.8

Source: US Census Bureau and CED

[a] "Other" represents the aggregated Census data from the following populations; American Indian or Alaska Native Alone, Native Hawaiian and Pacific Islander, Some Other Race Alone, Two or More Races.

[b] Hispanics may be of any race.

3.12.4 Health and disabilities

In 2000 the national average of persons reporting one or more disabilities was 19.3 percent (UWM, 2010). Wisconsin reported a lower percentage at 14.7 percent of the state's population. Waukesha County provided an even lower percentage than the national and state average, with only 10.8 percent of the population reporting one or more disabilities. The City of Waukesha was slightly higher than the state average, with 14.9 percent of the population reporting one or more disabilities.

3.13 Economy

There has been a historic trend toward decentralization of jobs from the urban centers to the outlying counties in the region between 1960 and 2000. Tables 3-7f and 3-7g show job growth patterns for southeastern Wisconsin counties.

Table 3-7f: Job Distribution for Southeastern Wisconsin

County	1960		1970		1980		1990		2000	
	Jobs	%	Jobs	%	Jobs	%	Jobs	%	Jobs	%
Kenosha	42,200	6.3	42,100	5.4	54,100	5.7	52,200	4.6	68,700	5.6
Milwaukee	503,300	74.8	525,200	66.9	583,200	61.5	609,800	53.3	624,600	51.1
Ozaukee	10,200	1.5	21,300	2.7	28,200	3.0	35,300	3.1	50,800	4.2
Racine	49,900	7.4	64,600	8.2	81,200	8.6	89,600	7.8	94,400	7.7
Walworth	19,600	2.9	26,400	3.4	33,500	3.5	39,900	3.5	51,800	4.2
Washington	15,200	2.3	24,300	3.1	35,200	3.7	46,100	4.0	61,700	5.0
Waukesha	32,600	4.8	81,000	10.3	132,800	14.0	189,700	16.6	270,800	22.1
Region	673,000	100.0	784,900	100.0	948,200	100.0	1,143,700	100.0	1,222,800	100.0

Source: Bureau of Labor Statistics and the US Census Bureau as reported by UWM, 2010

Table 3-7g: Job Growth in Southeastern Wisconsin

County	1960	2000	1960 to 2000		
			Change	Percent	Compound Annual Growth Rate
Kenosha	42,200	68,700	26,500	62.8	1.23
Milwaukee	503,300	624,600	121,300	24.1	0.54
Ozaukee	10,200	50,800	40,600	398.0	4.10
Racine	49,900	94,400	44,500	89.2	1.61
Walworth	19,600	51,800	32,200	164.3	2.46
Washington	15,200	61,700	46,500	305.9	3.56
Waukesha	32,600	270,800	238,200	730.7	5.44
Region	673,000	1,222,800	549,800	81.7	1.50

Source: Bureau of Labor Statistics and the US Census Bureau

The economy in Waukesha County also has grown over the last 20 years. Economic growth in the City of Waukesha has been much greater than the overall southeastern Wisconsin region, increasing from nearly five percent of the total in 1960 to more than 22 percent in 2000 (Table 3.8). This is consistent with the regional trend of employment migration from the urban areas to the more suburban areas and the shift from manufacturing to service sector jobs in the southeastern Wisconsin region.

Table 3-8. Waukesha and regional economy (Source: Bureau of Labor Statistics and the US Census Bureau as reported in UWM 2010)

	1960		1970		1980		1990		2000	
	Jobs	%	Jobs	%	Jobs	%	Jobs	%	Jobs	%
Waukesha	32,600	4.8	81,000	10.3	132,800	14	189,700	16.6	270,800	22.1
SE Wisconsin	673,000	100	784,900	100	948,200	100	1,143,700	100	1,222,800	100

SEWRPC has developed long-term economic and jobs projections for southeastern Wisconsin. The most recent projections are in Planning Report No. 48 *A Regional Land Use Plan for Southeastern Wisconsin: 2035* (SEWRPC, 2006). The most recent projections were developed for the planning year 2035 (see Table 3-8a).

Table 3-8a: Projected Jobs Distribution for Southeastern Wisconsin

County	2003		Projected Jobs			
	Jobs	Percent of Regional Jobs	2035	Change (2000 – 2035)	Percent Change	Percent of Regional Jobs
Kenosha	69,500	5.9	88,500	19,000	27.3	6.5
Milwaukee	589,800	50.0	628,900	39,100	6.6	46.0
Ozaukee	49,200	4.2	62,300	13,100	26.6	4.6
Racine	90,000	7.6	106,600	16,600	18.4	7.8
Walworth	52,300	4.4	69,400	17,100	32.7	5.1
Washington	61,800	5.2	78,900	17,100	27.7	5.8
Waukesha	266,400	22.6	333,700	67,300	25.3	24.4
Region	1,179,000	100.0	1,368,300	189,300	16.1	100.0

Source: SEWRPC and US Bureau of Economic Analysis

The economy in Waukesha County is projected to increase by 67,000 jobs, or 25 percent, by 2035. This is considerably higher than for Milwaukee County (seven percent increase) but similar to the surrounding counties.

Much of the industry in the southeastern Wisconsin region is considered to be water-intensive, but many large industrial water users rely on private high-capacity groundwater wells rather than municipal water. A review of the large businesses in Waukesha County indicates there are no known major water-intensive businesses or industries using municipal supplies (UWM, 2010, p.15).

SEWRPC also developed job projections for each urbanized service area under the Regional Water Supply Plan. Table 3-8b shows population and job predictions for each selected water utility service area for 2000 and 2035. Each utility service, except Milwaukee Water Works is expected to have some job growth. The Milwaukee Water Works service area is not anticipated to expand over this period.

Table 3-8b: Existing and Forecast Population for Selected Water Service Areas

Community	2000			2035		
	Population	Jobs	Jobs Per 100 Persons	Population	Jobs	Jobs Per 100 Persons
Kenosha Water Utility	98,700	45,269	45.9	105,100	48,693	46.3
Milwaukee Water Works	650,750	410,929	63.1	664,550	404,650	60.9
City of Oak Creek Water and Sewer Utility	26,000	19,916	76.6	50,850	28,349	55.8
City of Port Washington Water Utility	10,600	7,092	66.9	15,000	8,933	59.6
City of Racine Water and Wastewater Utility	103,800	58,601	56.5	113,500	59,644	52.5
City of Brookfield Municipal Water Utility and Village of Elm Grove[a]	30,249	34,772	115.0	51,600	50,711	98.3
City of Cedarburg Light and Water Commission	11,250	8,120	72.2	14,900	8,754	58.8
Village of Germantown Water Utility	15,050	10,545	70.1	23,450	18,071	77.1
Village of Grafton Water and Wastewater Commission	10,500	8,473	80.7	16,450	12,662	77.0
City of Muskego Public Water Utility	7,800	4,344	55.7	28,650	8,068	28.2
City of New Berlin Water Utility	30,100	24,237	80.5	41,300	33,058	80.0
Village of Saukville Municipal Water Utility	4,150	3,306	79.7	5,650	5,245	92.8
City of Waukesha Water Utility	65,000	51,792	79.7	88,500	58,196	65.8

Source: SEWRPC and CED

[a] Based on the analysis methodology, SEWRPC combines forecast jobs data for the Village of Elm Grove with the City of Brookfield Municipal Water Utility. Job estimates are based on both the City of Brookfield Municipal Water Utility and the Village of Elm Grove sewer service area. The year 2000 population projections include the estimate of 24,000 people served by the City of Brookfield Municipal Water Utility and the estimated population of the Village of Elm Grove served by municipal sewer, or 6,249 people.

There has been a widening gap in median household income between the counties over the past 50 years. In 1960, the median income in five of the seven counties was relatively similar, but by 2008 this gap had grown to 40 percent. Table 3-8c shows this increase. Waukesha County had the highest median household income in the region in 2008.

Table 3-8c: Historic Median Household Income for Southeastern Wisconsin (Median Income Adjusted to Reflect 2008 Dollars)

County	1960	1970	1980	1990	2000	2008
Kenosha	50,305	57,599	52,477	50,470	60,701	54,464
Milwaukee	50,691	60,929	47,351	45,906	49,238	45,091
Ozaukee	52,022	70,029	66,770	70,332	81,088	73,186
Racine	48,894	60,862	54,725	53,951	54,354	54,241
Walworth	41,402	53,754	45,613	49,988	59,802	55,988
Washington	45,163	62,566	57,455	63,308	73,706	65,061
Waukesha	52,298	71,000	67,483	73,412	81,209	74,688

Note:Data from Table 4-I. Dollars are adjusted to 2008 dollars based on the Consumer Price Index.
Source: US Census Bureau and American Community Survey as reported by UWM 2010

An estimate of the ranges in household incomes provides information about the distribution of household incomes and provides an assessment of low-income households in each county. This data is shown in Table 3-8d. In 2008, Ozaukee, Washington, and Waukesha Counties had the lowest percentages of households with annual incomes under $10,000.

Table 3-8d: 2000 Annual Household Income Ranges for Southeastern Wisconsin

County	Numbers of Households						
	Less than $10,000	$10,000 to $14,999	$15,000 to $24,999	$25,000 to $34,999	$35,000 to $49,999	$50,000 to $74,999	Over $75,000
Kenosha	3,554	2,926	6,896	6,957	9,300	12,959	13,501
Milwaukee	40,098	25,500	54,013	53,352	66,510	72,565	65,945
Ozaukee	837	881	2,453	2,850	4,360	7,324	12,182
Racine	4,423	3,643	8,428	8,453	11,812	17,196	16,841
Walworth	2,106	2,024	3,913	4,459	6,256	8,307	7,450
Washington	1,479	1,414	3,494	4,642	7,298	12,255	13,328
Waukesha	3,698	4,416	9,696	12,097	19,686	33,478	52,379
Region	56,195	40,804	88,893	92,810	125,222	164,084	181,626

County	Percent of Households						
	Less than $10,000	$10,000 to $14,999	$15,000 to $24,999	$25,000 to $34,999	$35,000 to $49,999	$50,000 to $74,999	Over $75,000
Kenosha	6.3	5.2	12.3	12.4	16.6	23.1	24.1
Milwaukee	10.6	6.7	14.3	14.1	17.6	19.2	17.4
Ozaukee	2.7	2.9	7.9	9.2	14.1	23.7	39.4
Racine	6.2	5.1	11.9	11.9	16.7	24.3	23.8
Walworth	6.1	5.9	11.3	12.9	18.1	24.1	21.6
Washington	3.4	3.2	8.0	10.6	16.6	27.9	30.4
Waukesha	2.7	3.3	7.2	8.9	14.5	24.7	38.7
Region	7.5	5.4	11.9	12.4	16.7	21.9	24.2

Source: US Census Bureau as reported by UWM 2010

Table 3-8e shows, among selected communities in the region, that there has been a widening gap in median incomes over the past 50 years. Other than Brookfield and New Berlin, in 1960 median income in most of the communities was similar. By 2008, four of the smaller suburban communities for which data are available had higher incomes than Kenosha, Milwaukee, Racine, and Waukesha.

Table 3-8e: Historic Median Household Income for Selected Communities in Southeastern Wisconsin (Reported Median Income)

Community	1960	1970	1980	1990	2000	2008
Kenosha	7,035	10,191	18,927	27,770	41,902	46,356
Milwaukee	6,664	10,262	16,028	23,627	32,216	37,022
Oak Creek	6,984	11,715	23,413	39,995	53,779	69,304
Port Washington	6,801	11,465	21,914	36,515	53,827	NA
Racine	6,758	10,526	18,437	26,540	37,164	40,976
Brookfield	8,909	16,052	32,159	57,132	76,225	89,361
Cedarburg	6,729	12,521	22,716	38,322	56,431	NA
Elm Grove	NA	21,969	38,922	66,852	86,212	NA
Germantown	NA	13,128	25,314	43,486	60,742	NA
Grafton	6,980	12,669	23,647	40,596	53,918	NA
Muskego	NA	12,581	25,648	46,119	64,247	82,327
New Berlin	7,503	13,185	28,547	49,394	67,576	77,299
Saukville	NA	NA	22,264	34,461	53,159	NA
Waukesha	6,779	11,547	21,175	36,192	50,084	55,157

Note: 1960 and 1970 Census reports Median Family Income not Median Household Income. 2008 ACS estimates are not available for communities under 25,000 people (Cedarburg, Elm Grove, Germantown, Grafton, Port Washington,

and Saukville).
Source: US Census Bureau and American Community Survey s reported by UWM 2010

Between 1970 and 2000, poverty levels in southeastern Wisconsin counties have fluctuated (see Table 3-8f).

Table 3-8f: Population With Incomes At or Below the Poverty Level in Southeastern Wisconsin

County	1970		1980		1990		2000	
	Persons	Percent of Population	Persons	Percent of Population	Persons	Percent of Population	Persons	Percent of Population
Kenosha	8,844	7.5	12,437	10.1	14,613	11.4	11,218	7.5
Milwaukee	95,920	9.1	135,098	14.0	181,303	18.9	143,845	15.3
Ozaukee	2,449	4.5	3,081	4.6	1,602	2.2	2,140	2.6
Racine	12,471	7.3	16,621	9.6	19,779	11.3	15,862	8.4
Walworth	6,535	10.3	8,581	12.0	8,025	10.7	7,876	8.4
Washington	3,383	5.3	6,194	7.3	3,146	3.3	4,230	3.6
Waukesha	9,255	4.0	12,609	4.5	9,751	3.2	9,741	2.7
Region	138,856	7.9	194,621	11.0	238,218	13.2	194,912	10.1

Source: US Census Bureau as reported by UWM 2010

Table 3-8g shows the historic percentage of population living at or below the poverty threshold by county in in the region. The data indicates that all counties share declined somewhat, except that there was an increase in Milwaukee County's share.

Table 3-8g: Percent of Regional Population With Incomes At or Below the Poverty Level in Southeastern Wisconsin

County	1970	1980	1990	2000
Kenosha	6.4	6.4	6.1	5.8
Milwaukee	69.1	69.4	76.1	73.8
Ozaukee	1.8	1.6	0.7	1.1
Racine	9.0	8.5	8.3	8.1
Walworth	4.7	4.4	3.4	4.0
Washington	2.4	3.2	1.3	2.2
Waukesha	6.7	6.5	4.1	5.0
Region	100	100	100	100

Source: US Census Bureau as reported by UWM 2010

3.13.1 Industries

As shown in Table 3.9, the leading industry in Wisconsin shifted from manufacturing in 2000 to educational services by 2010. In Waukesha County, educational services remained the leading industry from 2000 to 2010. Similar to the Wisconsin trend, the City of Waukesha experienced a shift in leading industries, from manufacturing in 2000 to educational services in 2010 (USCB, 2000 and 2010b).

Table 3-9. Employment percentage in leading industries in 2000 and 2010 (Source: 2010 Census (USCB, 2010b), 2000 American Community Survey (USB, 2000))

	Industries										In Labor Force (population 16 yrs & older)	
	Manufacturing		Educational Services		Retail Trade		Recreation & Entertainment		Professional, Scientific & Management			
Geography	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**
Wisconsin	22.2	17.9	20.0	23.0	11.6	11.6	7.3	9.1	6.6	7.9	69.1	68.3
Milwaukee County	18.5	14.3	22.4	27.1	10.4	10.4	7.7	9.6	9.3	10.7	65.4	66.8
City of Milwaukee	18.5	13.6	23.4	27.7	9.9	11.0	8.6	10.4	8.9	11.2	63.9	66.0
Waukesha County	14.1	16.5	19.9	23.3	11.7	12.1	7.9	7.1	9.3	10.6	63.9	70.3
City of Waukesha	22.0	16.6	20.5	22.3	12.0	14.2	6.8	10.7	9.2	9.6	73.2	74.8

As reported by the CED (Rast and Madison, 2010), all commercial and industrial businesses and industries use water but most would not be considered water-intensive users. The most water-intensive industries in southeastern Wisconsin include brewing and bottling manufacturers, mining, thermoelectric power generators, and agriculture. There are also some large food processors and manufacturers in the region that likely rely on large quantities of water.

Many of the largest water users do not rely on the use of municipal water, instead relying on private high-capacity wells. The most intensive water-using industries are those that generate thermoelectric power, and most are located within the Lake Michigan watershed using Lake Michigan water. There are currently no known major water-intensive businesses or industries located within the regional communities that rely on municipal groundwater. All but one of the bottling and brewing/beverage manufacturers in southeastern Wisconsin are in the Lake Michigan basin.

3.13.2 Unemployment

Unemployment throughout the Milwaukee-Waukesha-West Allis Metropolitan Statistical Area has increased over the past decade. In 2005 the annual average unemployment rate was 5.0 percent. For 2010 the annual average unemployment rate had risen to 8.9 percent, before falling to an annual average 6.0 percent for the 2014 the Bureau of Labor Statistics (BLS, 2015).

Waukesha County and the City of Waukesha reported similar unemployment trends over the past decade. The County's annual average unemployment rate in 2005 was 3.8 percent, it had risen to an annual average of 7.3 percent for 2010, and fallen to an annual average of 4.5 percent for 2014 (BLS, 2015). The City of Waukesha's average annual unemployment rate was 4.8 percent for 2005. It had risen to an annual average of 9.2 percent for 2010; and had fallen to an annual average of 4.8 percent for 2014 (BLS, 2015).

A study by CED (Levine, 2002) looked at the impact of this shift on inner city populations in Milwaukee. Unemployment in the inner city was about four times higher than the average for metropolitan Milwaukee. From 1970 to 2000, the inner city population dropped by 45 percent.

3.13.3 Trends

As described in the report *A Socio-Economic Impact Analysis of the Regional Water Supply Plan for Southeastern Wisconsin* (UWM, 2010), Waukesha County experienced an annual increase in jobs from 1960 to 2000 by approximately 5.4 percent. Before 1960, less than five percent of the regional distribution of jobs was from Waukesha County. By 2000, Waukesha County provided 22 percent of the jobs in southeastern Wisconsin. Percent increases and decreases in the number of jobs in a specific area is considered separately from changes in employment and unemployment rates, which are based on the total number of employable persons in an area.

A similar increase was reflected in the historical labor force pattern. Before 1960, most of the regional labor force, about 68 percent, resided in Milwaukee County. Although Milwaukee County's labor force continued to grow through 1990, its share of the regional labor force decreased to 46.5 percent by 2000. Meanwhile, Waukesha County's share of the regional labor force grew from 9.1 percent in 1960 to 19.9 percent in 2000. Waukesha County experienced an average annual growth rate of 3.15 percent from 1960 to 2000, whereas Milwaukee County experienced an annual growth rate of only 0.21 percent.

3.13.4 Tax base

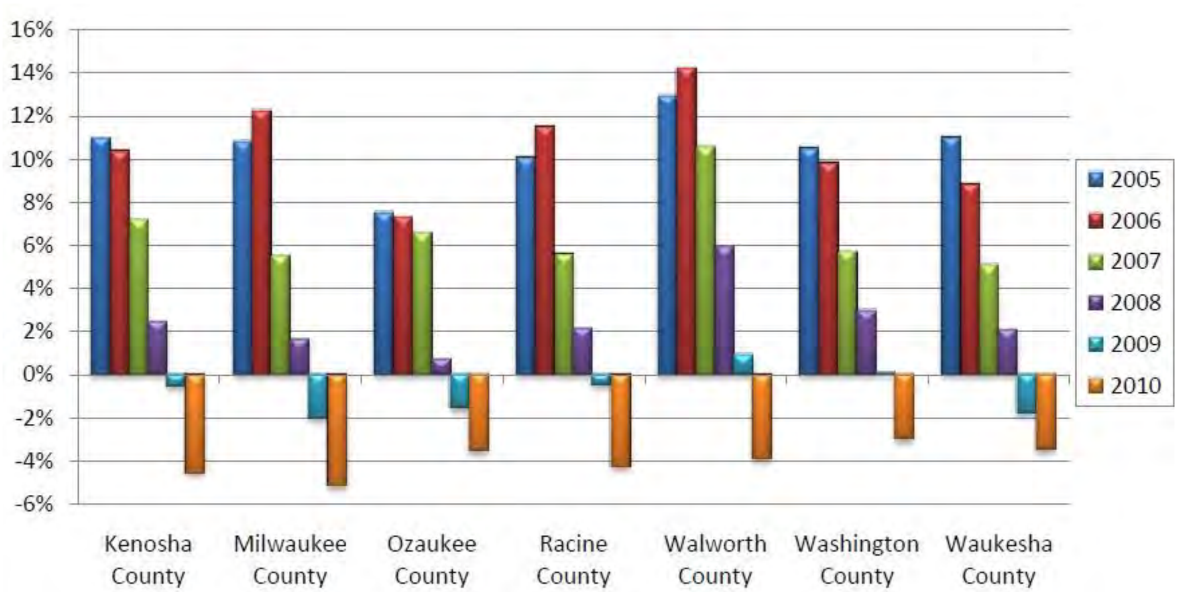
Municipal tax rates (tax base) are based on the total value of all taxable property in a particular municipality. To compare tax bases accurately across multiple municipalities, the State of Wisconsin equalizes assessed values by using tools such as market sales analysis, random appraisals, and local assessors' reports to bring values to a uniform level. Tax base analysis uses equalized values determined by the Wisconsin Department of Revenue. An overview of relevant equalized values for 2010 (Table 3.10) within the seven county region of southeastern Wisconsin, Waukesha County is 28 percent of the tax base (Public Policy Forum, 2011).

Table 3-10. Total equalized value in southeastern Wisconsin 2010 (Source: Public Policy Forum, 2011)

Geography	2010 Total Equalized Value ($)	1 Year % Change in Property Value
Milwaukee County	63,403,508,200	-4.9
City of Milwaukee	29,500,535,100	-5.6
Waukesha County	50,270,294,500	-2.9
City of Waukesha	5,904,933,100	-3.2
SE Wisconsin (7counties)	182,621,628,700	-4.2

In recent years, property values in southeastern Wisconsin have declined by at least three percent in each of the seven counties (Public Policy Forum, 2011). Figure 3.12 provides a visual representation of property value trends in southeast Wisconsin from 2005 to 2010.

Figure 3-12. County aggregate changes in property values: 2005-2010 (Source: Public Policy Forum, 2011)



The Public Policy Forum (2011) reported that the major factors contributing to the decline in property values in southeastern Wisconsin were the economic change in real estate values and the slowed growth of new construction in the region (Table 3.11). The noticeable decline of five percent is believed to be a result of declining property values. New construction is an important criterion in measuring real estate values, as “new construction drives total value growth because as parcels are used more intensively, they generate a higher land utility and thus a higher value” (Public Policy Forum, 2011).

Table 3-11. Changes in aggregate real estate values: 2009-2010 (Source: Public Policy Forum, 2011)

County	2009 Real Estate Value ($USD)	Economic Change ($USD)	New Construction ($USD)	Other Change ($USD)	2010 Real Estate Value ($USD)
Kenosha	14,641,117,700	(885,124,100)	237,637,200	(56,119,800)	13,937,511,000
Milwaukee	64,849,423,300	(3,611,491,400)	398,632,100	(213,156,700)	61,423,407,300
Ozaukee	11,053,112,400	(459,394,700)	89,167,800	(40,538,800)	10,642,346,700
Racine	15,584,722,400	(713,582,400)	69,673,000	(39,075,600)	14,901,737,400
Walworth	15,450,442,800	738,054,200)	134,579,100	1,621,600	14,848,589,300
Washington	13,857,974,100	(512,119,500)	120,946,200	(26,570,000)	13,440,230,800
Waukesha	51,011,477,100	(2,182,165,900)	394,097,100	(37,613,800)	49,185,794,500
SE Wisconsin	**186,448,269,800**	**(9,101,932,200)**	**1,444,732,500**	**(411,453,100)**	**178,379,617,000**
Wisconsin	**499,856,206,900**	**(19,377,213,300)**	**4,575,602,300**	**(1,087,907,700)**	**483,966,688,200**

Table 3-11a shows data from the year 2000 for median housing values and median gross rents selected communities in the region.

Table 3-11a Year 2000 Median Housing Values and Median Gross Rents within the Selected Communities

Community	Median Housing Value	Median Gross Rent
Kenosha	$108,000	$571
Milwaukee	80,400	527
Oak Creek	139,100	704
Port Washington	136,200	624
Racine	83,600	520
Brookfield	189,100	1,014
Cedarburg	179,900	670
Elm Grove	263,900	673
Germantown	169,900	709
Grafton	145,800	625
Muskego	166,700	785
New Berlin	162,100	830
Saukville	135,700	589
Waukesha	139,900	675

Source: US Census Bureau as reported by UWM 2010

3.14 Land use, zoning and transportation

In 2000, there were about 761 square miles of urban land uses in southeast Wisconsin, or 28 percent of the total area of the region. Areas considered "urban" include residential, commercial, industrial, transportation-communication-utility, governmental-institutional, and intensive recreational lands. The largest category of urban land was residential land comprising about 362 square miles, or about 48 percent of all urban land and about 14 percent of the overall area of the region. Sixty three square miles were commercial and industrial lands, or about eight percent of all urban land and about two percent of the region overall. Land used for governmental and institutional purposes covered 34 square miles, or four percent of all urban land and one percent of the region overall. Intensive recreational use lands encompassed about 50 square miles, or seven percent of all urban land and two percent of the region. A total of 201 square miles was used for transportation, communication, and utilities. This included areas used for streets and highways, railways, airports, and utility and communication facilities and covered 26 percent of all urban land and eight percent of the region overall. Unused urban lands encompassed 51 square miles, which was seven percent of all urban land and two percent of the overall area of the region. Land use in the region is shown in Figure 3.13, and is listed in Table 3.12.

Figure 3-13. Land use in the southeast Wisconsin region in 2000 (Source: SEWRPC, 2006)

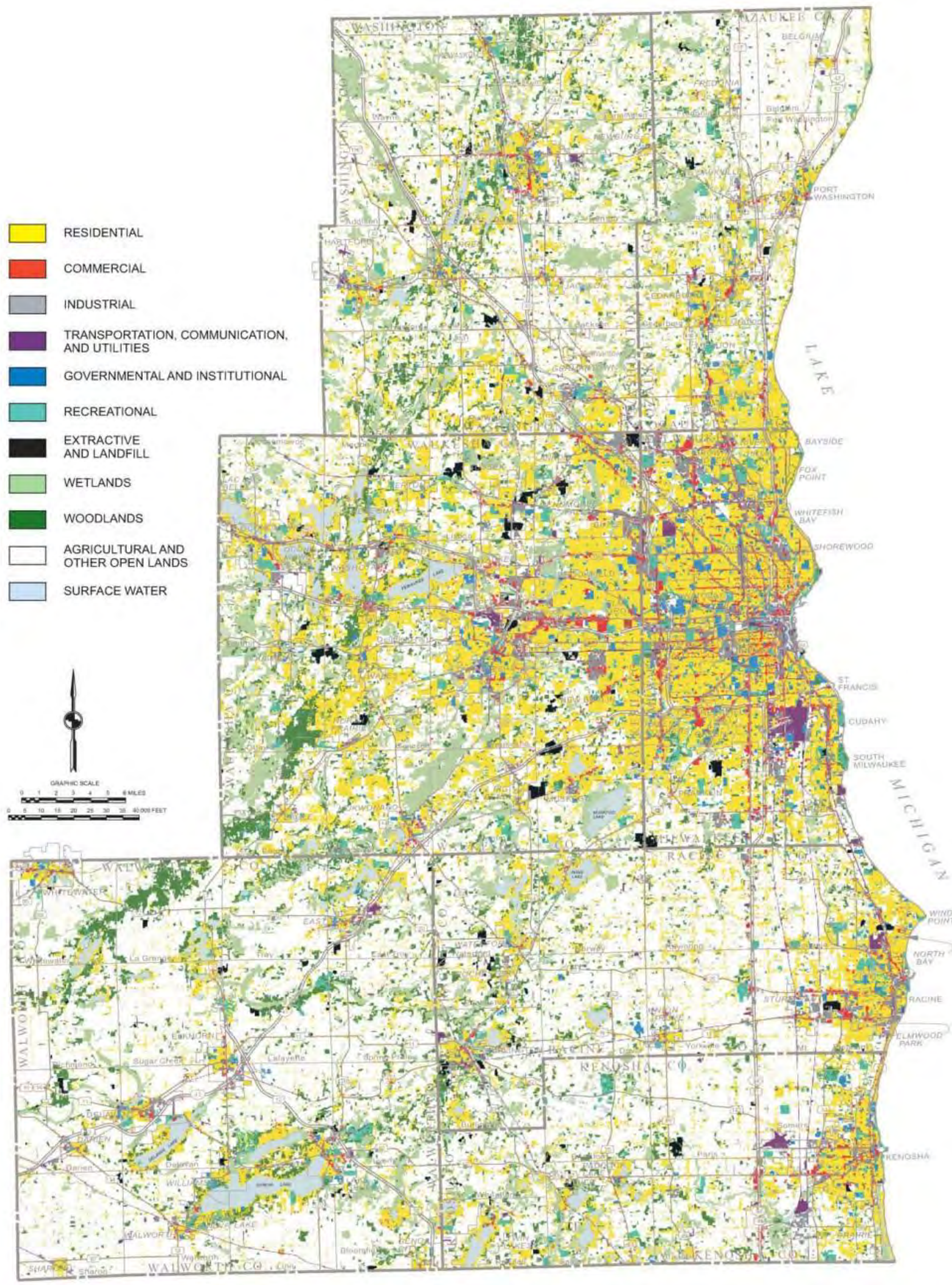


Table 3-12. Land use area in SE Wisconsin region and Waukesha County in 1963 and 2000 (Source: SEWRPC, 2006)

	Region				Waukesha County			
	1963		2000		1963		2000	
Land Use Category	Ac	%	Ac	%	Ac	%	Ac	%
Urban								
Residential	115,170	6.7	231,737	13.5	28,148	7.6	75,221	20.2
Commercial	7,390	0.4	19,397	1.1	1,197	0.3	5,351	1.4
Industrial	8,651	0.5	21,053	1.2	924	0.2	5,525	1.5
Transportation, communication, & utilities	86,366	5.0	128,570	7.5	16,079	4.3	30,001	8.1
Governmental & institutional	13,980	0.8	21,543	1.3	2,550	0.7	4,887	1.3
Recreational	16,669	1.0	32,245	1.9	3,311	0.9	8,253	2.2
Unused urban land	34,895	2.0	32,566	1.9	8,509	2.3	7,806	2.1
Subtotal urban	**283,123**	**16.4**	**487,111**	**28.4**	**60,717**	**16.3**	**137,045**	**36.8**
Non-urban								
Natural areas								
Surface waters	45,794	2.7	49,566	2.9	16,076	4.3	16,892	4.5
Wetlands	175,564	10.2	176,450	10.2	52,588	14.2	52,661	14.2
Woodlands	119,583	6.9	116,905	6.8	31,181	8.4	28,932	7.8
Subtotal natural areas	**340,941**	**19.8**	**342,921**	**19.9**	**99,846**	**26.9**	**98,484**	**26.5**
Agricultural	1,047,740	60.9	806,011	46.8	200,242	53.9	112,611	30.4
Unused rural & other open land	49,378	2.9	85,413	4.9	10,786	2.9	23,397	6.3
Subtotal non-urban	**1,438,059**	**83.6**	**1,234,345**	**71.6**	**310,873**	**83.7**	**234,492**	**63.2**
Totals	**1,721,182**	**100.0**	**1,721,456**	**100.0**	**371,591**	**100.0**	**371,537**	**100.0**

The occupancy and tenure (owner- or renter-occupied) housing stock for the year 2000 is shown in Table 3-12a for selected communities. Several communities in the region have housing policies in place. The Applicant's policy calls for a desirable mix of housing types; 65% single family units and 35% multi-family units.

Table 3-12a Year 2000 Occupancy and Tenure for Households in Selected Communities

Community	Total Housing Units	Occupied Housing Units					Vacant Units	
		Total Occupied Housing Units	Owner Occupied Units		Renter Occupied Units			
			Number	Percent	Number	Percent	Number	Percent
Kenosha	36,162	34,546	21,488	59.4	13,058	36.1	1,616	4.5
Milwaukee	249,215	232,178	105,186	42.2	126,992	51.0	17,037	6.8
Oak Creek	11,897	11,239	6,907	58.1	4,332	36.4	658	5.5
Port Washington	4,225	4,050	2,554	60.4	1,496	35.4	175	4.1
Racine	33,458	31,498	18,977	56.7	12,521	37.4	1,960	5.9
Brookfield	14,246	13,947	12,555	88.1	1,392	9.8	299	2.1
Cedarburg	4,534	4,408	2,831	62.4	1,577	34.8	126	2.8
Elm Grove	2,557	2,444	2,202	86.1	242	9.5	113	4.4
Germantown	7,068	6,898	5,380	76.2	1,518	21.5	170	2.4
Grafton	4,211	4,075	2,870	68.2	1,205	28.6	136	3.2
Muskego	7,694	7,530	6,229	81.0	1,301	16.9	164	2.1
New Berlin	14,939	14,505	11,787	78.9	2,718	18.2	434	2.9
Saukville	1,644	1,585	950	57.8	635	38.6	59	3.6
Waukesha	26,858	25,665	14,480	53.9	11,185	41.6	1,193	4.4

Source: US Census Bureau as reported by UWM, 2010

SEWRPC is the statutorily designated regional planning agency for the southeastern Wisconsin region, and is responsible for making and adopting a master plan for the physical development of the region, including land use, transportation, communications, sewer infrastructure, and this first generation Regional Water Supply Plan. The regional plans that SEWRPC develops are advisory by nature and implementation is based on local or county actions or initiatives.

3.15 Recreation and aesthetic resources

Southeastern Wisconsin Regional Planning Commission Planning Report No. 48, A Regional Land Use Plan for Southeastern Wisconsin: 2035, provides an overview of recreational lands and aesthetic resources in the project area (2006). Land devoted to intensive recreational uses encompassed about 50 square miles, or 7 percent of all urban land and 2 percent of the Region overall. The most important elements of the natural resource base, and features closely related to that base - including wetlands, woodlands, prairies, wildlife habitat, major lakes and streams and associated shorelands and floodlands, and historic, scenic, and recreational sites – when combined result in essentially elongated patterns referred to as “environmental corridors.”

“Primary” environmental corridors, which are the longest and widest type of environmental corridor, are generally located along major stream valleys, around major lakes, and along the Kettle Moraine; they encompassed 462 square miles, or 17 percent of the total area of the Region, in 2000.

“Secondary” environmental corridors are generally located along small perennial and intermittent streams; they encompassed 75 square miles, or 3 percent of the Region, in 2000. In addition to the environmental corridors, “isolated natural resource areas,” consisting of small pockets of natural resource base elements separated physically from the environmental corridor network, have been identified. Widely scattered throughout the Region, isolated natural resource areas encompassed about 63 square miles, or 2 percent of the Region, in 2000.

Vernon Wildlife Area is a 4,655 acre property (4,154 acres owned and 501 acres leased) located just north of Mukwonago in eastern Waukesha County. The wildlife area provides opportunities for public hunting, fishing, trapping and other outdoor recreation while protecting the qualities of the unique native communities and associated species found on the property. The Vernon Wildlife Area offers many recreational opportunities: birding, boating, canoeing, cross country skiing, dog trial grounds, fishing, hiking, hunting - especially noted for pheasant, snowmobiling, trapping, wild edibles/gathering, and wildlife viewing.

3.16 Archaeological and historical resources

Sites and structures representing all of the recognized prehistoric culture periods are found throughout the area, from Paleo-Indian (ca. 10,000-8000 BC), through Archaic (ca. 8000-500 BC), Woodland (ca. 500 BC-1000 AD), and Oneota (ca. 900-1650 AD). Associated sites include Native American camps, villages, burial and effigy mounds, and more. Historic period sites (ca. 1650-present) include farmsteads, dams, mills, cemeteries, and others. The region’s towns and rural roads are dotted with numerous historic homes, businesses, bridges, and other early structures, many used continuously to this day. Whether populated by ancient Indian peoples or more recent arrivals, the area’s numerous archaeological sites and historic structures reflect a lengthy record of settlement, as well as intensive utilization of the diverse water, mineral, plant, animal, and other resources characteristic of the region.

3.17 Regional public water supplies and uses

3.17.1 City of Waukesha public water supplies and uses

The Applicant currently obtains approximately 80 percent of its water supply from the confined deep sandstone aquifer. Just east of the City the aquifer is confined by a geological feature—the Maquoketa shale layer—that limits natural recharge of the aquifer. Continued use of the aquifer by the City and surrounding communities since the 19th century and the presence of the Maquoketa shale have led to the decline of 500 feet in aquifer water levels (SEWRPC, 2010, pp. 108, 113). Reductions in groundwater pumping over the last 15 years have resulted in a gradual rebound of the deep confined aquifer by approximately 100 feet. Reduced groundwater levels in southeastern Wisconsin have in turn affected regional surface waters. According to the regional model for southeastern Wisconsin, the volume of deep pumping in 2000 is equivalent to four percent of overall groundwater recharge and has caused a reduction of 6.7% of predevelopment inland baseflow over the 7-county area (Feinstein, et al. 2005). As aquifer water levels rise, the groundwater contribution to surface water will also increase. Significant water quality issues occur with declining water levels in the deep aquifer, including increased levels of salts and radium (a naturally occurring element in the deep aquifer that can cause cancer). As the aquifer water level has risen, radium concentrations have continued to be a problem.

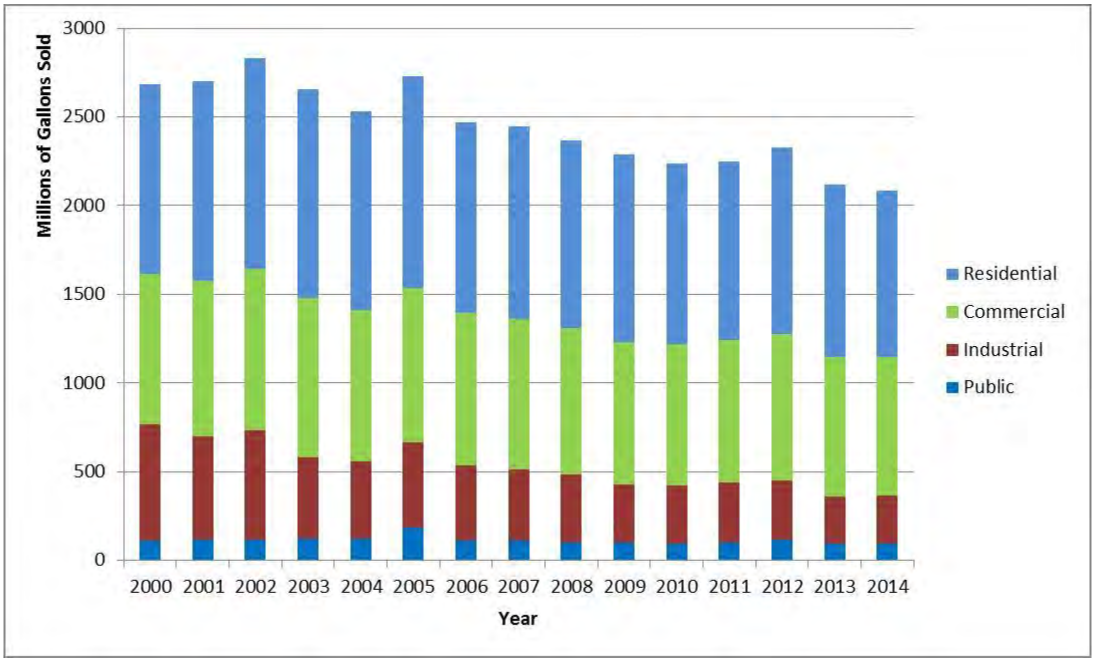
To provide drinking water with low levels of radium, the City treats some deep aquifer water to remove radium and mixes it with radium-free water from the shallow Troy Bedrock aquifer. The City obtains approximately 20 percent of its water supply from the shallow aquifer. Increased pumping of the shallow aquifer will stress surface water resources by reducing baseflows to local streams and wetlands (SEWRPC, 2010).

3.17.1.1 Water use in the City of Waukesha

3.17.1.1.1 Historic water use in Waukesha

Figure 3.14 summarizes water use by customer class and historic water consumption for the period 2000 to 2014. Over this period, total water pumping decreased 20.3 percent.

Figure 3-14. Water Sales by Sector (Source: WPSC)



After the Applicant adopted its 2006 Water Conservation and Protection Plan, additional focus was provided on water use efficiency. While some water use reduction may be attributed to weak economic conditions and seasonal rainfall over the same period, much of the decline can be attributed to decreased water demand resulting from more efficient water use, conservation education, regulation, and incentives. Additional details of historic water use and conservation are included in the Water Supply Service Area Plan (CH2MHill, 2013, Vol. 2).

3.17.1.1.2 Current water use in Waukesha

The Applicant actively tracks water use by customer class for the following:

- *Residential*. Residential water demand typically includes indoor water-using activities, such as those for bathroom, kitchen, and laundry, and outdoor water use, such as lawn irrigation, swimming pools, and car washing. Waukesha's four categories of residential customers were analyzed:

  - Single-family Residential
  - Two-family Residential
  - Three-family Residential
  - Multi-family Residential (multi-family is tracked separately as outlined below)

  For summary purposes, residential water use is measured in accordance with requirements set forth by the Public Service Commission of Wisconsin.

- *Industrial.* Manufacturing, processing, warehouses, foundries, and dairies.
- *Commercial.* Commercial water use is presented by customers such as retail, restaurants, office buildings, medical facilities, and private schools.
- *Public.* Public water use includes water demands for municipal buildings, public facilities, parks, public schools and institutions

- *Unbilled authorized consumption.* Water uses that are measured (or estimated) but not included in sales. Examples of this water use include water used in annual water main flushing to maintain water quality and water used in firefighting exercises.

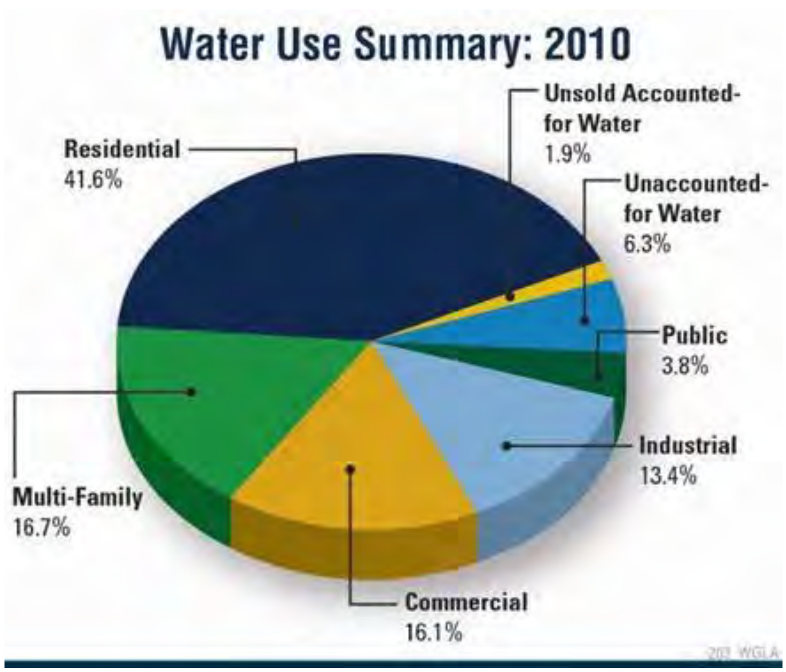
- *Unaccounted for Water.* From 2000 to 2010 PSC used unaccounted for water to calculate water loss. Unaccounted for water is the difference between total pumpage and total authorized water use.

- *Water loss.* From 2011 on PSC discontinued the use and reporting of 'unaccounted for water' and instead used 'water loss.' PSC defines water loss as water placed into the distribution system that does not find its way to billed customers or unbilled authorized users.

Water use categories aid the utility in effectively managing water, planning for future water demand, and in developing a strategic water conservation plan (CH2MHill, 2012, Vol. 3).

Water use by sector for 2010 is shown in Figure 3.15. Single family and multi-family residential water use accounts for nearly 60 percent of all water use by the Applicant.

Figure 3-15. Water use by customer class for the Waukesha Water Utility



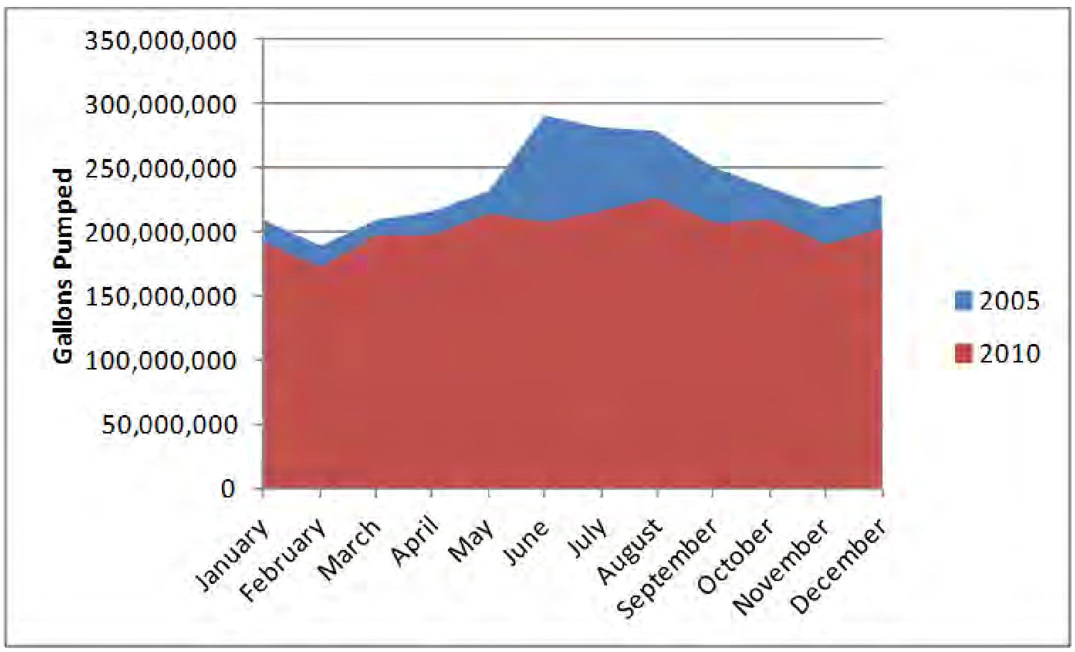
3.17.1.1.2.1 Variations in customer demand

Water demand varies and is typically influenced by several factors including precipitation, temperature, personal income, and community conservation goals. While reductions in water use in wet and cool years or increases in water use associated with higher personal income may be observed, correlating how the factors affect one another is not a straightforward process. Quantification and disaggregation of the effect of variables such as weather (especially temperature and rainfall), and public awareness on water use require extensive data collection and analysis. Results of the City's review of available water use-related data indicating trends that provide insights into long-range water demand forecasts are described below.

3.17.1.1.2.2 Seasonal variation in water use in Waukesha

Seasonal water use patterns provide helpful information regarding the water use in the City's service area. Figure 3.16 presents monthly water use in 2005 (before the 2006 Water Conservation and Protection Plan) and in 2010. In 2006, the City adopted a municipal ordinance restricting lawn and landscape irrigation to no more than 2 days per week between May 1 and October 1. Since Waukesha's water conservation ordinance has been in effect, seasonal peak water demands have declined significantly. The City must plan for a peak pumping season from May through September, but its water demand forecasts for the future assume the City will continue to restrict peak season outdoor water use. Additional information on water conservation can be found in the City of Waukesha Water Conservation Plan (CH2MHill, 2012, Vol. 3).

Figure 3-16. City of Waukesha seasonal water use in 2005 and 2010 (Source: WPSC)

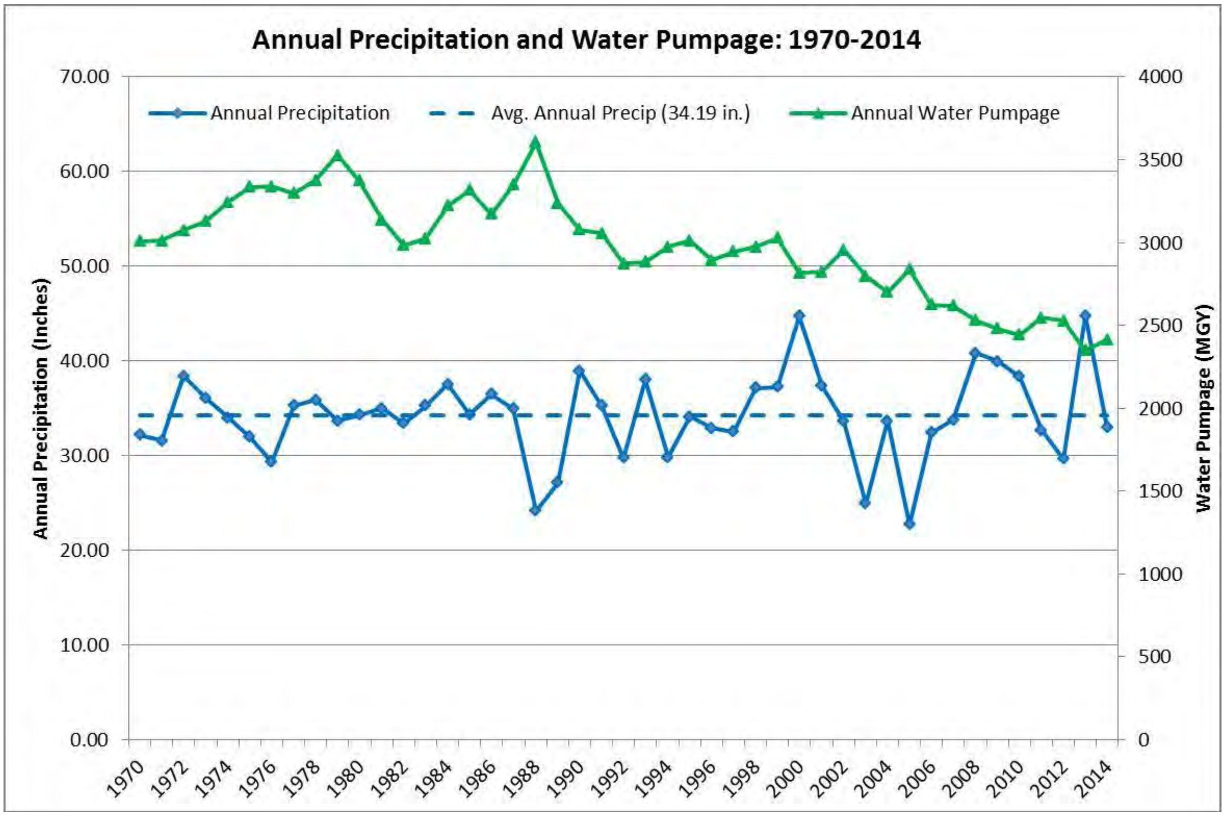


3.17.1.1.2.3 Variation of water use in Waukesha with precipitation

Local climate conditions (such as temperature and wind) and precipitation events (duration, number, and intensity of rainfall and snow) vary widely throughout the year and from year-to year. To some extent, their effect on water use can be observed. In Waukesha, for example, some years that experienced high precipitation correlate with reduced demands, such as 2008 through 2013, as shown in Figure 3-16, while in other years they do not. Figure 3-17 shows a declining trend in the volume of water pumped. The data also illustrate that water demand in the City increases in years of below-average rainfall.

Even though the City receives an average of 34.2 inches of precipitation annually and has implemented a conservation program, it must plan for periods of abnormally dry to moderate drought conditions or high temperatures when water demands may increase or supplies may be constrained. Sound engineering practice and Wisconsin law requires planning for potential droughts to ensure adequate water supply availability to meet essential water needs, such as those for residential sanitation, firefighting, economic stability, system maintenance, and other similar requirements.

Figure 3-17. City of Waukesha Annual Pumping and Precipitation (source: City of Waukesha, WPSC, and National Weather Service)



3.17.1.1.2.4 Variation in daily water use in Waukesha

Table 3.13 summarizes historical variation in average day and maximum day demand over the past 10 years, with the ratio of the annual maximum day to average day water pumpage ranging from a low of 1.29 to 1.66.

Table 3-13. City of Waukesha Maximum and Average Daily Flow, 1999-2010

Year	Average Day Pumpage (MGD)	Max. Day Pumpage (MGD)	Max. Pumpage Date	Ratio of Max. to Ave. Day
2010	6.69	8.65	28-Aug	1.29
2009	6.79	9.35	04-Aug	1.38
2008	6.91	9.93	19-Aug	1.43
2007	7.17	9.79	24-Jul	1.36
2006	7.18	10.23	18-Jul	1.42
2005	7.76	12.87	23-Jun	1.66
2004	7.39	10.48	13-Sep	1.42
2003	7.66	11.67	22-Aug	1.52
2002	8.09	12.78	17-Jul	1.58
2001	7.73	12.53	09-Jul	1.62
2000	7.72	10.15	27-Jun	1.31
1999	8.3	11.59	07-Jul	1.4

Based on the analysis of the City's pumpage data, including review of recent water conservation impacts upon water demand, the maximum day to average day pumping factor used for water system facility design is 1.66. This reflects that, with a 98 percent confidence level, in recent years the actual peak day pumping will be of equal or lesser value (CH2MHill, 2013, Vol. 2). The average to peak ratio appears to be trending downward since 2005, but it is unknown how much of the decrease is due to reliable long-term water use efficiency and how much is due to other factors.

3.17.1.2 Water conservation in the City of Waukesha

Proposed diversions are held to Tier 3 water conservation and efficiency standards of Wis. Admin Code ch. NR 852. These standards require the Applicant to implement all mandatory Conservation and Efficiency Measures (CEM), create a water conservation plan, undertake a CEM analysis prior to applying for a diversion, and provide annual water conservation reporting to the department.

Within its water conservation plan the Applicant identified a number of conservation measures that it has implemented or plans to implement that would result in water savings. These include:

- High efficiency toilet rebates. Customers who replace a pre-1994 high volume (3.5 gallon or more) toilet with a WaterSense High-Efficiency toilet (1.28 gallons/flush) will receive up to a $100 rebate.
- A Lawn sprinkling ordinance which limits lawn watering to twice a week, and limits times to before 9 am or after 5 pm.
- Targeted reductions at municipally owned buildings and school facilities.
- Promoted discounted replacement of spray rinse valves for commercial customers.
- Facilitated major water use reductions with several industrial customers.

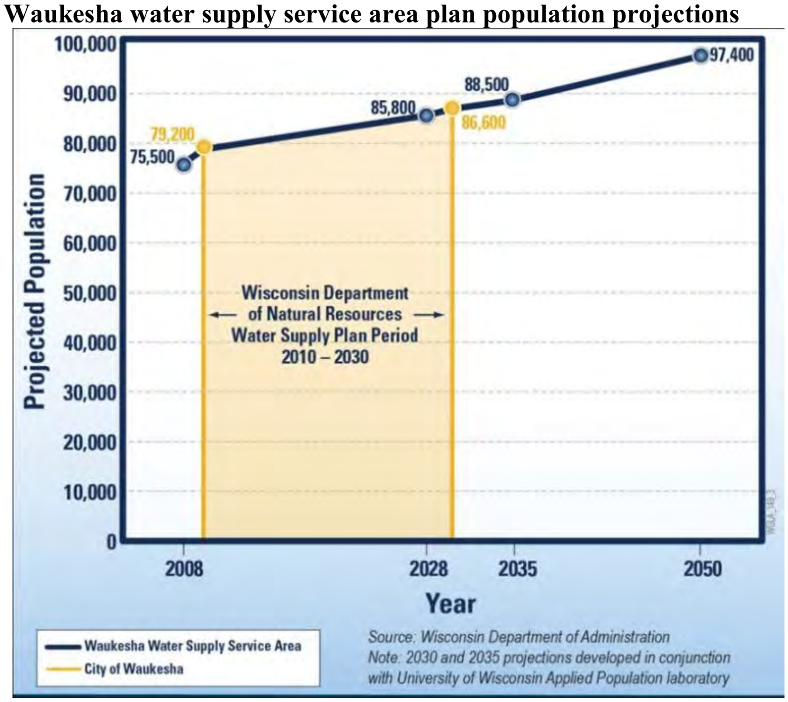
To date, the applicant's conservation plan implementation has directly resulted in an estimated water savings of nearly 90,000 gallons per day. These quantifiable plan savings are in addition to an estimated 170,000 gallons per day passive savings stemming from conservation education, outreach and ongoing replacement of inefficient fixtures and appliances.

Under current water service rules promulgated by the Wisconsin Public Service Commission (PSC), all customers are subject to the City's conservation measures. If water service is extended to areas outside the City, customers will be required to adhere to the City's conservation program as established in the service rules as well as in future service contracts. The City will provide water conservation public education to new customers and make available information, services and incentives to help its customers use water wisely.

3.17.1.3 Water demand forecast for the City of Waukesha

Water demand forecasts for the Applicant were developed on the basis of the delineated water supply service area, population projections for the service area, historical water use by customer class, and the expansion of the City's water conservation program. SEWRPC prepared population projections for the water supply service area including 85,800 people in 2028, 88,500 people in 2035, and an ultimate build-out population of 97,400 people (Figure 3.18). The projections are based on municipal estimates from the State of Wisconsin Department of Administration and multiple planning factors, including but not limited to land use, household size, demographic trends, and community development plans. Additional details of the water supply service area are included in the Water Supply Service Area Plan (CH2MHill, 2013, Vol. 2).

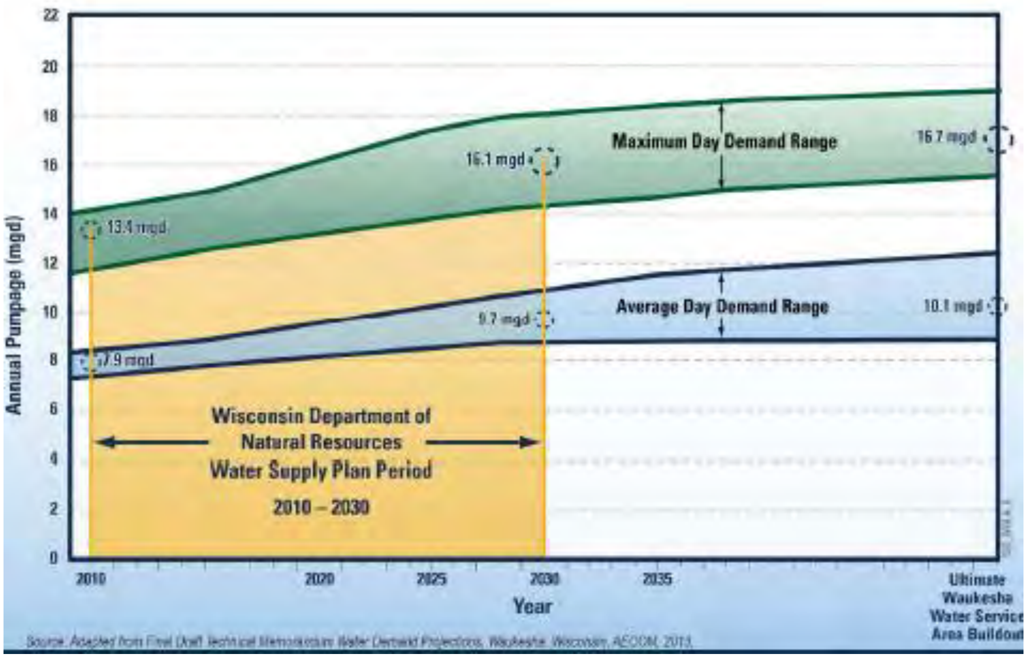
Figure 3-18. City of Waukesha water supply service area plan population projections



As part of its 2006 water system master plan, Applicant prepared water demand forecasts. These were updated in 2013 to reflect updated water service area population projections and water use after implementation of conservation measures (Figure 3.19). The Water Demand

Projections memorandum attachment to the Water Supply Service Area Plan (CH2MHill, 2013, Vol. 2) contains the analysis of future water demands used during the planning process.

Figure 3-19. City of Waukesha water supply service area water demand forecasts



The future water demand forecasts are based on the following assumptions:

- The City's water conservation program is maintained and expanded to meet long-term conservation goals and customer needs.
- The water conservation measures will continue to be implemented, monitored, and adopted as needed to cost-effectively meet the City's water savings goal of 0.5 MGD by 2030 and 1.0 MGD at ultimate build-out. The water conservation plan has been included in the average day demand and maximum day demand projections.
- The 1.0 MGD average day conservation reduction (approximately 10 percent) by 2050 complies with *A Regional Water Supply Plan for Southeastern Wisconsin* (SEWRPC, 2010), which evaluated several levels of water conservation ranging from four to ten percent reductions of average daily demand.
- The ranges of future water forecasts shown in Figure 3.18 were determined by applying water use intensity factors, water savings from conservation, and some contingency to address uncertainty associated in long-term water supply planning for the project population. The uncertainties considered include drought, changes in customer class (particularly the number and type of commercial and industrial users).

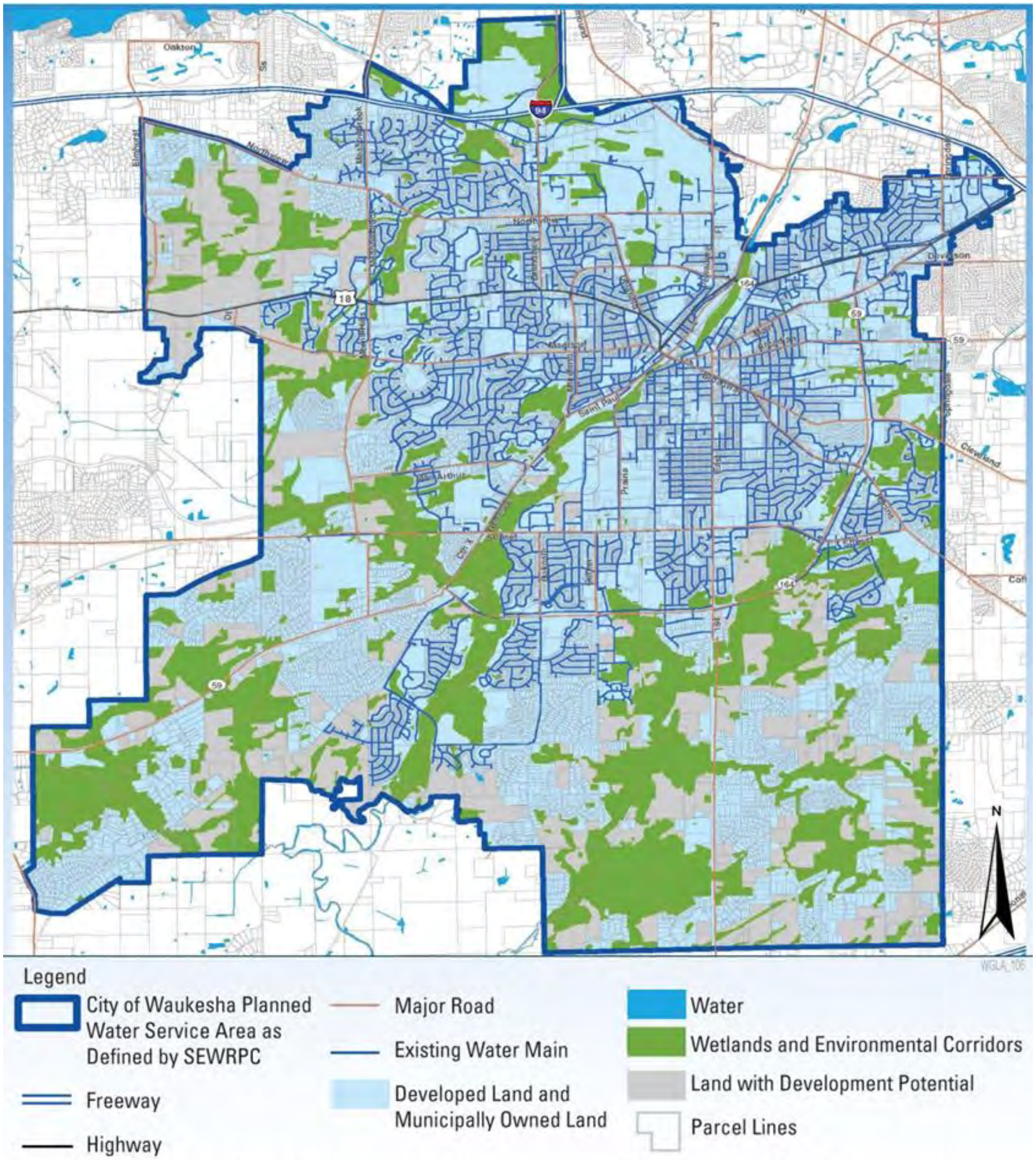
3.17.1.4 Water supply service area for the City of Waukesha

The Applicant presently provides water service to the City of Waukesha and limited areas located outside the city limits. In accordance with Wisconsin's statutory water supply service area planning requirements (Wis. Stat. §281.348), SEWRPC delineated the Applicant's water supply service area to align with its existing sewer service area, include portions of neighboring communities. Service area planning is designed to promote the orderly management of growth. As such, the delineated service area includes portions of neighboring communities currently served by private wells and septic, where future land use plans, sanitary sewer area plans, or historic private well contamination indicate municipal service may be needed. The delineated water supply service area sets the outer boundary of where Waukesha's municipal water supply service can expand.

Wisconsin law generally prohibits the department from limiting a water supply service area based on jurisdictional boundaries (Wis. Stat. § 281.348(3)(e)) . Whether public water service is extended within the delineated service area, and the pace at which public water service is extended within the service area, is primarily up to the jurisdictions within the service area and the Wisconsin Public Service Commission (WPSC) (See generally Wis. Stat. § 196 Regulation of Public Utilities).

The water supply service area includes 3.7 percent of the City of Pewaukee, 9 percent of the Town of Delafield, 14.9 percent of the Town of Genesee, and 83.6 percent of the Town of Waukesha. Within the delineated water supply service area 70 percent of the land is already developed, 15 percent is designated as environmentally protected and 15 percent is currently undeveloped. The Applicant's water supply service area is shown in Figure 3.20. It represents the full development land use envisioned in the Waukesha County Comprehensive Plan at full build-out, projected to occur around 2050, based on historical state population trends.

Figure 3-20. City of Waukesha Proposed Water Supply Service Area



Source: Adapted from Water Supply Service Area for the City of Waukesha and Environs, Waukesha County, Wisconsin, SEWRPC, December 2008

Section 4 Environmental Effects

4 Environmental effects

Section 4 describes the potential impacts on the human environment for the no action alternative (section 4.1), the water supply alternatives (section 4.2) and the return flow alternatives (section 4.3). Section 4.4 provides general information on typical pipeline construction techniques used in pipeline construction.

4.1 No action alternative environmental effects

The "no action" alternative could potentially have an adverse effect upon the health of City of Waukesha (the Applicant) residents because the current water supply source is non-compliant for radium, a cancer causing contaminant naturally occurring in the deep aquifer. The Applicant's existing deep aquifer wells do not provide sufficient quality and quantity of water to meet the projected water supply needs of the Applicant. The Applicant must develop a permanent solution to the radium contamination problem by 2018 and meet the drinking water standard for radium, including meeting the radium maximum contaminant level (MCL) at each entry point to the distribution system as required under a 2009 Wisconsin circuit court judgment (State of Wisconsin vs. City of Waukesha, Case No. 2009-CX, April 8, 2009. Stipulation and Order for Judgment). Currently, the Applicant is allowed to use a temporary solution to meet the federal radium standard that involves treatment of some deep aquifer wells and blending with low radium shallow aquifer water to reduce the overall concentration as allowed in the court judgment. However, the Applicant is having difficulty meeting the radium MCL at all entry points to the water supply system.

The no action alternative would continue use of the deep aquifer and shallow aquifer. Currently approximately 80 percent of the Applicant's water supply comes from the deep aquifer and 20 percent comes from the shallow aquifer. As the Applicant's water demand increases, the no action alternative would result in increased use of the deep aquifer as the shallow aquifer wells are currently pumped to maximum capacity (CH2MHill, 2013, Vol. 2). The no action alternative assumes 7.3 MGD from the deep aquifer and 1.2 MGD from the shallow aquifer under an 8.5 MGD average day demand. Note that the Applicant's request is for 10.1 MGD average day demand; however, the groundwater flow modeling conducted to review the Mississippi River Basin alternatives used 8.5 MGD average day demand, actual impacts of a 10.1 average day demand would be proportionally greater. The increase in long-term water withdrawal from the deep aquifer would contribute to increased deep aquifer drawdown, enlarging the deep aquifer cone of depression and widening the deep aquifer zone of influence, causing deep aquifer groundwater to flow westward toward Waukesha County, away from Lake Michigan. This increased withdrawal would also likely increase the concentrations of contaminants (including radium, gross alpha and TDS) in the water supply, as groundwater withdrawn from lower elevations has higher occurrences of these contaminants.

Flow in the Fox River would be expected to increase by 4 percent from current modeled base flows due to increase use of the deep aquifer (see EIS, Appendix A). Under the no action alternative, additional water to meet a demand increase from a current withdrawal is withdrawn from the deep aquifer. With the additional withdrawal, there is an assumed corresponding increase in discharge from the Wastewater Treatment Plant to the Fox River. Under this alternative, as the shallow aquifer pumping remains the same as current withdrawals, no additional baseflow is diverted from Fox River.

The no action alternative would continue use of the shallow aquifer at the same rate as used between 2010 and 2014. See section 4.2.3 for a description of the expected impacts from continuing to use the existing shallow wells.

The “no action” alternative is not feasible. The Applicant must comply with drinking water quality standards and the deep aquifer water supply does not meet radium standards.

4.2 Zero demand increase alternative

The zero demand increase alternative is similar to the deep and shallow aquifer alternative, in that it would continue using existing deep aquifer and shallow aquifer wells, however with no additional new wells. Upon implementation, this alternative includes radium treatment for four deep aquifer wells with blending of all well water at the Hillcrest Reservoir. However, the zero demand increase alternative does not have sufficient firm capacity[2] to meet the projected 11.1 Maximum Day Demand (MDD) identified in the proposed alternative. The reduced insufficient firm well capacity is a result of the removal of existing Well No. 9 due to water quality problems, reduced capacities in two of the existing shallow wells, and reduced capacities from the existing deep wells that would add radium treatment (Duchniak, 2015).

This alternative assumes an average day demand (ADD) of 6.7 MGD and a MDD of 11.1 MGD. The Applicant calculated full build-out demand for the existing service area as 8.2 MGD ADD and for the delineated water supply service area as 8.8 - 10.1 MGD ADD including water conservation. This ADD does not consider the SEWRPC delineated water supply service area for calculating demand projections and uses alternative assumptions for calculating demand than those used by the Applicant. The department does not consider this alternative viable because it does not meet the Agreement/Compact criteria to meet all applicable state laws. State law requires the Applicant to consider the delineated water supply service area in developing a projected water demand. This alternative only considers the existing service area not the delineated service area (see Technical Review S3 for additional information).

4.2.1 Proposed Water Supply System Demand Analysis

The department analyzed the proposed system capacity in the zero demand increase alternative to determine if the proposed system could meet the 6.7 MGD ADD and 11.1 MGD MDD previously discussed.

Section NR 811.26 Wis. Adm. Code, provides that the total number of [pumping] units shall have sufficient capacity so that if any one pump is taken out of service, the remaining pumps are capable of supplying the peak demand. “Peak demand” is defined as the “maximum water demand in gallons per minute at any given time. Section NR 811.02(47), Wis. Adm. Code, defines peak demand is sometimes estimated to be 2.0 times the total maximum day water use in

[2] Firm capacity is the system capacity with the largest well out of service. In the Applicant’s system this is Well No. 10.

gallons averaged over [a day], or the peak hour demand in gallons per minute on the maximum day of use." Under the Great Lakes-Upper Mississippi River Board (GLUMRB) Policy for the Review and Approval of Public Water Supplies, recommends that the "groundwater source capacity, unless otherwise specified by the [Wisconsin Department of Natural Resources], shall equal or exceed the design maximum day demand (MDD) with the largest producing well out of service."

When determining the source capacity of a system, less than a 24 hour time period of calculated firm well capacity is used for a variety of reasons. Causes of well failures can be attributed to overpumping, lowering of the water table, clogging of the aquifer, screen failure, casing failure, or worn pump. To allow recovery of the aquifer and/or maintenance of pumping equipment, the industry standard (Al-Layla, 1977; AWWA, 2001) is to base an average day capacity on a 12 hour well run time and a maximum day capacity on an 18-22 hour run time. Using these criteria, the source (well) capacities of this alternative are provided in Table 4-1 below.

Table 4-1 Applicant well capacities assuming RO treatment for zero demand increase alternative (Duchniak, 2015)

Well	*24-hr Firm Well Capacity (MGD)*	*12-hr Firm Well Capacity (MGD)*	*18-hr Firm Well Capacity (MGD)*	*22-hr Firm Well Capacity (MGD)*
3	1.1	0.6	0.8	1.0
5	1.4	0.7	1.1	1.3
6[1]	2.2	1.1	1.6	2.0
7	0.9	0.5	0.7	0.8
8[1]	1.9	1.0	1.4	1.8
9	0.0	0.0	0.0	0.0
10[1]	3.0	1.5	2.3	2.8
11	0.2	0.1	0.2	0.2
12	0.7	0.4	0.5	0.6
13	0.9	0.5	0.7	0.8
Firm Capacity[2]:	**9.3**	**4.6**	**7.0**	**8.5**

[1] Reverse Osmosis treatment results in reject water. Reject water is brine that is discharged to the sanitary sewer. A 20% reject water volume is calculated for Reverse Osmosis treatment technology at Wells No. 6, 8 and 10.
[2]As described above, firm capacity is the system capacity with the largest well out of service. In the Applicant's system this is Well 10.

As shown, the ADD of 6.7 MGD is greater than the 12-hr firm well capacity of the zero demand increase alternative, reflected as 4.6 MGD in Table 4-1. In this scenario, it would take nearly 18 hours to meet the ADD of 6.7 MGD, which is higher than the industry standard for meeting ADD. Further, the 24-hr firm well capacity cannot meet the 11.1 MGD MDD, which also exceeds the industry standard for meeting the MDD, and does not provide any recovery time for the wells.

If the zero demand increase alternative was implemented with an alternate radium treatment method to RO, the firm capacity of the proposed water supply system would be greater as a result of increased well capacity at Wells No. 6 and 8 due to elimination of RO reject water (note

Well 10 is not included in the calculation of firm capacity). Table 4-2 reflects the system's firm source capacity with an alternate radium treatment technology.

Table 4-2 Applicant well capacities assuming alternate radium treatment for zero demand increase alternative.

Well	*24-hr Well Capacity (MGD)*	*12-hr Well Capacity (MGD)*	*18-hr Well Capacity (MGD)*	*22-hr Well Capacity (MGD)*
3	1.1	0.6	0.8	1.0
5	1.4	0.7	1.1	1.3
6	2.7	1.4	2.0	2.5
7	0.9	0.5	0.7	0.8
8	2.4	1.2	1.8	2.2
9	0.0	0.0	0.0	0.0
10	3.8	1.9	2.9	3.5
11	0.2	0.1	0.2	0.2
12	0.7	0.4	0.5	0.6
13	0.9	0.5	0.7	0.8
Firm Capacity[1]:	**10.3**	**5.2**	**7.7**	**9.4**

[1] Firm capacity is the system capacity with the largest well out of service. In the Applicant's system this is Well 10.

As shown above in Table 4-2, with an alternate radium treatment method to RO the proposed water supply system could provide 5.2 MGD for an ADD with 12 hour pump run times and 7.7-9.4 MGD for a MDD. However, both of these capacities are still below the proposed demands for this alternative.

4.2.2 Water Treatment Options for Deep Aquifer Wells

The zero demand increase alternative follows the same configuration for radium treatment as the Applicant's deep and shallow aquifers alternative. In these alternatives, reverse osmosis (RO) is identified as the preferred treatment alternative for three of the existing deep wells and hydrous manganese oxide (HMO) treatment for one of the existing deep wells. There are five treatment alternatives commonly considered for treating water to remove radium: RO, HMO, radium selective absorptive media, lime softening and cation exchange. The USEPA (2000) report "Update of: Technologies and Cost for the removal of Radionuclides from Potable Water Supplies" provides additional information on radium water treatment technologies.

4.2.2.1 RO treatment

RO treatment removes inorganic and organic compounds from the water supply including radium, total dissolved solids (TDS) and hardness. The treatment process results in a 10-20% loss of water as reject water. The reject water is brine that is typically discharged to the sanitary sewer system and treated through the wastewater treatment plant.

There are two water utilities in Wisconsin that have RO treatment systems, Waupun Water Utility and Stanley Water Utility. The Waupun Water Utility installed RO treatment to replace a lime softening treatment system that was used to remove radium and to reduce the hardness of the water delivered to utility customers. In a cost analysis, the Waupun Water Utility determined it was less expensive to convert to an RO treatment system than to replace the existing lime softening system. The Waupun Water Utility had an average day demand of 0.9 MGD in 2014. The Waupun wastewater treatment plant treats the reject water from the RO treatment plant.

The Stanley Water Utility has two water treatment plants, one uses cation exchange softening and the other uses an RO treatment plant for water softening. The Stanley Water Utility had an average day demand of 0.8 MGD in 2014. The Stanley wastewater treatment plant treats the reject water from the RO treatment plant.

RO treatment is used by public water systems in other nearby states to treat for radium, including approximately a dozen in Illinois, two in Indiana, thirteen in Ohio, and several in Minnesota. The size of these systems varies from much smaller to larger than the Applicant's system. Systems of a similar size to the Applicant typically discharge reject water to the sanitary sewer system. There are some public water systems that have investigated use of RO treatment and not selected the alternative due to problems with disposal of the waste (CH2M, 2015c). Reject water from RO treatment systems is addressed as part of the WPDES permit. The WPDES permit review considers the following: the volume of RO reject water, the quality of the reject water including TDS concentration, and the volume of radium in the sludge, to be disposed.

Under the proposed water supply alternatives that addition of radium treatment, the volume of deep aquifer water pumped is not proposed to increase. Thus the quantities of radium that are currently in the wastewater sludge already are approved under the Waukesha wastewater treatment plant WPDES permit should be approximately the same in the wastewater sludge under the RO treatment. Similarly, the volume of inorganics that pass through the wastewater treatment plant from the deep aquifer water would remain the same. If concentrations of radium or TDS increase, then these would result in greater concentrations in the reject water and may affect the Applicant's WPDES permit.

When evaluating costs for adding RO treatment to implement the zero demand increase alternative, the department estimates capital costs[3] to be $13.8 million for an 18-hr MDD well capacity (5.3 MGD), with an operation and maintenance (O&M) cost of $0.43/thousand gallons for treatment.

4.2.2.2 HMO treatment

HMO treatment removes radium, barium, iron and manganese, but does not remove hardness or TDS. The radium (or other contaminants) adsorb on to the HMO chemical and are then filtered out. These filters are periodically backwashed and the wastewater is discharged to the sanitary sewer system and treated at the wastewater treatment plant. Approximately 3-5% of water pumped is lost to the system for filter backwashing. Approximately ten Wisconsin water utilities use HMO treatment to remove radium, including the Applicant. In the deep and shallow aquifer alternative, one of the deep aquifer wells would continue to use HMO treatment. Fond du Lac Water Utility, with an average day demand in 2014 of 4.8 MGD, uses HMO treatment and is the most similar in treatment volume to the Applicant.

[3] Capital costs were obtained from the U.S. EPA 2007 Drinking Water Infrastructure Needs Survey and Assessment Cost Models adjusted to 2013 dollars for the Milwaukee, WI, region, and include materials, overhead and profit, bonds and insurance, engineering design and construction services, legal, permits, and construction contingency.

When evaluating costs for adding HMO treatment to implement the zero demand increase alternative, the department estimates capital costs[4] to be $13.8M for an 18-hr MDD well capacity (5.34MGD), with an operation and maintenance (O&M) cost of $0.43/ thousand gallons for treatment.

4.2.2.3 Lime softening

Lime softening treatment removes iron, manganese, hardness and radium. The treatment process is a chemical process that results in the formation of a waste sludge. The volume of sludge can be an issue for waste disposal. Lime softening is used by the City of Beaver Dam for radium removal.

When evaluating costs for adding lime softening treatment to implement the zero demand increase alternative, the department estimates capital costs[5] to be $23.7M for an 18-hr MDD well capacity (5.34MGD), with an O&M cost of $1.30/ thousand gallons for treatment.

4.2.2.4 Cation exchange

Cation Exchange treatment removes radium and hardness. With cation exchange, radium is adsorbed on to the resin and is then removed through regeneration with salt (the same as a home water softener removes hardness). The regeneration wastewater is a brine that includes elevated concentrations of chloride and concentrated into a brine that is discharged to the sanitary sewer and treated at the wastewater treatment plant. The chloride waste can be problematic for wastewater treatment plants and the receiving water bodies of the treated effluent. The Waukesha WWTP WPDES permit already has a variance for chloride discharge to the Fox River. Cation exchange treatment should eliminate the need for home water softeners.

When evaluating costs for adding cation exchange treatment to implement the zero demand increase alternative, the department estimates capital costs[6] to be $17.5M for an 18-hr MDD well capacity (5.34MGD), with an O&M cost of $0.55/thousand gallons for treatment.

4.2.2.1 Radium selective adsorptive media

Radium selective adsorptive media removes radium, but does not remove hardness or TDS. The adsorptive media is infrequently backwashed and so a minimal amount of wastewater is discharged to the sanitary sewer. Instead the adsorptive media is replaced when no longer able to remove radium. This media becomes a low level radioactive waste and must be disposed of at a federally licensed radioactive waste site. Radium selective adsorptive media is used by Brookfield and Pewaukee Water Utilities to treat for radium. These water utilities treated 0.7 MGD and 0.02 MGD, respectively, using radium selective adsorptive media in 2014. Fond du Lac Water Utility originally treated for radium using an adsorptive media, but switched to HMO after problems with filters installed before the media required frequent replacement.

[4] See footnote 6.
[5] See footnote 6
[6] See footnote 6

Due to the scarcity of information available for the construction and O&M costs for using radium selective adsorptive media treatment technology, these costs were not calculated for implementation of the zero demand increase alternative.

4.2.3 Impacts to surfaces waters from Existing Shallow Wells

The Applicant has three existing shallow wells. Two of these wells were installed in 2006 and the third in 2009. The shallow wells pumped 1.2 MGD and accounted for 20% of the Applicant's pumping from 2010-2014. Two of the wells are less than 250 feet from the Fox River, the third is approximately a half mile from the Fox River. Other surface water features in the area include wetlands, Genesee Creek, and Pebble Creek. The wells are located approximately 1.5 miles from each of the creeks (See section 3.4 for a description of these water bodies.)

The department calculated impacts to surface water features using the USGS Upper Fox Model projected 20 years out (See Appendix B and C for more details on the groundwater flow modeling and results). Maximum drawdown from these three wells pumping at a combined rate of 1.2 MGD is estimated to be 24 – 28 feet. Streamflow depletion in Pebble Brook, Pebble Creek, Mill Creek and Genesee Creek are estimated to be 0 – 1%. The wastewater outfall is upstream of the withdrawal wells, so the net streamflow depletion from the Fox River would be zero. 305 – 467 acres of wetlands are in the one-foot drawdown contour after a 5 year pumping period. After an additional 20 years of pumping the total of wetlands in the one-foot drawdown contour is 430 – 484 acres.

4.3 Water supply alternatives environmental effects

Section 4.2 is broken down into several subsections to evaluate the potential impacts of each of the water supply alternatives considering effects to each of the following: Lake Michigan; Fox River; Fox River tributaries; unnamed and intermittent streams; groundwater; wetlands; upland forests and grasslands; geomorphology and soils; air emissions; population; economics; land use; recreation and aesthetic resources; archeological and historic resources; public water supply and use in the City of Waukesha; and cost and energy use.

4.3.1 Deep and shallow aquifers alternative environmental effects

Note that the impacts of wastewater discharge are discussed separately in section 4.4.

4.3.1.1 Lake Michigan effects from the deep shallow aquifers supply alternative

The deep and shallow aquifer supply alternative would continue to withdraw water from the deep aquifer. The United States Geological Survey (USGS) and Wisconsin Geological and Natural History Survey (WGNHS) jointly constructed a groundwater flow model for southeast Wisconsin to understand the effects of groundwater pumping on the groundwater flow system in southeast Wisconsin. The results of this model found that deep aquifer pumping by the Applicant, along with all the other regional pumping of the deep aquifer, has changed the groundwater flow system in southeast Wisconsin. Prior to pumping of the deep aquifer the groundwater divide was in western Waukesha County and groundwater flowed toward Lake Michigan through the deep sandstone. Based on the modeling results for withdrawals similar to 2000 withdrawal rates, groundwater no longer flows towards Lake Michigan, but rather flows towards pumping centers, such as the pumping center in Waukesha County. In addition, the groundwater pumped is replenished to the deep aquifer by water that would have flowed to streams or other surface waters.

Modeling results show that 70 percent of this replenishing water comes from Mississippi River Basin surface water and 30 percent comes from Lake Michigan Basin surface waters. Lake Michigan itself accounts for approximately 4 percent of the replenishing water (Feinstein, et al.

2005, USGS, 2006) These impacts would continue under this alternative. Withdrawals from the deep aquifer with this alternative would be 4.5 MGD. This would be slightly less (16.7 percent less) than the current 5.4 MGD (2010 – 2014 average) pumping rate from the deep aquifer by the Applicant.

4.3.1.2 Fox Fiver effects from the deep and shallow aquifers supply alternative

Pebble Brook would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative. The stream crossing would be approximately 46.5 feet in length and approximately 0.08 acres in area (CH2MHill, 2013, Vol. 5, Table 6-13). The crossing would likely be accomplished by the horizontal directional drilling (HDD) or another proper construction method for stream crossings to avoid or minimize construction impacts (Section 4.4).

4.3.1.2.1 Flow and flooding effects in the Fox Fiver from the deep and shallow aquifers supply alternative

Flow

Groundwater modeling results predict a slight decrease in baseflow from current baseflow in the Fox River for this alternative. The change is due to the decrease in use of the deep aquifer (from 5.4 MGD to 4.5 MGD) and an increase in the use of the shallow aquifer (from 1.2 MGD to 4 MGD). Note that the source of water to the shallow aquifer is diverted baseflow from the Fox River and nearby tributaries to the Fox River. This water, pumped from the shallow aquifer, returns to the Fox River system via the wastewater treatment plant. However, water that is pumped from the deep aquifer does not induce water from the Fox River, and thus just augments baseflow in the Fox River. Baseflow decreases because of a decrease in the augmentation of Fox River from the deep aquifer.

In this alternative, the water supply comes from two sources. The first source is the deep aquifer. Currently, the Applicant pumps 5.4 MGD (2010-2014 average) from the deep aquifer. Under this alternative this would decrease to 4.5 MGD. All of this water is, and would continue to be, discharged to the Fox River from the WWTP. The reduction in deep aquifer pumping would result in a 0.9 MGD average annual decrease in flow to the Fox River.

The second source of water is the shallow aquifer. Water pumped from the shallow aquifer is water diverted from surface water features such as wetlands, rivers and streams. Groundwater flow models also show that 70 percent of the water pumped from the deep aquifer comes from shallow groundwater diverted from streams and rivers in the Mississippi Basin. Currently the Applicant pumps 1.3 MGD (2010-2014 average) from the shallow aquifer. With this alternative, the shallow aquifer pumping would increase to 4 MGD.

Depending on the location of additional shallow wells, groundwater modeling results predict that baseflow to the Fox River would decrease by one to two percent with this alternative (Appendix A). This reduction in baseflow is due to a decrease in the use of the deep aquifer and an increase in use of the shallow aquifer.

Flooding

This alternative would not affect flooding on the Fox River because flows would be slightly reduced. In addition, no regulatory floodplain changes are anticipated as floodplain studies look at the watershed infiltration capabilities and surface water runoff as a system. Flow changes due to point sources such as wells are not considered in the calculations. The aboveground structures associated with this alternative would be located outside the regulatory floodplain.

4.3.1.2.2 Water quality effects in the Fox River from the deep and shallow aquifers supply alternative

Supply and pipeline effects

This alternative would include new water supply treatment plants and pump stations that could impact over 30 acres and could produce stormwater runoff from previously undeveloped land. The increased runoff could affect water quality in the Fox River. However, the runoff would be managed to meet the Wisconsin Department of Natural Resources' (the department) stormwater quality requirements for new development, as provided in ch.NR 151, Wis. Adm. Code, as well as local stormwater management requirements. By doing so, runoff impacts to the Fox River are anticipated to be negligible.

The Applicant would be expected to use the approved stream crossing procedures (HDD or jack and bore) and follow proper procedures through construction. These methods avoid most of the potential impacts that are a concern with pipeline crossings of waterways, as the pipeline is installed beneath the bed of the waterway (Section 4.4).

The potential for reductions to the water table in adjacent corridors of the Fox River and indirect impacts to riparian vegetation could increase the potential for runoff from unvegetated or unstable bank conditions. Increasing the sedimentation could be anticipated if bank stability and riparian vegetation are not maintained.

4.3.1.2.3 Geomorphology and sediments effects in Fox River from the deep and shallow aquifers supply alternative

Supply effects

Groundwater modeling results predict one to two percent baseflow reduction from current baseflow in the Fox River from this alternative (Appendix A). This reduction would likely not affect Fox River geomorphology and sediments.

Pipeline effects

The HDD pipeline crossing of the Fox River, following proper drilling procedures, would likely not result in impacts to Fox River geomorphology and sediments. Use of other crossing methods would result in temporary disruption and require restoration and stabilization of stream bed and banks. Construction trenches through streams are filled with clean, stabile materials like rock while banks have topsoil replaced.

4.3.1.2.4 Flora and fauna (including T/E/SC) effects in the Fox River from the deep and shallow aquifers supply alternative

Supply effects

The slight flow reduction in the Fox River could have a minimal impact on the flora and fauna of the River. This reduction in flow could stress the biological community of the Fox River by reducing habitat, impacting water quality and increasing water temperature. If tributary streams (Pebble Brook, Pebble Creek, Mill Creek, Mill Brook and Genesee Creek) experience flow reductions, flow reduction in the Fox River could be cumulative, as these waterways are largely influenced by groundwater. Increased water temperature could occur because less cold groundwater would seep into the tributaries because of the proposed shallow aquifer pumping. The temperature in the lower flow remaining in the tributaries then further increases from solar radiation. Effects would especially be felt during low flow periods when groundwater baseflow accounts for most of the flow to these tributaries.Lower flow conditions could also increase stresses to macroinvertebrate populations including mussels. Reduced baseflow could alter the environment that the macroinvertebrate community depends upon (increasing competition, predation, etc.).

Baseflow reduction would likely impact semi-aquatic mammal species including beavers, muskrats, otters, and mink. Increased depth to groundwater would cause a change in wetland type, therefore impacting mammal species that rely on a variety of wetland types that have surface water throughout the year. The slight flow reduction in the Fox River would not likely affect any mammal species in the Fox River or its associated habitats.

Pipeline effects

The HDD pipeline crossing of the Fox River, following proper drilling procedures, would likely not result in impacts to Fox River flora and fauna. However, use of other crossing methods would temporarily restrict aquatic organism movements, would present some stress to organisms due to suspended sediments, and possibly result in an Incidental Take Permit (ITP) if take cannot be avoided. Short term impacts from a proposed open cut crossing could decrease or shift macroinvertebrate populations; however, they could quickly reestablish populations (macroinvertebrate drift) within the restored stream bed if crossings were completed successfully. Fish would temporarily move out of the construction zone, while the less mobile organisms like mussels and fish eggs would be destroyed in the immediate construction zone. Options such as mussel relocation and timing of the project may prevent these impacts and the need for an ITP. Recolonization of the construction zone may occur as the stream bed returns to a more natural condition through normal sedimentation over time. Recently disturbed areas in the riparian corridor would be more susceptible to the invasive species and should be managed accordingly. There are other special concern species that may be present at this crossing and avoidance/minimization measures would be recommended.

4.3.1.3 Fox River tributaries environmental effects from the deep and shallow aquifers supply alternative

Proposed Pipeline

Pebble Brook would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative. The stream crossing would be approximately 46.5 feet in length and approximately 0.08 acres in area (CH2MHill, 2013, Vol. 5, Table 6-13). The crossing would likely be accomplished by the horizontal directional drilling (HDD) or another proper construction method for stream crossings to avoid or minimize construction impacts (Section 4.4).

4.3.1.3.1 Flow and flooding effects in Fox River tributaries from the deep and shallow aquifers supply alternative

Flow

Shallow groundwater pumping would draw down the aquifer, lowering the water table and decreasing groundwater discharge to Pebble Brook, Pebble Creek, Genesee Creek and Mill Creek. Detailed groundwater modeling assessed the potential adverse environmental impacts to these creeks (Table 4-3).

Flooding

Shallow groundwater pumping from this alternative would not affect flooding on the cold water streams, because flows in these inland waterways would not increase. No regulatory floodplain changes are anticipated as floodplain studies look at the watershed infiltration capabilities and surface water runoff as a system. Flow changes due to point sources such as wells are not considered in the calculations.

Table 4-3. Modeled baseflow reductions from shallow wells near Pebble Brook and the Fox River. See Appendix B for groundwater flow modeling summary. Mill Brook is not listed in this table as it is outside of the model domain.

	Flow Reduction	
Stream	Wells near Pebble Brook	Wells near Fox River
Pebble Brook	18-19%	2-3%
Pebble Creek	0-1%	1%
Mill Creek	0-1%	0%
Genesee Creek	1%	1-2%

4.3.1.3.2 Water quality effects in Fox River tributaries from the deep and shallow aquifers supply alternative

Supply effects

Lower baseflows in these cold water streams could lead to warmer temperatures and potential temperature impairment in Pebble Brook, Pebble Creek, Mill Brook, Genesee Creek and Mill

Creek with this alternative. More effects due to increased temperature are discussed in the flora and fauna section below.

Pipeline effects

The Applicant would be expected to use the approved stream crossing procedures (HDD or jack and bore) and follow proper procedures through construction. These methods avoid most of the potential impacts that are a concern with waterway pipeline crossings, as the pipeline is installed beneath the bed of the waterway (Section 4.4).

4.3.1.3.3 Geomorphology and sediments effects in Fox River tributaries from the deep and shallow aquifers supply alternative

Supply Effects

Reduced baseflows in Pebble Brook, Pebble Creek, Mill Brook and Mill Creek and Genesee Creek could result in smaller channel dimensions over time with this alternative, but are not expected to do so because channel morphometric stability is associated primarily with larger channel-forming flows, generally those flow and flood events having a recurrence interval of one to two years.

Pipeline effects
The HDD pipeline crossing, using proper drilling methods, would likely not result in impacts to the geomorphology and sediments of these tributaries. Use of other crossing methods would result in temporary disruption and require restoration and stabilization of stream bed and banks. Construction trenches through streams are often filled with clean, stabile materials like rock while banks have topsoil replaced (Section 4.4).

4.3.1.3.4 Flora and fauna effects in Fox River tributaries from the deep and shallow aquifers supply alternative

Supply effects

Reductions in baseflow to Pebble Brook, Pebble Creek, Mill Creek, Mill Brook and Genesee Creek could reduce habitat, impact water quality and increase temperature, stressing the cold water species present in these streams. Increased water temperature could occur because less cold groundwater would be available as groundwater discharge decreases from the proposed shallow aquifer pumping. Groundwater discharge provides cool-water environments that protect fish from excessively warm stream temperatures during the summer, and conversely, relatively warm groundwater discharge can protect against freezing of the water during the winter. The temperature in the lower flow remaining in the waterway then further increases from solar radiation. The coldwater species brown trout, mottled sculpin as well as one state threatened fish species would be affected by reduced flows and increased water temperature. Coolwater species including northern pike and walleye would also be negatively affected as a result of reduced baseflow of the coldwater tributaries which provide seasonal cool water refuge and nursery habitat. Effects would especially be felt during low flow periods when groundwater baseflow accounts for most of the flow (Diebel et al., 2014).

Low flow conditions can also increase stresses to macroinvertebrate populations including mussels. Reduced baseflow could alter the environment that the macroinvertebrate community depends upon (changing competition, predation, organic decomposition, etc.). Recently disturbed areas in the riparian corridor would be more susceptible to the invasive species and should be managed accordingly.

Baseflow reduction would also likely impact semi-aquatic mammal species including beavers, muskrats, otters, and mink. Increased depth to groundwater would cause a change in wetland type, therefore impacting mammal species that rely on a variety of wetland types that have surface water throughout the year.

Pipeline effects

The HDD pipeline crossing of Pebble Brook, following proper drilling procedures, would likely not result in impacts to Pebble Brook flora and fauna. However, use of other crossing methods would temporarily restrict aquatic organism movement, would present some stress to organisms due to suspended sediments, and possibly result in an Incidental Take Permit (ITP) if take cannot be avoided. Mobile organisms like fish would temporarily move out of the construction zone, while the less mobile organisms like mussels or fish eggs would be destroyed in the immediate construction zone. Options such as mussel relocation and timing of the project may prevent these impacts and the need for an ITP. Recolonization of the construction zone may occur as the stream bed returns to a more natural condition through normal sedimentation over time. There are other special concern species that may be present at this crossing and avoidance/minimization measures would be recommended.

4.3.1.4 Unnamed and intermittent streams environmental effects from the deep and shallow aquifers supply alternative

Shallow groundwater pumping would minimally affect area unnamed and intermittent streams, ditches and canals by lowering of the water table, decreases in groundwater availability to discharge to these resources and increase in outflow from these resources to the ground. Two intermittent streams (WBIC 5037071, WBIC 771200) would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative. One intermittent stream (WBIC 5037071) would have a pipeline crossing length of approximately 17.4 feet, and an approximate area of 0.03 acres. The other stream (WBIC 771200) would have an approximate pipeline crossing length of 11.6 feet and an approximate area of 0.02 acres (CH2MHill, 2013, Vol. 5, Table 6-13). These crossings may be accomplished by the open cut method if the crossings can be completed under no-flow conditions. Crossing these streams under no flow conditions would likely result in impacts only during construction and restoration. Bed and banks would be required to be restored to preconstruction profiles, and the construction zone topsoil replaced, stabilized and revegetated. If crossed under flowing conditions, some temporary sediment suspension and downstream sedimentation is expected until the bed and banks are restored, stabilized and revegetated.

Other crossing methods would be used if the streams must be crossed while flowing (Section 4.4). These two tributaries could be susceptible to short term impacts from a proposed open cut crossing, which would cause short term impacts that range from a decrease in macroinvertebrate populations. However, they could quickly reestablish populations (macroinvertebrate drift) within the restored stream bed if crossings were completed successfully. Mussel populations would most likely be the most affected by open channel crossings as they are unable to relocate quickly. Relocation of existing mussel populations could help reduce effects of the stream crossing construction on the species. Resident fish population would relocate in the short term during construction and almost immediately return upon completion of the project.

Recently disturbed areas in the riparian corridor would be more susceptible to the invasive species and should be managed accordingly.

4.3.1.5 Groundwater effects from the deep and shallow aquifers supply alternative

The aquifers that would be used for this water supply alternative include the unconsolidated sand and gravel aquifer (shallow aquifer) and the Cambrian-Ordovician sandstone aquifer (deep aquifer).

Construction impacts to shallow aquifers resulting from construction and placement of a 30-inch water main from new water treatment plants to the City and of 8-inch to 20-inch pipelines generally less than 10 feet deep from the well field to the water treatment plants are expected to be minor. Temporary impacts may include short-duration trench dewatering efforts. It is anticipated that the shallow aquifers would return to preconstruction conditions following construction. Long term impacts could occur if pipe trenching allows the redirection of subsurface flows, especially in wetlands and at stream crossings.

4.3.1.5.1 Groundwater quantity effects from the deep and shallow aquifers supply alternative

Long-term water withdrawal from the deep and shallow aquifers would result in a slower recovery rate for the deep aquifer and a decrease in shallow aquifer water levels.

Groundwater modeling results predicted a maximum drawdown of 14 to 22 feet in the shallow aquifer (Appendix B). Deep aquifer modeling was not conducted because the Applicant currently uses the aquifer and the performance is well known. Impacts of groundwater withdrawals on surface waters and other natural resources are described later in this section.

Water withdrawals from the deep aquifer in this alternative are predicted to be 0.9 MGD less than the current average annual withdrawals. Water levels in the deep aquifer have been recovering from the lows observed in the late 1990s. A further decrease in the pumping rates from the deep aquifer should continue this trend. However, the deep aquifer water levels are dependent on the regional pumping from this aquifer, not only the pumping from the Applicant.

4.3.1.5.2 Groundwater quality effects from the deep and shallow aquifers supply alternative

Deep aquifer water quality is expected to continue to have concentrations of radium and gross alpha above the state and federal drinking water standards under this alternative. This water would need to be treated or blended to meet both state and federal drinking water standards. There are no other known water quality changes that would occur in the shallow aquifer if it continues to be used as a water supply source.

4.3.1.5.3 Springs effects from the deep and shallow aquifers supply alternative

Springs represent points on the landscape where groundwater discharges to the land surface or to a surface water body. One spring exists within the one-foot groundwater drawdown contour. Maps depicting the Wisconsin Geological and Natural History Service spring inventory were reviewed and compared to the groundwater drawdown to see which springs may be affected

(WGNHS, 2010, and CH2MHill, 2013, Vol. 5, Appendix 6-3). One spring with a recorded flow rate of 0.09 cfs is located within the one foot drawdown contour and may be impacted by this alternative. Pumping from the shallow aquifer may lead to reductions in spring flow, a change in springflow from perennial to ephemeral, or elimination of springs altogether. Pumping from the shallow aquifer may also affect the amount of flow from different sources, thus affecting the chemical composition of the spring water.

4.3.1.6 Wetland effects from the deep and shallow aquifers supply alternative

Wetlands are sensitive to the effects of groundwater pumping. Groundwater pumping can affect wetlands not only as a direct result of progressive lowering of the water table, but also indirectly by increased seasonal changes in the altitude of the water table. The effects on the wetland environment from changes to the hydroperiod may depend greatly on the time of year at which the effects occur. For example, lower than usual water levels during the non-growing season might be expected to have less effect on the vegetation than similar water-level changes during the growing season. The effects of pumping on seasonal fluctuations in groundwater levels near wetlands add a new dimension to the usual concerns about sustainable development that typically focus on annual withdrawals (Bacchus, 1998). The department's groundwater modeling results estimate from 910 to 1036 acres of wetlands with a projected drawdown of one foot or more with a well configuration that includes shallow wells adjacent to Pebble Brook. When this alternative is configured with shallow wells only adjacent to the Fox River, the groundwater modeling results estimate 804 to 1069 acres of wetland with a projected drawdown of one foot or more (Appendix B). The degree of impact on wetlands from groundwater drawdown and lowering of the water table would vary depending on the wetland type, proximity to the zone of drawdown, severity of drawdown, frequency and amount of rainfall. The impacts could vary from total loss of all wetland functions to a shift from one wetland type to another. The degree of impact is dependent on a variety of factors including the hydrologic category of the wetland. Wetlands with saturated soils with no prolonged period of inundation are most vulnerable to conversion to uplands. Of these wetland types the depth of the capillary fringe, determined by the soil type, will also affect the susceptibility of the wetland to conversion to upland. The capillary fringe is typically one foot or less for all soil types. For wetlands with no prolonged period of inundation, it is reasonable to assume that these wetlands will convert to uplands (Table 4-4).

Table 4-4.Ground water drawdown in wetlands of one foot or greater from the deep and shallow aquifers supply alternatives (Source: DNR data, Total acreage is in Appendix B)

	Drawdown of 1 ft. or more in wetlands (ac)					
Alternative	**Emergent/wet meadow**	**Scrub/shrub**	**Forested**	**Open water**	**Flats**	**Total**
Wells adjacent to Pebble Creek	229-276	294-382	321-304	35-37	29-35	**910-1036**
Wells adjacent to Fox River only	177-252	330-450	128-235	35-46	26-191	**804-1069**

Table 4-5 lists wetland crossing acreages from the pipeline associated with this alternative.

Table 4-5. Wetland crossing acreages from the pipeline associated with this alternative (Source: WWI-layer, CH2MHill, 2013, Vol. 5, Table 6-42)

No.	Type	Width*	Acre
7963	Emergent/wet meadow	556.9	1.6
7982	Emergent/wet meadow	597.2	1.83
8111	Flats/unvegetated wet soil	-	0.01
8122	Scrub/shrub	-	0.13
8129	Scrub/shrub	474.7	1.34
8146	Scrub/shrub	872.4	1.5
8178	Scrub/shrub	480.3	0.83
8197	Scrub/shrub	526.8	0.71
8246	Scrub/shrub	-	0.07
8263	Scrub/shrub	283.3	0.58
8315	Forested	-	0.02
8325	Forested	-	0.02
8392	Forested	-	0.84
8395	Forested	235.7	0.4
8399	Forested	611.9	0.95
8401	Forested	-	0.01
	Totals	**4639.2**	**10.84**

*Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland. Because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts.

Two palustrine emergent (PEM) wetlands, seven palustrine scrub-shrub (PSS) wetlands, six palustrine forested (PFO) wetlands, and one flat/unvegetated wetland would be affected by the pipeline construction or aboveground structures proposed as part of this alternative. A total of 10.84 acres of wetland would be affected. Above ground structures would affect four acres of wetland.

The temporary removal of wetland vegetation is a primary impact of pipeline construction. Wetland crossings would be required to be restored to original contours, topsoil replaced and revegetated. Construction also would temporarily diminish the recreational and aesthetic value of the wetlands crossed. These effects would be greatest during and immediately following construction. However, wetland invasive species may become more dominant in wetlands that become disturbed as a result of reduced ground water influence.

In wet meadow/emergent wetlands, the impact of construction would be relatively brief, since herbaceous vegetation typically regenerates within one or two seasons. In forested and shrub-dominated wetlands, the impact would last longer due to the longer recovery period of these vegetation types. Long term vegetation management over the pipeline to allow access and inspection would prevent regeneration of tree and shrub cover.

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be less than 0.1 acre of wetland type change from forested to emergent associated with this alternative.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code. Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

4.3.1.6.1 Vernon Marsh effects from the deep and shallow aquifers supply alternative

Supply effects

A related effect of surface groundwater pumping is the lowering of groundwater levels below the depth that streamside or wetland vegetation needs to survive. The overall effect is a loss of riparian and/or wetland vegetation and associated wildlife habitat. Wetland acres affected by shallow aquifer withdrawals in the Vernon Marsh are included in the wetland totals above. Wetland invasive species may become more dominant in wetlands that become disturbed as a result of reduced ground water influence. Construction of facilities for the deep and shallow aquifers supply alternative would directly affect 1.25 acres of the Vernon Marsh Wildlife areas if constructed as proposed by the Applicant (CH2MHill, 2013, Vol. 5, Table 6-56).

Pipeline effects

The temporary removal of wetland vegetation is a primary impact of pipeline construction and right-of-way maintenance activities. Construction also would temporarily diminish the recreational and aesthetic value of the wetlands crossed. These effects would be greatest during and immediately following construction. In wet meadow/emergent wetlands, the impact of construction would be relatively brief, since herbaceous vegetation regenerates within one or two seasons. In forested and shrub-dominated wetlands, the impact would last longer due to the longer recovery period of these vegetation types. Long-term vegetation management over the pipeline to allow access and inspection would prevent regeneration of tree and shrub cover. Plant diversity and other wetland functional values may decrease if invasive wetland plants become established as a result of lowered ground water levels.

4.3.1.6.1.1 Flora and fauna effects on Vernon Marsh from the deep and shallow aquifers supply alternative

This level of groundwater drawdown would likely result in wetland habitat type changes. Species changes, habitat changes or destruction could occur when groundwater levels are lowered below that needed for wetland plant species. Vernal pool habitat is also very susceptible to changes in water depth, and lowered groundwater levels could reduce the occurrence or duration of this seasonal habitat where it exists within the groundwater drawdown zone. Because of this, significant adverse impacts could occur to the rare species that are known to use Vernon Marsh's wetland and waterway habitats. While it does not appear that protected species would be impacted with the pipeline installation, recommended avoidance and minimizations measures could be made for the non-protected rare species.

Calcareous fen occurs in the southern end of the Vernon Marsh Wildlife Area, but is not within the predicted area of groundwater drawdown. Consequently, no known calcareous fens would be impacted by the anticipated drawdown.

Wetland invasive species may become more dominant in wetlands that become disturbed as a result of reduced ground water influence. See also the discussions of effects on forested and open wetlands below.

4.3.1.6.1.2 Forested and scrub/shrub wetlands (other than Vernon Marsh) effects from the deep and shallow aquifers supply alternative

Wetland trees have a morphological adaptation to survive in wet soil conditions. When wet soils are exposed to air for several years, the tree subcanopy and canopy would show signs of stress, the soil can subside, and trees topple as a result of reduced soil strength. With the loss of trees, the habitat would be less suitable for nesting and denning. Animal food source changes (different plant seeds/berries) may also occur, which may affect mammals, birds, or reptiles.

A pipeline crossing a forested or scrub/shrub wetland would have a permanent wetland type change across the pipeline maintenance width because maintenance would include managing woody vegetation. Consequently, pipeline maintenance would cause a shift from forested or scrub/shrub wetland to emergent marsh or wet meadow wetland type.

4.3.1.6.1.3 Open wetlands (other than Vernon Marsh) effects from the deep and shallow aquifers supply alternative

A prolonged or permanent decrease in groundwater levels of one foot or greater could lower the surface water level and soil saturation within such wetlands to such a degree that detrimental impacts to wildlife, endangered resources, and vegetative cover may occur. Impacts might include loss of habitat for invertebrates, fish, amphibians, or wading birds. Other impacts might be seen as a change in wildlife species that use the wetland, that is, with fewer wetland-dependent species present, more terrestrial species move in. Changes in herbaceous groundcover species would be observed first, followed by growth of a shrub layer. Wetland invasive species may become more dominant in wetlands that become disturbed as a result of reduced ground water influence.

Changes in groundcover could include a shift toward upland species, and upland shrubs could invade, resulting in a shift from herbaceous wetland to herbaceous/shrubby upland. In many stressed wetlands, invasive plants become established and out-compete native vegetation. Invasive exotics can include reed canary grass (*Phalaris arundinacea*), giant reed (*Phragmites communis*), and purple loosestrife (*Lythrum salicaria*).

A permanent loss of surface water would most certainly preclude fish habitat and amphibian habitat, which likely would degrade the potential for the wetland to support other wildlife that feed on fish or amphibians.

Open water and aquatic bed wetland systems, which have much deeper water and are typically a permanent year-round flooded wetland type, can retain many of the functions associated with wetlands depending on the severity with which the hydrology has been affected. Some wetland plants along open-water areas may adapt to lowered water levels by extending runners and rhizomes farther into the deeper water zones as they drain. A change in vegetation composition may also occur, in which more drought-tolerant plants become established. Within the predicted one to five foot drawdown range, the deeper systems might lose some deep-water wetland characteristics, such as waterfowl habitat, but may transition to wet meadow or marsh habitat.

Previously impacted (drained or filled) wetlands are likely to have diminished wetland functions and characteristics. Further and prolonged reductions in surface hydrology would in most situations result in complete loss of remaining functions.

The temporary removal of wetland vegetation is a primary impact of pipeline construction and right-of-way maintenance activities. Construction also would temporarily diminish the recreational and aesthetic value of the wetlands crossed. These effects would be greatest during and immediately following construction. In wet meadow/emergent wetlands, the impact of construction would be relatively brief, since herbaceous vegetation regenerates within one or two seasons. In forested and shrub-dominated wetlands, the impact would last longer due to the longer recovery period of these vegetation types. Long term vegetation management over the pipeline to allow access and inspection would prevent regeneration of tree and shrub cover.

4.3.1.7 Upland forest and grassland effects from the deep and shallow aquifers supply alternative

No woodlands would be affected by this alternative. This alternative would affect 6.31 acres of open lands/grasslands (CH2MHill, 2013, Vol. 5, Table 6-52).

4.3.1.8 Geomorophology and soils effects from the deep and shallow aquifers supply alternative

Proposed installation of water mains would require trenching to shallow depths of less than 10 feet. As a result, this alternative is not expected to encounter significant bedrock and would have negligible impacts to surficial geology during construction. Above ground structures associated with this alternative likely would not involve construction or excavation deeper than 10 feet. Parts of the foundations for the water treatment plants may be deeper than 10 feet below ground, but the water treatment plants are limited, nonlinear elements that would affect only a minor amount of surface area (33.2 acres for this alternative), and therefore would have only minor impacts on surficial geology.

The operational and maintenance impacts to soils are those that would occur from the proposed facilities permanently altering the land use, such as the WTP, wells, and service roads. The WTP proposed for this alternative would affect 33.20 acres, all prime farmland soils. The 11 proposed well houses would affect 38.41 acres, of which 30.96 acres, or 80.6 percent, are prime farmland. Impacts to land in active agriculture use would be much lower, however, since land uses other than agricultural occur on most of the remaining affected prime farmland soils.

4.3.1.9 Air emissions (construction and operation) effects from the deep and shallow aquifers supply alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the deep and shallow aquifers supply alternative would release an estimated 24,600 tons/yr (CO2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.3.1.10 Population effects from the deep and shallow aquifers supply alternative

All of the water supply alternatives considered population projections discussed in Section 3 of this EIS and all alternatives can meet the projected water demand. Thus, meeting the demand using any alternative source would not have any constraints on population in the City of Waukesha. No residents would be displaced by the construction or operation of the proposed project alternatives. Economic development projections are consistent under all the water supply alternatives. No low income or minority populations would be displaced in the water supply service area by the project or any of the alternatives.

4.3.1.11 Economic effects from the deep and shallow aquifers supply alternative

Projections of water demand take into account the Applicant's economy and associated water demand as it relates to the water supply service area (CH2MHill, 2013, Vol. 2). By serving the projected demand, water supply would not constrain or otherwise affect economic growth and thus be consistent with all land use planning in the water supply service area. The source of the supply does not affect the quantity; thus, all supply source alternatives are similar with respect to quantity and do not affect the local economy.

The Center of Economic Development (CED) at the University of Wisconsin-Milwaukee (UWM) found that the source of water is not a differentiating factor on development within a municipal service area (UWM, 2010, p. 19).

Construction of the infrastructure for the deep and shallow aquifers supply alternative is expected to provide economic benefits to the well and pipeline construction industries. Operational costs to the Applicant would increase incrementally as wastewater volume use increases with increasing population and economic activity in the City. Construction and operation costs would be borne by the City's residents.

4.3.1.12 Land use effects from the deep and shallow aquifers supply alternative

The deep and shallow aquifers supply would affect a total of 152.6 acres of land. Pipeline construction would impact 121.11 acres. Construction and operation of above ground facilities and access roads would affect 31.49 acres (CH2MHill, 2013, Vol. 5, Table 6-51). A total of 13.75 acres would be affected by 11 well houses, and an additional 14.74 acres would be affected by a new water treatment plant (CH2MHill, 2013, Vol. 5, Table 6-55).

The land use construction and operation acreage impacts of this alternative are listed in Table 4-6 (CH2MHill, 2013, Vol. 5, Table 6-52). Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Land use changes resulting from the operational phase of the deep and shallow aquifers supply alternative would occur because of the need for a new water treatment plant, new driveways/access roads, and aboveground structures. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use. This alternative would affect no private residences.

Table 4-6. Deep and shallow aquifers supply alternative land use impacts (Source: SEWRPC, 2000)

Land Use	Acres	Percent
Residential	10.84	7.1
Commercial & Industrial	2.18	1.43
Transportation & Communication/Utilities	77.57	50.83
Government. & Institutional	0.82	0.54
Recreational Areas	0.66	0.43
Agricultural Lands	46.53	30.49
Open Lands	6.31	4.13
Woodlands	0	0
Surface Water	0.24	0.16
Wetlands	7.46	4.89
Totals	**152.61**	**100**

*Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland acreage differs from WWI data.

Transportation

Eight percent of the pipelines for the deep and shallow aquifers supply alternative would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The only new access roads proposed would be under the deep and shallow aquifers and shallow aquifer and Fox River alluvium supply alternatives in Waukesha County. The new gravel access roads would be used for access to the well houses, during construction and operation. Access roads would be 15 feet wide, constructed only between well houses, and would not involve water body crossings. The deep and shallow aquifers supply alternative 1 would include construction of two new access roads covering three acres (CH2MHill, 2013, Vol. 5, Table 6-54). Other access would be from existing municipal roadways and trails.

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.3.1.13 Recreation and aesthetic resources effects from the deep and shallow aquifers supply alternative

Table 4-7 below summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this supply alternative (CH2MHill, 2013, Vol. 5, Table 6-56).

Table 4-7. Public or conservation lands within or adjacent to the deep and shallow aquifers supply alternative (Source: Google Earth (2009), SEWRPC (2005))

Name of Resource	Acres
Vernon Marsh Wildlife Area	1.25
American Legion Memorial Park	0.10
Fox River Park	1.40
Hillcrest Park	0.06
Spring City Soccer Club Athletic Fields	0.72
Total	**3.53**

Above ground construction-related impacts may also occur to state and local public or conservation land and natural, recreational, or scenic areas depending on the final project designs. No permanent aboveground structures are envisioned within such areas. The deep and shallow aquifers supply alternative and its associated aboveground structures (well houses and WTP) would be entirely within Waukesha County and, therefore would not impact a Coastal Zone Management Area. The well houses and water treatment plant for the deep and shallow aquifers supply alternative would be located within primarily agricultural areas, with a small amount of wetland and very limited residential areas (about 1.0 acre) impacted. If required, designs for these above-ground structures would be coordinated with local architectural requirements.

Visual impacts from the proposed supply alternatives are expected to be minor. In agricultural areas, previously disturbed easements, roadway corridors and residential properties, visual disturbance would likely be difficult to detect by the first growing season following completion of construction and surface restoration efforts. Visual impacts could result from a drawdown of the groundwater table with the deep and shallow aquifers supply alternative. Groundwater drawdown may affect areas as described above in Section 4.2.1.7, Wetlands.

4.3.1.14 Archeological and historical resources effects from the deep and shallow aquifers supply alternative

Archival investigations were conducted by The Public Service Archaeology & Architecture Program of the University of Illinois at Urbana-Champaign (PSAAP) to identify significant cultural resources within or adjacent to construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The deep and shallow aquifers supply alternative may affect nine cultural sites and two previous cultural resource surveys (CH2MHill, 2013, Vol. 5, Appendix 5-3). In addition, there are 25 National Register of Historic Places (NRHP) sites within 0.1 mile of facilities proposed for the deep and shallow aquifers supply alternative in Waukesha County (NHRP, 2010). The City intends to meet all regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.3.1.15 Public water supply and use in the City of Waukesha effects from the deep and shallow aquifers supply alternative

No changes in water use sectors are expected with a change in water supply source. Water use by residential, commercial, and industrial sectors is not dependent upon water source. Instead, water use will change over time due to varying factors such regional economic conditions, impacts from water conservation, and climatic conditions.

4.3.1.16 Costs and energy (construction and operation) effects from the deep and shallow aquifers supply alternative

The department considered costs based on a 50-year present worth analysis that includes both capital costs, long-term operation and maintenance, and assumes a six percent interest rate (Technical Review S2). The total costs associated with the deep and shallow aquifer water supply alternative (includes return flow) are estimated as $275,560,000 (Cost estimates by the applicant included operational and maintenance costs for home water softening, but the department did not consider these costs). Capital costs are estimated at $210,560,000.Capital costs were estimate in June 2013 dollars and operation and maintenance costs were estimated as $4,100,000. Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD).

Operation of the deep and shallow aquifers water supply alternative would be anticipated to use 23,700 megawatt-hours (MWh) of electricity annually. This estimate assumes future average daydemand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

The energy used in the deep and shallow aquifer water supply alternative would release an estimated 24,600 tons (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.3.2 Shallow aquifer supply alternative environmental effects

4.3.2.1 Note that the impacts of wastewater discharge are discussed separately in section 4.4.Lake Michigan effects from the shallow aquifer supply alternative

Under this water supply alternative, pumping of the deep aquifer wells for the Applicant would cease, eliminating 5.4 MGD (2010 – 2014 average) of pumping from the deep aquifer. SEWRPC and consultants estimated projected rebound to the deep aquifer using the Southern Wisconsin Regional Groundwater Model. SEWRPC projects a rebound of 270 feet if deep aquifer pumping ceased from several communities including Waukesha (SEWRPC, 2010). Consultants projected a rebound of 100 feet assuming Waukesha ceased pumping from the deep aquifer (CH2MHILL and Ruekert-Mielke, 2003). Prior to pumping of the deep aquifer the groundwater divide was in western Waukesha County and groundwater flowed toward Lake Michigan through the deep sandstone. Based on the modeling results for withdrawals similar to 2000 withdrawal rates, groundwater no longer flows towards Lake Michigan, but rather flows towards pumping centers, such as the pumping center in Waukesha County. In addition, the groundwater pumped is replenished to the deep aquifer by water that would have flowed to streams or other surface waters. Modeling results show that 70 percent of this replenishing water comes from Mississippi River Basin surface water and 30 percent comes from Lake Michigan Basin surface waters. Lake Michigan itself accounts for approximately 4 percent of the replenishing water (Feinstein, et al. 2005, USGS, 2006). Ceasing the Applicant's pumping from the deep aquifer would result in a decrease in the volume of water induced from surface waters to replenish the deep aquifer. Consequently, less groundwater flow away from Lake Michigan and Lake Michigan tributaries could occur and may result in a benefit to the Lake Michigan basin. There would be no adverse impact on the water quality, geomorphology, sediments, or flora and fauna of Lake Michigan with this alternative.

4.3.2.2 Fox River effects from the shallow aquifer supply alternative

The Fox River would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative (CH2MHill, 2013, Vol. 5, Table 6-13). The stream crossing would be approximately 342.7 feet in length and approximately 0.59 acres in area. The crossing would likely be accomplished by the horizontal directional drilling (HDD) or another proper construction method for stream crossings to avoid or minimize construction impacts (Section 4.4).

4.3.2.2.1 Flow and flooding effects in the Fox River from the shallow aquifer supply alternative

Groundwater modeling results predict a nine percent decrease in Fox River baseflow from current baseflow with this alternative (See Appendix A). The change is due to the decrease in the use of the deep aquifer (from 5.4 MGD to 0 MGD) and an increase in the use of the shallow aquifer (from 1.2 MGD to 8.5 MGD). Currently the use of the deep aquifer results in a net addition of water to the Fox River. The source of water to the deep aquifer is western Waukesha County outside of the Fox River basin where the Maquoketa Shale is not present below the ground surface. For this alternative, the sources of water to the shallow aquifer wells would be from intercepting baseflow to the Fox River and its tributaries, wetlands, lakes, and quarries, and from flow across the Fox River basin boundary. Water pumped to the shallow aquifer returns to the Fox River system via the wastewater treatment plant. However, water that is pumped from the deep aquifer does not induce water from the Fox River, and thus augments baseflow in the Fox River. Baseflow to the Fox River decreases because augmentation of the Fox River from the deep aquifer ceases. This alternative would not affect flooding on the Fox River because there would be no floodplain changes. No regulatory floodplain changes are anticipated as floodplain studies look at the watershed infiltration capabilities and surface water runoff as a system. Flow changes due to point sources such as wells are not considered in the calculations. The aboveground structures associated with this alternative would be located outside the regulatory floodplain.

4.3.2.2.2 Water quality effects in the Fox River from the shallow aquifer supply alternative

This alternative would include new aboveground structures that could impact over 50 acres and could produce stormwater runoff from previously undeveloped land (CH2MHill, 2013, Vol. 5, Table 6-51). The increased runoff may affect water quality in the Fox River. The runoff would be managed to meet the department's stormwater quality management requirements for new development in Chapter NR 151, Wis. Admin. Code*,* as well as local stormwater management requirements. By doing so, runoff impacts to the Fox River are anticipated to be negligible.

The potential for water table reductions in adjacent corridors of the Fox River and indirect impacts to riparian vegetation could increase the potential for runoff from unvegetated or unstable bank conditions. Increasing the sedimentation and water quality would be anticipated if bank stability and riparian vegetation is not maintained.

4.3.2.2.3 Geomorphology and sediments effects from the shallow aquifer supply alternative

Supply effects

Groundwater modeling results predict a nine percent baseflow reduction in the Fox River from this alternative. (See Appendix B). This reduction would likely not affect Fox River geomorphology and sediments.

Pipeline effects

The HDD pipeline crossing of the Fox River, following proper drilling procedures, would likely not result in impacts to Fox River geomorphology and sediments (Section 4.4). Use of other crossing methods would result in temporary disruption and require restoration and stabilization of stream bed and banks. Construction trenches through streams are filled with clean, stabile materials like rock while banks have topsoil replaced.

4.3.2.2.4 Flora and fauna (including TE/SC) effects in the Fox River from the shallow aquifer supply alternative

Supply effects

The flow reduction in the Fox River could have a minimal impact to the flora and fauna of the River. A baseflow reduction could reduce habitat, impact water quality and increase temperature, stressing the biological community of the Fox River in this scenario. Baseflow reduction would also be cumulative due to the baseflow reductions in Pebble Brook, Pebble Creek, Mill Creek, Mill Brook and Genesee Creek with this alternative. As these waterways are largely influenced by groundwater it would further impact the Fox River. Increased water temperature occurs because less cold groundwater would seep into the tributaries because of the proposed shallow aquifer pumping. The temperature in the lower flow remaining in the tributaries then further increases from solar radiation. Effects would especially be felt during low flow periods when groundwater baseflow accounts for most of the flow to these tributaries, thus causing increased temperature impacts and stresses to the biological community of the Fox River.

Coolwater species including walleye may also be negatively affected as a result of the cumulative reduced baseflow of the Fox River. Adult and juvenile coolwater species of the Fox River including walleye and northern pike depend upon connectivity to cold water tributaries which provide refuge during hot summer months as well as critical nursery habitat throughout the year. These lower flow conditions can also increase stresses to macroinvertebrate populations including mussels. Reduced baseflow may alter the stream environment changing the competition, predation and organic decomposition that the macroinvertebrate community depends upon.

The flow reduction in the Fox River would not likely affect any mammal species in the Fox River or its associated habitats. However, baseflow reduction would likely impact semi-aquatic mammal species including beavers, muskrats, otters, and mink. Increased depth to groundwater would cause a change in wetland type, therefore impacting mammal species that rely on a variety of wetland types that have surface water throughout the year.

Pipeline effects

Short term impacts from a proposed open cut crossing could include a decrease in most macroinvertebrate populations, however those populations could quickly reestablish (macroinvertebrate drift) within the restored stream bed if crossings were completed successfully. Mussel populations would most likely be the most affected by open channel crossings as they are unable to relocate quickly. Relocation of existing mussel populations could help reduce effects of the stream crossing construction on the species. Resident fish population would relocate in the short term during construction and almost immediately return upon completion of the project.

There are other special concern species that may be present on land at this crossing and avoidance/minimization measures would be recommended.

Recently disturbed areas in the riparian corridor would be more susceptible to invasive species and should be managed accordingly.

4.3.2.3 Fox River tributaries environmental effects from the shallow aquifer supply alternative

Pebble Brook would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative. The stream crossing would be approximately 46.5 feet in length and approximately 0.08 acres in area (CH2MHill, 2013, Vol. 5, Table 6-13). Under the Applicant's proposal, an unnamed intermittent stream would also be crossed by the pipeline for this alternative. The crossing would be about 11.6 feet long and cover about 0.02 acres. These crossings would be accomplished by one of the drilling methods outlined in Section 4.4. Shallow groundwater pumping that would occur with this alternative would affect groundwater flow to these streams.

All of these locations would be susceptible to short term impacts from a proposed open cut crossing, ranging from decreases in most macroinvertebrate populations; however, those populations could quickly reestablish (macroinvertebrate drift) within a restored stream bed if crossings were completed successfully. Mussel populations would most likely be the most affected by open channel crossings as they are unable to relocate quickly. Relocation of existing mussel populations could help reduce effects of the stream crossing construction on the species. Resident fish population would relocate in the short term during construction and almost immediately return upon completion of the project.

Recently disturbed areas in the riparian corridor would be more susceptible to invasive species and should be managed accordingly.

4.3.2.3.1 Flow and flooding effects in the Fox River tributaries from the shallow aquifer supply alternative

Flow

Shallow groundwater pumping would draw down the aquifer, lowering the water table and decreasing groundwater discharge to Pebble Brook, Pebble Creek, Genesee Creek and Mill Creek. Mill Creek is a tributary to Pebble Brook. For purposes of this EIS, impacts to Mill Creek are included in the broader watershed context of Pebble Brook. Detailed groundwater modeling describes the potential environmental impacts to these creeks (Table 4-6, Technical Review S2 Appendix, 2015).

Table 4-8. Modeled baseflow reduction from shallow wells near Pebble Brook. See Appendix B for the groundwater flow modeling summary. Mill Brook is not listed in this table as it is outside of the model domain.

Stream	Flow reductions (percent) Wells near Pebble Creek
Pebble Brook	36-39 percent
Pebble Creek	1 percent
Mill Creek	3-5 percent
Genesee Creek	3-4 percent

Flooding

Shallow groundwater pumping from this alternative would not affect flooding on the cold water streams, because flows in these inland waterways would not increase. No regulatory floodplain changes are anticipated as floodplain studies look at the watershed infiltration capabilities and surface water runoff as a system. Flow changes due to point sources such as wells are not considered in the calculations.

4.3.2.3.2 Water quality effects in Fox River Tributaries from the shallow aquifer supply alternative

Lower baseflows in these cold water streams could lead to warmer temperatures and potential temperature impairment in Pebble Brook, Pebble Creek, Mill Brook, Genesee Creek, and Mill Creek with this alternative. Pebble Creek is listed as Impaired on Wisconsin's §303d list for temperature and this could get worse.

Pipeline effects

The Applicant would be expected to use the approved stream crossing procedures (HDD or jack and bore) and follow proper procedures through construction. These methods avoid most of the potential impacts that are a concern with pipeline crossings of waterways, as the pipeline is installed beneath the bed of the waterway (Section 4.4).

The Applicant would be expected to use the approved stream crossing procedures (HDD or jack and bore) and follow proper procedures through construction. These methods avoid most of the potential impacts that are a concern with pipeline crossings of waterways, as the pipeline is installed beneath the bed of the waterway (Section 4.4).

4.3.2.3.3 Geomorphology and sediments effects in Fox River tributaries from the shallow aquifer supply alternative

Supply effects

Reduced baseflows could result in smaller channel dimensions over time in Pebble Brook, Pebble Creek, Mill Brook, Mill Creek and Genesee Creek with this alternative, but are not expected to do so because channel morphometric stability is associated primarily with larger channel-forming flows, generally those flow and flood events having a recurrence interval of one to two years.

Pipeline effects

The HDD pipeline crossing, using proper drilling methods, would likely not result in impacts to the geomorphology and sediments of these tributaries. Use of other crossing methods would result in temporary disruption and require restoration and stabilization of stream bed and banks. Construction trenches through streams are filled with clean, stabile materials like rock while banks have topsoil replaced (Section 4.4).

4.3.2.3.4 Flora and Fauna effects in Fox River Tributaries from the shallow aquifer supply alternative

Supply effects

Baseflow reduction reduces habitat, impacts water quality, increases temperature, and stresses cold water species. Baseflow reduction would consequently adversely affect the fishery in Pebble Brook, Pebble Creek, Mill Creek, Mill Brook and Genesee Creek with this alternative. Increased water temperature occurs because less cold groundwater would seep into the waterways because of the proposed shallow aquifer pumping. Because groundwater-temperature fluctuations are relatively small compared to daily and seasonal streamflow- temperature fluctuations, groundwater discharge at a nearly constant temperature provides a stable- temperature environment for fish and other aquatic organisms. Groundwater discharge provides cool-water environments that protect fish from excessively warm stream temperatures during the summer, and conversely, relatively warm groundwater discharge can protect against freezing of the water during the winter. The temperature in the lower flow remaining in the waterway then further increases from solar radiation. The coldwater species brown trout, mottled sculpin as well as one state threatened fish species would be affected by reduced flows and increased water temperature. Coolwater species including northern pike and walleye would also be negatively affected as a result of reduced baseflow of the coldwater tributaries which provide seasonal coolwater refuge and nursery habitat. Effects would especially be felt during low flow periods when groundwater baseflow accounts for most of the flow (Diebel, 2014).

Low flow conditions can also increase stresses to macroinvertebrate populations including mussels. Reduced baseflow and constriction of these stream changes the competition, predation and organic decomposition can all alter the environment that the macroinvertebrate community depends upon.

The flow reduction in Fox River tributaries would not likely affect any mammal species in the Fox River or its associated habitats. However, baseflow reduction would likely impact semi-aquatic mammal species including beavers, muskrats, otters, and mink. Increased depth to groundwater would cause a change in wetland type, therefore impacting mammal species that rely on a variety of wetland types that have surface water throughout the year.

Pipeline effects

The HDD pipeline crossing the Fox River tributary streams could be susceptible to short term impacts from a proposed open cut crossing would cause short term impacts such as a decrease in most macroinvertebrate populations. However, those populations could quickly reestablish (macroinvertebrate drift) within a restored stream bed if crossings were completed successfully. Mussel populations would most likely be the most affected by open channel crossings as they are unable to relocate quickly. Relocation of existing mussel populations could help reduce effects of the stream crossing construction on the species. Resident fish populations would relocate in the short term during construction and almost immediately return upon completion of the project. Recently disturbed areas in the riparian corridor would be more susceptible to invasive species and should be managed accordingly.

4.3.2.4 Unnamed and intermittent streams environmental effects from the shallow aquifer supply alternative

Shallow groundwater pumping would minimally impact area unnamed and intermittent streams, ditches and canals by lowering the water table, decreasing groundwater availability to discharge to these resources and increasing outflow from these resources to the ground.

Two intermittent streams (WBIC 5037071, WBIC 771200) would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative. One intermittent stream (WBIC 5037071) would have a pipeline crossing length of approximately 17.4 feet, and an approximate area of 0.03 acres. The other stream (WBIC 771200) would have an approximate pipeline crossing length of 11.6 feet and an approximate area of 0.02 acres (CH2MHill, 2013, Vol. 5, Table 6-13). These crossings may be accomplished by the open cut method if the crossings can be completed under no-flow conditions. Crossing these streams under no flow conditions would likely result in impacts only during construction and restoration. Bed and banks would be required to be restored to preconstruction profiles, and the construction zone topsoil replaced, stabilized and revegetated. If crossed under flowing conditions, some temporary sediment suspension and downstream sedimentation is expected until the bed and banks are restored, stabilized and revegetated.

Other crossing methods would be used if the streams must be crossed while flowing (see Section 4.4). These two tributaries could be susceptible to short term impacts from a proposed open cut crossing such as a decrease in macroinvertebrate populations. However, those populations could quickly reestablish (macroinvertebrate drift) within a restored stream bed if crossings were completed successfully. Mussel populations would most likely be the most affected by open channel crossings as they are unable to relocate quickly. Relocation of existing mussel populations could help reduce effects of the stream crossing construction on the species.

Resident fish population would relocate in the short term during construction and almost immediately return upon completion of the project.

Recently disturbed areas in the riparian corridor would be more susceptible to invasive species and should be managed accordingly.

4.3.2.5 Groundwater effects from the shallow aquifer supply alternative

Effects of the shallow aquifer supply alternative on groundwater resources would be entirely within Waukesha County in the sand and gravel aquifer (shallow aquifer). Construction impacts to shallow aquifers resulting from construction and placement of a 30-inch water main from new water treatment plants to the City and of eight to 20 inch pipelines generally less than 10 feet deep from the well field to the water treatment plants are expected to be minor. Temporary impacts may include short-duration trench-dewatering efforts. It is anticipated that the shallow aquifers would return to preconstruction conditions following construction. Long term impacts could occur if pipe trenching allows redirection of subsurface flows, especially in wetlands and at stream crossings (Section 4.4).

4.3.2.5.1 Ground water quantity effects from the shallow aquifer supply alternative

Groundwater modeling results for the shallow aquifer supply alternative found a maximum drawdown of 54 to 77 feet in the shallow aquifer (Appendix B). Impacts of groundwater withdrawals on surface waters and other natural resources are described in other parts of this section. The extent of shallow aquifer groundwater drawdown is shown in the maps in the EIS, Appendix B.

Water withdrawals from the deep aquifer would stop with this alternative resulting in a 5.4 MGD decrease in withdrawal from the current withdrawal amount. Water levels in the deep aquifer have been recovering from the lows observed in the late 1990s. Cessation of pumping from the deep aquifer by the Applicant should continue the trend of aquifer recovery and possibly accelerate the recovery. However, the deep aquifer water levels are dependent on the regional pumping from this aquifer, not only the pumping from the Applicant.

4.3.2.5.2 Groundwater quality effects from the shallow aquifer supply alternative

There are no known groundwater quality changes that would occur in the shallow aquifer if they were used as a water supply source.

4.3.2.5.3 Spring effects from the shallow aquifer supply alternative

Springs represent points on the landscape where groundwater discharges to the land surface or to a surface water body. One to three springs exist within the modeled one-foot groundwater drawdown contour (See Appendix B). The springs possibly affected include WGNHS spring numbers 680253 (0.0891 cfs), 680257 (0.0668 cfs), and 680240 (0.0446 cfs) (Macholl, 2007). These springs may be impacted by this alternative (CH2MHill, 2013, Vol. 5, Appendix 6-3 for map of springs). Pumping from the shallow aquifer may lead to reductions in spring flow, a change in springflow from perennial to ephemeral, or elimination of springs altogether. Pumping from the shallow aquifer may also affect the amount of flow from different sources, thus affecting the chemical composition of the spring water.

4.3.2.6 Wetland effects from the shallow aquifer supply alternative

Wetlands are sensitive to the effects of groundwater pumping. Groundwater pumping can affect wetlands not only as a direct result of progressive lowering of the water table, but also indirectly by increased seasonal changes in the altitude of the water table. The effects on the wetland environment from changes to the hydroperiod may depend greatly on the time of year at which the effects occur. For example, lower than usual water levels during the non-growing season might be expected to have less effect on the vegetation than similar water-level changes during the growing season. The effects of pumping on seasonal fluctuations in ground-water levels near wetlands add a new dimension to the usual concerns about sustainable development that typically focus on annual withdrawals (Bacchus, 1998). Groundwater modeling results estimate 1939 to 2326 acres of wetlands within a projected drawdown of one foot or more for the shallow aquifer water supply alternative (Appendix B). The degree of impact on wetlands from groundwater drawdown and the lowering of the water table would vary depending on the wetland type, proximity to the zone of drawdown, severity of drawdown, frequency and amount of rainfall. The impacts could vary from total loss of all wetland functions to a shift from one wetland type to another. The degree of impact is dependent on a variety of factors including the hydrologic category of the wetland. Wetlands with saturated soils with no prolonged period of inundation are most vulnerable to conversion to uplands. Of these wetland types the depth of the capillary fringe, determined by the soil type, will also affect the susceptibility of the wetland to conversion to upland. The capillary fringe is typically one foot or less for all soil types. For wetlands with no prolonged period of inundation, it is reasonable to assume that these wetlands will convert to uplands. See Table 4-9.

Table 4-9. Groundwater drawdown in wetlands of one foot or greater from the shallow aquifer supply alternative (WDNR data)

Drawdown of 1 ft. or more in wetlands (ac)					
Emergent/wet meadow	**Scrub/shrub**	**Forested**	**Open water**	**Flats**	**Totals**
473 - 526	731 - 921	643 - 768	47 - 56	44-55	**1939 - 2326**

Table 4-10 lists the wetland crossing acreages associated the pipeline of this alternative.

Table 4-10. Wetland crossings of the shallow aquifer supply alternative (Source: WWI layer, CH2MHill, 2013, Vol. 5, Table 6-42)

No.	Type	Width (ft)	Area (ac)
7963	Emergent/wet meadow	556.9	1.6
7982	Emergent/wet meadow	597.2	1.83
8044	Emergent/wet meadow	—	0.52
8089	Emergent/wet meadow	58.6	0.28
8111	Flats/unvegetated wet soil	—	0.01
8122	Scrub/shrub	—	0.13
8129	Scrub/shrub	474.7	1.34
8146	Scrub/shrub	872.4	1.5
8178	Scrub/shrub	480.3	0.83
8179	Scrub/shrub	45.8	0.31
8184	Scrub/shrub	220.8	1.09
8197	Scrub/shrub	526.8	0.71
8246	Scrub/shrub	—	0.07
8249	Scrub/shrub	—	0.11
8263	Scrub/shrub	283.3	0.58
8266	Scrub/shrub	—	0.15
8303	Forested	782.9	1.34
8315	Forested	—	0.02
8324	Forested	—	1.23
8325	Forested	902.8	2.06
8392	Forested	—	0.84
8395	Forested	235.7	0.4
8399	Forested	611.9	0.95
8401	Forested	248.5	1.59
8402	Forested	213.5	2.42
Totals		**7112.1**	**21.91**

Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland. Because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts

Four palustrine emergent (PEM) wetlands, 11 palustrine scrub-shrub (PSS) wetlands, nine palustrine forested (PFO) wetlands, and one flat/unvegetated wetland would be affected by the proposed pipeline and aboveground structures. A total of 21.91 acres of wetland would be affected.

The Applicant would need to meet requirements under NR 103, Wis. Adm. Code. Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

4.3.2.6.1 Vernon Marsh effects from the shallow aquifer supply alternative

Construction of the shallow aquifer and Fox River alluvium supply alternative would affect 1.25 acres of the Vernon Wildlife Area if it were constructed as proposed (CH2MHill, 2013, Vol. 5, Table 6-56). Groundwater modeling shows groundwater level drawdown associated with this alternative (RJN Environmental Services, 2010, 2013). Drawdown relative to the VWA is shown in the maps in Vol. 5, Appendix 6-3 (CH2MHill, 2013). This level of groundwater drawdown could result in wetland habitat type changes.

4.3.2.6.2 Flora and fauna (including T/E/SC) effects on Vernon Marsh from the shallow aquifer supply alternative

This level of groundwater drawdown would likely result in wetland habitat type changes. Species changes, habitat changes or destruction could occur when groundwater levels are lowered below that needed for wetland plant species. Vernal pool habitat is also very susceptible to changes in water depth, and lowered groundwater levels could reduce the occurrence or duration of this seasonal habitat where it exists within the groundwater drawdown zone. Because of this, significant adverse impacts could occur to the rare species that are known to use Vernon Marsh's wetland and waterway habitats. While it does not appear that protected species would be impacted with the pipeline installation, recommended avoidance and minimization measures could be made for the non-protected rare species.

Calcareous fen occurs in the southern end of the Vernon Marsh Wildlife Area, in an area not predicted to be within the area of groundwater drawdown. Consequently, no known calcareous fens would be impacted by the anticipated drawdown.

See also the discussions of effects on forested and open wetlands below.

4.3.2.6.3 Forested and scrub/shrub wetland (other than Vernon Marsh) effects from the shallow aquifer supply alternative

Wetland trees have a morphological adaptation to survive in wet soil conditions. When wet soils are exposed to air for several years, the tree subcanopy and canopy would show signs of stress, the soil can subside, and trees topple as a result of reduced soil strength. With the loss of trees, the habitat would be less suitable for nesting and denning. Animal food source changes (different plant seeds/berries) may also occur, which may affect mammals, birds, or reptiles.

A pipeline crossing a forested or scrub/shrub wetland would have a permanent wetland type change across the pipeline maintenance width because maintenance would include managing woody vegetation. Consequently, pipeline maintenance would cause a shift from forested or scrub/shrub wetland to emergent marsh or wet meadow wetland type (CH2MHill, 2013, Vol.5, Table 6-43).

4.3.2.6.4 Open wetlands (other than Vernon Marsh) effects from the shallow aquifer supply alternative

A prolonged or permanent decrease in groundwater levels of one foot or greater could lower the surface water level and soil saturation within such wetlands to such a degree that detrimental impacts to wildlife, endangered resources, and vegetative cover may occur. Impacts might include loss of habitat for invertebrates, fish, amphibians, or wading birds. Other impacts might be seen as a change in wildlife species that use the wetland, that is, with fewer wetland-dependent species present, more terrestrial species move in. Changes in herbaceous groundcover species would be observed first, followed by growth of a shrub layer.

Changes in groundcover could include a shift toward upland species, and upland shrubs could invade, resulting in a shift from herbaceous wetland to herbaceous/shrubby upland. In many stressed wetlands, invasive plants become established and out-compete native vegetation. Invasive exotics can include reed canary grass (*Phalaris arundinacea*), giant reed (*Phragmites communis*), and purple loosestrife (*Lythrum salicaria*).

A permanent loss of surface water would most certainly preclude fish habitat and amphibian habitat, which likely would degrade the potential for the wetland to support other wildlife that feed on fish or amphibians.

Open water and aquatic bed wetland systems, which have much deeper water and are typically a permanent year-round flooded wetland type, can retain many of the functions associated with wetlands depending on the severity with which the hydrology has been affected. Some wetland plants along open-water areas may adapt to lowered water levels by extending runners and rhizomes farther into the deeper water zones as they drain. A change in vegetation composition may also occur, in which more drought-tolerant plants become established. Within the predicted one to five foot drawdown range, the deeper systems might lose some deep-water wetland characteristics, such as waterfowl habitat, but may transition to wet meadow or marsh habitat. Previously impacted (drained or filled) wetlands are likely to have diminished wetland functions and characteristics. Further and prolonged reductions in surface hydrology would in most situations result in complete loss of remaining functions.

4.3.2.7 Upland forest and grassland effects from the shallow aquifer supply alternative

No woodlands would be affected by this alternative. This alternative would affect 6.31 acres of open lands/grasslands (CH2MHill, 2013, Vol. 5, Table 6-52).

4.3.2.8 Geomorophology and soils effects from the shallow aquifer supply alternative

Proposed installation of water mains would require trenching to shallow depths of less than 10 feet. As a result, the proposed supply and return flow alternative structures are not expected to encounter significant bedrock and would have negligible impacts to surficial geology during construction. Aboveground structures associated with the proposed alternatives likely would not involve construction or excavation deeper than 10 feet. Parts of the foundations for the WTPs may be deeper than 10 feet below ground, but the WTPs are limited, nonlinear elements that would affect only a minor amount of surface area (up to 33.2 acres), and therefore would have only minor impacts on surficial geology.

The proposed WTP would affect 14.74 acres, all prime farmland. The 15 well houses proposed for the shallow aquifer and Fox River alluvium alternative would affect 51.26 acres, of which 50.62 acres, or 99 percent, are as prime farmland. Impacts to land in active agriculture use would be much lower, however, since land uses other than agricultural occur on most of the remaining affected prime farmland soils.

4.3.2.9 Air emissions (constructions and operation) effects from the shallow aquifer supply alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the deep and shallow aquifers supply alternative would release an estimated 22,400 tons/yr (CO2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.3.2.10 Population effects from the shallow aquifer supply alternative

All of the water supply alternatives considered population projections and can meet the projected water demand. Thus, meeting the demand using any alternative source would not have any constraints on population in the City of Waukesha. No residents would be displaced by the construction or operation of the proposed project alternatives. Economic development projections are consistent under all the water supply alternatives. No low income or minority populations would be displaced in the water supply service area by the project or any of the alternatives.

4.3.2.11 Economic effects from the shallow aquifer supply alternative

Projections of water demand take into account the Applicant's economy and associated water demand as it relates to the City's water supply service area (Vol. 2, Water Supply Service Area Plan). By serving the projected demand, water supply would not constrain or otherwise affect economic growth and thus be consistent with all land use planning. The source of the supply does not affect the quantity; thus, all supply source alternatives are similar with respect to quantity and do not affect the economy.

The Center of Economic Development (CED) at the University of Wisconsin-Milwaukee (UWM) found that the source of water is not a differentiating factor on development within a municipal service area (UWM, 2010, p. 19).

Construction of the infrastructure for the shallow aquifer and Fox River alluvium supply alternative is expected to provide economic benefits to the well and pipeline construction industries. Operational costs to the Applicant would increase incrementally as wastewater volume use increases with increasing population and economic activity in the City. Construction and operation costs would be borne by the City's residents.

4.3.2.12 Land use effects from the shallow aquifer supply alternative

The shallow aquifer and Fox River alluvium supply alternative would affect a total of 190.7 acres of land. Pipeline construction would impact 134.51 acres. Construction and operation of above ground facilities and access roads would affect 56.19 acres (CH2MHill, 2013, Vol. 5, Table 6-51). A total of 17.99 acres would be affected by 15 well houses, and an additional 33.20 acres would be affected by a new water treatment plant (CH2MHill, 2013, Vol. 5, Table 6-55). A larger water treatment plant is needed for this alternative for treatment of groundwater under the influence of surface water.

The land use construction and operation acreage impacts of this alternative are listed in Table 4-9 (SEWRPC). Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Table 4-11. Shallow aquifer supply alternative land use impacts (Source for base land use data: SEWRPC, 2000, analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	10.70	5.61
Commercial & Industrial	2.18	1.14
Transportation & Communication/Utilities	77.70	40.74
Government. & Institutional	0.82	1.43
Recreational Areas	0.66	0.35
Agricultural Lands	73.72	38.65
Open Lands	6.31	3.31
Woodlands	0.00	0.00
Surface Water	0.55	0.29
Wetlands	18.10	9.49
Totals	**190.74**	**101.01[b]**

[a] Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland acreage differs from WWI data.
[b] Includes rounding errors.

Land use changes resulting from the operational phase of the shallow aquifer and Fox River alluvium supply alternative would occur because of the need for a new water treatment plant, new driveways/access roads, and aboveground structures. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use.

This alternative would affect no private residences.

Transportation

Seven percent of the shallow aquifer supply alternative pipelines would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The only new access roads proposed would be under the deep and shallow aquifers and shallow aquifer supply alternatives in Waukesha County. The new gravel access roads would be used for access to the well houses, during construction and operation. Access roads would be 15 feet wide, constructed only between well houses, and would not involve water body crossings. The shallow aquifer supply alternative would include construction of three new access roads covering five acres (CH2MHill, 2013, Vol. 5, Table 6-54). Other access would be from existing municipal roadways and trails.

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.3.2.13 Recreation and aesthetic resources effects from the shallow aquifer supply alternative

Table 4-12 summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this supply alternative (CH2MHill, 2013, Vol. 5, Table 6-56).

Table 4-12. Public or conservation lands within or adjacent to the shallow aquifer supply alternative (Source: Google Earth (2009); SEWRPC (2005))

Name of Resource	Acres
Vernon Marsh Wildlife Area	1.25
American Legion Memorial Park	0.10
Fox River Park	1.41
Hillcrest Park	0.06
Spring City Soccer Club Athletic Fields	0.72
Total	**3.54**

Above ground construction-related impacts may also occur to state and local public or conservation land and natural, recreational, or scenic areas depending on the final project designs. No permanent aboveground structures are envisioned within such areas. The shallow aquifer supply alternative and its associated aboveground structures (well houses and water treatment plants) would be entirely within Waukesha County and, therefore would not impact a Coastal Zone Management Area.

The well houses and water treatment plant for the shallow aquifer supply alternative would be located within primarily agricultural areas, with a small amount of wetland and very limited residential areas (about 1.0 acre) impacted. If required, designs for these above-ground structures would be coordinated with local architectural requirements.

Visual impacts from the proposed supply alternatives are expected to be minor. In agricultural areas, previously disturbed easements, roadway corridors and residential properties, visual disturbance would likely be difficult to detect by the first growing season following completion of construction and surface restoration efforts.

Visual impacts could result from a drawdown of the groundwater table with the shallow aquifer supply alternative. Vernon Wildlife Area may be impacted and is described in the open wetlands section above.

4.3.2.14 Archaeological and historical resources effects from the shallow aquifer alternative

Archival investigations were conducted by The Public Service Archaeology & Architecture Program of the University of Illinois at Urbana-Champaign (PSAAP) to identify significant cultural resources within or adjacent to construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The shallow aquifer supply alternative may affect 10 cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). There are 25 National Register of Historic Places (NRHP) sites within 0.1 mile of facilities proposed for the shallow aquifer supply alternative in Waukesha County (NHRP, 2012). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.3.2.15 Public water supply and use in the City of Waukesha from the shallow aquifer supply alternative

No changes in water use sectors are expected with a change in water supply source. Water use by residential, commercial, and industrial sectors is not dependent upon water source. Instead, water use will change over time due to varying factors such regional economic conditions, impacts from water conservation, and climatic conditions.

4.3.2.16 Costs and energy (construction and operation) effects from the shallow aquifer supply alternative

The department considered costs based on a 50-year present worth analysis that includes both capital costs, long-term operation and maintenance, and a six percent interest rate (Technical Review S2, 2015). The total costs associated with the shallow aquifer water supply alternative are estimated as $350,560,000 (cost estimates by the applicant include lime softening at the water treatment plant in operational and maintenance costs; 50-year present worth). Capital costs are estimated at $210,560,000. Capital costs were estimated in June 2013 dollars, while operation and maintenance costs are estimated as $8,900,000. Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD.

Operation of the shallow aquifers water supply alternative would be anticipated to use 21,200 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

The energy used in the shallow aquifers water supply alternative would release emissions estimated at 22,400 tons (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.3.3 Lake Michigan supply alternatives environmental effects

Note that the impacts of wastewater discharge are discussed separately in section 4.4.

4.3.3.1 Common environmental effects of the Lake Michigan supply alternative

Pipeline effects

A Lake Michigan supply, regardless of the water source location would include construction of supply pipelines and a pump station.

The primary construction-related impact to Lake Michigan water quality would be elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would tend to be minimized by adhering to environmental permit conditions and BMPs designed to reduce the turbidity and erosion (see CH2MHill, 2013, Vol. 5, Appendix 5-2).

4.3.3.1.1 Lake Michigan volume effects from the Lake Michigan supply alternatives

Withdrawal from Lake Michigan with associated return flow is not anticipated to result in a significant change in Lake Michigan water levels. The proposed annual diversion represents 0.00028 percent of the volume of Lake Michigan and 0.000061 percent of the volume of the Great Lakes. These percentages exclude treated wastewater return flow to the GLB. Based on the preferred return flow alternative, 95-100 percent of the water withdrawn (using water use data from 2005-2012) would have been returned to the basin had the return flow plan been in place over that time period

4.3.3.1.2 Lake Michigan geomorphology and sediments effects from the Lake Michigan supply alternatives

The geomorphology and sediments of Lake Michigan would not be adversely affected by any Lake Michigan water supply alternative, because the supply would use existing treatment plant intakes in the lake, and no construction would occur within the lake for a water supply.

4.3.3.1.3 Lake Michigan flora and fauna effects from the Lake Michigan supply alternatives

A Lake Michigan water supply would have negligible effects on the lake's aquatic habitat. No new infrastructure is needed in Lake Michigan to provide water to Waukesha, so no construction impacts to aquatic habitat in the lake would occur. Increased pumping of water through the existing Lake Michigan communities' intake pipes would not affect aquatic organism entrainment and entrapment.

4.3.3.1.4 Fox River, Pebble Brook, Pebble Creek and Mill Brook, Vernon Marsh Flora and fauna effects from the Lake Michigan supply alternatives

Fox River baseflow at the confluence of the Fox River and Pebble Brook would be expected to decrease by approximately 11 percent with a switch to Lake Michigan supply (Appendix A). The percent decrease in baseflow decreases downstream of the Fox River and Pebble Brook confluence as additional flow enters the river system from tributaries. At the Waterford dam, the percent reduction in baseflow is reduced to 5-8% of the total baseflow (See Appendix A for a discussion of the estimated decrease in baseflow downstream of the City of Waukesha). This baseflow reduction could reduce habitat, impact water quality and increase temperature and related stresses in the biological community of the Fox River watershed. Lower flow conditions can also increase stresses on macroinvertebrate populations including mussels. Reduced baseflow of these streams can alter the environment resulting in changes of competition, predation and organic decomposition that the biological community depends upon.

This decrease would be due to the decrease in water discharged at the wastewater treatment plant that is currently discharged by the WWTP to the Fox River. With the change in water supply to Lake Michigan, the average annual water withdrawal would be returned to the Great Lakes basin. Some wastewater discharge would continue to the Fox River – approximately equivalent to the wastewater flow that enters the wastewater system from infiltration and inflow.

There would be no groundwater pumping under a Lake Michigan water supply alternative. Consequently, groundwater flows to Pebble Brook, Pebble Creek, Mill Brook, Mill Creek, Genesee Creek and Vernon Marsh would not be negatively affected. Under this alternative the Applicant would cease shallow groundwater pumping from existing shallow aquifer wells along the Fox River between Pebble Creek and Genesee Creek. These streams may see up a 2% increase in baseflow (see Appendix C) that would be beneficial to these streams.

A Lake Michigan supply, regardless of the water source, would include new aboveground pump stations. Since these structures would involve less than a quarter acre of land disturbance, operational stormwater quality impacts to the Fox River are not anticipated.

With a Lake Michigan supply, the Fox River would still receive some treated effluent from the City's wastewater treatment plant (approximately an annual average of 2-3 MGD, see Technical Review R1, 2015). Some water quality based limits for Lake Michigan return flow scenarios may be more stringent than the Fox River, and effluent added to the Fox may be of higher quality than it is currently.

4.3.3.1.5 Deep confined aquifer effects from the Lake Michigan supply alternatives

This alternative would not involve groundwater withdrawals, except for the emergency purposes (CH2MHill, 2013, Vol. 2). The proposed Lake Michigan water supply would eliminate the need for pumping the deep aquifer, which would continue to rebound in southeast Wisconsin. Withdrawal from Lake Michigan with return flow is not anticipated to result in a change in lake water levels, and thus is not expected to result in adverse effects to regional aquifer supplies influenced by Lake Michigan.

4.3.3.1.6 Geomorphology and soils effects from the Lake Michigan supply alternatives

The geomorphology and sediments of Lake Michigan would not be adversely affected by any Lake Michigan water supply alternative, because the supply would use existing treatment plant intakes in the lake, and no construction would occur within the lake for a water supply.

Proposed installation of water mains would require trenching to shallow depths of less than 10 feet. As a result, the proposed supply alternative structures are not expected to encounter significant bedrock and would have negligible impacts to surficial geology during construction. Aboveground structures associated with the proposed alternatives likely would not involve construction or excavation deeper than 10 feet. Parts of the foundations for the WTPs may be deeper than 10 feet below ground, but the WTPs are limited, nonlinear elements that would affect only a minor amount of surface area (up to 33.2 acres), and therefore would have only minor impacts on surficial geology.

4.3.3.1.7 Population effects from the Lake Michigan supply alternatives

All of the water supply alternatives considered population projections and can meet the projected water demand. Thus, meeting the demand using any alternative source would not have any constraints on population in the City of Waukesha. No residents would be displaced by the construction or operation of the proposed project alternatives. Economic development projections are consistent under all the water supply alternatives. No low income or minority populations would be displaced in the water supply service area by the project or any of the alternatives. See also section 4.6.

4.3.3.1.8 Public water supply and use effects from the Lake Michigan supply alternatives – City of Waukesha

No changes in water use sectors are expected with a change in water supply source. Water use by residential, commercial, and industrial sectors is not dependent upon water source. Instead, water use will change over time due to varying factors such regional economic conditions, impacts from water conservation, and climatic conditions.

4.3.3.2 Milwaukee supply alternative environmental effects

4.3.3.2.1 Stream crossings effects of the Milwaukee supply alternative

The water bodies that would be crossed by the estimated 75-foot-wide pipeline construction corridor for this alternative are listed in below in Table 4-11 (CH2MHill, 2013, Vol. 5, Table 6-13). All inland waterway crossings would result in construction-related impacts. Once construction is complete, the surface water crossings would be restored.

Table 4-13. Waterbody crossings of the Milwaukee supply alternative

No.	Name	Type	Width[a] (ft)	Area (ac)	Fisheries Classification[b]
1845	Poplar Creek	Perennial	16.8	0.030	Unknown
3294	Unnamed	Intermittent/ephemeral	—	0.002	—
3305	Unnamed	Intermittent/ephemeral	—	0.005	—
3315	Deer Creek	Perennial	—	0.020	WWSF
4310	Honey Creek	Perennial	—	0.002	—
22799	North Branch Root River	Perennial	—	0.170	WWSF
22800	North Branch Root River	Perennial	19.8	0.040	WWSF
Totals			**36.6**	**0.269**	

[a] Where no crossing width is included, the pipeline construction either infringes upon the adjacent surface water, based on aerial confirmation of the GIS data, or there was no surface water width information available in GIS format.

4.3.3.2.1.1 Stream water quality effects of stream crossings of the Milwaukee supply alternative

The primary construction-related impact to the water quality of affected streams would be elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed (see Section 4.4 for crossing methods). Clearing of streambanks of large trees could also lead to increased water temperatures due to lack of shady cover. Impact severity would be a function of sediment load, particle size, and duration of construction activities.

Impacts would tend to be minimized by adhering to environmental permit conditions and best management practices designed to reduce the turbidity and erosion (CH2MHill, 2013, Vol.5, Appendix 5-2).

4.3.3.2.1.2 Flora and fauna stream crossing effects of the Milwaukee supply alternative

The pipeline stream crossings of the Milwaukee supply alternative would not likely result in significant impacts on the flora and fauna assuming all stream crossing methodology procedures are properly followed. Streambank habitat could be altered and have a negative impact on aquatic or semi-aquatic organisms (for example, trees being removed, increasing stream temperature and negatively affecting fish populations). There are other special concern species that may be present on land at these crossings and avoidance/minimization measures would be recommended.

4.3.3.2.2 Wetland effects of the Milwaukee supply alternative

Table 4-14 lists the wetland crossing acreages associated with this alternative.

Table 4-14. Wetland crossings of the Milwaukee supply alternative (Source: WWI layer, CH2Hill, 2013, Vol. 5 Table 6-42)

No.	Type	Width[a] (ft)	Area (ac)
4965	Scrub/shrub	216.7	0.380
7962	Emergent/wet meadow	-	0.370
8145	Scrub/shrub	-	0.160
8239	Scrub/shrub	-	0.130
8290	Scrub/shrub	-	0.490
8465	Forested	-	0.120
8723	Emergent/wet meadow	-	0.080
8909	Scrub/shrub	-	0.300
8911	Scrub/shrub	-	0.170
8915	Scrub/shrub	-	0.001
8920	Scrub/shrub	-	0.110
8921	Scrub/shrub	-	0.140
8923	Scrub/shrub	-	0.070
9184	Forested	-	0.010
9306	Open water	-	0.010
10454	Emergent/wet meadow	-	0.020
11047	Emergent/wet meadow	313.4	0.500
11672	Scrub/shrub	-	0.020
11796	Forested	637.4	1.080
11799	Forested	1286.9	2.503
11973	Forested	-	0.002
12645	Forested	-	0.020
12650	Forested	-	0.150
12660	Forested	-	0.010
Totals		**2454.4**	**6.846**

[a] Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts

Four palustrine emergent (PEM) wetlands, 11 palustrine scrub-shrub (PSS) wetlands, eight palustrine forested (PFO) wetlands, and one open water wetland would be affected by pipeline construction. A total of 6.846 acres of wetland would be affected by pipeline construction for this alternative (CH2MHill, 2013, Vol. 5, Table 6-42). The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be approximately 5.866 acres of wetland type change from forested to emergent associated with this alternative.

There are two special concern herptile species, one crustacean, and three plant species that may be impacted that occur in wetlands. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code (water quality standards for wetlands). Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

4.3.3.2.3 Upland forests and grasslands effects of the Milwaukee supply alternative

The pipeline crossings for this alternative would affect 0.45 acres of woodlands. The pipeline crossings for this alternative would affect 7.97 acres of open lands/grasslands (CH2MHill, 2013, Vol. 5, Table 6-52).

4.3.3.2.4 Air emissions (construction and operation) effects of the Milwaukee supply alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the City of Milwaukee water supply alternative would release an estimated 13,200 tons/yr (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.3.3.2.5 Economic effects from the Milwaukee supply alternative

Projections of water demand take into account the Applicant's economy and associated water demand as it relates to the City's water supply service area (CH2MHill, 2013, Vol. 2). By serving the projected demand, water supply would not constrain or otherwise affect economic growth and thus be consistent with all land use planning. The source of the supply does not affect the quantity; thus, all supply source alternatives are similar with respect to quantity and do not affect the economy.

The CED study found that the source of water is not a differentiating factor on development within a municipal service area (UWM, 2010, p. 19).

Construction of the infrastructure for the Milwaukee supply alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant, and payments to the City of Milwaukee, would increase incrementally as water volume use increases with increasing population and economic activity in Waukesha. Construction and operation costs would be borne by Waukesha residents.

4.3.3.2.6 Land use effects from the Milwaukee supply alternative

The Milwaukee supply alternative would affect a total of 122.4 acres of land for pipeline construction. A pump station may be required, and if so is expected to impact approximately 0.25 acres (CH2MHill, 2013, Vol.5, Table 6-51).

The land use construction and operation acreage impacts of this alternative are listed in Table 4-13. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Table 4-15. Milwaukee water supply alternative land use impacts (Source for base land use data: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	3.03	2.48
Commercial & Industrial	3.29	2.69
Transportation & Communication/Utilities	97.86	80.08
Government & Institutional	0.04	0.03
Recreational Areas	2.35	1.92
Agricultural Lands	0.00	0.00
Open Lands	7.97	6.52
Woodlands	0.45	0.37
Surface Water	0.00	0.00
Wetlands	7.21	5.90
Totals [b]	**122.20**	**99.99** [c]

[a] Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory (Note: Wetland acreage differs from WWI data)

[b] Lake Michigan supply and return flow options share the same workspace for about six miles. Actual land use totals would be less than reported if a Lake Michigan supply and return flow option was selected.

[c] Includes rounding errors.

No new access roads would be required for the Lake Michigan supply alternatives. Access is anticipated to be from existing municipal roadways and trails. The residential land within the assumed 75-foot construction corridor borders roads. The majority of residential land that could be affected by the proposed alignments is described as single family low density. The construction corridor may be further minimized to avoid private property, or temporary construction easements would be obtained by the City. This alternative would affect no private residences. A single private building in Waukesha County is located within the proposed 75-foot-wide construction corridor at the terminus of the Lake Michigan supply alternatives. Based on a review of aerial photography, it appears to be used as a storage structure. The City would coordinate with the owner of the building if a Lake Michigan supply was approved and would avoid this building or minimize the construction-related impacts.

The Milwaukee supply alternative pipelines would not affect active agricultural lands. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use. No changes to zoning would be required for construction and operation of the Milwaukee supply alternative.

Transportation

Eighty percent of the Milwaukee supply alternative pipelines would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.3.3.2.7 Recreation and aesthetic resources effects of the Milwaukee supply alternative

Table 4-16 (CH2MHill, 2013, Vol. 5, Table 6-56) summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this supply alternative.

Table 4-16. Public or conservation lands within or adjacent to the Milwaukee supply alternative (Source: Google Earth, 2009, SEWRPC, 2005)

Name of Resource	Acres
Greenfield Park	0.17
Hillcrest Park	1.16
New Berlin Golf Course	1.51
Root River Parkway	21.28
Total	**24.12**

Above ground construction-related impacts may also occur to state and local public or conservation land and natural, recreational, or scenic areas depending on the final project designs. No permanent aboveground structures are envisioned within such areas. Depending upon the final booster pump station location, however, Greenfield Park could be affected. If so, impacts would be limited to approximately 0.25 acres and would be coordinated with local public officials and the public. The Milwaukee supply alternative would not impact a Coastal Zone Management Area. Visual impacts from the proposed supply flow alternatives are expected to be minor.

4.3.3.2.8 Archeological and historical resources effects of the Milwaukee supply alternative

Archival investigations were conducted by The Public Service Archaeology & Architecture Program of the University of Illinois at Urbana-Champaign (PSAAP) to identify significant cultural resources within or adjacent to construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The Milwaukee supply alternative may affect five cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.3.3.2.9 Costs and energy (construction and operation)effects of the Milwaukee supply alternative

Specific cost estimates for an alternative of obtaining Lake Michigan water by connecting to the City of Milwaukee's existing distribution system were not supplied as part of the Applicant's Environmental Report or Application. The Applicant and City of Oak Creek have entered in agreement for public water supply under a 'letter of intent' for Oak Creek to supply potable water to the Waukesha Water Utility.

Operation of the Lake Michigan water supply via Milwaukee would be anticipated to use 11,500 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.3.3.3 Oak Creek supply alternative environmental effects

4.3.3.3.1 Stream crossings effects of Oak Creek supply alternative

The water bodies that would be crossed by the estimated 75-foot-wide pipeline construction corridor for this alternative are listed in Table 4-17 (CH2MHill, 2013, Vol. 5, Table 6-13).

Table 4-17. Water body crossings of the Oak Creek supply alternative

No.	Name	Type	Width (ft)	Area (ac)	Fisheries Classification[a]
3732	Unnamed	Intermittent/ephemeral	14.3	0.02	Unknown
3932	North Branch Root River	Perennial	49.7	0.09	WWSF
5109	Unnamed	Intermittent/ephemeral	18.9	0.04	Unknown
Totals			**82.9**	**0.15**	

4.3.3.3.1.1 Water quality stream crossings effects of the Oak Creek supply alternative

The primary construction-related impact to the water quality of affected streams could be possible elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed. Increase in water temperatures due to bank clearing of large trees could also occur. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would tend to be minimized by adhering to environmental permit conditions and best management practices to reduce the turbidity and erosion (CH2MHill, 2013, Vol. 5, Appendix 5-2).

4.3.3.3.1.2 Flora and fauna stream crossings effects of the Oak Creek supply alternative

The pipeline stream crossings of the Oak Creek supply alternative would not likely result in impacts on the flora and fauna assuming proper stream crossing methods are used (Section 4.4). There are other special concern species that may be present on land at these crossings and avoidance/minimization measures would be recommended.

4.3.3.3.2 Wetland effects of the Oak Creek Supply alternative

Table 4-18 lists the wetland crossing acreages associated with this alternative.

Table 4-18. Wetland crossings of the Oak Creek supply alternative (Source: WWI layer, CH2MHill, 2013, Vol.5, Table 6-42)

No.	Type	Width[a] (ft)	Area (ac)
8714	Emergent/wet meadow	—	0.07
9020	Forested	—	0.02
9026	Forested	—	0.07
9028	Forested	—	0.01
10401	Emergent/wet meadow	—	<0.01
10573	Emergent/wet meadow	—	<0.01
11286	Scrub/shrub	—	0.01
11290	Scrub/shrub	—	0.02
11369	Scrub/shrub	—	0.02
11376	Scrub/shrub	—	0.05
11539	Scrub/shrub	—	<0.01
11896	Forested	—	0.07
11900	Forested	—	0.13
11906	Forested	—	0.03
11914	Forested	—	<0.01
12293	Forested	—	0.01
12301	Forested	—	0.01
12314	Forested	—	<0.01
12392	Forested	—	0.01
12399	Forested	—	<0.01
Totals		**—**	**0.5[b]**

[a] Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland. Because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts.
[b] Total acreage is an estimated maximum.

Three palustrine emergent (PEM) wetlands, five palustrine scrub-shrub (PSS) wetlands, and 13 palustrine forested (PFO) wetlands would be affected by pipeline construction. A total of up to 0.5 acres of wetland would be affected by pipeline construction for this alternative (CH2MHill, 2013, Vol. 5, Table 6-42).

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be less than 0.1 acre of wetland type change from forested to emergent associated with this alternative.

There are two special concern herptile species and one crustacean that occur in wetlands and may be impacted. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

4.3.3.3.3 Upland forest and grassland effects of the Oak Creek supply alternative

This alternative would affect 0.48 acres of woodlands (CH2MHill, 2013, Vol. 5, Table 6-52). There are four rare plants that occur in dry-mesic to mesic woodlands and recommended measures may be suggested in order to avoid and/or minimize impacts to this species. In addition, there is a forested natural community that runs adjacent to a portion of this route and buffers would be recommended to avoid impacts. This alternative would affect 1.18 acres of open lands/grasslands (CH2MHill, 2013, Vol. 5, Table 6-52).

4.3.3.3.4 Air emissions (construction and operation) effects of the Oak Creek supply alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the Oak Creek water supply alternative would release an estimated 15,700 tons/yr (CO2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.3.3.3.5 Economic effects of the Oak Creek supply alternative

Projections of water demand take into account the Applicant's economy and associated water demand as it relates to the City's water supply service area (Vol. 2, Water Supply Service Area Plan). By serving the projected demand, water supply would not constrain or otherwise affect economic growth and thus be consistent with all land use planning. The source of the supply does not affect the quantity; thus, all supply source alternatives are similar with respect to quantity and do not affect the economy.

The CED study found that the source of water is not a differentiating factor on development within a municipal service area (UWM, 2010, p. 19).

Construction of the infrastructure for the Oak Creek supply alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant, and payments to the City of Oak Creek, would increase incrementally as water volume use increases with increasing population and economic activity in Waukesha. Construction and operation costs would be borne by Waukesha residents.

4.3.3.3.6 Land use effects of the Oak Creek supply alternative

The Oak Creek supply alternative would affect a total of 176.8 acres of land for pipeline construction. A pump station may be required, and if so is expected to impact approximately 0.25 acres (CH2MHill, 2013, Vol. 5, Table 6-51).

The land use construction and operation acreage impacts of this alternative are listed in Table 4-19. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Table 4-19. Oak Creek water supply alternative land use impacts (Source for base land use: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	5.60	3.17
Commercial & Industrial	0.25	0.14
Transportation & Communication/Utilities	165.57	93.65
Government. & Institutional	0.36	0.2
Recreational Areas	0.25	0.14
Agricultural Lands	2.62	1.48
Open Lands	1.18	0.67
Woodlands	0.48	0.27
Surface Water	0.00	0
Wetlands	0.49	0.28
Totals[b]	**176.8**	**100**

[a] Represents the total land along each alternative that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland data differs from WWI data.
[b] Lake Michigan supply and return flow options share the same workspace for about six miles. Actual land use totals would be less than reported if a Lake Michigan supply and return flow option was selected.

The Lake Michigan City of Oak Creek supply and Root River return flow share the same workspace for about 15 miles. Actual land use totals would be less than reported if this combination of Lake Michigan supply and return flow options were selected. No new access roads would be required for the Lake Michigan supply alternatives. Access is anticipated to be from existing municipal roadways and trails.

The Oak Creek supply alternative pipelines would not affect active agricultural lands.

For this alternative, four single private buildings in the City of Franklin, Milwaukee County, are partially located within the estimated 75-foot-wide construction corridor of the proposed supply project. The pipeline corridor is planned to be within existing street rights-of-way. Impacts should be able to be minimized by adjusting the construction technique at these locations. Based on a review of aerial photography, the structures appear to be two garages, one apartment complex and one storage shed. Impacts to these structures should be avoidable. The City would coordinate with the owners of each structure, if the proposed project was approved, and would avoid these buildings or construction-related impacts. Appropriate mitigation measures would be taken to restore properties disturbed during construction. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use. No changes to zoning would be required for construction and operation of the Oak Creek supply alternative.

Transportation

Ninety four percent of the Oak Creek supply alternative pipelines would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

4.3.3.3.7 Recreation and aesthetic resources effects of the Oak Creek supply alternative

Table 4-20 summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this supply alternative.

Table 4-20. Public or conservation lands within or adjacent to the Oak Creek supply alternative (Source: Google Earth, 2009, SEWRPC, 2005)

Name of Resource	Acres
Franklin Woods Nature Center	0.65
Hidden Lakes Park	0.38
Hillcrest Park	0.04
Park Arthur	0.48
Prospect Hill School	0.62
Total	**2.17**

Above ground construction-related impacts may also occur to state and local public or conservation land and natural, recreational, or scenic areas depending on the final project designs. No permanent aboveground structures are envisioned within such areas. The Oak Creek supply alternative would not impact a Coastal Zone Management Area. Visual impacts from the proposed supply and corresponding return flow alternative are expected to be minor.

4.3.3.3.8 Archeological and historical resources effects of the Oak Creek supply alternative

Archival investigations were conducted by The Public Service Archaeology & Architecture Program of the University of Illinois at Urbana-Champaign (PSAAP) to identify significant cultural resources within or adjacent to construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The Oak Creek supply alternative may affect seven cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.3.3.3.9 Costs and energy (construction and operation) effects of the Oak Creek supply alternative

The department considered costs based on a 50-year present worth analysis that includes both capital costs, long-term operation and maintenance, and assumes a six percent interest rate (Technical Review S2, 2015). The total costs of a Lake Michigan water supply from Oak Creek and return flow to the Lake Michigan basin are estimated at $332,400,000 (50 year present worth). Capital costs are estimated at $206,400,000[7] while operation and maintenance costs are estimated as $8,000,000[8].

Operation of the Lake Michigan water supply from Oak Creek alternative would be anticipated to use 14,200 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). The energy used in the Oak Creek water supply

[7] Capital costs were estimate in June 2013 dollars, and assume a 2013 construction start.

[8] Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD.

alternative (not including return flow) would release an estimated 15,700 tons (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.3.3.4 Racine supply alternative environmental effects

4.3.3.4.1 Stream Crossings water quality effects

The primary construction-related impact to the water quality of affected streams would be elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would tend to be minimized by adhering to environmental permit conditions and best management practices designed to reduce the turbidity and erosion (CH2MHill, 2013, Vol. 5, Appendix 5-2).

The water bodies that would be crossed by the estimated 75-foot-wide pipeline construction corridor for this alternative are listed in Table 4-21 (CH2MHill, 2013, Vol. 5, Table 6-13).

Table 4-21. Water body crossings of the Racine supply alternative

No.	Name	Type	Width[a] (ft)	Area (ac)	Fisheries Classification
1845	Poplar Creek	Perennial		0.03	Unknown
3280	Poplar Creek	Perennial	—	1.09	Unknown
3333	Unnamed	Intermittent/ephemeral	—	0.07	—
3335	Unnamed	Intermittent/ephemeral	—	0.05	—
3408	Unnamed	Intermittent/ephemeral	—	0.02	—
3413	Unnamed	Intermittent/ephemeral	—	0.08	—
3432	Muskego Drainage Canal	Perennial	—	0.51	Unknown
3459	Unnamed	Intermittent/ephemeral	—	0.2	—
3484	Unnamed	Intermittent/ephemeral	—	0.02	—
3486	Unnamed	Intermittent/ephemeral	—	0.06	—
8339	Unnamed	Intermittent/ephemeral	—	0.24	—
210	Husher Creek	Perennial	2.5	0.01	—
668	Hoods Creek	Perennial	11.5	0.02	—
1827	Goose Lake Branch Canal[b]	Perennial	3.9	2.23	—
2282	Root River Canal	Perennial	35.4	0.07	—
20172	Mill Creek	Perennial	4.2	0.01	
Totals			**57.5**	**4.71**	

[a] Where no crossing width is included, the pipeline construction either infringes upon the adjacent surface water, based on aerial confirmation of the GIS data, or there was no surface water width information available in GIS format.

[b] The current theoretical project alignment for Lake Michigan–Racine Supply is parallel to the Goose Lake Branch Canal, but the actual construction corridor would be narrowed to avoid impacts to the water body.

4.3.3.4.1.1 Flora and fauna stream crossings effects

The pipeline stream crossings of the Racine supply alternative would not likely result in impacts on the flora and fauna assuming proper HDD procedures are followed. There are other special concern species that may be present on land at these crossings and avoidance/minimization measures would be recommended.

4.3.3.4.2 Wetland effects of the Racine supply alternative

A total of 56.382 acres of wetland would be affected by pipeline construction for this alternative. Twenty-nine palustrine emergent (PEM) wetlands, 29 palustrine scrub-shrub (PSS) wetlands, 15 palustrine forested (PFO) wetlands, four filled/drained, eight flats/unvegetated soil, and six open-water wetlands would be affected by pipeline construction.

Table 4-22 lists wetland crossing acreages associated with this alternative.

Table 4-22. Wetland crossings of the Racine water supply alternative (Source: WWI, CH2MHill, 2013, Vol. 5, Table 6-42)

No.	Type	Area (ac)
3	Emergent/wet meadow	0.610
4965	Scrub/shrub	0.380
7512	Scrub/shrub	0.020
7895	Open water	0.390
7962	Emergent/wet meadow	0.370
8050	Emergent/wet meadow	1.940
8126	Scrub/shrub	0.510
8139	Scrub/shrub	0.090
8145	Scrub/shrub	0.160
8168	Scrub/shrub	0.430
8183	Scrub/shrub	0.960
8188	Scrub/shrub	0.540
8192	Scrub/shrub	0.700
8239	Scrub/shrub	0.130
8290	Scrub/shrub	0.490
8338	Forested	1.140
8382	Forested	0.030
8383	Forested	0.050
8436	Forested	0.200
8465	Forested	0.120
8625	Filled/drained wetland	0.170
8632	Filled/drained wetland	0.370
8766	Emergent/wet meadow	3.230
8872	Scrub/shrub	3.460
8873	Scrub/shrub	2.720
8901	Scrub/shrub	0.470
9139	Forested	0.060
9184	Forested	0.010
9309	Scrub/shrub	2.250
9336	Emergent/wet meadow	0.220
9337	Emergent/wet meadow	0.360
9345	Emergent/wet meadow	0.400
9353	Emergent/wet meadow	0.810
9358	Emergent/wet meadow	0.001
9366	Emergent/wet meadow	0.430
9378	Emergent/wet meadow	1.850
9381	Emergent/wet meadow	0.120
9382	Emergent/wet meadow	0.100
9395	Emergent/wet meadow	0.260
9396	Emergent/wet meadow	0.550
9406	Emergent/wet meadow	0.450
9408	Emergent/wet meadow	0.150
9423	Flats/unvegetated wet soil	0.210
9432	Flats/unvegetated wet soil	0.610
9434	Flats/unvegetated wet soil	0.440
9450	Flats/unvegetated wet soil	1.840
9451	Flats/unvegetated wet soil	0.630
9457	Scrub/shrub	1.260
9459	Scrub/shrub	0.540

No.	Type	Area (ac)
9461	Scrub/shrub	0.420
9464	Scrub/shrub	1.220
9477	Scrub/shrub	0.750
9503	Forested	0.510
9531	Forested	0.030
9552	Open water	0.200
9556	Open water	0.500
9559	Open water	0.220
9561	Open water	0.050
9592	Emergent/wet meadow	0.460
9597	Emergent/wet meadow	0.260
10058	Emergent/wet meadow	0.720
10090	Emergent/wet meadow	0.260
10164	Scrub/shrub	0.020
10195	Forested	1.310
13701	Filled/drained wetland	0.050
13719	Filled/drained wetland	0.070
14241	Emergent/wet meadow	0.020
14301	Emergent/wet meadow	0.230
14655	Flats/unvegetated wet soil	0.120
15492	Emergent/wet meadow	0.210
15519	Emergent/wet meadow	0.320
15593	Emergent/wet meadow	0.120
15606	Emergent/wet meadow	0.260
15748	Emergent/wet meadow	0.360
15821	Emergent/wet meadow	0.730
16339	Flats/unvegetated wet soil	0.050
16468	Flats/unvegetated wet soil	0.660
16601	Scrub/shrub	2.030
16870	Scrub/shrub	0.680
16945	Scrub/shrub	0.860
16956	Scrub/shrub	0.001
16957	Scrub/shrub	0.260
16973	Scrub/shrub	0.140
17124	Scrub/shrub	0.720
17253	Scrub/shrub	0.180
17860	Forested	0.850
18252	Forested	0.300
18661	Forested	0.020
18669	Forested	0.750
18679	Forested	1.470
20167	Open water	0.260
Totals		**56.382**

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be approximately 19.182 acres of wetland type change from forested to emergent associated with this alternative. A state endangered bird occurs within the vicinity of this project and suitable habitat may be impacted. Required measures in order to avoid take of this species could be surveys and/or time of year restrictions. There are four other special concern wetland-dependent birds, including the bald eagle, that occur within the vicinity of the project and recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

There is an endangered herptile species that occurs within the vicinity of supply line; however, there is no suitable habitat within the 2-mile buffer of that occurrence. There are two special concern herptile species and five plant species that occur in wetlands and may be impacted. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code (water quality standards for wetlands). Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

4.3.3.4.3 *Upland forest and gr*asslands effects of the Racine supply alternative

This alternative would affect 7.74 acres of woodlands (CH2MHill, 2013, Vol. 5, Table 6-52). There are five rare plants that occur in dry-mesic to mesic woodlands and recommended measures may be suggested in order to avoid and/or minimize impacts to this species. In addition, there are two forested natural communities that run adjacent to portions of this route and buffers would be recommended to avoid impacts.

This alternative would affect 30.70 acres of open lands/grasslands (CH2MHill, 2013, Vol. 5, Table 6-52). A state endangered grassland bird occurs within the vicinity of this project and suitable habitat may be impacted. There are also two rare plants that occur in a variety of prairies and oak barrens and recommended measures may be suggested in order to avoid and/or minimize impacts to this species.

4.3.3.4.4 Air emissions (construction and operation) effects of the Racine supply alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the Racine supply alternative would release an estimated 17,500 tons/yr (CO2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.3.3.4.5 Economic effects of the Racine supply alternative

Projections of water demand take into account the Applicant's economy and associated water demand as it relates to the City's water supply service area (CH2MHill, 2013, Vol. 2). Serving the projected demand would not constrain or otherwise affect economic growth and thus be consistent with all land use planning. The source of the supply does not affect the quantity; thus, all supply source alternatives are similar with respect to quantity and do not affect the economy.

The CED study found that the source of water is not a differentiating factor on development within a municipal service area (UWM, 2010, p. 19).

Construction of the infrastructure for the Racine supply alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant, and payments to the City of Racine, would increase incrementally as wastewater volume use increases with increasing population and economic activity in Waukesha. Construction and operation costs would be borne by Waukesha residents.

4.3.3.4.6 Land use effects of the Racine supply alternative

The Racine supply alternative would affect a total of 341.6 acres of land for pipeline construction. A pump station may be required, and if so is expected to impact approximately 0.25 acres (CH2MHill, 2013, Vol. 5, Table 6-51).

The land use construction and operation acreage impacts of this alternative are listed in Table 4-22. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction. Note that Table 4-23 uses SEWRPC land use data.

Table 4-23. Racine water supply alternative land use impacts (Source for base land use data: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	**Acres[a]**	**Percent**
Residential	9.31	2.73
Commercial & Industrial	4.24	1.24
Transportation & Communication/Utilities	33.85	9.91
Government. & Institutional	0.04	0.01
Recreational Areas	3.75	1.10
Agricultural Lands	213.05	62.37
Open Lands	30.70	8.99
Woodlands	7.74	2.27
Surface Water	0.26	0.08
Wetlands	38.67	11.32
Totals[b]	**341.61**	**100.02[c]**

[a] Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory.
[b] Lake Michigan supply and return flow options share the same workspace for about six miles. Actual land use totals would be less than reported if a Lake Michigan supply and return flow option was selected.
[c] Includes rounding errors.

No new access roads would be required for the Lake Michigan supply alternatives. Access is anticipated to be from existing municipal roadways and trails.

The residential land within the assumed 75-foot construction corridor borders roads. The majority of residential land that could be affected by the proposed alignments is described as single family low density. The construction corridor may be further minimized to avoid private property, or temporary construction easements would be obtained by the City. This alternative would affect no private residences.

A single private building in Waukesha County is located within the proposed 75-foot-wide construction corridor at the terminus of the Lake Michigan supply alternatives. Based on a review of aerial photography, it appears to be used as a storage structure. The City would coordinate with the owner of the building if a Lake Michigan supply was approved and would avoid this building or minimize the construction-related impacts. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use. No changes to zoning would be required for construction and operation of the Racine supply alternative.

Transportation

Sixty nine percent of the Racine supply alternative pipeline would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.3.3.4.7 Recreation and aesthetic resources effects of the Racine supply alternative

Table 4-24, (CH2MHill, 2013, Vol. 5, Table 6-56) summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this supply alternative.

Table 4-24. Public or conservation lands within or adjacent to the Racine supply alternative (Source: Google Earth, 2009; SEWRPC 2005)

Name of Resource	Acres
Big Muskego Lake Wildlife Area (WDNR)	2.64
Cheska Farms Riding Stables (WDNR site)	2.29
WDNR designated area	5.66
Hillcrest Park	1.16
Minooka Park	8.64
Total	**20.39**

Above ground construction-related impacts may also occur to state and local public or conservation land and natural, recreational, or scenic areas depending on the final project designs. No permanent aboveground structures are envisioned within such areas. The Racine supply alternative would not impact a Coastal Zone Management Area. Visual impacts from the proposed supply alternatives are expected to be minor.

4.3.3.4.8 Archeological and historical resources effects of the Racine supply alternative

Archival investigations were conducted by The Public Service Archaeology & Architecture Program of the University of Illinois at Urbana-Champaign (PSAAP) to identify significant cultural resources within or adjacent to construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The Racine supply alternative may affect two cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.3.3.4.9 Costs and energy (construction and operation) effects of the Racine supply alternative

The Applicant did not provide cost estimates for an alternative of obtaining Lake Michigan water by connecting to the City of Racine's existing water supply system. Operation of a Lake Michigan water supply from Racine would be anticipated to use 16,100 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb,2015).

4.4 Return flow alternatives environmental effects

4.4.1 Fox River discharge alternative environmental effects

Any of the Mississippi River basin (deep and shallow aquifer, shallow aquifer) water supply alternatives would continue to discharge all of the Applicant's treated wastewater to the Fox River. The Fox River effluent discharge would not affect upland resources or surface water resources within the Lake Michigan basin, including Lake Michigan.

Returning all flow to the Fox River cannot be considered with the Lake Michigan water supply alternatives because the Compact requires that all water withdrawn from Lake Michigan, less an amount for consumptive use, be returned to the Lake Michigan basin. Some treated effluent (approximately 2-3 MGD) will be discharged to the Fox River under the Lake Michigan supply alternatives and that is addressed in later sections of this EIS.

The Fox River discharge alternative only addresses effects on the Fox River under the Mississippi River Basin 'only' water supply alternatives.

4.4.1.1 Flow and flooding effects on the Fox River and Fox River Tributaries from the Fox River discharge alternative

Fox River

The Applicant's wastewater treatment plant (WWTP) currently discharges to the Fox River and would continue to do so under the Mississippi River Basin water supply alternatives. Baseflow at the USGS Waukesha flow gage (05543830) is 49.6 cfs (Feinstein et al., 2012). The average annual discharge from the WWTP from 2008 to 2012 was 15.8 cfs, accounting for approximately 32 percent of the Fox River flow at the WWTP outfall (based on USGS gage station flows approximately 3100 feet upstream from the WWTP).

During high flow and flooding events, the WWTP contributes a small percent of the overall flow in the Fox River. The peak flow recorded at the USGS Waukesha gage flow on the Fox River, June 9, 2008 was 2,390 cfs and downstream, the peak discharge from the City's WWTP was 53 cfs (approximately 34 MGD), contributing about 2 percent of the flow to the Fox River on this date.

Pebble Brook, Pebble Creek, Mill Brook, Mill Creek, and Genesee Creek

Continued discharge of all of the WWTP's treated wastewater to the Fox River would not affect flow or flooding in Pebble Brook, Pebble Creek, Mill Brook, Mill Creek and Genesee Creek.

4.4.1.2 Water quality effects on the Fox River and Fox River Tributaries from the Fox River discharge alternative

Fox River

The Applicant's WWTP currently meets Wisconsin's Pollutant Discharge Elimination System (WPDES) permit requirements to discharge to the Fox River. No change in the plant permit limits would be expected due to a switch in Mississippi River basin water supply sources (CH2MHill, 2013, Vol. 4). The Applicant's current WPDES permit (issued 2013) for the Fox River discharge has a chloride variance that includes a compliance schedule, interim limits and specific requirements for chloride reductions. Continued private water softening would still be expected with any of the Mississippi River basin alternatives. The City continues to implement a chloride reduction scenario to meet interim limits in its 2013 WPDES permit (Technical Review R4, 2015). The Applicant's 2013 Approved Facilities Plan includes plans to meet the phosphorus water quality criterion of the Fox River (0.075 mg/L TP) and upgrades to the WWTP's UV disinfection system (Strand Associates, 2011).

Pebble Brook, Pebble Creek, Mill Brook, Genesee Creek and Mill Creek

Continued discharge of the City's treated wastewater to the Fox River would not affect water quality in any of the Fox River tributaries.

4.4.1.3 Geomorphology and sediments effects on the Fox River and Fox River Tributaries form the Fox River discharge alternative

Continued discharge of the City's treated wastewater to the Fox River would not create any change in geomorphology to the Fox River. Continued discharge of the City's treated wastewater to the Fox River would not affect the geomorphology or sediments in Pebble Brook, Pebble Creek, Mill Brook, Genesee Creek and Mill Creek.

4.4.1.4 Wetlands and Vernon Marsh effects from the Fox River discharge alternative

Continued discharge of the City's treated wastewater to the Fox River would not affect Vernon Marsh or other wetlands.

4.4.1.5 Flora and fauna effects on the Fox River and its tributaries from the Fox River discharge alternative

Continued discharge of the City's treated wastewater to the Fox River is not likely to have a net negative effect on the flora and fauna in the Fox River or its associated habitats. In addition, continued wastewater discharge to the Fox River would not affect the flora and fauna in Pebble Brook, Pebble Creek, Mill Brook, Mill Creek, and Genesee Creek.

4.4.1.6 Upland forest and grassland effects of the Fox River discharge alternative

Continued discharge of the City's treated wastewater to the Fox River would not affect area forests and open lands/grasslands.

4.4.1.7 Air emissions (construction and operations) effects of the Fox River discharge alternative

During operation, energy use and associated air emissions, to pump and discharge treated wastewater effluent would increase only incrementally as the volume of water use increases with increasing population and economic activity in the City of Waukesha. No immediate change from current air emissions is expected with this alternative.

4.4.1.8 Population effects of the Fox River discharge alternative

The Fox River discharge alternative is not anticipated to affect the populations of Waukesha, or other communities in the southeast Wisconsin region. No residents would be displaced by the construction or operation of this alternative. No low income or minority populations would be displaced by this alternative, and the project operation is not expected to cause any adverse impacts to low income or minority populations.

4.4.1.9 Economic effects of the Fox River discharge alternative

Construction of the infrastructure for the Fox River discharge alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant would increase incrementally as wastewater effluent flows increase with increasing population and economic activity. Construction and operation costs would be borne by the residents of the approved water supply service area.

4.4.1.10 Land use effects of the Fox River discharge alternative

No land use changes are anticipated with this alternative.

4.4.1.11 Recreation and aesthetic resources effects of the Fox River discharge alternative

Continued discharge of the Applicant's treated wastewater to the Fox River would not affect area recreation and aesthetic resources.

4.4.1.12 Archeological and historical resources effects of the Fox River discharge alternative

Continued discharge of the Applicant's treated wastewater to the Fox River would not affect area archeological and historical resources.

4.4.1.13 Public water supply and uses in the City of Waukesha from the Fox River discharge alternative

Continued discharge of the Applicant's treated wastewater to the Fox River would not affect public water supply and use in Waukesha or other south east Wisconsin communities.

4.4.1.14 Costs and energy (construction and operation) effects of the Fox River discharge alternative

Continued discharge of the City's treated wastewater to the Fox River would result in incremental increases in wastewater treatment costs and energy use as Waukesha water use increases with increasing population and economic activity. As mentioned above, additional upgrades are outlined in the Applicant's 2013 Approved Facilities Plan related to meeting future phosphorus limits and adding UV disinfection upgrades (Strand Associates, 2011).

4.4.2 Lake Michigan return flow alternatives

4.4.2.1 Common effects from the Lake Michigan Return flow alternatives

4.4.2.1.1 Fox River effects from the Lake Michigan return flow alternatives

The Return Flow Management Alternative 6 (returning the previous year's average daily withdrawal to the Great Lakes basin) was proposed to minimize Mississippi River basin water in return flow and to reduce impacts to both receiving watersheds (Technical Review R 1). Fox River baseflow at the confluence of the Fox River and Pebble Brook is expected to decrease by approximately 11 percent with a switch to Lake Michigan supply (Appendix A) under the proposed management scheme. The percent decrease in baseflow decreases downstream of the Fox River and Pebble Brook confluence as additional flow enters the river system from tributaries. At the Waterford dam, the percent reduction in baseflow is reduced to 5-8% of the total baseflow (See Appendix A for a discussion of the estimated decrease in baseflow downstream of the City of Waukesha). The decrease in baseflow is due to a reduction in the discharge to Fox River from the wastewater treatment plant.

4.4.2.1.1.1 Flow flooding effects on the Fox River from the Lake Michigan return flow alternatives

A Lake Michigan supply would include a portion of wastewater flow continuing to be discharged to the Fox River. The department used historical data to project what may occur in the future under a diversion scenario. Based on the City's previous year's water withdrawals and WWTP effluent data (2005-2012), the Fox River would receive on average, 2-3 MGD or approximately 3-5 cfs. During dry years the average flow to the Fox would be less under a Lake Michigan supply, due to limited I/I, and during wet years, this average could increase.

No regulatory floodplain changes are anticipated as floodplain studies look at the watershed infiltration capabilities and surface water runoff as a system. Flow changes due to point sources such as wells are not considered in the calculations.

4.4.2.1.1.2 Water quality effects on the Fox River from the Lake Michigan return flow alternatives

The portion of effluent at the WWTP that would continue to be discharged into the Fox River would meet permit limits. Some water quality based limits for a Lake Michigan return flow scenarios may be more stringent than the Fox River, and therefore, effluent added to the Fox may be of higher quality than it is currently. Consequently, water quality impacts to the Fox River are not anticipated with return flow to the Lake Michigan watershed.

4.4.2.1.1.3 Geomorphology and sediments effects on the Fox River from the Lake Michigan return flow alternatives

While some additional sediments may be more frequently exposed, no significant change in geomorphology or sediments is expected on the Fox River from the Lake Michigan return flow alternatives.

4.4.2.1.1.4 Flora and fauna effects on the Fox River from the Lake Michigan return flow alternatives

A reduction in flow in the Fox River (due to the removal of the current levels of wastewater discharge) could have a minimal impact to the flora and fauna of the River by reducing habitat - possibly increasing temperature, which can stress the biological community.

Coolwater species including walleye may be negatively affected as a result of the removal of the City's wastewater discharge to the Fox River. Adult and juvenile coolwater species of the Fox River including walleye and northern pike depend upon connectivity to cold water tributaries which provide refuge during hot summer months as well as critical nursery habitat throughout the year. Lower baseflow conditions can stress macroinvertebrate populations including mussels. Reduced baseflow can alter the environment and change the competition, predation and organic decomposition that the macroinvertebrate community depends upon.

The reduction of flow in the Fox River due to the removal of the City's wastewater effluent would not likely affect any mammal species in the Fox River or its associated habitats. Baseflow reduction would likely impact semi-aquatic mammal species including beavers, muskrats, otters, and mink. Increased depth to groundwater would cause a change in wetland type, therefore impacting mammal species that rely on a variety of wetland types that have surface water throughout the year. The slight flow reduction in the Fox River would not likely affect any mammal species in the Fox River or its associated habitats.

Invasives

During the operation phase, multiple barriers would prevent the spread of invasive species. Drinking water treatment includes filters and disinfection procedures to remove and inactivate viruses. This level of treatment would not allow transfer of invasive species through the water distribution system. Once the water is distributed in pipelines, an ongoing disinfectant residual would be maintained, as required, to prevent microbial growth within the pipelines.

Once water is used and collected in the sanitary sewer collection system, the Applicant's WWTP would provide treatment before the water was discharged to the Fox River or to Lake Michigan. The WWTP is an advanced facility with settling and biological treatment systems, dual media sand filters, and ultraviolet light disinfection designed to meet WPDES requirements. The treated wastewater would be contained within the WWTP before being discharged as return flow. Consequently, there would be no opportunities for invasive species or VHS from the Mississippi Basin to be introduced to the Lake Michigan basin from the return flow discharge.

4.4.2.1.2 Effects on Pebble Brook, Pebble Creek, Mill Brook and Vernon Marsh from the Lake Michigan return flow alternatives

Under this alternative the Applicant would cease shallow groundwater pumping from existing shallow aquifer wells along the Fox River between Pebble Creek and Genesee Creek. Groundwater flow modeling found a 0 – 2% increase in baseflow with ceasing existing shallow groundwater pumping that may be beneficial to these streams.

4.4.2.1.3 Lake Michigan volume effects from the Lake Michigan return flow alternatives

Return flow to the Lake Michigan basin is not anticipated to result in a change in Lake Michigan water levels.

4.4.2.1.4 Groundwater effects from the Lake Michigan return flow alternatives

Because of the small water depth change anticipated in Lake Michigan tributaries under the Lake Michigan return flow alternatives, no impacts to regional aquifers or groundwater quality are anticipated. The Lake Michigan return flow alternatives are also not anticipated to result in impacts to springs.

If the pipeline for the Lake Michigan return flow alternatives crosses a property with groundwater contamination, there is the potential for the groundwater contamination to migrate along the assumed permeable backfill around the pipeline. If the pipeline leaks in the area of a contaminated property with soil and/or groundwater contamination, it is possible that the influx of water due to the leak could, under unique conditions (strong downward vertical gradient, contaminant with a high solubility or specific gravity greater than water, etc.), cause the contamination to migrate to the shallow aquifer or to a spring if the leak is not repaired. Proper permitting process would mitigate these risks should any of the Lake Michigan flow alternatives be selected.

4.4.2.1.5 Geomorphology and soils effects from the Lake Michigan return flow alternatives

Proposed return flow pipeline installations would require trenching to shallow depths of less than 10 feet. The proposed return flow alternative structures are not expected to encounter significant bedrock and would have negligible impacts to surficial geology during construction. Adverse impacts to the local geology are not expected under any of the Lake Michigan return flow alternatives.

4.4.2.1.6 Population effects from the Lake Michigan return flow alternatives

The Lake Michigan return flow alternatives are not anticipated to affect the populations of Waukesha, or other communities in the southeast Wisconsin region.

No residents would be displaced by the construction or operation of the proposed project or alternatives. No low income or minority populations would be displaced by the project or any of the alternatives, and the project operation is not expected to cause any adverse impacts to low income or minority populations.

4.4.2.1.7 Public water supply and use effects from the Lake Michigan return flow alternatives- City of Waukesha

The Lake Michigan return flow alternatives are not anticipated to affect water supply and use in Waukesha.

4.4.2.2 MMSD return flow alternative environmental effects

After review of the Applicant's Technical Memorandum entitled *Evaluation of treated return flow to Lake Michigan through the MMSD* (CH2MHill, 2015a), the department determined more information would be needed to determine if the South Shore Water Reclamation Facility (South Shore) could accommodate pretreated effluent from the Applicant's WWTP. The Applicant would need to work with the MMSD to evaluate pumping capacity at South Shore and pumping stations along the pipeline corridor to ensure that the MMSD would not result in additional combined system overflows during wet weather events. The impacts evaluated below are based on an assumption that the South Shore Facility would have future capacity (greater than the current peak hour capacity of 300 MGD) to handle the additional 10.1 MGD from the Applicant's WWTP under all flow conditions, especially during wet weather events.

4.4.2.2.1 Discharge effects on Lake Michigan from the MMSD return flow alternative

4.4.2.2.1.1 Discharge effects on Lake Michigan water quality from the MMSD return flow alternative

All water returned to the Lake Michigan watershed would be required to meet all of the department's water quality permit (WPDES) requirements.

Waukesha's historical discharge quality is equal to or better than the performance MMSD is required to achieve to protect Lake Michigan water quality. Waukesha return flow is likely to have a biological oxygen demand (BOD) requirement of 5.7 to 10 mg/L with historical operations averaging 1.8 mg/L (CH2MHill, 2013, Vol. 4). MMSD has a permit requirement of 30 mg/L BOD monthly average. Waukesha return flow is likely to have a total suspended solids (TSS) requirement of 10 mg/L with historical operations averaging 1.2 mg/L. MMSD has a permit requirement of 30 mg/L monthly average TSS. Waukesha return flow has had historical phosphorus concentration of 0.16 mg/L with MMSD permit requirement of 0.6 mg/L over a 24-month average. Home water softening could be eliminated with a Lake Michigan water supply source. Consequently, a reduction in chloride concentration in return flow over time is expected. Based on these historical operations and MMSD permit requirements, water quality concentrations would not negatively affect Lake Michigan.

4.4.2.2.1.2 Discharge effects on Lake Michigan geomorphology and sediments from the MMSD return flow alternative

The Applicant would work with the MMSD South Shore facility to use the existing outfall pipe, so no construction-related impacts to geomorphology or sediments to Lake Michigan would be expected.

4.4.2.2.1.3 Discharge effects on Lake Michigan flora and fauna from the MMSD return flow alternative

With the Waukesha return flow quality better than or equal to the MMSD South Shore WRF effluent quality, no adverse impacts to Lake Michigan flora and fauna are expected with this alternative.

4.4.2.2.2 Stream crossings effects of the MMSD return flow alternative

The streams that would be crossed by the estimated 75-foot-wide pipeline construction corridor for this alternative are listed in Table 4-25 (CH2MHill, 2015a). The crossing would likely be accomplished by the horizontal directional drilling (HDD) or another proper construction method for stream crossings to avoid or minimize construction impacts (Section 4.4).

Table 4-25. Water body crossings of the MMSD return flow alternative

No.	Name	Type	Width (ft)	Area (ac)	Fisheries Classification
3732	Unnamed	Intermittent/ephemeral	14.3	0.02	—
3932	North Branch Root River	Perennial	49.7	0.09	WWSF
4264	Root River	Perennial	52.2	0.01	WWSF
Totals			**116.2**	**0.12**	

4.4.2.2.2.1 Flora and fauna stream crossing effects of the MMSD return flow alternative

The pipeline stream crossings of the MMSD return flow alternative would not likely result in impacts on the flora and fauna assuming the proper drilling procedures would be followed (Section 4.4). There are other special concern species that may be present on land at these crossings and avoidance and/or minimization measures would be recommended.

Invasives

During the construction phase of the water supply and return flow pipelines, best management practices would be used to reduce the potential introduction or spread of invasive species. Example practices that would be considered include: washing equipment and timber mats before entering wetlands/water bodies, removing aquatic vegetation from equipment leaving waterways, steam cleaning and disinfecting equipment used in waterways where invasive species may exist, utilizing non-invasive construction techniques. Post construction restoration methods would only use native species and the City would consider methods to encourage existing native species to thrive to reduce the potential of the invasive species establishing a foothold. Using these approaches would reduce the potential for spreading invasive species during construction.

4.4.2.2.2.2 Wetlands effects of the MMSD return flow alternative

Table 4-24 lists wetland crossing acreages associated with this alternative (CH2MHill, 2015a). Five palustrine emergent (PEM) wetlands, six palustrine scrub-shrub (PSS) wetlands, and 15 palustrine forested (PFO) wetlands would be affected by pipeline construction. A total of 1.06 acres of wetland would be affected by pipeline construction for this alternative.

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be approximately 0.79 acres of wetland type change from forested to emergent associated with this alternative.

Table 4-26. Wetland crossings of the MMSD return flow alternative (Source: WWI)

No.	Type	Width[a] (ft)	Area (ac)
8714	Emergent/wet meadow	—	0.07
9020	Forested	—	0.02
9026	Forested	—	0.07
9028	Forested	—	0.01
10401	Emergent/wet meadow	—	<0.01
10573	Emergent/wet meadow	—	< 0.01
10801	Emergent/wet meadow	—	0.02
10810	Emergent/wet meadow	—	0.16
11286	Scrub/shrub	—	0.01
11290	Scrub/shrub	—	0.02
11368	Scrub/shrub	—	0.08
11369	Scrub/shrub	—	0.02
11376	Scrub/shrub	—	0.05
11381	Scrub/shrub	—	0.01
11896	Forested	—	0.07
11897	Forested	—	<0.01
11900	Forested	—	0.13
11902	Forested	—	0.19
11906	Forested	—	0.03
11914	Forested	—	< 0.01
12293	Forested	—	0.01
12301	Forested	—	0.01
12314	Forested	—	< 0.01
12363	Forested	—	< 0.01
12392	Forested	—	0.01
12399	Forested	—	< 0.01
Totals		**—**	**1.06[b]**

[a] Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland. Because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts.
[b] Total acreage is an estimated maximum.

There are two special concern herptile species, one crustacean, and two plant species that occur in wetlands and could be impacted. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

The Applicant would need to meet requirements under NR 103, Wis. Adm. Code (Water Quality Standards for Wetlands). Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

4.4.2.2.2.3 Upland forests and grasslands effects of the MMSD return flow alternative

Upland Forests

This alternative would affect less than 0.5 acres of woodlands (CH2MHill 2015a). The return flow pipeline follows transportation corridors so that the construction corridor would only intersect edges of forested areas. Wooded areas that would be affected by the project generally consist of deciduous upland forests. To facilitate construction trees within the construction corridor would be removed and stumps would be flush-cut with the ground surface. In cleared areas wooded habitat removed by construction would initially be replaced by non-woody vegetation, which may provide food, shelter, and breeding space for small mammals and birds. The pipeline right-of-way would be maintained in non-woody vegetation, but trees would be allowed to grow back on cleared workspace beyond the maintained maintenance corridor.

There are four rare plants that occur in dry-mesic to mesic woodlands and recommended measures may be suggested in order to avoid and/or minimize impacts to this species. In addition, there is one forested natural community that runs adjacent to a portion of this route and buffers would be recommended to avoid impacts.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code. Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

Open lands/Grasslands

The return flow pipeline would follow transportation corridors so that the construction corridor would only intersect edges of grassland areas. Open areas that would be affected by the project generally include cropland (fallow and active), undeveloped non-forested areas, and scrub-shrub land. Open lands crossed by the project total less than 5 acres.

Construction would accommodate general and site-specific protective measures for sensitive wildlife habitats and species identified during the course of detailed design and permitting. Seasonal construction scheduling to accommodate reproductive and migratory patterns would be coordinated with state and federal agencies. Construction would cause only the temporary displacement of more mobile wildlife from workspaces and adjacent areas. Surface restoration would include coordination with regulatory agencies to provide preferred habitat vegetation applicable to adjacent land use and operational considerations. Thus impacts in grasslands would only be temporary and generally one growing season or less. After construction, wildlife is expected to return and recolonize.

4.4.2.2.2.4 Air emissions (construction and operation) effects of the MMSD return flow alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the MMSD return alternative would release an estimated 7,500 tons/yr (CO2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.4.2.2.2.5 Economic effects of the MMSD return flow alternative

Construction of the infrastructure for the MMSD return alternative is expected to provide economic benefits to the well and pipeline construction industries. Operational costs to the Applicant and to MMSD would increase incrementally as wastewater effluent flows increase with increasing population and economic activity in Waukesha.

4.4.2.2.2.6 Land use effects of the MMSD return flow alternative

The MMSD return flow alternative would affect a total of 235.1 acres of land for pipeline construction (CH2MHill, 2015a). An additional pump station may be required, and if so is expected to impact approximately 0.25 acres.

The land use construction and operation acreage impacts of this alternative are listed in Table 4-25. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction. Note that Table 4-27 uses SEWRPC land use data (CH2MHill, 2015a).

Table 4-27. MMSD return flow alternative land use impacts (Source for base land use data: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	7.52	3.2
Commercial & Industrial	0.55	0.2
Transportation & Communication/Utilities	217.35	92.5
Government. & Institutional	1.08	0.5
Recreational Areas	0.34	0.1
Agricultural Lands	2.97	1.3
Open Lands	4.14	1.8
Woodlands	0.48	0.2
Surface Water	0	0.0
Wetlands	0.61	0.3
Totals[b]	**235.04**	**100.1[c]**

[a] Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland acreage differs from WWI data.
[b] Lake Michigan supply and return flow options share the same workspace for about six miles. Actual land use totals would be less than reported if a Lake Michigan supply and return flow option was selected.
[c] Includes rounding errors.

No new access roads would be required for the MMSD return flow alternative. Access is anticipated to be from existing municipal roadways and trails. The residential land within the assumed 75-foot construction corridor borders roads. The majority of residential land that could be affected by the proposed alignments is described as single family low density. The construction corridor may be further minimized to avoid private property, or temporary construction easements would be obtained by the City. This alternative would affect no private residences. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use. No changes to zoning would be required for construction and operation of the MMSD return flow alternative.

Transportation

Over 92 percent of the MMSD return flow alternative pipeline would follow existing utility and transportation corridors. Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.4.2.2.2.7 Recreation and aesthetic resources effects of the MMSD return flow alternative

Table 4-28 summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this return flow alternative. The MMSD return flow alternative would not impact a Coastal Zone Management Area. Visual impacts from the proposed return flow alternatives are expected to be minor.

Table 4-28. Public or conservation lands within or adjacent to the MMSD return flow alternative (Source: Google Earth, 2009; SEWRPC, 2005)

Name of Resource	Acres
Buchner Park	0.09
Carroll College (Athletic Fields)	0.05
Fox River Sanctuary	<0.01
Franklin Woods Nature Center	0.65
Hidden Lakes Park	0.38
Oak Creek High School	<0.01
Oak Creek Library	<0.01
Park Arthur	0.48
Prospect Hill School	0.62
Total	

4.4.2.2.2.8 Archeological and historical resources effects of the MMSD return flow alternative

Archival investigations were conducted by The Public Service Archaeology & Architecture Program of the University of Illinois at Urbana-Champaign (PSAAP) to identify significant cultural resources within or adjacent to construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor.

The MMSD return flow alternative may affect 12 known cultural sites (CH2MHill, 2015a). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.4.2.2.2.9 Public water supply and use effects from the MMSD return flow alternative

The MMSD return flow alternative would connect directly to the MMSD South Shore WRF discharge pipe and would have no impact on MMSD's treatment processes. Coordination with MMSD and the department on the WPDES permitting would be expected.

4.4.2.2.2.10 Costs and energy (construction and operation) effects of the MMSD return flow alternative

The department considered costs for return flow alternatives based on their 50-year present worth. The 50-year present worth assumes a six percent interest rate (Technical Review S2). The 50-year present worth of the MMSD South Shore return flow alternative is $145,408,000. Capital costs are estimated at $135,408,000[9] while operation and maintenance costs are estimated as $855,000[10].
Operation of returning the water to MMSD South Shore is anticipated to use 8,100 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

The energy used in this return flow alternative (not including water supply) would release an estimated 7,500 tons (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

Operation of the MMSD return flow alternative is anticipated to use 8,100 megawatt-hours (MWh) of electricity annually (CH2MHill, 2015a).

4.4.2.3 Root River flow alternative environmental effects

4.4.2.3.1 Discharge effects from the Root River return flow alternative

The United States Environmental Protection Agency (EPA) delegates Clean Water Act authority to Wisconsin. Wisconsin's Pollutant Discharge Elimination System (WPDES) program has the authority to permit the discharge of treated wastewater effluent from wastewater treatment plants into the waters of the state under Wis. Stats. s. 283.31. The Applicant would need to apply for a WPDES permit in order to discharge treated effluent to its preferred return flow location, the Root River. The proposed discharge location to the Root River is near the intersection of West Oakwood Road and South 60th Street, in the City of Franklin, directly downstream of the confluence of the Root River Canal and the Root River mainstem (WBIC 2900).

4.4.2.3.1.1 Discharge effects on Lake Michigan water quality from the Root River return flow alternative

Water quality impacts to Lake Michigan are considered for two different areas, as there is no immediate and sudden transition from the Root River to Lake Michigan proper. The first potentially impacted area is Lake Michigan proper, the area beyond the Racine Harbor breakwater mouth. Due to shore currents, impacts are considered within the near shore and deep water areas. The second potentially impacted area is the Root River estuary. This area begins at the point where the Root River flows into the City of Racine and is influenced from Lake Michigan backwater augmenting river volumes. The water volume of the Root River is influenced by two factors:

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[9] Capital costs were estimate in June 2013 dollars, and assume a 2013 construction start.
[10] Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD

- the river reaching grade with Lake Michigan surface elevations due to dredging the stream bed from the harbor back up the river and
- the seiche effect - where windblown Lake Michigan water 'stacks up' at the river mouth and occasionally reverses or slows river flows for a brief time.

The Root River then transitions to the Racine Harbor. The Harbor is semi-isolated from Lake Michigan by the north and south breakwaters. The estuary can be considered the wetted area back from the breakwater mouth to that portion of the river where Lake Michigan backwater elevations can reach.

No impacts to minimal impacts to the water quality of the deep waters of Lake Michigan are expected from the Root River return flow alternative. In the very long term, nutrient loadings from *the entire Root River watershed* to Lake Michigan could contribute towards a more eutrophic condition, however, the wastewater discharge is less than two percent of the overall loading to the Root River watershed, so this project will have minimal impacts. Near the shore of Lake Michigan, at the mouth of Racine Harbor and south along the breakwater, minimal impacts may result from elevated levels of chlorides and increased turbidity associated with phosphorus fueled planktonic algae growth coming from the estuary and the Root River.

The department reviewed available data collected by several agencies, primarily the department, the MMSD, SEWRPC, and the City of Racine Health Department. At the outlet of the Root River Watershed (Lake Michigan), the average annual phosphorus load is approximately 65,877 pounds per year as determined by the department's Pollutant load Ratio Estimation Tool (PRESTO) model. The department assumed 100 percent of the phosphorus delivered to the stream network throughout the Root River Watershed reaches Lake Michigan.[11][12] The Root River return flow alternative would contribute approximately 1200 pounds TP/yr, less than 2 percent of the overall phosphorus loading to Lake Michigan (Technical Review, R5). The Applicant would be required to meet all discharge requirements to minimize any short or long-term impacts to Lake Michigan from the proposed Root River discharge.

4.4.2.3.1.2 Discharge effects on Lake Michigan geomorphology and sediments from the Root River return flow alternative

No impacts to Lake Michigan deep water and near-shore geomorphology, and Lake Michigan deep water sediments are expected. No impacts to Root River estuary geomorphology and inorganic sediments are expected. However, increased loading of phosphorus from the entire Root River watershed, of which the return flow would be a small portion, may result in increased aquatic plant and algae growth within the estuary, and to a much lesser degree, along the near-shore Lake Michigan area beyond the Harbor breakwater and south. The death and subsequent decomposition of these plants and algae may result in increased organic sedimentation.

[11] Spatially-referenced Regression on Watershed Attributes (SPARROW) model developed by the USGS.

4.4.2.3.1.3 Discharge effects on Lake Michigan flora and fauna from the Root River return flow alternative

No long-term pollutant loading effects are expected on deep-water Lake Michigan invertebrates, plants, or fish.

This discharge will not have an immediate impact within the estuary or along the near-shore Lake Michigan area beyond the Harbor breakwater and south. However, phosphorus is a conservative pollutant and since the Root River Harbor is a semi-confined area, the eventual effects of cumulative nutrient loading from the entire Root River watershed, with a small contribution from the proposed discharge, may result in increased aquatic plant and algae growth. Increased plant growth within the estuary could alter fish spawning and available resident habitat, both positively and negatively. Fish and aquatic macroinvertebrate communities within the estuary may shift in density and species. Racine Harbor may require an increase in aquatic plant management, such as expanded herbicide treatments or mechanical plant harvesting. These activities require permits under chapters NR 107 and 109, Wis. Admin Code.

Increased concentrations of chlorides within the Root River from Waukesha flow may present a slight increase in risk to fish and aquatic invertebrates within the Root River estuary.

In addition, some pharmaceuticals are known to pass through wastewater treatment plants. Pharmaceuticals can lead to surface water contamination and toxicity to fish and wildlife. While no studies to date have definitively demonstrated harmful effects on human health from long-term exposure to trace amounts of active pharmaceutical ingredients - such as through drinking water - studies have found pharmaceuticals present in some ecosystems at levels likely to harm entire populations of aquatic organisms. Accordingly, there is a slight risk of pharmaceuticals exposure to resident fish and aquatic macroinvertebrates within the estuary. Pharmaceutical exposures in treated effluent have been shown to alter sex ratios in some fish species (Woodling et. al, 2006). The department recognizes that pharmaceuticals are a growing concern. However, the department does not have current regulatory authority to mandate the monitoring of pharmaceuticals or require limits in wastewater effluent. If these limits were established in the future, the Applicant would be required to comply with them under their WPDES discharge permit.

No direct impacts to Lake Michigan birds or mammals are expected from the Root River return flow alternative.

4.4.2.3.1.4 Flow and flooding effects on the Root River from the Root River return flow alternative

The proposed return flow to the Root River would increase the flow in the river downstream of the return flow location. To minimize the discharge of Mississippi River basin water to the Lake Michigan basin, the maximum average annual flow from the WWTP to the Root River under return flow Alternative 6 would be 10.1 MGD (15.6 cfs).

The influence of the Applicant's proposed return flow, 10.1 million gallons per day (15.6 cfs), is dependent on the existing flow regime of the Root River. To calculate the change the additional return flow would have on the Root River the department modeled Root River flow regimes (high, base, and low flow[12]), at the discharge location and further downstream in Racine. The proposed return flow was added to the modeled flow allowing the calculation of the percent contribution from the proposed return flow. Table 4-29 summarizes the flow regimes and Table 4-30 the percent contribution of flow that the proposed discharge would be responsible for.

Table 4-29 Root River Flow Regime

Flow Regime	Proposed Waukesha Discharge Site	Root River at Racine USGS #04087240
High Flow (Q10 – Q5)	230 – 392 cfs	358 – 607 cfs
Baseflow	35.9 cfs	62.6 cfs
Low (Q90 - Aug Q50)	7.92 – 16.7 cfs	11.2 – 26.1 cfs

Table 4-30 Percent Contribution of Proposed Return Flow on Root River

Site	Maximum Waukesha Return Flow (cfs)	Return Flow Contribution During High Flow (%)	Return Flow Contribution During Baseflow Flow (%)	Return Flow Contribution During Low Flow (%)
Proposed Waukesha Root River Return Flow	15.6	3.8 - 6.4 %	30.3%	48.3 – 66.3%
Root River at Racine		2.5 - 4.2%	19.9%	37.4 – 58.2%

The department reviewed the Root River return flow rates at the discharge location for the 2-year through 100-year profiles that the Applicant provided (CH2MHill, 2015b). The proposed discharge location is slightly downstream of the Franklin gage and downstream of the confluence with the Root River Canal. The watershed area at the Franklin gage location is about 49.2 square miles. The watershed area at the discharge location is 126.2 square miles. The discharge location was used as a conservative estimate for low flow impacts from the return flow because it has a significantly smaller watershed area. The maximum return flow (10.1 MGD, 15.6 cfs) would be less than two percent of the river flow during a two year frequency storm, and would be an even smaller fraction of the flow during a 100 year flood. The maximum return flow rate would be less than one percent of the 100 year river flow (4,820 cfs) near the return flow discharge location (MMSD, 2007). The maximum return flow rate would have an even smaller impact on the Root River Steelhead Facility downstream. The 100 year river flow at the Root River Steelhead Facility is 5,916 cfs. For example, this equates to a water depth change of 0.02 feet near the return flow discharge location and 0.01 feet at Root River Steelhead Facility for the 100

[12] Flow conditions were tied to specific flow statistic (Q5 and Q10 represent high flow, hydrograph separation for baseflow, and Q90 and Aug Q50 represent low flow).

year return period flood. Additionally, discharging the maximum return flow rate is expected to occur infrequently.

The flows calculated for the Flood Insurance Study (FIS) are not expected to be affected by the addition of the return flow. The Flood Insurance Rate Map (FIRM) would not be required to be revised for the area along the Root River. Typically, when calculating floodplain hydrology, Waste Water Treatment Plant (WWTP) discharge is not added to the flow calculations because a conservative approach is used when calculating flows that accounts for standard error.
For the Federal Emergency Management Agency (FEMA) to incorporate revised hydrology into the Flood Insurance Study (FIS) it would require an increase of approximately 10 percent to the 100 year flow. For example, the maximum return flow would need to be approximately 482 cfs before a Letter of Map Revision (LOMR) would be required for significant changes in hydrology.

4.4.2.3.1.5 Discharge effects on Root River water quality from the Root River return flow alternative

The department calculated draft water quality-based effluent limits (WQBELs) based on current applicable water quality standards under Chapters NR 102, 103, 104, 105, 106, 207, 210 and 217, Wis. Admin. Code, to assess whether the Applicant could meet applicable water quality discharge standards. WQBELs are set at or below water quality criteria, designed to protect fish and aquatic life and in some cases public health and recreational uses. To determine discharge effects on the Root River from return flow, the department focused on the primary pollutants of concern below.

Phosphorus

Phosphorus is a vital nutrient in aquatic ecosystems. However, excessive phosphorus in the Root River, from existing point sources (urban stormwater runoff, wastewater treatment plants) and nonpoint sources (runoff from agriculture and natural land areas, and failing septic systems), have contributed to degraded stream habitat, increased eutrophic conditions, and unbalanced resident fish and macroinvertebrate populations. As a result, the Root River is listed on Wisconsin's 303(d) Impaired Waters List for excessive phosphorus.

The Applicant may be subject to Water Quality Based Effluent Limits for phosphorus significantly below the current Wisconsin water quality criterion for phosphorus of 0.075 mg/L in order to discharge to the Root River. Regardless, phosphorus is a conservative pollutant. The addition of phosphorus loading to the Root River from the return flow may increase the planktonic algal, periphyton, and aquatic plant communities in the river and estuary. An increase in these communities could increase the range of diurnal dissolved oxygen swings within portions of the Root River where the biological community is utilizing the increased phosphorus. Turbidity increases due to planktonic algae growth may also occur.

When the Root River is experiencing low flow conditions, phosphorus concentrations in the river may actually decrease due to dilution from the proposed effluent. Biological community effects may be seen further downstream in the Root River and in the Root River estuary from cumulative loading impacts, but are expected to be minimal as a result of return flow from the Applicant's proposed discharge (see Technical Review Appendix D) .

Total Suspended Solids

Total Suspended solids (TSS) consist of a wide variety of materials including: silt, sand and clay particles, decaying plant and animal matter, sewage, and industrial waste. High volumes of TSS can increase turbidity, blocking light from reaching beneficial aquatic vegetation and algae. Decreased light penetration can reduce photosynthesis, leading to decreased dissolved oxygen levels in the water column. Macrophytes, algae, and periphyton communities may die, increasing bacterial decay processes and using up more of the oxygen in the water. Decreased water clarity from TSS can also affect fish, reducing their ability to see and catch food. TSS can also abrade and clog fish gills. Increased loading of TSS can alter suitable habitat for macroinvertebrates and bury fish spawning beds, and can lead to increased water temperatures.

The proposed Root River return flow would be subject to WQBELs for TSS. TSS levels under the permit would likely be very low, therefore the Root River should experience little to no impacts from this return flow.

Chlorides

Chlorides are found in both salt and fresh water and are essential elements of life. Chlorides in the Root River primarily result from anthropogenic sources (e.g. deicing road salt and discharge from water softeners) - since the background geology in the area contains relatively little chloride (SEWRPC, 2014). High chloride concentrations in freshwater can be harmful to aquatic organisms, hindering reproduction, growth and survival. The department sets chronic and acute toxicity water quality limits for chlorides to prevent long-term and immediate exposure effects to aquatic organisms.

The City would have to significantly reduce chloride sources to meet the proposed water quality based effluent limit of 400 mg/L for return flow to the Root River, since the current chloride effluent concentrations are higher than the proposed WQBEL for the Root River.

The Applicant drafted a compliance plan to demonstrate how future chloride effluent limits may be met (CH2MHill, Volume 4, Appendix A, Attachment A-5). Currently, the Applicant is required to submit annual chloride progress reports to the department to comply with requirements outlined in its current WPDES permit to discharge to the Fox River. The Applicant submitted its Annual Chloride Progress Report to the department on June 30, 2014 documents steps the Applicant has taken to reduce chlorides in its WWTP discharge (primarily by concentrating on source reduction measures). The department understands quantifying potential sources of chloride within the sewer service area is difficult. In the most recent report, the Applicant examined 6 main sources of chlorides:

a) Residential softening (includes industrial and commercial)
b) Road Salt (through infiltration and inflow)
c) Brine
d) Hauled Waste
e) Ferric Chloride
f) Normal Domestic Wastewater/Background from Groundwater

As an additional chloride strategy, the City of Waukesha approved on April 4th 2014, Waukesha, Wis. Code § Ord 29.036 (2014) an amendment to their sewer use ordinance with respect to water softening and brine reclamation. The ordinance requires that all residential, commercial and industrial users installing new or replacement water softeners must install high efficiency, demand initiated regeneration softeners equipped with a water meter or sensor. In addition, the City encourages brine reclamation systems for all significant industrial users where feasible.

A change from a groundwater water supply to a Lake Michigan surface water supply would significantly reduce the need for home water softening. Currently, salt residue from residential home softening is the largest source of chlorides to the Applicant's WWTP (estimated at ~22,000 lbs/day in the Applicant's annual chloride progress report). Groundwater wells supply 'hard' water to customers, consequently many homeowners use water softeners. The current hardness concentration ($CaCO_3$) based on an average range of well concentrations is 260-530 mg/L.[13] Recent alkalinity data (hardness $CaCO_3$) from the City of Oak Creek Water Utility shows an average of ~111 mg/L, a level that does not require home water softening.[14]

In addition, the City can also expect reductions in background chloride concentrations and loading since concentrations of chloride are lower in a Lake Michigan supply (~12 mg/L[15]), versus the current groundwater supply (~31 mg/L[16]). This reduces loading by approximately 1600 lbs/day.[17]

The Applicant is already taking additional steps to reduce infiltration and inflow (therefore reducing infiltration of chlorides from road salt) and brine from Waukesha County Highway salt storage facilities. The Applicant would need to fully implement all efforts outlined in the current annual chloride progress report as well as additional efforts, including education and outreach, to meet the proposed draft water quality based effluent limits.

There could be potential impacts to the Root River with the proposed return flow due to an increased toxicity risk to the biota resulting from the current elevated chloride levels in the Root River combined with the additional chloride loading from the Applicant's return flow effluent.

Dissolved Oxygen

Dissolved oxygen (DO) contained within the water column is essential to aquatic life. Air pressure and temperature, water temperature, photosynthesis, organic and chemical demand, and turbulence all contribute to oxygen levels. The Root River mainstem at and downstream of the proposed outfall has typically met state water quality criteria of 5 mg/l for maintaining fish and aquatic life.

The proposed return flow may have both a local effect on DO concentrations in the Root River at the discharge location as well as minimal effects downstream.

Locally, especially during low-flow periods where the return flow would make up approximately

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[13] City of Waukesha IOC samples from 1993 to 2012 for wells 10, 11, 12 and 13.
[14] Raw water sample results, Oak Creek, average for April 2015 ~111 mg/L.
[15] Result from Oak Creek Water from intake EP 1 4/13/04. 12 mg/L is consistent with Milwaukee Water Works. 2011 Raw Water Annual Water Quality Report.
[16] City of Waukesha IOC samples from 1993-2012 for wells 10, 11, 12 and 13.
[17] This estimate is lower than Application, Volume 4, Appendix A, A-4, page 5. Exhibit 2. The Applicant's estimates were based on an average flow of 10.9 MGD, not a maximum flow of 10.1 MGD.

80-90 percent of the river flow, the return water emerging from the outfall pipe may contain low oxygen levels (depending on the method chosen by the Applicant to aerate the discharge via cascades or other techniques). The water emerging from the return flow outfall would have been underground for 20 miles, increasing the possibility of the discharge water containing low DO levels. Permit limits for DO would need to be met at the outfall to ensure oxygen concentrations are at levels protective of fish and aquatic life.

Downstream, DO levels of the Root River may be affected due to possible increased periphyton, suspended algae, and aquatic plant growth fueled by additional phosphorus loading. Oxygen levels would rise and fall throughout the 24-hour photosynthetic growth period, where at times oxygen is released into the water, and at other times absorbed. These diurnal swings, where excessive plant and algae growth is present, can result in periods of very low dissolved oxygen levels – typically in the early morning hours.

Biological Oxygen Demand

Biological oxygen demand (BOD) is the measured amount of oxygen utilized by microorganisms during aerobic breakdown of organic material. Treatment plants release a certain amount of organic matter in effluent, and BOD WQBELs are put in place to ensure this organic loading is low.

The proposed return flow would have permit limits in place on the release of organic material. The Root River downstream of the proposed outfall may face a slight risk from elevated levels of organic material and the associated drop in dissolved oxygen levels due to microbial facilitated decomposition of this material. Additionally, the Root River in the vicinity of the outfall may see a slight risk of attached microbial/algae growth associated with organic materials and sulfur.

Temperature

Water temperature is an important factor for the health and success of fish and aquatic communities. Temperature can affect embryonic development, growth cycles, migration patterns, competition with aquatic invasive species, and risk and disease severity. The water temperature also affects the DO concentration and can influence respiration of aquatic communities, and the activity of bacteria and other toxic chemicals in water.

The proposed return flow would be subject to temperature limits under a discharge permit. The effect on the Root River downstream of the return flow outfall would depend on the time of year, temperature of the discharge water, and temperature and amount of flow in the Root River. During low-flow summer months, effluent temperatures may be cooler than current river temperatures. During fall and winter months, the discharge water temperature would likely be higher than current temperatures. If temperature limits can be met, no impacts are expected to the Root River due to temperature from the effluent.

Bacteria (Pathogens)

Bacteria are single-celled organisms, live in various environments and provide functions that can be beneficial or harmful. Bacteria that can cause diseases are referred to as pathogens. Coliform bacteria present in surface water can originate naturally from soil, however, bacteria from the intestinal tracks of human and other animals, such as pets, livestock and wildlife are known as fecal coliform bacteria. Human sources of fecal coliform bacteria include wastewater treatment plants, leaking sewer lines, illicit discharges to streams and urban stormwater runoff. *E.coli* are a subgroup of fecal coliform bacteria, often monitored as indicator organisms, assessing the likelihood that other risks to human health may be present in the environment.

The proposed return flow would be subject to fecal coliform bacteria limits under a WPDES permit. Planned upgrades to the Applicant's WWTP UV disinfection system, as well as historical operations having less than 100 CFU/100 mL during the recreational season, would meet draft WQBELs for fecal coliform bacteria to the Root River. Treated wastewater can contain residual pathogens, so there is a risk to human health from this added return flow. However, current concentrations of pathogens in wastewater are unknown and not regulated by the department at this time.

Pharmaceuticals and endocrine disruptors are known to pass through wastewater treatment plants. Endocrine disruptors are a diverse class of chemicals that are known to disrupt or act like hormones that can disrupt the endocrine systems of fish, wildlife, and possibly humans. Pharmaceuticals may lead to surface water contamination and toxicity to fish and wildlife. While no studies to date have definitively demonstrated harmful effects on human health from long-term exposure to trace amounts of active pharmaceutical ingredients - such as through drinking water - studies have found pharmaceuticals present in some ecosystems at levels likely to harm entire populations of aquatic organisms.

Accordingly, there is a slight risk of pharmaceuticals exposure to resident fish and aquatic macroinvertebrates within the estuary. Pharmaceutical exposures in treated effluent have been shown to alter sex ratios in some fish species (Woodling et. al, 2006). The department recognizes that pharmaceuticals and endocrine disruptors are a growing concern. However, the department does not have current regulatory authority to mandate the monitoring of pharmaceuticals and endocrine disruptors or require limits in wastewater effluent. If these limits were established in the future, the Applicant would be required to comply with them under their WPDES discharge permit.

In conclusion, all water returned to the Root River would be required to meet all of the department's water quality related permit requirements (e.g. WPDES and Chapter 30) under Wisconsin Statutes and Administrative Codes.

4.4.2.3.1.6 Discharge effects on Root River geomorphology and sediments from the Root River return flow alternative

The Wastewater Treatment Plant Facility Plan Amendment which is an attachment to the Return Flow Plan (Strand, 2011) discusses potential outfall structure designs. The outfall structure would be designed to blend in with the streambanks along the Root River and be required to not adversely affect regional flood elevations. A recent Root River sediment transport study concluded that the river stability in the location of the proposed outfall is relatively insensitive to changes in flow because of the erosion resistance of the channel boundary materials, the relatively flat channel gradient, and the presence of a functional floodplain (MMSD, 2007). For these reasons, and because the proposed return flow is a small fraction of higher flow events where the majority of fluvial processes occur, the return flow should not adversely affect the geomorphic conditions in the river.

4.4.2.3.1.7 Discharge effects on Root River flora and fauna from the Root River return flow alternative

Flora

The algal community in the Root River, represented by attached and suspended species, as well as those contained within periphyton complexes, would likely see an increase in total biomass. During low-flow periods, there would be more stream bottom substrate and water column available for colonization and growth. The added nutrient load may also fuel growth. Similarly, the aquatic macrophyte community of the Root River and estuary may see an increase in biomass.

Impacts of increased biomass downstream of the outfall could be both positive and negative. Positive impacts of increased biomass would provide expanded direct and secondary grazing opportunities for benthic invertebrates and fish, as well as expanded refuge habitat. The potential negative impact would be the risk of an expanded lower range of the diurnal oxygen cycle (low DO).

Benthic invertebrates

The proposed Root River return flow would increase available habitat for aquatic invertebrates during low-flow periods due to the increased dimensional wetted area of the stream bottom. Riffle and pool depths may increase. Aquatic macroinvertebrates would be able to utilize or benefit from these areas. If algal and periphyton amounts increase due to phosphorus loading, aquatic macroinvertebrate communities may see a shift in species composition and an increase in numbers.

In addition, some viruses and pharmaceuticals are known to pass through wastewater treatment plants. Pharmaceuticals can lead to surface water contamination and toxicity to fish and wildlife. Studies have found pharmaceuticals present in some ecosystems at levels likely to harm entire populations of aquatic organisms. Accordingly, there is a slight risk of pharmaceuticals exposure to resident fish and aquatic macroinvertebrates within the estuary. Pharmaceutical exposures in treated effluent have been shown to alter sex ratios in some fish species (Woodling et. al, 2006). The department recognizes that viruses and pharmaceuticals are a growing concern. However, the department does not have current regulatory authority to mandate the monitoring of pharmaceuticals or require limits in wastewater effluent. If these limits were established in the future, the Applicant would be required to comply with them under their WPDES discharge permit.

Fish

The proposed Root River return flow has the potential to both positively and negatively affect the fishery of the Root River. Positive effects could result from the addition of flow during low-flow periods (middle to late summer), while both potential positive and negative effects could be evidenced from added phosphorus. Temperature effects would likely have a slightly positive effect. And lastly, the addition of chlorides, and possibly pharmaceuticals, could have a negative effect on the Root River fishery and estuary (see sections above).

The addition of a maximum of 15.6 cfs (where previously a low-flow of three cfs could be expected) to the Root River would greatly compound the availability of wetted fish spawning and resident habitat during the lower flow periods, increase the ability of fish to mobilize between shallow river segments, and enhance forage opportunities. This would all have a positive effect on the numbers, and possibly diversity, of the Root River fishery. During periods of higher flow, there would be no positive or negative impact to the Root River fishery from the flow addition.

Additionally, during low-flow periods, the proposed Waukesha return flow could benefit the department's Root River Steelhead Facility. The Root River Steelhead Facility is Wisconsin's main source of rainbow trout (steelhead) eggs and brood (parent) stock and is the back-up facility for the collection of eggs of other trout and salmon species. During some years when flow on the Root River is low, the department has not met fish egg collection quotas. The department has evaluated flow augmentation of the Root River to improve fish migration for egg collection. The proposed return flow would provide the flow augmentation (during low-flow periods) considered by the department to allow more fish to reach the Steelhead Facility, meet egg collection quotas, and fish stocking goals.

Nutrients, principally phosphorus, contained in the Waukesha return flow may increase algal, periphyton, and aquatic plant communities in the Root River and the estuary. This growth may increase the forage base for fish that consume algae or the macroinvertebrates that reside on aquatic plants. Alternately, there could be a corresponding decrease in some sight feeders in the Root River, should excessive suspended algae growth occur. In general, an overall shift towards higher productivity across all trophic levels in the Root River could be an outcome of the additional nutrients.

The Root River at the proposed outfall location downstream to the Horlick Dam is classified in the SEWRPC 2014 Root River Watershed Restoration Plan as a Warm Mainstem fishery. The department has made recent refinements to the classification methodology, confirmed by biological community, and the results show that this segment of the Root River should be classified as Cool-Warm Mainstem. The Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM) document describes a Cool-Warm Mainstem fish community as, "moderate to large but still wadeable perennial streams with cool to warm summer temperatures. Coldwater fish range from absent to common, transitional fish from common to dominant, and warmwater fish from absent to abundant. Small-stream fish range from absent to very common, medium-stream fish from very common to dominant, and large-river fish from absent to very common." The additive flow from the proposed Waukesha outfall would likely not alter this classification and the fish community associated with this temperature range, assuming that current effluent temperatures reflect future output. Thermal WQBELs, in addition, would likely be applied to the discharge.

Chlorides contained in the proposed discharge could have a negative effect on the fish community of the Root River. Current chloride levels in the Root River exceed both chronic and acute toxicity. Adding effluent flow from Waukesha could exacerbate chloride issues in the Root River, resulting in a negative effect on the fish community. The Root River estuary fish community could be exposed to the increased levels of chlorides from the Root River/Waukesha effluent. However, there is greater dilution afforded by water movement from Lake Michigan into the estuary. Measures will need to be taken by the City to reduce sources of chlorides to meet the proposed water quality based effluent limit (see *Chlorides* subsection in Section 4.4.2.3.1.5 above).

In addition, some pharmaceuticals are known to pass through wastewater treatment plants. Pharmaceuticals can lead to surface water contamination and toxicity to fish and wildlife. While no studies to date have definitively demonstrated harmful effects on human health from long-term exposure to trace amounts of active pharmaceutical ingredients - such as through drinking water - studies have found pharmaceuticals present in some ecosystems at levels likely to harm entire populations of aquatic organisms. Accordingly, there is a risk of pharmaceuticals exposure to resident fish within the Root River. Pharmaceutical exposures from treated effluent have been shown to alter sex ratios in some fish species (Woodling, et al., 2006).

In summary; the proposed additional flow to the Root River during low-flow periods may positively impact the Root River fish community, phosphorus may both negatively and positively impact the fish community of the Root River and estuary, temperature impacts to the Root River should likely be minimal, and the addition of chlorides, and possibly pharmaceuticals, would likely negatively affect the fish of the Root River and possibly have a slightly negative effect on the fish community in the Root River estuary.

Mammals

Nutrient loading may have negative health impacts on semi-aquatic mammals, resulting in population declines. However, due to the minimal nutrient loading expected from the proposed discharge to the Root River (less than two percent of the overall watershed load), no significant negative impacts on semi-aquatic mammals are expected. It is more likely the increased flow to the Root River from the proposed discharge could create more riparian habitat for semi-aquatic mammals, thus positively impacting local mammal populations.

See above section regarding water quality impacts for potential public health impacts associated with the proposed discharged.

4.4.2.3.2 Stream crossing effects of the Root River return flow alternative

The primary construction-related impact to the water quality of affected streams could be potential elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would be minimized by adhering to environmental permit conditions and best management practices (BMPs) designed to reduce the turbidity and erosion (CH2MHill, 2013, Vol. 5, Appendix 5-2). All inland waterway crossings would result in construction-related impacts. Once construction is complete, the surface water crossings would be restored.

Table 4-31 lists the waterbodies that would be crossed by the estimated 75-foot-wide pipeline construction corridor for the proposed Root River return flow alternative (CH2MHill, 2013, Vol.5, Table 6-13).

Table 4-31. Water body crossings of the Root River return flow alternative

No.	Name	Type	Width (ft)	Area (ac)	Fisheries Classification
3732	Unnamed	Intermittent/ephemeral	14.3	0.02	—
4264	North Branch Root River	Perennial	38.7	0.07	WWSF
4325	North Branch Root River	Perennial	6.6	0.17	WWSF
5109	Unnamed	Intermittent/ephemeral	18.9	0.04	—
Totals			**78.5**	**0.3**	

4.4.2.3.2.1 Flora and fauna stream crossing effects of the Root River return flow alternative

The pipeline stream crossings of the Root River return flow alternative would not likely result in impacts on the flora and fauna assuming proper drilling procedures are followed (Section 4.4). There are other special concern species that may be present on land at these crossings and avoidance/minimization measures would be recommended.

4.4.2.3.2.2 Wetland effects of the Root River return flow alternative

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be less than 0.1 acre of wetland type change from forested to emergent associated with this alternative. A total of up to 0.62 acre of wetland would be affected by pipeline construction for this alternative.

Two palustrine emergent (PEM) wetlands, four palustrine scrub-shrub (PSS) wetlands, 11 palustrine forested (PFO) wetlands, and one flat/unvegetated wetland would be affected by pipeline construction.

There are two special concern herptile species and one crustacean species that occur in wetlands and may be impacted. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code. Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

Table 4-32 lists wetland crossing acreages associated with the pipeline of this alternative.

Table 4-32. Wetland crossings of the Root River return flow alternative (Source: WWI, CH2MHill, 2013, Vol. 5, Table 6-42)

No.	Type	Width[a] (ft)	Area (ac)
8714	Emergent/wet meadow	—	0.07
9020	Forested	—	0.02
9026	Forested	—	0.07
9028	Forested	—	0.01
10573	Emergent/wet meadow	—	< 0.01
11209	Flats/unvegetated wet[a] soil	12.96	0.04
11286	Scrub/shrub	—	0.01
11290	Scrub/shrub	—	0.02
11369	Scrub/shrub	—	0.02
11376	Scrub/shrub	—	0.05
11777	Forested	37.48	0.07
11890	Forested	—	0.01
11896	Forested	—	0.07
11914	Forested	—	< 0.01
12263	Forested	—	0.11
12314	Forested	—	< 0.01
12392	Forested	—	0.01
12399	Forested	—	< 0.01
Totals		**50.44**	**0.62[b]**

[a] Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland. Because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts.

[b] Total acreage is an estimated maximum

4.4.2.3.2.3 Upland forests and grasslands effects of the Root River return flow alternative

This alternative would affect 0.09 acres of woodlands (CH2MHill, 2013, Vol. 5, Table 6-52). There are four rare plant species that occur in dry-mesic to mesic woodlands and recommended measures may be suggested in order to avoid and/or minimize impacts to this species

this alternative would affect 3.51 acres of open lands. There is one rare plant species that occurs in upland grasslands and prairies and recommended measures may be suggested in order to avoid and/or minimize impacts to this species (CH2MHill, 2013, Vol. 5, Table 6-52).

4.4.2.3.2.4 Air emissions (construction and operation) effects of the Root River return flow alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the deep and shallow aquifers supply alternative would release an estimated 6,800 tons/yr (CO2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

Odor associated with the return wastewater, which can carry a characteristic treatment plant smell, may persist for an unknown distance downstream of the proposed Root River outfall. Treatment plant odors on the Fox River can occasionally be discerned 8.4 miles downstream of the current Waukesha outfall as observed by department staff while collecting water quality data on the Fox River at the County Highway I location.

4.4.2.3.2.5 Economic effects of the Root River return flow alternative

Construction of the infrastructure for the Root River return flow alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant would increase incrementally as wastewater effluent flows increase with increasing population and economic activity in the City. Construction, operation and maintenance costs would be borne by the residents of Waukesha.

4.4.2.3.2.6 Land use effects of the Root River return flow alternative

The Root River return flow alternative would affect a total of 183.7 acres of land for pipeline construction (CH2MHill, 2013, Vol. 5, Table 6-51).The land use construction and operation acreage impacts of this alternative are listed in Table 4-33. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Table 4-33. Root River return flow alternative land use impacts (Source for base land use data: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	6.39	3.48
Commercial & Industrial	0.43	0.23
Transportation & Communication/Utilities	167.62	91.24
Government. & Institutional	1.13	0.62
Recreational Areas	0.22	0.12
Agricultural Lands	3.92	2.13
Open Lands	3.51	1.91
Woodlands	0.09	0.05
Surface Water	0.05	0.03
Wetlands	0.36	0.20
Totals[b]	**183.72**	**100.01[c]**

[a] Represents the total that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland acreage differs from WWI data.
[b] Lake Michigan supply and return flow options share the same corridor for about 6 miles. Land use totals would be less than reported if a Lake Michigan supply and return option are approved.
[c] Includes rounding errors.

No new access roads would be required for this Lake Michigan return flow alternative. Access is anticipated to be from existing municipal roadways and trails.

The residential land within the assumed 75-foot construction corridor borders roads. The majority of residential land that could be affected by the proposed alignments is described as single family low density. The construction corridor may be further minimized to avoid private property, or temporary construction easements would be obtained by the City. This alternative would affect no private residences.

A single private building in Waukesha County is located within the proposed 75-foot-wide construction corridor at the terminus of this Lake Michigan return flow alternative. Based on a review of aerial photography, it appears to be used as a storage structure. The City would coordinate with the owner of the building if a Lake Michigan supply was approved and would avoid this building or minimize the construction-related impacts.

Land affected by pipeline construction would be restored, or allowed to revert to, its previous use.

No changes to zoning would be required for construction and operation of the Root River return flow alternative.

Transportation

Ninety five percent of the Root River return flow alternative pipeline would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.4.2.3.2.7 Recreation and aesthetic resources effects of the Root River return flow alternative

Table 4-34 summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this return flow alternative.

Table 4-34. Public or conservation lands within or adjacent to the Root River return flow alternative (Source: Google Earth, 2009, SEWRPC, 2005)

Name of Resource	Acres
Buchner Park	0.09
Carroll College athletic fields	0.05
Catholic Memorial High School	0.15
Fox River Sanctuary	<.01
Hidden Lakes Park	0.38
Park Arthur	0.48
Prospect Hill School	0.62
Randall School	0.18
Root River Parkway	0.2
Total	**2.16**

No permanent aboveground structures are envisioned within conservation land and natural, recreational, or scenic areas. The booster pump needed for this alternative would be constructed within the Waukesha WWTP site, in a previously disturbed area. The Root River return flow alternative would not impact a Coastal Zone Management Area.

Visual impacts from the proposed return flow alternatives are expected to be minor.

4.4.2.3.2.8 Archeological and historical resources effects of the Root River return flow alternative

Archival investigations were conducted by The Public Service Archaeology & Architecture Program of the University of Illinois at Urbana-Champaign (PSAAP) to identify significant cultural resources within or adjacent to construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The Root River return flow alternative may affect 10 cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). Eight National Register of Historic Places (NRHP) sites were identified within 0.1 mile of the proposed Root River return flow alternative, all within Waukesha County (NRHP, 2012). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.4.2.3.2.9 Costs and energy (construction and operation) effects of the Root River return flow alternative

The department considered costs for return flow alternatives based on their 50-year present worth. The 50-year present worth assumes a six percent interest rate (Technical Review S2, 2015). The 50-year present worth of the Root River return flow alternative is $106,038,000.

Capital costs are estimated at $98,038,000[18] while annual operation and maintenance costs are estimated as $618,000[19].

Operation of the Root River return flow alternative would be anticipated to use 14,200 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

The energy used in the Root River return flow alternative (not including water supply) would release emissions estimated at 15,700 annual greenhouse gas emissions (tons CO_2) (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.4.2.4 Direct to Lake Michigan return flow alternative environmental effects

4.4.2.4.1 Discharge effects on Lake Michigan water quality from the direct to Lake Michigan return flow alternative

All water returned to the Lake Michigan watershed would be required to meet all of the department's water quality (WPDES) permit requirements.

4.4.2.4.2 Lake Michigan geomorphology and sediments effects of the direct to Lake Michigan return flow alternative

The geomorphology and sediments of Lake Michigan may be affected by this alternative. This alternative could require a pipeline and discharge structure on the bottom of the Lake to provide an offshore discharge. The proposed offshore pipeline trenching activities and erosion of cleared banks could increase loads of suspended sediments to Lake Michigan. The Lake Michigan substrate composition along the pipe alignment could change as well. Impact severity would be a function of sediment load, particle size and duration of construction activities. The construction near Lake Michigan would require various environmental permits and BMPs would be used to minimize impacts from suspended solids, turbidity and erosion.

4.4.2.4.3 Discharge effects on Lake Michigan flora and fauna from the direct to Lake Michigan return flow alternative

Flora

The outfall is expected to be in a water depth greater than the maximum rooting depth of macrophytes (Eurasian water milfoil, coontail, *Elodea*) commonly found in Lake Michigan (WPSC, 2003). Areas along the outfall pipe that might be shallow enough to be within the range of water depths supportive of macrophyte growth are subject to long-shore drift and high-energy wave action.

[18] Capital costs were estimated in June 2013 dollars, and assume a 2013 construction start.

[19] Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD.

Benthic invertebrates

Benthic invertebrates would not be impacted as a result of an increased discharge to Lake Michigan.

Fish

There are many examples of outfalls (e.g. municipal wastewater, power plants) discharging directly into Lake Michigan. This outfall would be designed and placed similar to those outfalls and would be required to meet all of the necessary state and federal approvals and/or permit requirements. This proposed discharge would also be required to meet all water quality effluent limits under the WPDES program, which are designed to protect fish and aquatic life. The proposed discharge to Lake Michigan is not expected to have any positive or negative impacts to the Lake Michigan fish community

Birds

Birds would not be impacted as a result of an increased discharge to Lake Michigan.

Mammals

Mammals would not be impacted as a result of an increased discharge to Lake Michigan.

Invasives

During the construction phase of the water supply and return flow pipelines, best management practices would be used to reduce the potential introduction or spread of invasive species. Example practices that would be considered include: washing equipment and timber mats before entering wetlands/water bodies, removing aquatic vegetation from equipment leaving waterways, steam cleaning and disinfecting equipment used in waterways where invasive species may exist, utilizing non-invasive construction techniques. Post construction restoration methods would only use native species and the City would consider methods to encourage existing native species to thrive to reduce the potential of the invasive species establishing a foothold. Using these approaches would reduce the potential for spreading invasive species during construction.

4.4.2.4.4 Stream crossings effects of the direct to Lake Michigan return flow alternative

Table 4-35 lists the waterbodies that would be crossed by the estimated 75-foot-wide pipeline construction corridor for this alternative (CH2MHill, 2013, Vol. 5, Table 6-13).

Table 4-35. Water body crossings of the direct to Lake Michigan return flow alternative

No.	Name	Type	Width (ft)	Area (ac)	Fisheries Classification
1845	Poplar Creek	Perennial	—	0.03	Unkown
3052	Unnamed	Intermittent/ephemeral	—	0.01	—
3054	Unnamed	Intermittent/ephemeral	—	0.08	—
3055	Unnamed	Intermittent/ephemeral	—	0.001	—
3294	Unnamed	Intermittent/ephemeral	—	0.003	—
3305	Unnamed	Intermittent/ephemeral	—	0.005	—
3315	Deer Creek	Perennial	—	0.02	WWSF
5428	Lake Michigan	Lake	—	6.24	—
6566	Kinnickinnic River	Perennial	74.5	0.07	—
Totals			**74.5**	**6.459**	

[a] Where no crossing width is included, the pipeline construction either infringes upon the adjacent surface water, based on aerial confirmation of the GIS data, or there was no surface water width information available in GIS format.

4.4.2.4.4.1 Bed and banks of stream crossing effects of the direct to Lake Michigan return flow alternative

All inland waterway crossings would have result in construction-related impacts. Once construction is complete, the surface water crossings would be restored.

4.4.2.4.4.2 Water quality stream crossings effects of the direct to Lake Michigan return flow alternative

The primary construction-related impact to the water quality of affected streams could be potential elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would be minimized by adhering to environmental permit conditions and best management practices designed to reduce the turbidity and erosion (CH2MHill, 2013, Vol. 5, Appendix 5-2).

4.4.2.4.4.3 Flora and fauna stream crossings effects of the direct to Lake Michigan return flow alternative

The pipeline stream crossings of the Lake Michigan return flow alternative would not likely result in impacts on the flora and fauna assuming proper HDD procedures are utilized. There are other special concern species that may be present on land at these crossings and avoidance/minimization measures would be recommended.

4.4.2.4.4.4 Wetland effects of the direct to Lake Michigan return flow alternative

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way.

There would be approximately one acre of wetland type change from forested to emergent associated with this alternative. A total of 3.9 acres of wetland would be affected by pipeline construction for this alternative. Seven palustrine emergent (PEM) wetlands, 11 palustrine scrub-shrub (PSS) wetlands, six palustrine forested (PFO) wetlands, one open-water, and one filled/drained wetland would be affected by pipeline construction.

There are two special concern herptile species, one special concern crustacean species, and three rare plant species that occur in wetlands and may be impacted. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code. Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

Table 4-36 lists wetland crossing acreages associated with this alternative.

Table 4-36. Wetland crossings of the direct to Lake Michigan return flow alternative (Source: WWI, CH2MHill, 2013, Vol.5, Table 6-42)

No.	Type	Width[a] (ft)	Area (ac)
7962	Emergent/wet meadow	-	1.38
7970	Emergent/wet meadow	-	0
8015	Emergent/wet meadow	-	0.17
8125	Scrub/shrub	-	0.75
8145	Scrub/shrub	-	0.16
8239	Scrub/shrub	-	0.13
8290	Scrub/shrub	-	0.49
8463	Forested	-	0.11
8723	Emergent/wet meadow	-	0.08
8909	Scrub/shrub	-	0.3
8911	Scrub/shrub	-	0.17
8915	Scrub/shrub	-	0
8920	Scrub/shrub	-	0.11
8921	Scrub/shrub	-	0.14
8923	Scrub/shrub	-	0.07
9184	Forested	-	0.01
9306	Open water	-	0.01
10321	Filled/drained wetland	121.6	0.13
11046	Emergent/wet meadow	270.9	0.45
11053	Emergent/wet meadow	-	0.19
11054	Emergent/wet meadow	-	0.1
11676	Scrub/shrub	-	0.01
12613	Forested	-	0.08
12627	Forested	-	0.08
12628	Forested	-	0.01
12643	Forested	193.6	0.32
Totals		586.1	3.9

Where a crossing length is not included the pipeline centerline would not intersect wetland only the edge of the ROW would be located in the wetland. Because of this it is anticipated that construction techniques could be adjusted to avoid most, if not all wetland impacts.

4.4.2.4.4.5 Upland forests and grassland effects of the direct to Lake Michigan return flow alternative

This alternative would affect 0.08 acres of woodlands (CH2MHill, 2013, Vol. 5, Table 6-52). There are four rare plant species that occur in dry-mesic to mesic woodlands and recommended measures may be suggested in order to avoid and/or minimize impacts to this species.

This alternative would affect 11.33 acres of open lands (CH2MHill, 2013, Vol. 5, Table 6-52). There is one rare plant species that occurs in beach dunes and recommended measures may be suggested in order to avoid and/or minimize impacts to this species if suitable habitat is present onsite.

4.4.2.4.4.6 Air emissions (construction and operation) effects of the direct to Lake Michigan return flow alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the Lake Michigan return flow alternative would release an estimated 4,300 tons/yr (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.4.2.4.4.7 Economic effects of the direct to Lake Michigan return flow alternative

Construction of the infrastructure for the direct to Lake Michigan return flow alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant would increase incrementally as wastewater effluent flows increase with increasing population and economic activity in the City. Construction and operation costs would be borne by the residents of Waukesha. See also sections 3.14 and 4.6.

4.4.2.4.4.8 Land use effects of the direct to Lake Michigan return flow alternative

The direct to Lake Michigan return flow alternative would affect a total of 206 acres of land for pipeline construction (CH2MHill, 2013, Vol. 5, Table 6-51).

The land use construction and operation acreage impacts of this alternative are listed in Table 4-37. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Table 4-37. Lake Michigan return flow alternative land use impacts (Source for base land use data: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	4.8	2.40
Commercial & Industrial	9.81	4.91
Transportation & Communication/Utilities	154.77	77.47
Government & Institutional	4.29	2.15
Recreational Areas	4.51	2.26
Agricultural Lands	0.00	0.00
Open Lands	11.33	5.67
Woodlands	0.08	0.04
Surface Water	0.17	0.09
Wetlands	10.03	5.02
Totals [b-c]	**199.79**	**100.01 [d]**

[a] Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland acreage differs from WWI data.
[b] Lake Michigan supply and return flow options share the same workspace for about six miles. Actual land use totals would be less than reported if a Lake Michigan supply and return flow option was selected.
[c] Total does not include 6.2 acres of surface waters within Lake Michigan (not included in the SEWRPC Digital Land Use Inventory)
[d] Includes rounding errors.

No new access roads would be required for this Lake Michigan return flow alternative. Access is anticipated to be from existing municipal roadways and trails.

The residential land within the assumed 75-foot construction corridor borders roads. The majority of residential land that could be affected by the proposed alignments is described as single family low density. The construction corridor may be further minimized to avoid private property, or temporary construction easements would be obtained by the City. This alternative would affect no private residences.

Land affected by pipeline construction would be restored, or allowed to revert to, its previous use.

No changes to zoning would be required for construction and operation of the direct to Lake Michigan return flow alternative.

Transportation

Seventy nine percent of the direct to Lake Michigan return flow alternative pipeline would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.4.2.4.4.9 Recreation and aesthetic resources effects of the direct to Lake Michigan return flow alternative

Table 4-38 summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this return flow alternative.

Table 4-38. Public or conservation lands within or adjacent to the direct to Lake Michigan return flow alternative (Source: Google Earth, 2009; SEWRPC, 2005)

Name of Resource	Acres
Bethesda Springs Park	0.30
Carroll College athletic fields	0.28
Fox River Sanctuary	2.48
Greene Park	0.61
Greenfield Park	0.64
Kinnickinnic River Parkway	0.35
Sheridan Park	0.60
Saint Francis High School	0.49
Saint Francis Property	0.30
Total	**6.05**

No permanent aboveground structures are envisioned within conservation land and natural, recreational, or scenic areas. The booster pump needed for this alternative would be constructed within the Waukesha WWTP site, in a previously disturbed area.

The Direct to Lake Michigan return flow alternative would be within the designated Wisconsin Coastal Zone. If this alternative was utilized, the City would coordinate with the department, United States Army Corps of Engineers, and applicable agencies to avoid and/or minimize impacts to the Wisconsin Coastal Zone.

Visual impacts from the proposed return flow alternatives are expected to be minor.

4.4.2.4.4.10 Archeological and historical resources effects of the direct to Lake Michigan return flow alternative

Archival investigations were conducted by The Public Service Archaeology & Architecture Program of the University of Illinois at Urbana-Champaign (PSAAP) to identify significant cultural resources within or adjacent to construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor.

The direct to Lake Michigan return flow alternative may affect 17 cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). There are 10 National Register of Historic Places (NRHP) sites within 0.10 mile of the proposed Direct to Lake Michigan return flow alternative within Waukesha County, and two NRHP sites within Milwaukee County (NHRP, 2012). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.4.2.4.4.11 Costs and energy (construction and operation) effects of the direct to Lake Michigan return flow alternative

The department considered costs for return flow alternatives based on their 50-year present worth. This calculation assumes a six percent interest rate (Technical Review S2). The 50-year present worth of the Lake Michigan return flow near Oak Creek return flow alternative is $124,247,000. Capital costs are estimated at $117,247,000[20] while operation and maintenance costs are estimated as $423,000[21].

Operation of discharging return flow to Lake Michigan near Oak Creek would be anticipated to use 4,600 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

The energy used to return flow to Lake Michigan near Oak Creek (not including pumping water supply from Oak Creek) would release emissions estimated at 4,300 annual greenhouse gas emissions (tons CO_2) (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.5 General pipeline construction effects

4.5.1 Process overview

Regardless of which project alternative is used, similar impacts will occur as a result of pipeline construction through waterways and wetlands. There are a variety of methods to install a pipeline across a waterway or wetland. The Wisconsin Department of Natural Resources (WDNR) has authorization under Chapter 30, Wis. Stats., to permit and dictate the construction method authorized at each waterway.

To allow the passage of construction equipment and materials along the right of way (ROW), temporary bridges may be installed across waterways. Equipment crossings of waterways will be restricted to bridges that are authorized under the WDNR's Chapter 30 permit.

Waterway crossings for the proposed may be accomplished using five distinct construction methods:

- open trench
- dam and pump
- flume
- horizontal direction drill (HDD), and
- jack and bore.

These crossing methods have common procedures and unique components, which are discussed below.

[20] Capital costs were estimated in June 2013 dollars, and assume a 2013 construction start.
[21] Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD.

Standard crossing methods normally require a gradual and uniform approach to the waterbody to prepare a suitable work area for construction equipment and place the pipeline. This usually requires removing bank vegetation and grading the banks away from the waterbody. This process could temporarily increase the potential for soil erosion until construction is complete and the right of way is stabilized and reseeded.

Erosion control measures would be required to be installed before construction. Temporary erosion controls include storing all excavated spoil in containment areas that prevent the spoil from entering the stream, and installation of silt fence and/or straw bales to prevent runoff from upland areas from entering the stream. Additional temporary workspaces on each side of the waterbody are generally required for staging the crossing. These are typically 50 feet wide by 150 feet long. There will be an undisturbed buffer between the additional temporary workspace and the waterway.

Following installation of the pipeline across the waterway, the ROW on either bank would be re-graded to its approximate preconstruction contours. Disturbed stream and river banks would be stabilized with biodegradable geotextile fabric, jute thatching, or bonded fiber blankets. Disturbed soils would be fertilized, seeded, and mulch would be applied as needed. Temporary bridges would be removed after seeding and mulching are complete. Temporary erosion control measures would be removed after permanent erosion control measures are installed and vegetation is re-established. Construction equipment would be required to be decontaminated to prevent the spread of invasive species which may be attached from previous construction sites.

4.5.2 Open trench crossing method

For an open trench crossing, a trench would be excavated through the stream using draglines or backhoes operating from one or both banks. The potential impacts to a waterway and its biota from open trench construction are quite different if the trenching is done when the waterway has flowing water rather than when the stream is dry. The WDNR typically limits open trench installation of the proposed pipelines to intermittent waterways with no flowing water at the time of construction. If there is flowing water, one of the other crossing methods would have to be used. This EIS assumes that open trench construction would be allowed only during times of no stream flow.

Restricting open trenching to times of no flow eliminates the direct construction impacts to the stream's water column, avoiding the associated sedimentation of habitat for fish and aquatic invertebrates, water quality degradation, and reduced light for aquatic plants and algae.

No long term impacts to streams would be expected if the contours of the streambed are restored to their pre-construction condition, required by Chapter 30 permitting.

4.5.3 Dam and pump crossing method

The dam and pump stream crossing method is slower and more expensive than the open trench method, however it generally reduces the water quality impacts caused by open trenching. It is also preferred for small streams that are sensitive to sediment loading.

This method involves damming the stream on either side of the construction area before trench excavation, using sand bags or other methods that greatly minimize the addition of sediment to the stream. Before the dams are installed, one or more water pumps would be placed on the upstream side of the proposed trench so water can be pumped around to the downstream side of the construction area.

The placement and removal of the pumps and damming material would cause minor sediment suspension. Where the pump hose discharges downstream of the crossing, energy dissipation devices would be used as necessary to prevent scouring of the stream bed. Trenching, installation of the pipeline, and restoration of the banks and ROW would be completed in the same manner as described for the open trench method. However, because the stream flow is pumped around the construction area instead of through it, only minimal sediments would be displaced by construction.

The use of the bypass pumping to redirect stream water flow around the construction area would temporarily block movements of fish and other aquatic organisms through the area.

4.5.4 Flume crossing method

The flume method is suitable for small to intermediate streams with straight channels at the crossing area, and that are sensitive to sediment loading.

Flumes made of large pipe sections would be aligned in the stream parallel to the water flow. The stream would then be dammed with a diversion bulkhead to direct stream flow through the flumes. A similar bulkhead would be installed at the downstream end of the flumes to prevent backwash from entering the construction area. Energy dissipation devices would be installed as needed to prevent scouring at the discharge location.

A trench would then be excavated underneath the flumes in the exposed section of stream bed. A section of pipeline long enough to span the stream would be welded together and pulled beneath the flume. The flumes would be removed after the installation of the pipeline. Backfilling and bank restoration would be completed as described for the open trench method.

Fluming, like the dam and pump method, isolates stream flow from the construction area and allows installation of the pipeline without significant displacement of sediments. The use of the flume to redirect stream water flow through the construction area would also temporarily prevent movement of fish and other aquatic organisms.

4.5.5 Horizontal directional drilling crossing method

Directional drilling minimizes the environmental effects of pipeline construction on a waterbody or waterway by going beneath its bed and avoiding direct disturbance of the bed and banks. This technique is especially useful for wide crossings, where navigation traffic is high, areas where bottom sediments are contaminated, or where there are sensitive habitats or cultural resources near the banks.

The HDD method involves using a special drill rig to drill a gently curved borehole below the surface of the ground and the bed of the waterway. After it exits on the opposite side of the stream, the drilling machine pulls a long, pre-welded pipeline section back through the drilled hole.

Temporary workspaces would be cleared for drilling equipment, measuring approximately 250 feet long by 50 feet wide on the entry side of the crossing. A slant drill unit would be placed on one bank and a small-diameter pilot hole would be drilled under the stream. After the pilot hole has been completed, it would be enlarged to accept the pipeline by pulling a barrel reamer back and forth through the bore hole. Drilling mud would be continuously pumped into the hole to remove cuttings and maintain the integrity of the enlarged hole. After the hole has been reamed, a prefabricated pipeline section long enough for the crossing would be pulled through the hole by the drilling rig.

An HDD crossing avoids most of the potential impacts that are a concern with pipeline crossings of waterways, as the pipeline is installed beneath the bed of the waterway. There is no disturbance or change to either the bed or water column. Many of the potential concerns described for other methods of crossing waterways, including sedimentation and turbidity, habitat alteration, disrupting breeding and movement patterns, and the introduction of pollutants into the water column, do not occur when the HDD method is properly used.

HDD construction uses a drill “mud” under pressure to lubricate the drill pipe, remove drill cuttings and maintain the integrity of the drill hole. The drilling mud is usually a water-based slurry of bentonite clay which may have an emulsifier added. Drilling mud and cuttings would also require disposal.

Pressurized drilling mud may leak to the surface, or “frac-out.” Such failures are not easily predicted; however, the impacts from failure can be reduced by monitoring mud pressure and drilling head location, inspecting the surface during the drill process, and by increasing the depth of the drill path below the bed of the river. In most cases the volume of sediment resulting from seepage of drilling mud would be far less than the amount produced by a conventional open-cut crossing.

During the crossing, drilling mud is stored away from the river in an earthen berm containment structure or fabricated containment tanks sized to accommodate the volume of mud necessary for the drill. Following completion of directional drilling, mud is disposed of in accordance with applicable state and local requirements. Where landowner permission is available, mud is typically land-spread in upland, agricultural fields. If landowner permission is not available or land-spreading is not appropriate for some other reason, drilling mud would be disposed of in a landfill or other authorized disposal site.

If an unanticipated frac-out were to occur in an upland location, the drilling mud would be contained to the extent possible with standard erosion control measures such as silt fences and/or hay bales, then disposed of properly by removing and spreading over an upland area or hauled off-site to an approved location.

A frac-out can occur in the bed of a waterbody or an adjacent wetland. If an in-stream frac-out occurred, the drilling would stop to develop an appropriate response. If proceeding with the

HDD crossing would cause significant adverse impacts to waterbodies and fisheries resources, the HDD would stop, and an alternative crossing method would be used. For a wetland frac-out, the slurry at the surface would be isolated using silt fence and/or hay bales, then removed by vacuum truck, machinery, or by hand, and disposed of in an acceptable upland location.

4.5.6 Jack and bore crossing method

This method is used primarily to install pipe under a surface, or shallow obstructions such as roads, railroads and other existing utilities. In some instances it may be used to install a pipeline under waterways. This method is also called auger boring or pipe jacking.

With this method, two construction pits are dug, a jacking pit and a receiving pit. The pits are typically about 15 feet wide and 35 feet long. A rotating boring machine is used to create a hole, starting from the jacking pit and ending in the receiving pit. A casing pipe, larger in diameter than the water pipe, is pushed into the hole following the boring machine. After the casing pipe has been installed between the jacking and receiving pits, the water pipe is slid into the casing pipe. The void area between the casing pipe and the bored soils is filled with grout and the area between the casing pipe and the water pipe is filled with pea gravel or sand.

There is little potential for a frac-out condition occurring during jack and bore installation, unlike that for a HDD installation, because the bentonite drilling slurry is not pressurized. The unpressurized drilling slurry would not have a force mechanism to push it far enough out of the drill hole to result in a frac-out release.

The use of this method to install a pipeline avoids most of the potential impacts that are a concern with pipeline crossings of waterways that place the pipe beneath the bed of the waterway. There is no disturbance or change to either the waterway's bed or water column.

Many of the potential impacts of some other methods of crossing waterways, including sedimentation and turbidity, habitat alteration, disrupting breeding and movement patterns, and the introduction of pollutants into the water column, do not occur when this method is used.

4.5.7 Operation and maintenance related impacts

Other than inspections from vehicles and routine removal of brush and trees, there should be little long-term disturbance of the corridor, and associated long-term effects on water quality due to operating and maintaining the proposed pipelines.

4.5.8 Waterway summary

For intermittent waterways, open trench crossings of these waterways would only be allowed at times of no flow. With this restriction, open cut trenching would not alter the streams' water quality or have any direct effect on aquatic life. With simple restoration efforts, using this method would also not substantially change either streambed configuration or flow characteristics.

For perennial waterways that would be crossed, the potential environmental consequences using HDD or jack and bore pipeline construction methods would be minimal, because those pipeline installation methods do not directly disturb the bed or water column of the waterway. The potential impacts to the perennial waterways crossed using a dam and pump or flume method, are also expected to be minor, with impacts primarily of temporarily inhibiting movements of fish and other aquatic organisms through the construction zone.

4.5.9 Pipeline Construction Impacts on Wetlands

The temporary removal of wetland vegetation is a primary impact of pipeline construction and right-of-way maintenance activities. Construction also would temporarily diminish the recreational and aesthetic value of the wetlands crossed. These effects would be greatest during and immediately following construction. In wet meadow/emergent wetlands, the impact of construction would be relatively brief, since herbaceous vegetation regenerates within one or two seasons. In forested and shrub-dominated wetlands, the impact would last longer due to the longer recovery period of these vegetation types. Long-term vegetation management over the pipeline to allow access and inspection would prevent regeneration of tree and shrub cover.

Clearing of wetland vegetation would also temporarily, or in some cases, permanently, remove or alter wetland wildlife habitat.

Trench excavation is a major disturbance of a wetland, but construction activities would also impact wetlands outside of the trench area. Compaction and rutting of wetland soils could result from the temporary stockpiling of soil and the movement of heavy machinery. Surface drainage patterns and hydrology could be temporarily altered, and there would be increased potential for the trench to act as a drainage channel. Trench breakers would be placed in the trench to prevent the flow of groundwater in the backfilled trench. Increased siltation in adjacent wetland areas may result from trenching activities. Disturbance of wetlands also could temporarily affect the wetland's capacity to reduce/moderate erosion and floods.

Construction through wetlands would comply, at a minimum, with conditions set in the state and federal permitting. The evaluation of potential impacts from crossing wetlands is based on WDNR waterway and wetland permitting which requires the use of appropriate erosion control practices along with the restoration of the wetland contours to preconstruction conditions.

The following discussion summarizes the major components of proposed construction methods. Staging areas and extra workspace would be needed on both sides of larger wetlands. These areas would be located at least 50 feet away from the wetland boundaries, where topographic conditions permit, and would be limited to the minimum area needed for assembling the pipeline. Storage of hazardous materials, chemicals, fuels, and lubricating oils would generally be prohibited within 100 feet of wetland boundaries.

Temporary erosion control devices would be installed at the base of cleared slopes leading to wetlands. If there is no slope, erosion control devices would be installed as necessary to prevent exposed soils from flowing off the ROW into the wetland or to prevent sediment from flowing from adjacent uplands into the wetlands.

During clearing, woody wetland vegetation would be cut at ground level and removed from the wetland, leaving the root systems intact. In most areas, removal of stumps and roots would be limited to the area directly over the trench. Stumps from areas outside of the trench line would be removed, as necessary, to provide a safe work surface.

To facilitate revegetation of wetlands, topsoil would be stripped over the trench, except in areas where standing water or saturated soils make it impracticable, where no topsoil layer is evident, or where the topsoil layer exceeds the depth of the trench.

The use of either low ground-pressure equipment or standard construction equipment operating from timber pads would reduce disturbance of wetlands with saturated soils or standing water.

Imported rock, stumps, brush, or offsite soil would not be used as temporary or permanent fill in wetlands. Following construction, materials used in wetlands to provide stability for equipment access would be removed.

If the standard crossing method is not practical because of saturation or standing water, either a push/pull method or winter construction might be used. Use of the push/pull method is generally limited to large wetlands with standing water and/or saturated soils that have adequate access for pipeline assembly and equipment operation on either side of the wetland. If this method is used, a long section of pipeline would be assembled on an upland area of the ROW adjacent to the wetland. Usually this requires use of extra temporary workspace adjacent to the ROW. The trench would be dug by a backhoe supported on timber mats. The prefabricated section of pipeline would then be floated across the wetland. When the pipeline is in position, the floats would be removed and the pipeline would sink into position. The trench would then be backfilled and the original contours would be restored by a backhoe working from construction mats.

Under frozen conditions, the pipe would be installed in wetlands similar to conventional upland construction. Because equipment is supported by frozen soil and ice, temporary mats would not be required. The success of winter construction depends on prolonged periods of subfreezing temperatures, which produce sufficient frost depth. Because these conditions are not always predictable, the ability to use the winter construction method is generally not assured.

Ice roads may also be used to decrease impacts. Ice roads are created by plowing the snow off of the wetland surface, and driving sequentially heavier pieces of equipment across the wetland surface to facilitate the penetration of the frost deeper in the ground, creating a stable working surface.

Following restoration of contours, wetlands would typically be seeded with annual ryegrass as a cover crop. Other measures such as replacement of the original surface soil, with its stock of roots and tubers can facilitate restoration. The wetland would either be seeded with an appropriate native wetland seed mix or allowed to re-vegetate naturally to preconstruction vegetative covers. No lime or fertilizer would be added to disturbed wetland areas, unless required in writing by the appropriate permitting agency. After a period of monitoring, wetlands that do not appear to be regenerating by this process may need to be seeded with an approved native seed mix.

Most of the wet meadow wetlands have, or are dominated by, reed canary grass, which is a very aggressive invasive plant. In wetlands that contain the grass, it is likely that, following construction, the ROW and workspace area would become dominated by the grass because of the disturbance and spreading of the plant rhizomes, which facilitate spread. A wetland free of reed canary grass should be protected from its introduction by construction mitigation techniques.

Operation of the pipelines would not require alteration of wetlands other than periodic brush and tree control in the pipeline's permanent ROW. No permanent filling, dredging or other long term wetland disturbance is anticipated.

4.6 Socioeconomic effects

The UW-Milwaukee's Center for Economic Development (CED) made a detailed study of socioeconomic factors for SEWRPC's Regional Water Supply Plan. The conclusions from that study are summarized here (Rast, 2010).

CED's evaluation of the Regional Water Supply Plan (RWSP) considered SEWRPC's Regional Land Use Plan (RLUP), and relevant local and countywide comprehensive plans, including the planned land use components. Plans were evaluated in order to understand how the recommendations set forth in the RWSP would impact development and land use. Existing and planned land uses for specific communities were examined in order to determine whether and use patterns in areas proposed for expansion or conversion under the RWSP could have an impact on environmental justice.

Over the past 50 years, there has been an outward migration of population and jobs from the large lakeshore manufacturing cities to the outlying counties and suburbs. The loss of an economy based on manufacturing and the movement of economic and development activity inland negatively impacted jobs and income in the central city areas. A substantial increase in the number and percent of people living at or below the poverty level has occurred in the Kenosha, Milwaukee, and Racine while it has declined in many suburban communities. Racial and ethnic minority and low-income populations have been disproportionately affected. These populations have become increasingly concentrated in Kenosha, Milwaukee, and Racine.

Job projections and population projections by race, ethnicity, and disability for the year 2035 were also evaluated.

If trends continue, migration of the White Alone, Non-Hispanic populations from Milwaukee and Racine will continue to contribute to growth in suburban areas. White Alone populations in Kenosha and Waukesha are expected to decline in number and proportion while being offset by increases in minority populations that will result in the population growth of those cities.

USGS and SEWRPC studies indicate that groundwater issues are not currently a constraint on development in the region, and that the source of water would not have an impact on development.

CED's land use analysis found that the delineations of the existing and proposed utility service areas in the RLUP include lands that are mostly either currently developed or undevelopable. The land use analysis also found that most of the undeveloped land within the projected service areas is primarily infill development. Growth is limited under the RWSP to the existing development and infill developable areas within the proposed expanded water utility service areas. Therefore it is not anticipated that projected population growth or the distribution of ethnic and racial minorities will be caused by implementation of the recommendation to change sources of water supply.

Based on the land use findings, CED concluded that it is unlikely that recommended water source changes from groundwater to Lake Michigan water would yield any significant socio-economic imbalances through 2035 (Rast, 2010).

Section 5 Comparison of Alternatives

5 Comparison of Alternatives

5.1 Introduction

This section provides a brief summary and comparison of the various water supply and return flow alternatives.

Under WEPA, an EIS must consider alternatives to the proposed action (Wis. Stat. 1.11(2)(c)3.). Section 2 describes the proposed alternatives and pipeline corridors, Section 3 describes the existing environment, and Section 4 identifies the potential impacts of the various water supply source alternatives, and return flow discharge alternatives. Section 4 also evaluates the "no action" alternative. Potential cumulative effects are summarized in Section 6 along with a general evaluation of the proposal.

5.2 Comparison of water supply source alternatives

Section 4 describes in detail the potential impacts of the water supply alternatives (section 4.2).

The Applicant reviewed six water supply alternatives in detail: four of the reviewed alternatives withdraw water exclusively from the Mississippi River Basin; one alternative withdraws water from a combination of Mississippi River Basin and Lake Michigan sources; and the final alternative withdraws water from the Lake Michigan Basin. Based on public comments, the department also modeled and reviewed an alternative scenario that included variations on well placement meant to minimize adverse environmental impacts.

Approximately 1.0 million gallons per day (MGD) is forecasted in water savings due to conservation and efficiency measures by final build-out (approximately the year 2050), and the department has taken this into account in calculating projected demand for the water supply service area. The proposed diversion cannot be reasonably avoided through the efficient use and conservation of existing water supplies.

The EIS analyzes the proposed water supply alternatives based on cost and potential impacts to the human environment. Table 5.1 indicates that all of the proposed Mississippi River basin water supply alternatives are similar in cost to the Lake Michigan alternative.

Table 5-1. Comparison of Water Supply Alternative Costs (50- year Present Worth 6 percent)

Alternative	50-year present worth ($, 6 percent)	Within 25 percent of the preferred alternative cost
1 - Deep and Shallow Aquifers	275,560,000*	√
2 - Fox Alluvium and Shallow Aquifer	350,560,000	√
3 - Unconfined Deep Aquifer	288,670,000*	√
4 - Multiple Sources	391,460,000*	√
5 - Lake Michigan and Shallow Wells	406,890,000*	√
6 - Preferred Lake Michigan Supply (Oak Creek, Return to Root)	**332,400,000**	**249,300,000 - 415,500,000**
6a – Lake Michigan Supply (Oak Creek, Return Direct to Lk. Michigan)	350,600,000	√
6b – Lake Michigan Supply (Oak Creek, Return to Mil. Met. Sewage	374,800,000	√
*Does not include home water softening.		

As described in Section 4, the water supply alternatives that include the Mississippi River Basin sources are likely to have greater overall adverse environmental impacts primarily due to projected impacts on wetlands and lakes than the proposed Lake Michigan alternative. The deep and shallow wells alternative has the potential to impact 809 to1069 acres of wetlands and the shallow wells alternative has the potential to impact 1939 to 2326 acres of wetlands due to groundwater drawdown from pumping. Wetland impacts to Vernon Marsh could be significant from the increased well pumping.

The proposed diversion would not result in significant adverse direct impacts or cumulative impacts to the quantity or quality of the waters of the Great Lakes basin or to water dependent natural resources, including cumulative impacts that might result due to any precedent-setting aspects of the proposed diversion. The proposed annual diversion represents 0.00028 percent of the volume of Lake Michigan and 0.000061 percent of the volume of the Great Lakes. These totals do not take into account any treated wastewater returned to the Lake Michigan basin. Based on the Applicant's preferred return flow alternative, the department determined that 95-109 percent of the water withdrawn (using water use data from 2005-2012) would have been returned to the basin had the return flow plan been in place over that time period.

5.3 Comparison of water supply pipeline alternatives

Sections 4.2.3.2 to 4.2.3.4 describe potential impacts from the various water supply pipeline alternatives on several aspects of the human environment. Table 5.2 summarizes the comparison of potential impacts of the route alternatives. The Milwaukee and Oak Creek alternatives would follow existing transportation or utility corridors for much of the route, while the Racine alternative would cross primarily agricultural and open lands. Natural resource features along any route will be affected during construction. Use of best management practices for protecting wetland and waterways and site restoration would be required to minimize the temporary impacts of the pipeline construction. Permanent changes to wooded areas, especially forested wetland conversion to emergent wetlands, is less for the Oak Creek alternative. The fewest overall impacts to natural resources features would occur for the Oak Creek pipeline alternative.

Table 5-2. Comparison of Water Supply Pipeline Alternatives

	Milwaukee	Oak Creek	Racine
Pipeline length in miles	15	19.4	38
Percent in transportation or utility corridor	80	94	9.9
Number waterways crossed	7	3	16
Acres of wetlands affected	6.8	0.5	56.4
Acres of forested wetlands converted to emergent	5.9	0.1	19.2
Acres of woodland affected	0.45	0.48	7.74
Acres of open or grassland	8.0	1.2	30.7
Acres recreation land near pipeline	24	2.2	20.4
Annual energy use in MWh	11,500	14,200	16,100
Number cultural sites near pipeline	5	7	2

5.4 Comparison of return flow discharge alternatives

Section 4.3.2 describes potential impacts from the various return flow discharge options for the Lake Michigan supply option. For any scenario that involves the Lake Michigan supply option, there could be an estimated 11% decrease in baseflow to the Fox-Illinois River due to decreased discharge from the City's existing WWTP (see Appendix A of the EIS for Fox River impacts). This decrease would likely have minimal impacts to the water quality and flora and fauna using the Fox River. Eliminating the current shallow aquifer well pumping near the Fox River would increase the baseflow of tributaries to the Fox River.

None of the return flow discharge alternatives would involve significant adverse impacts to Lake Michigan water quality, quantity and biota. The MMSD and Root River alternatives would not involve any construction activities in Lake Michigan.

The proposed additional flow to the Root River during low-flow periods may positively impact the Root River fish community. Phosphorus may both negatively and positively impact the fish community of the Root River and estuary. Temperature impacts to the Root River would likely be minimal, and the addition of chlorides, and possibly pharmaceuticals, would likely negatively affect the fish of the Root River and possibly have a slightly negative effect on the fish community in the Root River estuary and possibly the near shore areas of Lake Michigan.

5.5 Comparison of return flow pipeline route alternatives

Sections 4.3.2.2 to 4.3.2.4 describe potential impacts from the various return flow pipeline alternatives on several aspects of the human environment. Table 5.3 summarizes the comparison of potential impacts of the route alternatives. All of the return flow options have similar potential for impacts to natural resources features. All routes would follow existing transportation or utility corridors for much of the route, with the MMSD and Root River alternatives having over 90% of the route in that land use. Natural resource features along any route will be affected during construction. Use of best management practices for protecting wetland and waterways and site restoration will be required to minimize the temporary impacts of the pipeline construction. Permanent changes to wooded areas, especially a conversion from forested wetland to emergent wetlands, are less for the Root River alternative. Energy usage is proposed to be lowest for the direct discharge to Lake Michigan alternative.

Table 5-3. Comparison of Return Flow Pipeline Alternatives

	MMSD	Root River	Lake Michigan
Pipeline length in miles	17.6	20.2	22.5
% in transportation or utility corridor	92.5	91.2	77.5
# waterways crossed	3	4	9
acres of wetlands affected	1.06	0.62	3.90
acres of forested wetlands converted to emergent	0.79	0.1	1.0
acres of woodland affected	0.5	0.09	0.08
acres of open or grassland	5.0	3.5	11.3
acres recreation land near pipeline	2.3	2.2	6.0
annual energy use in MWh	8,100	14,200	4,600
# cultural sites near pipeline	12	10	17

Cumulative Effects and Evaluation

6 Cumulative Effects

The Applicant is without adequate supplies of potable water due to the presence of radium in its current groundwater water supply. The Applicant's current water supply, the deep sandstone aquifer, is derived from groundwater that is hydrologically interconnected to waters of the Lake Michigan basin. Groundwater pumping from the deep sandstone aquifer in southeast Wisconsin has changed the predevelopment groundwater flow direction from flowing towards Lake Michigan to flowing towards pumping centers. Currently the largest pumping center from the deep sandstone aquifer in southeast Wisconsin is in Waukesha County.

The proposed diversion would not result in significant adverse direct impacts or cumulative impacts to the quantity or quality of the waters of the Great Lakes basin or to water dependent natural resources, including cumulative impacts that might result due to any precedent-setting aspects of the proposed diversion. The proposed annual diversion represents 0.00028 percent of the volume of Lake Michigan and 0.000061 percent of the volume of the Great Lakes. These totals do not take into account any treated wastewater returned to the Lake Michigan basin. Based on the Applicant's preferred return flow alternative, the department determined approximately 100 percent of the water withdrawn (using water use data from 2005-2012) would have been returned to the basin had the return flow plan been in place over that time period.

The proposed Oak Creek water supply pipeline route right-of-way would require the permanent conversion of 19.62 acres of forested wetland to emergent wetland, and 7.74 acres of woodland to grassland. The proposed Root River return flow pipeline right-of-way would require that one acre of forested wetland be permanently converted to emergent wetland, and that 0.08 acres of woodland be permanently converted to grassland. Use of best management practices for protecting wetland and waterways and site restoration will be required to minimize the temporary impacts of the pipeline construction.

For the Lake Michigan supply there could be an estimated 11% decrease in baseflow to the Fox-Illinois River due to decreased discharge from the City's existing WWTP. This decrease would likely have minimal impacts to the water quality and flora and fauna using the Fox River. Eliminating the current shallow aquifer well pumping near the Fox River would minimally increase the baseflow of tributaries to the Fox River and to associated wetlands.

The return flow discharge would not involve significant adverse impacts to Lake Michigan water quality, quantity and biota. The proposed Root River return flow would not involve any construction activities in Lake Michigan. The proposed additional flow to the Root River during low-flow periods may positively impact the Root River fish community. Phosphorus may both negatively and positively impact the fish community of the Root River and estuary. Temperature impacts to the Root River would likely be minimal, and the addition of chlorides, and possibly pharmaceuticals, would likely negatively affect the fish of the Root River and possibly have a slightly negative effect on the fish community in the Root River estuary and possibly the near shore areas of Lake Michigan.

6.1 Effects on scarce resources

Other than the permanent conversion of forested wetlands to emergent wetlands within proposed pipeline rights-of-way, effects on scarce resources, such as listed species and archeological/historic resources, are not anticipated.

6.2 Unavoidable adverse effects

Proposed project pipelines are expected to result in a total permanent conversion of 20.62 acres of forested wetland to emergent wetland, and a total permanent conversion of 7.82 acres of woodland to grassland. Additional permitted pollutant loading to the Root River is expected. Fox River baseflows are estimated to decrease by 11%.

6.3 Consistency with plans

The proposed project is consistent with public plans and policies. The department's Technical Review finds that the proposed diversion meets all Agreement/Compact and statutory requirements for a community within a straddling county. The proposed diversion would be implemented to ensure that it is in compliance with all applicable municipal, state and federal laws as well as regional interstate and international agreements, including the Boundary Waters Treaty of 1909. The Applicant would be required to comply with all applicable laws and would need to work closely with regulatory authorities throughout any diversion process.

6.4 Short-term and long-term effects

Construction-related resource effects are anticipated to be short-term. Conversion of wooded to non-wooded areas would be a long-term effect as long as pipeline rights-of-way are maintained. Discharges to the Root River and reduced discharge to the Fox River will continue for the long-term. Energy and materials for construction and operation will be committed for the long-term. Long-term effects on Lake Michigan are not anticipated. A safe and sustainable public water supply for the Applicant is expected for the long-term.

6.5 Precedence

The department determined in the Technical Review that the proposed diversion is approvable under the Agreement/Compact and plans to forward the application to the Regional Body and Compact Council for review. The Agreement/Compact bans diversions, but provides limited exceptions for a public water system in a "straddling community" or a "community within a straddling county" to apply subject to Agreement/Compact requirements. There are no Agreement/Compact provisions that allow for areas outside of a straddling county to apply or become eligible for a diversion. Other diversions of Great Lakes water currently exist; therefore the department sees no precedent related to federal law for the proposed diversion.

Denying the proposed diversion is unlikely to set a precedent for denying all other diversion requests from communities in straddling counties. The specifics of each diversion proposal are likely to be a unique set of facts that have limited applicability to any other diversion approval. The decision on any necessary future permits and approvals would not be substantively affected by a diversion approval.

6.6 Risk

There is little degree of risk or uncertainty in predicting environmental effects or effectively controlling potential deleterious environmental impacts, including those relating to public health or safety. The proposed project would utilize well-known technologies for water supply, treatment and return. Water returned to the Root River would be required to meet permit requirements.

6.7 Controversy

This first-of-its-kind project has generated considerable public interest and controversy. The department received many public comments throughout the review process and has responded to those comments in the Public Comments and Responses document attached to this EIS.

Appendices

7 Appendix A: Impacts to the Fox Flow under different alternatives

DNR staff analyzed the anticipated change in flow to the Fox River from the current flow with current water supply based on the alternatives considered in the EIS. The results of this analysis ranged from 11% decrease in baseflow to a 4% increase in baseflow on the Fox River just downstream of the confluence of Pebble Brook.

Currently the Applicant relies on the deep and shallow aquifers for water supply: 80% of the water supply is from the deep aquifer and 20% from the shallow aquifer. The shallow aquifer wells are located adjacent to the Fox River downstream of the City's Wastewater Treatment Plant. As a result water captured by the wells drawing from the shallow aquifer that would have discharged to the Fox River is still discharged to the Fox River after use through the WWTP. In addition to the water withdrawn for water supply, additional water known as Infiltration and Inflow collects in sewer pipes, is treated at the WWTP and discharges to the Fox River. The City's 2010 – 2014 average annual water withdrawal was 6.7 MGD. The City's 2008 – 2012 average annual wastewater discharge was 10.2 MGD. Assuming a 10% consumptive use coefficient, I/I is assumed to be 4.3 MGD.

DNR staff took a simplified approach to the Fox River water budget for the analysis of flow in the Fox under different water supply alternatives. For all of the alternatives that include baseflow reductions to the Fox River from shallow aquifer withdrawals the water is returned to the Fox River Basin. However, the variable in the different Mississippi River Basin alternatives is the amount of deep aquifer water used for the water supply. Deep aquifer water comes from water recharge in western Waukesha County outside of the Fox River Basin – use of the deep aquifer essentially augments the flow in the Fox River.

The following table shows relative impacts to the Fox River flow from the different proposed water supply alternatives.

Table 7-1. Percent change in baseflow to the Fox River from current baseflow to the baseflow under water supply alternatives

Alternative	Deep Aquifer	Shallow aquifer Fox River Baseflow[a]	Shallow aquifer other streams baseflow[a]	Shallow aquifer other sources[b]	I/I[c]	Consumptive Use 10%	Lake Michigan	WWTP Fox River Discharge[d]	Additional Flow to the Fox River[e]	% Change from Current
Current[f]	5.4	0.9	0	0.3	4.3	0.53	0	10.2	5.1	0%
No Action[f]	7.3	0.9	0	0.3	4.3	0.68	0	12.1	6.8	4%
Deep/Shallow 1	4.5	2.3	1.1	0.6	4.3	0.68	0	12.1	4.6	-1%
Deep/Shallow 1a	4.5	3.5	0.2	0.3	4.3	0.68	0	12.1	4.3	-2%
Shallow	0	5.4	2.2	0.9	4.3	0.68	0	12.1	0.8	-9%
Lake Michigan	0	0	0	0	4.3	0.68	8.5	3.6	0	-11%

a – baseflow calculations from groundwater flow modeling with USGS Upper Fox River Basin Model, see Appendix B for further information. Baseflow from other streams are tributary to the Fox River and considered as Fox River flow.

b – other sources of water are the remaining volume of water not captured from Fox River or tributary to the Fox River. This water is from aquifer storage or captured from baseflow not tributary to the Fox River. Baseflow comparisons are based on modeled Fox River baseflow just downstream of Pebble Brook confluence with the Fox River. Current baseflow was modeled at 74.9 cfs.

c - I/I, infiltration and inflow, is calculated as the remaining flow greater than the average annual withdrawal discharged from the wastewater treatment plant. I/I was calculated for the current scenario and then held constant in the other scenarios. I/I = WWTP Discharge – (Total Water withdrawal*Consumptive Use coefficient).

d – WWTP Fox River Discharge for the Current alternative is the average from 2008 – 2012. All others the WWTP discharge are sums of sources and I/I.

e – Additional flow to the Fox River is flow that would not have naturally discharge to the Fox River – this includes flow from the deep aquifer and from other shallow aquifer sources minus consumptive use.

f –The department used the model results at the end of stress period 2 for alternative 4 as described in Appendix B for estimating impacts of the Current and No Action alternatives.

Description of Alternatives

Current– Withdrawals based on 2010-2014 average annual withdrawals

No Action – Assumes 2010-2014 average annual withdrawal from shallow aquifer and remainder from deep aquifer

Deep/Shallow 1 – Assumes Applicant configured alternative using the deep and shallow aquifers, with shallow wells along the Fox River and Pebble Brook

Deep/Shallow 1a – Assumes DNR configured alternative using the deep and shallow aquifers, with shallow wells along Pebble Brook

Shallow – Assumes Applicant configured alternative using shallow wells along the Fox River and Pebble

Lake Michigan – Assumes Lake Michigan supply and DNR proposed return flow management plan of average annual withdrawal returned to Lake Michigan basin.

The department also calculated the impact of the decrease in flow from the Waukesha WTTP to the Fox River with a switch to Lake Michigan water supply on flows at different points downstream of the City of Waukesha. Under the Lake Michigan water supply alternative the wastewater discharge to the Fox River would decrease by 8.1 cfs from the current discharge. For this analysis the department used modeled August Q50 and Annual Q90 flows from the Wisconsin Natural Communities Model (Diebel, 2014). Note that at the Fox River downstream of the confluence of Pebble Brook the August Q50 and Annual Q90 are 88.1 cfs and 57.2 cfs, respectively. The modeled baseflow from the USGS Upper Fox River Basin Groundwater Flow model at this same location (and used in the previous analysis) is 74.9 cfs. (See table 7-2)

Table 7-2 Estimated percent decrease in Fox-River streamflow with Lake Michigan water supply

Location on Fox River	August Q50	% decrease	Annual Q90	% decrease
Fox River @ Pebble Brook	88.1	9%	57.2	14%
Fox River @ Waterford Dam	160	5%	99.0	8%
Fox River @ Racine Co. Line	327	2%	224	4%
Fox River @ Kenosha County Line*	352	2%	225	4%

*Calculated to address discrepancies in the model.

The daily reduction in flow is expected to minimally impact the fishery of the Fox River. The individual fish habitat requirements for dominant species (Table 6-2) and threatened and endangered species generally would still be met (Table 6-2).

Table 7-3.Potential Changes to Fish Species habitat due to flow changes in the Fox River

Dominant Fish Species	Preferred Current Velocity Range	Stream Gradient	General Habitat Characteristics	Dominant Substrate Preference	Potential Changes to Habitat (with changes in flow to the Fox River)
Channel catfish	Wide range	Not documented in reviewed literature	Wide range	Mud, sand, clay, gravel	With the wide range of preferred velocities, habitat characteristics, and substrate preference, no to minimal impacts are expected.
Creek chub	< 0.98 ft/sec	3-23 m/km	Pools	Sand, gravel	Slightly less pool depth, but because pools are by definition deeper areas no significant changes expected. No to minimal impacts are expected to preferred substrate.
White sucker	1.31 ft/sec	Wide Range	Wide range	Gravel, sand	With the wide range of preferred habitat characteristics and substrate preference, minimal impacts are expected.
Golden redhorse	Not documented in reviewed literature	Not documented in reviewed literature	Pools in river bends	Sand, gravel	Slightly less pool depth, but because pools are by definition deeper areas no to minimal impacts are expected. No to minimal impacts are expected to preferred substrate.
Bluntnose minnow	Not documented in reviewed literature	Not documented in reviewed literature	Wide range	Gravel, sand	With the wide range of preferred habitat characteristics and substrate preference, no to minimal impacts are expected.
Common carp	Not documented in reviewed literature	Not documented in reviewed literature	Wide range	Sand, gravel, clay	With the wide range of preferred habitat characteristics and substrate preference, no to minimal impacts are expected.
White bass	Moderate currents	Not documented in reviewed literature	Generally occurs in waters 6m in depth or less	Sand, mud, rubble, gravel	With the wide range of preferred habitat characteristics and variety of substrate preference, no to minimal impacts are expected.
Common shiner	Not documented in reviewed literature	Not documented in reviewed literature	Rocky pools near riffles	Hard bottom, gravel, sand, rubble	Slightly less pool depth, but because pools are by definition deeper areas no impacts are expected. No to minimal impacts are expected to preferred substrate.

Northern pike	Not documented in reviewed literature	Not documented in reviewed literature	Shallow vegetated areas	Vegetated areas	No to minimal impacts are expected.
Largemouth bass	> 0.33 ft/sec	Not documented in reviewed literature	Not documented in reviewed literature	Vegetated areas, sand, gravel, mud	With the wide range of preferred substrate preference, no to minimal impacts are expected.
Rock bass	Not documented in reviewed literature	Not documented in reviewed literature	Preference for clear cool to warm water	Sand, gravel	No expected to general habitat characteristics or preferred substrate.
Emerald shiner	Not documented in reviewed literature	Not documented in reviewed literature	Wide range	Sand, gravel	With the wide range of preferred habitat characteristics and substrate preference, no to minimal impacts are expected.
Bluegill	< 0.33 ft/sec	≤ 0.5 m/km	60 percent pool areas	Submerged vegetation/ logs, brush	Slightly less pool depth, but because pools are by definition deeper areas no to minimal impacts are expected. No to minimal impacts are expected to preferred substrate.
Longnose gar	Not documented in reviewed literature	Not documented in reviewed literature	Backwaters, quiet currents	Gravel, sand	No to minimal impacts are expected to general habitat characteristics or preferred substrate.

Table 7-4. Potential impacts to state threatened, endangered, species of concern, and cold water species recorded since 1999 in the Fox River due to changes in Fox River flow

Fish Species	Preferred Current Velocity Range	Stream Gradient	General Habitat Characteristics	Dominant Substrate Preference	Potential Changes to Habitat (with changes in flow to the Fox River)
Greater Redhorse (special concern)	Not documented in reviewed literature	Not documented in reviewed literature	Pools and runs of medium to large rivers	Sandy to rocky pools	Slightly less pool depth, but because pools are by definition deeper areas no to minimal impacts are expected. No significant changes expected to preferred substrate.
Longear sunfish (threatened)	Not documented in reviewed literature	Not documented in reviewed literature	Slow moving rivers and streams	Shallow dense vegetation	Shallow areas would become shallower on average, but less than 2 inches water depth change would occur. Consequently, no to minimal impacts are expected.
Banded killifish (special concern)	Not documented in reviewed literature	Not documented in reviewed literature	Shallow sluggish streams	Sand/mud/near vegetation	Shallow areas would become shallower on average, but less than 2 inches water depth change would occur. No impacts are expected to the preferred substrate. Consequently, none are expected.
Starhead topminnow (endangered)	Not documented in reviewed literature	Not documented in reviewed literature	Quit pools and backwaters	Vegetated areas	Slightly less pool depth, but because pools are by definition deeper areas no to minimal impacts are expected. No to minimial impacts are expected to preferred substrate.
Brook trout (cold water species)	Not documented in reviewed literature	Not documented in reviewed literature	Clear, cool, well wxygenated streams	Sand/gravel/rubble	Lower flow in the Fox River could extend cool water influence from Genesee Creek. No to minimal impacts are expected to the preferred substrate. Consequently, no to minimal impacts are expected.
Brown trout (cold water species)	Not documented in reviewed literature	Not documented in reviewed literature	Cold, well oxygenated waters	Submerged rocks, undercut banks, overhanging vegetation	Lower flow in the Fox River could extend cool water influence from Genesee Creek. No to minimal impacts are expected to the preferred substrate. Consequently, no to minimal impacts are expected.

8 Appendix B: Shallow Aquifer Water Supply Alternatives for the Waukesha Water Utility – Evaluated with the USGS Upper Fox River Basin Model

Objective
The objective of this study is to identify the potential impacts to surface waters - including wetlands, rivers, streams, lakes and springs – using the latest tools, from several configurations of water supply alternatives that would use the shallow aquifer south of the City of Waukesha.

Background
The 2013 Waukesha Diversion Application (Application) reported modeled impacts to the shallow aquifer and connected surface waters for three water supply alternatives using the Troy Valley Bedrock Aquifer model.[22] The analysis provided in the Application assumed a total water demand of 10.9 million gallons per day (MGD), the anticipated build-out demand assumed in the 2010 Waukesha Diversion Application.[23] Following comments from several reviewers provided during the Fall 2013 Department of Natural Resources (department) comment period, the department conducted additional analysis. These comments questioned the results of the Applicant's modeling, recommended review of an alternative that focused water supply wells (and impacts) along the Fox River, questioned the Applicant's projected demand at build-out, and recommended using a groundwater flow model completed in 2012 specifically developed to assess surface water impacts from pumping in the shallow aquifer in the Upper Fox River Basin. In response, the department used the U.S. Geological Survey (USGS) Upper Fox River Basin Model to simulate the shallow aquifer impacts for the three alternatives considered in the Application, and for one additional scenario, River Bank Inducement (RBI). For each alternative, the department assumed an average daily maximum water supply need of 8.5 million gallons per day (MGD), similar to the low end of the department projected demand range. [24]

Upper Fox River Basin Model
The USGS developed the Upper Fox River Basin Model as a tool to evaluate water supply options for communities in Waukesha County, specifically the shallow aquifer system of the Upper Fox River Basin. The USGS modeling report provides a full description of the Upper Fox River Basin conceptual model, model construction, and calibration.[25]

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[22] A report on the modeling work conducted by the Applicant is provided in the Memo RJN Environmental Services, LLC, dated August 30, 2013. Additional information on the modeling work conducted by the Applicant is provided in Appendix 0 of the 2010 application "Results of Groundwater Modeling Study, Shallow Groundwater Source, Fox River and Vernon Marsh Area, Waukesha Water Utility". The report on the Troy Valley Bedrock Aquifer model is SEWRPC Memorandum Report No. 188.
[23] For the 2013 Application the full build-out demand was revised down to 10.1 MGD.
[24] The department analysis of the Applicant's water demand, see section S4 of the Technical Review, found a demand range of 8.4 – 12.1 MGD. For this analysis the department rounded the demand to 8.5 MGD and selected a conservative demand from the low end of the range.
[25] Feinstein, D.T., M.N Fienen, J.L. Kennedy, C.A. Buchwald, and M.M. Greenwood. *Development and Application of a Groundwater/Surface-Water Flow Model using MODFLOW-NWT for the Upper Fox River Basin, Southeastern Wisconsin*. Scientific Investigations Report 2012-5108. (2012)

In southeast Wisconsin, the shallow aquifer includes primarily unconsolidated glacial sediment overlying Silurian dolomite. The glacial sediments in the area of interest exhibit a high degree of heterogeneity resulting from a complicated history of glacial advances. This geologic history includes phases of erosion and deposition of till, including fine-grained material and coarser-grained material that result in interrupted clay layers and sandy layers. The Upper Fox model is a MODFLOW grid constructed with cell dimensions of 125 feet per side and thin layers. The model consists of seven layers; layers 1 - 5 represent unconsolidated material and layers 6 and 7 represent the Silurian dolomite. Within the Upper Fox model, there are two model versions with different sets of hydraulic parameters intended to bracket the possible variations in hydraulic conductivity. One version favors the continuity of fine-grained deposits; the other favors the continuity of coarse-grained deposits. In order to represent the range of possible geology, the pumping impacts reported in this document include the results from the fine-favored and the coarse-favored versions of the Upper Fox model.

Water Supply Alternatives

The department modeled the shallow aquifer impacts for four different potential water supply alternatives, including: (1) the Deep Sandstone and Shallow Aquifers, (2) the Shallow Aquifer only, (3) Multi-Source – Confined and Unconfined Deep Sandstone, Silurian Dolomite, and Shallow Aquifer, and (4) the Deep Sandstone Aquifer with Riverbank Inducement (RBI). Each alternative assumed a total water demand of 8.5 MGD, with between 3.2 MGD and 8.5 MGD being drawn from the shallow aquifer. The department replicated the Applicant's constructed alternatives for Alternatives 1 – 3 and created an additional alternative 4. See Table 1 for a full description of the water sources for each water supply alternative.

Wells modeled in the shallow aquifer include three existing Waukesha wells (11, 12, and 13), along with new wells and RBI wells. RBI wells are located directly adjacent to the Fox River and are expected to partially draw water directly from the river. New wells include wells in the Town of Waukesha not directly adjacent to the Fox River. The number and location of wells modeled in each alternative was based on an estimate of infrastructure needs provided by the Applicant.[26] For alternatives 1, 3, and 4, the remaining water supply demand not sourced from the shallow aquifer would be met from a combination of other sources, such as the deep sandstone aquifer, the Silurian dolomite aquifer, or the unconfined deep sandstone aquifer in western Waukesha County. The department's modeling considers only impacts related to shallow aquifer withdrawals. An analysis of impacts related to the water supply sources other than the shallow aquifer is available in the Application[27] and the Technical Review.

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[26] CH2MHill. *Changes to Water Supply Infrastructure and Environmental Impacts*. Prepared for WDNR. 18 February 2014.

[27] Application, Volume 2, Section 11.

Table 8-1 Water supply alternative water sources.

Scenario / Alternative	Water Supply	Average Day Demand (MGD)	Infrastructure to meet demand (shallow aquifer only)
(1) Deep and Shallow Aquifers[28]	Deep Sandstone Aquifer	4.5	
	Shallow Aquifer	**4**	
	- Existing wells	0.96	Waukesha wells 11, 12, 13;
	- New wells	3.04	5 wells on the Lathers property; 3 wells near Pebble Brook
(2) Shallow Aquifer Only[29]	Shallow Aquifer	**8.5**	
	- Existing wells	1.21	Waukesha wells 11, 12, 13
	- New wells	4.59	5 wells on the Lathers property; 4 wells near Pebble Brook
	- RBI wells	2.7	4 wells near Fox River
(3) Multi-source[30]	Deep Sandstone Aquifer	2.1	
	Unconfined Deep Aquifer	2.0	
	Silurian Dolomite Aquifer	1.2	
	Shallow Aquifer	**3.2**	
	- Existing wells	0.95	Waukesha wells 11, 12, 13
	- New wells	0.75	2 wells on Lathers property
	- RBI wells	1.5	3 wells near Fox River
(4) DNR - Deep Aquifer and RBI[31]	Deep Sandstone Aquifer	4.5	
	Shallow Aquifer	**4**	
	- Existing wells	1.2	Waukesha wells 11, 12, 13
	- RBI wells	2.8	5 wells near Fox River (4 wells as Alternative 2 and 1 additional)

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[28] Waukesha Water Supply Alternative 1: Deep Confined and Shallow Aquifer, Application, Volume. 2. Section 11, p 14. (2013). CH2MHill. Memo. 2 February 2014. p.1.
[29] Waukesha Water Supply Alternative 3: Shallow Aquifer, Application, Vol. 2. p. 11-28. (2013). Memo, CH2M Hill, 2 February 2014, p. 2.
[30] Waukesha Water Supply Alternative 6: Multiple Sources, Application, Vol. 2. p. 11-45. (2013). Memo, CH2M Hill, 2/18/2014, p. 3.
[31] This alternative is a variation on Waukesha Water Supply Alternative 1 that was not evaluated in the Waukesha Diversion application.

Model Setup
This section describes the inputs used to evaluate the surface water impacts of the various water supply alternatives.

The modeling runs for each alternative included three stress periods:

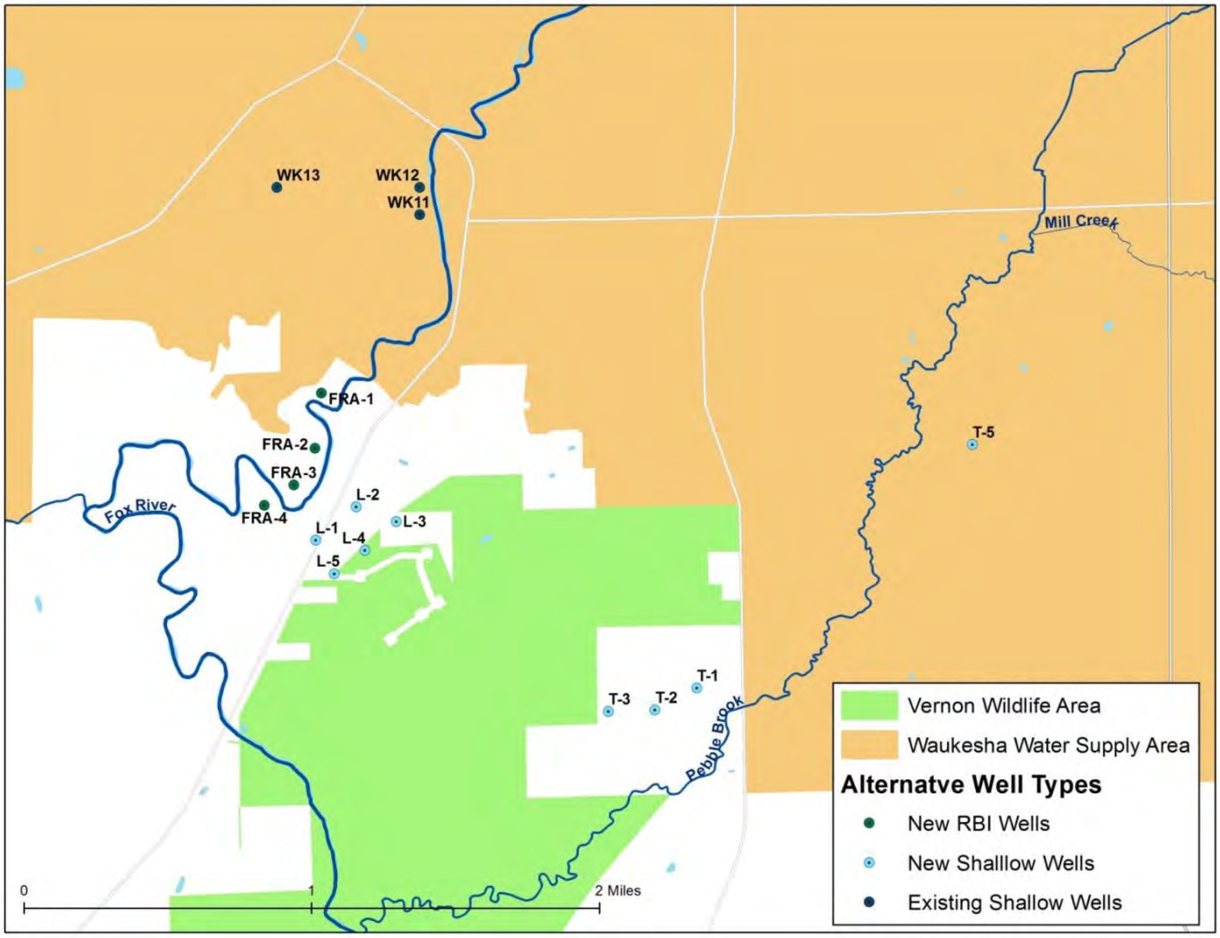
- Stress Period 1 – Model run in steady state mode without Waukesha's shallow wells 11, 12, and 13 pumping.

- Stress Period 2 – Model run in transient mode for 5 years with Waukesha's wells 11, 12, and 13 pumping at the same rate as these wells pump in stress period 2. The pumping for these wells was held constant between stress period 2 and 3 to avoid rebound scenarios in the aquifer. Wells 11 and 12 came online in 2006, Well 13 came online in 2009. The department chose a 5-year period to represent a period in which all three of these wells were in operation, prior to adding additional wells.

- Stress Period 3 – Models run in transient mode for 20 years. Waukesha's wells 11, 12, and 13 pump at the same rate as in stress period 2. Additional shallow wells pump at the average day demand rate anticipated for each water supply alternative. Attachment A provides a list of wells and pumping rates modeled and a map of well locations for each alternative.

Well Locations – See Figure 7-1 for well locations. Attachment B provides details on wells used in each alternative and pumping rates. Well locations were chosen to match the approximate locations used in the Applicant's groundwater flow model. The locations were checked to ensure that they were in model cells with appropriately high hydraulic conductivity values (e.g., a well would not be sited in a low conductivity area). Wells pump from layers 3 and 4 in the Upper Fox model described above.

Figure 8-1. Well locations for shallow aquifer wells used in water supply alternatives



Results

The USGS Upper Fox Model uses the MODFLOW-NWT version of MODFLOW. A full discussion of this solver is available in the model report.[32] One characteristic to note is that if a well pumping rate designated for a given well reduces the saturated thickness of the aquifer to less than 20 percent of the total saturated thickness, the pumping rate is reduced from the input pumping rate. Table 2 indicates the input pumping rate for each alterative and the modeled pumping rate for each scenario for both the coarse-favored and fine-favored versions of the model. Table 7-2 shows some reductions in pumping – particularly for the fine-favored version of the model with 8.5 MGD of desired pumping. The small reductions in the fine-favored version of the deep/shallow scenario and the coarse-favored version of the shallow scenario could easily be made up for by shifting pumping to other wells or moving wells to higher hydraulic conductivity locations. For the fine-favored version of the shallow scenario - where 8.5 MGD

[32] Feinstein, D.T., M.N Fienen, J.L. Kennedy, C.A. Buchwald, and M.M. Greenwood. *Development and Application of a Groundwater/Surface-Water Flow Model using MODFLOW-NWT for the Upper Fox River Basin, Southeastern Wisconsin*. Scientific Investigations Report 2012-5108. (2012)

comes from the shallow aquifer – adjusted pumping rates and likely additional wells would be needed to make up the lost 0.71 MGD. In the interest of time, the department did model these slight adjustments. Modeling results are assumed to be representative of impacts for pumping at the proposed rates. Attachment B includes well-by-well information for the reductions in each scenario.

Table 8-2. Comparison of well pumping input to model and sustained pumping for each alternative in the shallow aquifer

Alternative	Well Pumping Input to Model (MGD)	Actual Pumping – Coarse favored (MGD)	Actual Pumping – Fine favored (MGD)
Deep/Shallow Aquifer	4.00	4.00	3.84
Shallow Aquifer	8.50	8.48	7.79
Multiple Sources	3.20	3.20	3.20
Deep Aquifer/RBI	4.00	4.00	4.00

Results – Maximum Drawdown

Table 7-3 presents the maximum drawdown of the aquifer in model layer 1 (representing the water table). Results are provided for both the fine-favored and coarse-favored versions of the model. See Figure 7-3 – 7-10 for drawdown maps of each alternative modeled by the department.

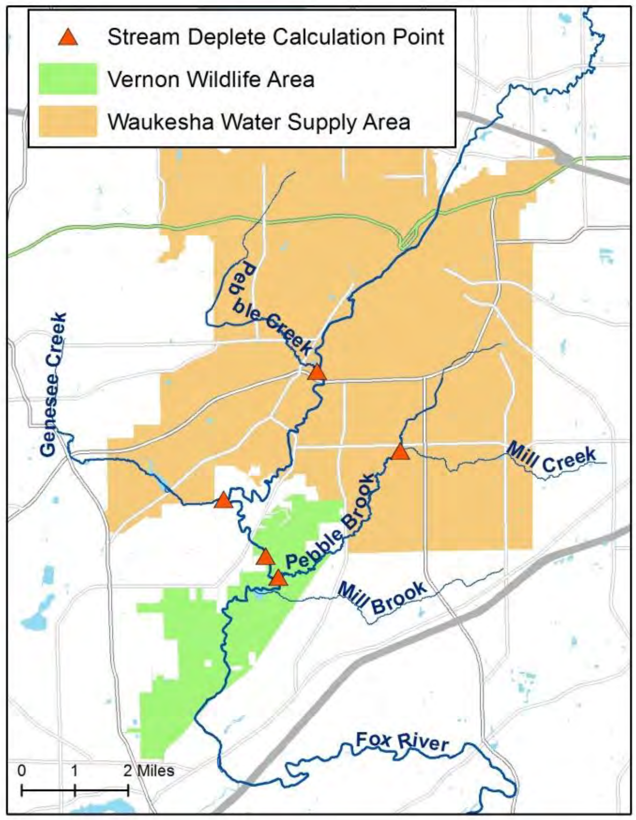
Table 8-3. Maximum draw down in model layer 1 for each alternative

Alternative	Maximum Drawdown – Coarse- favored (feet)	Maximum Drawdown – Fine-favored (feet)
Deep/Shallow Aquifer	22	15
Shallow Aquifer	54	77
Multiple Sources	16	12
Deep Aquifer/RBI	21	14

Results - Streamflow Depletion

The department determined streamflow depletion at the outlet of five streams: Pebble Brook, Pebble Creek, Fox River, Genesee Creek, and Mill Creek (see figure 8-2); and calculated depletion as the difference between modeled flow at the end of the second stress period (after five years of pumping of existing Waukesha wells) and at the end of the third stress period (after 20 years of pumping of additional shallow wells) from the baseflow simulated within the USGS model's streamflow routing package (SFR). The model was calibrated to baseflow estimates from a method developed by Gebert and others[33] in terms of the basin area and 90 percent flow duration value. These depletions represent the impact of additional wells in the shallow aquifer on the nearby streams and rivers after 20 years of pumping, not including the impacts of Waukesha's existing shallow wells 11, 12, and 13 after pumping for 5 years. Existing shallow well impacts are not included in this analysis to limit assessed impacts strictly to additional proposed wells. The department chose this approach to simplify the analysis and to provide a conservative estimate of impacts.

Figure 8-2. Locations for calculations of streamflow



The department calculated the percent change in stream baseflow with following equation:

$$B_1 = Cumulative\ Baseflow\ (Stress\ Period\ 2, Time\ Step\ 5)$$
$$B_2 = Cumulative\ Baseflow\ (Stress\ Period\ 3, Time\ Step\ 20)$$
$$Percent\ Change\ in\ Stream\ Baseflow = \frac{(B_1 - B_2)}{B_1} * 100$$

Note that the percent streamflow reductions do not account for water returned to the Fox River via the wastewater treatment plant. See Table 8-4 for streamflow depletion calculations.

[33] Gebert, W.A., Radloff, M.J., Considine, E.J., and Kennedy, J.L., Use of streamflow data to estimate base flow/ground-water recharge for Wisconsin. Journal of the American Water Resources Association, 43(2007): 220-236.

Table 8-4. Streamflow depletion - percent reduction in modeled baseflow due to new shallow wells

a) Alternative 1: Deep and Shallow Aquifers

Stream	Coarse-favored model (MGD)	Fine-favored model (MGD)
Pebble Brook	19 % (0.99)	18 % (0.86)
Fox River	3 % (1.55)	3 % (1.34)
Pebble Creek	1 % (0.02)	0 % (0.01)
Mill Creek	0 % (0.01)	1 % (0.01)
Genesee Creek	1 % (0.02)	1 % (0.03)

b) Alternative 2: Shallow Aquifer Only

Stream	Coarse-favored model (MGD)	Fine-favored model (MGD)
Pebble Brook	39 % (1.97)	36 % (1.74)
Fox River	9 % (4.56)	8 % (3.86)
Pebble Creek	1 % (0.03)	1 % (0.02)
Mill Creek	3 % (0.04)	5 % (0.06)
Genesee Creek	3 % (0.11)	4 % (0.19)

c) Alternative 3: Multi-source

Stream	Coarse-favored model (MGD)	Fine-favored model (MGD)
Pebble Brook	2 % (0.10)	3 % (0.12)
Fox River	4 % (2.00)	4 % (1.74)
Pebble Creek	1 % (0.03)	0 % (0.01)
Mill Creek	0 % (0.00)	0 % (0.00)
Genesee Creek	1 % (0.03)	2 % (0.08)

d) Alternative 4: DNR – Deep Aquifer and RBI.

Stream	Coarse-favored model (MGD)	Fine-favored model (MGD)
Pebble Brook	2 % (0.11)	3 % (0.14)
Fox River	5 % (2.58)	5 % (2.23)
Pebble Creek	1 % (0.03)	1 % (0.01)
Mill Creek	0 % (0.00)	0 % (0.00)
Genesee Creek	1 % (0.05)	2 % (0.11)

Results – Wetland Impacts
Wetland acres with greater than one-foot of drawdown were calculated by intersecting the one-foot drawdown contour area in model layer 1 with the Wisconsin wetlands GIS layer[34] for each alternative (See Table 8-5).

Table 8-5. Wetland acres in the one foot drawdown contour in model layer 1

Alternative	Coarse-favored model (acres)	Fine-favored model (acres)
Alternative 1 – Deep and Shallow Aquifers	910	1036
Alternative 2 – Shallow Aquifer	1939	2326
Alternative 3 – Multi-source	713	893
Alternative 4 – DNR-Deep Aquifer and RBI	804	1069

Results – Springs Impacts
The one-foot drawdown contour in model layer 1 was compared to a GIS layer of Wisconsin springs (See Table 8-6).[35]

Table 8-6. Springs located in the one foot drawdown contour in model layer 1

Alternative	Coarse-favored model (WGNHS Spring #)	Fine-favored model (WGNHS Spring #)
Alternative 1 – Deep and Shallow Aquifers	680253	680253
Alternative 2 – Shallow Aquifer	680253	680253, 680257, 680240
Alternative 3 – Multi-source	680253	680253
Alternative 4 – DNR-Deep Aquifer and RBI	680253	680253

[34] WDNR. Wetland Mapping. Web. 4 June 2015.
[35] Macholl, J. A. *Inventory of Wisconsin's Springs*. Rep. no. WOFR2007-03. Madison: U of Wisconsin Extension Wisconsin Geological and Natural History Survey, (2007).

Figure 8-3. Alternative 1- Deep and Shallow Aquifers - Fox River and Pebble Brook Wells - Course favored model

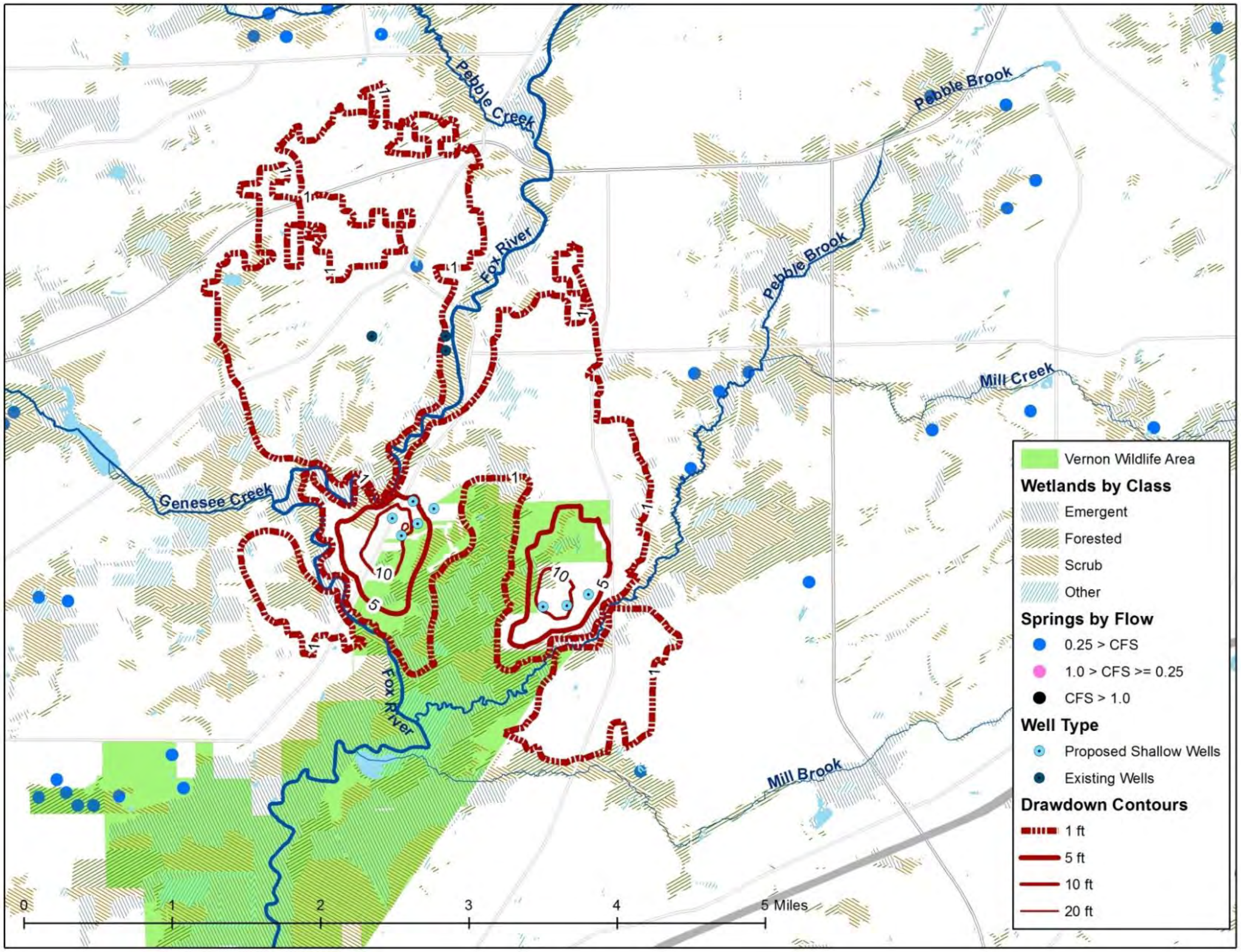


Figure 8-4. Alternative 1 - Deep and Shallow Aquifers - Fox River and Pebble Brook Wells - Fine favored model

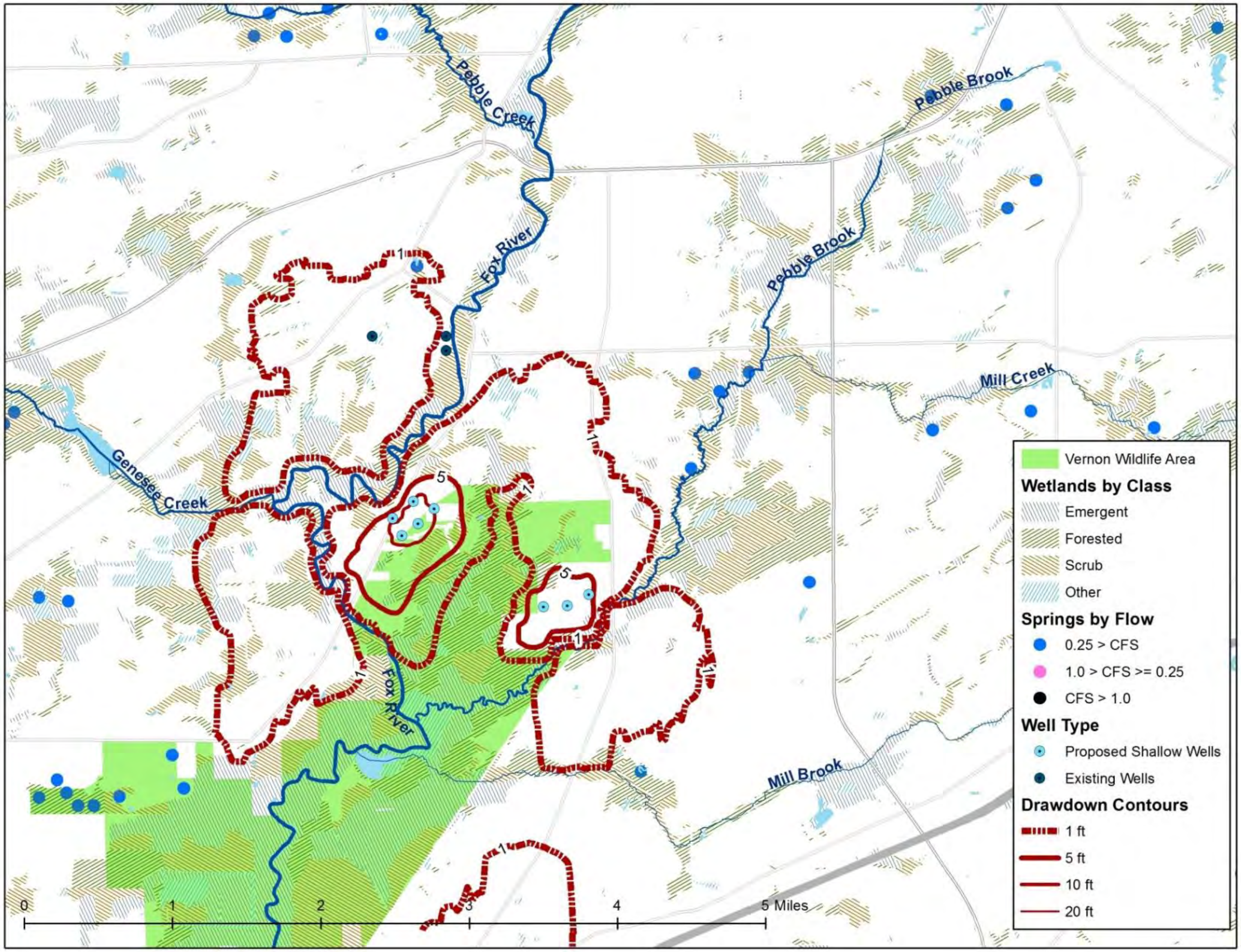


Figure 8-5. Alternative 2 - Shallow Aquifer Only - Course favored model

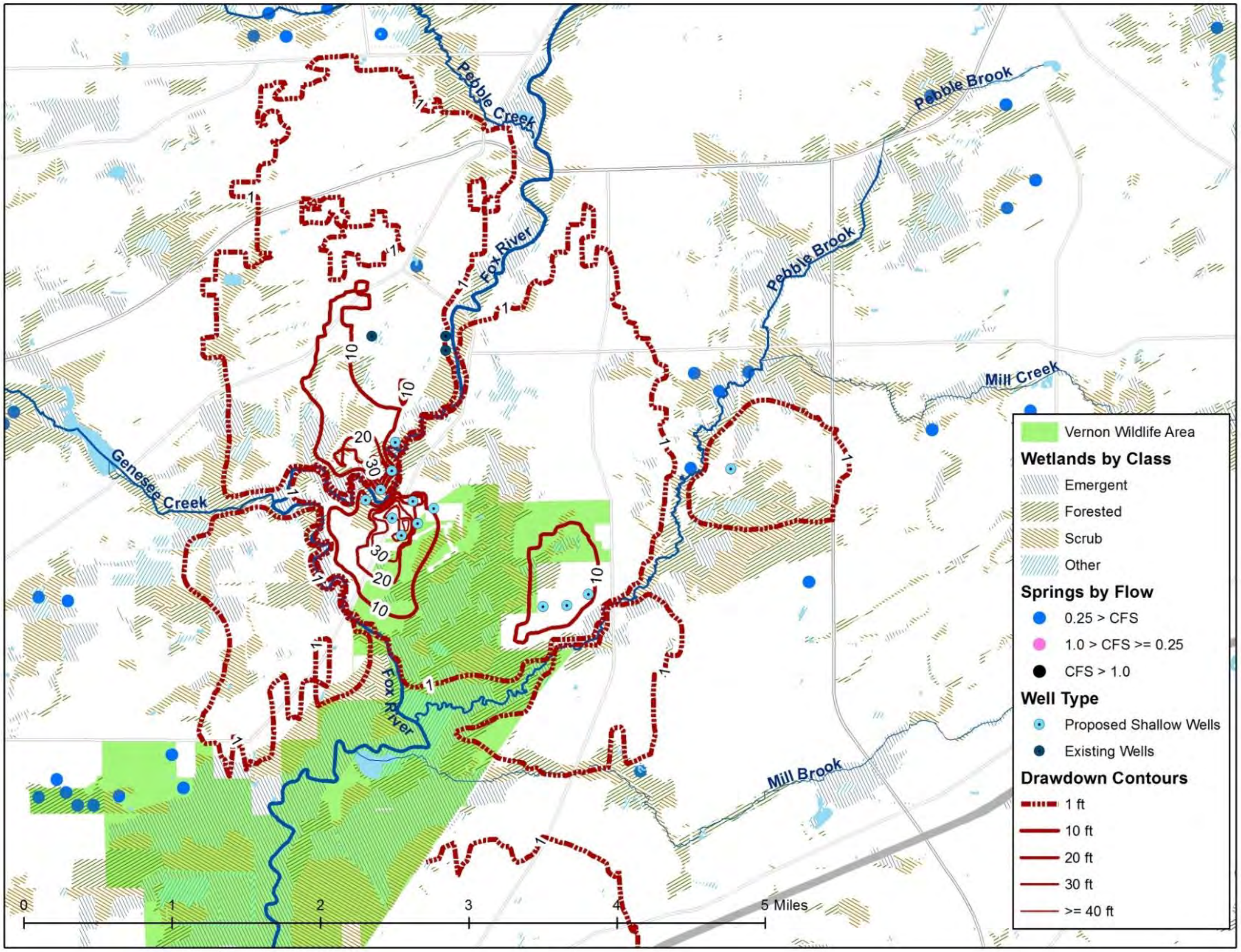


Figure 8-6. Alternative 2 - Shallow Aquifer Only - Fine favored model

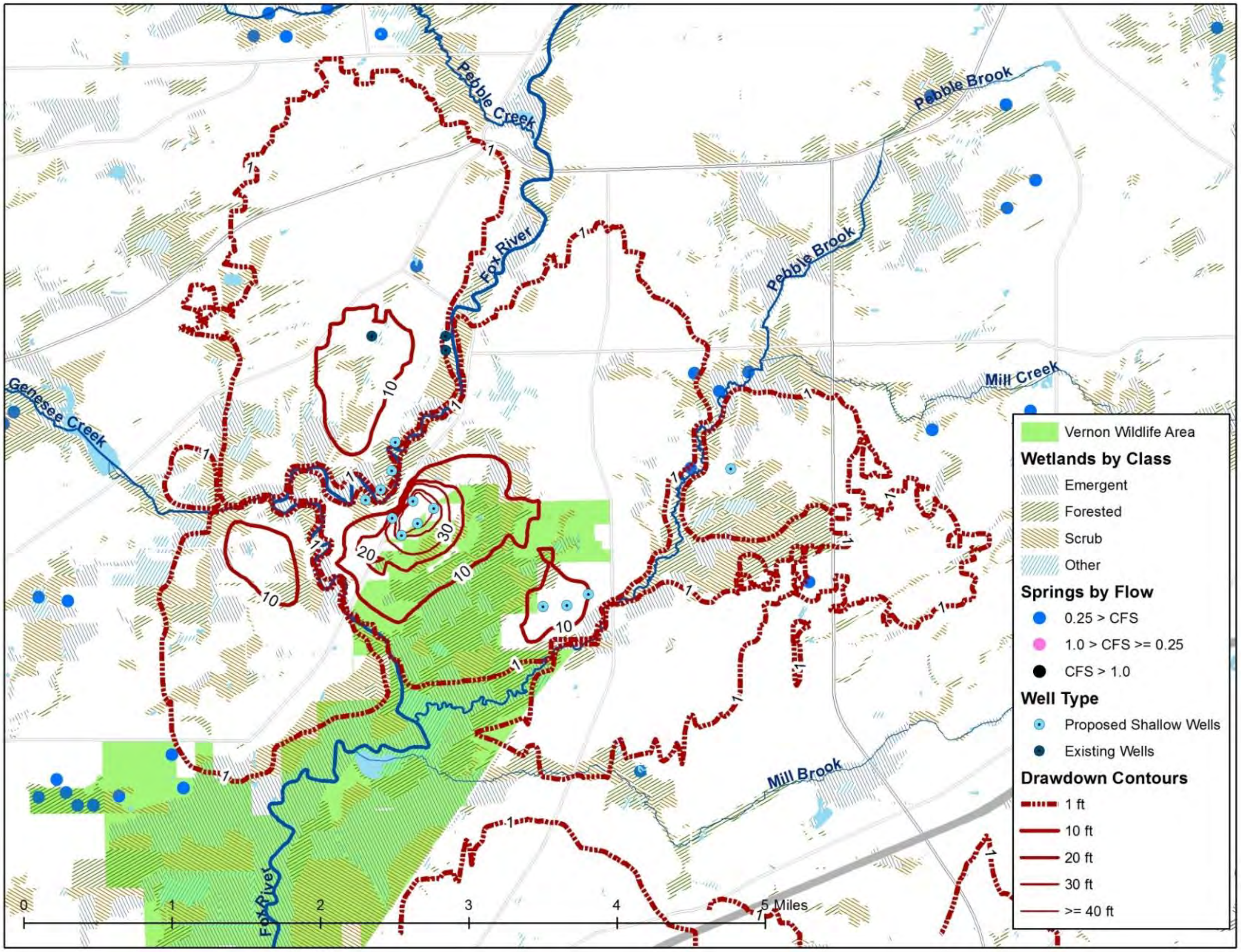


Figure 8-7. Alternative 3 - Multiple Sources Alternative - Course favored model

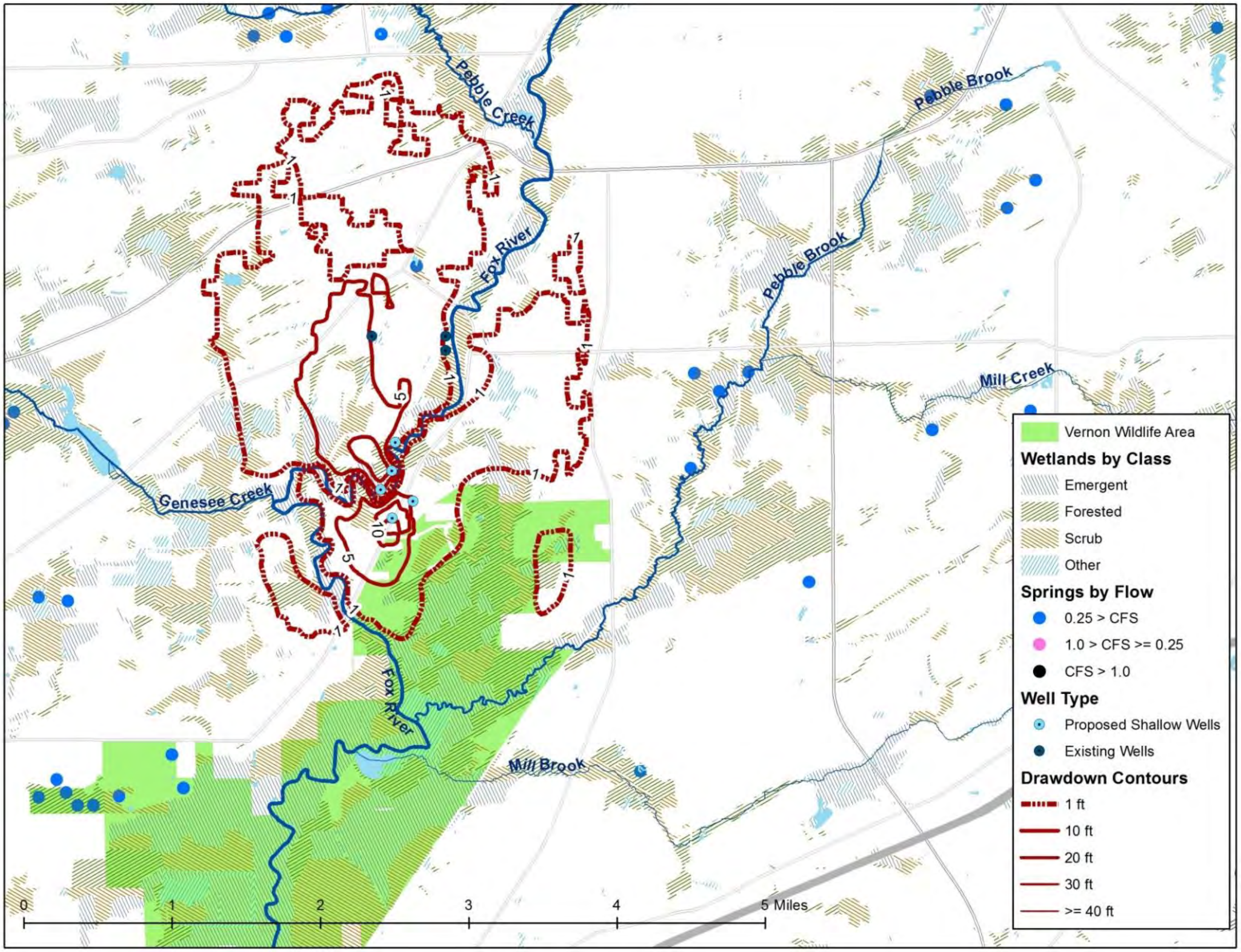


Figure 8-8. Alternative 3 - Multiple Sources Alternative - Course favored model

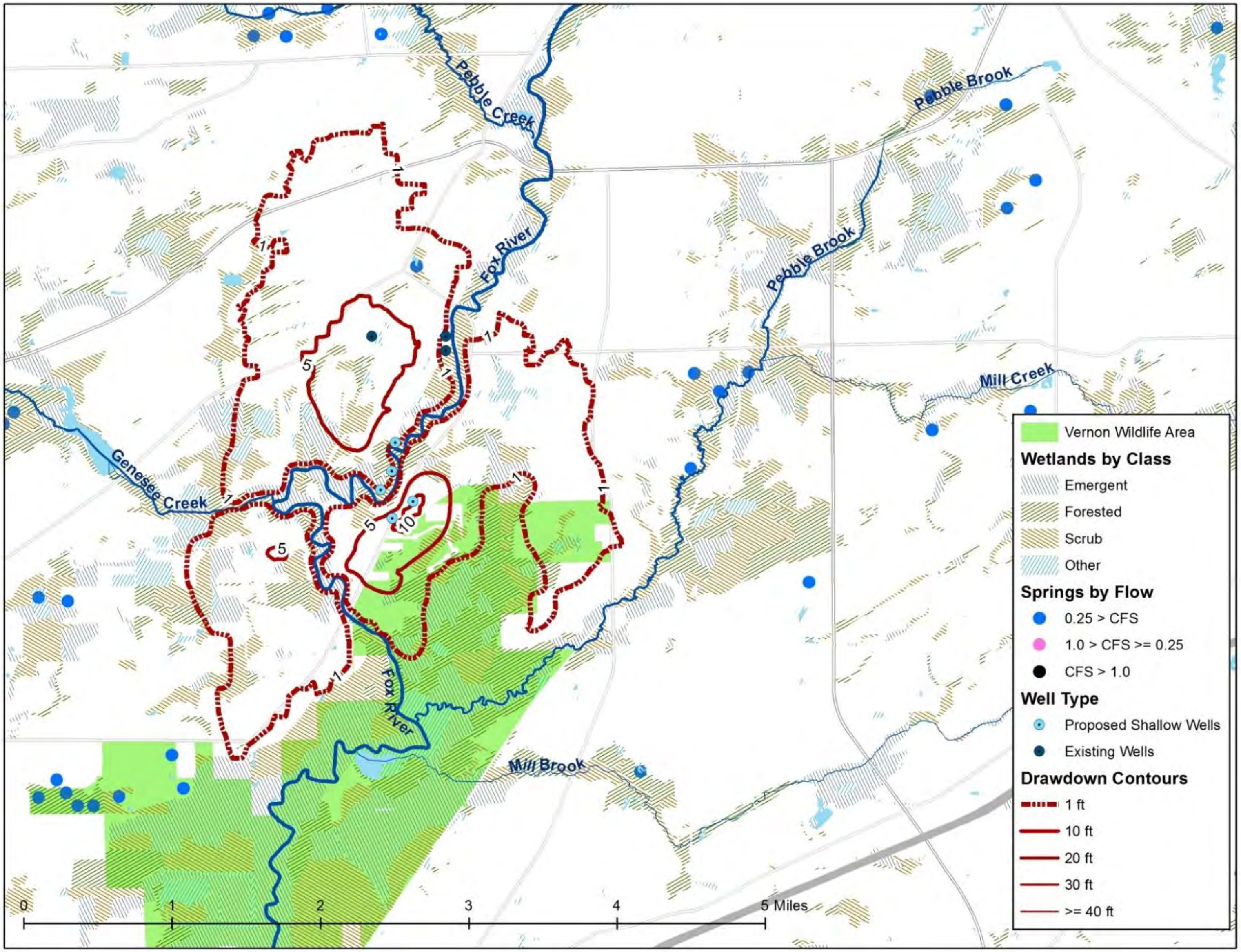


Figure 8-9. Alternative 4 - DNR Deep Aquifer and River Bank Inducement - Course favored model

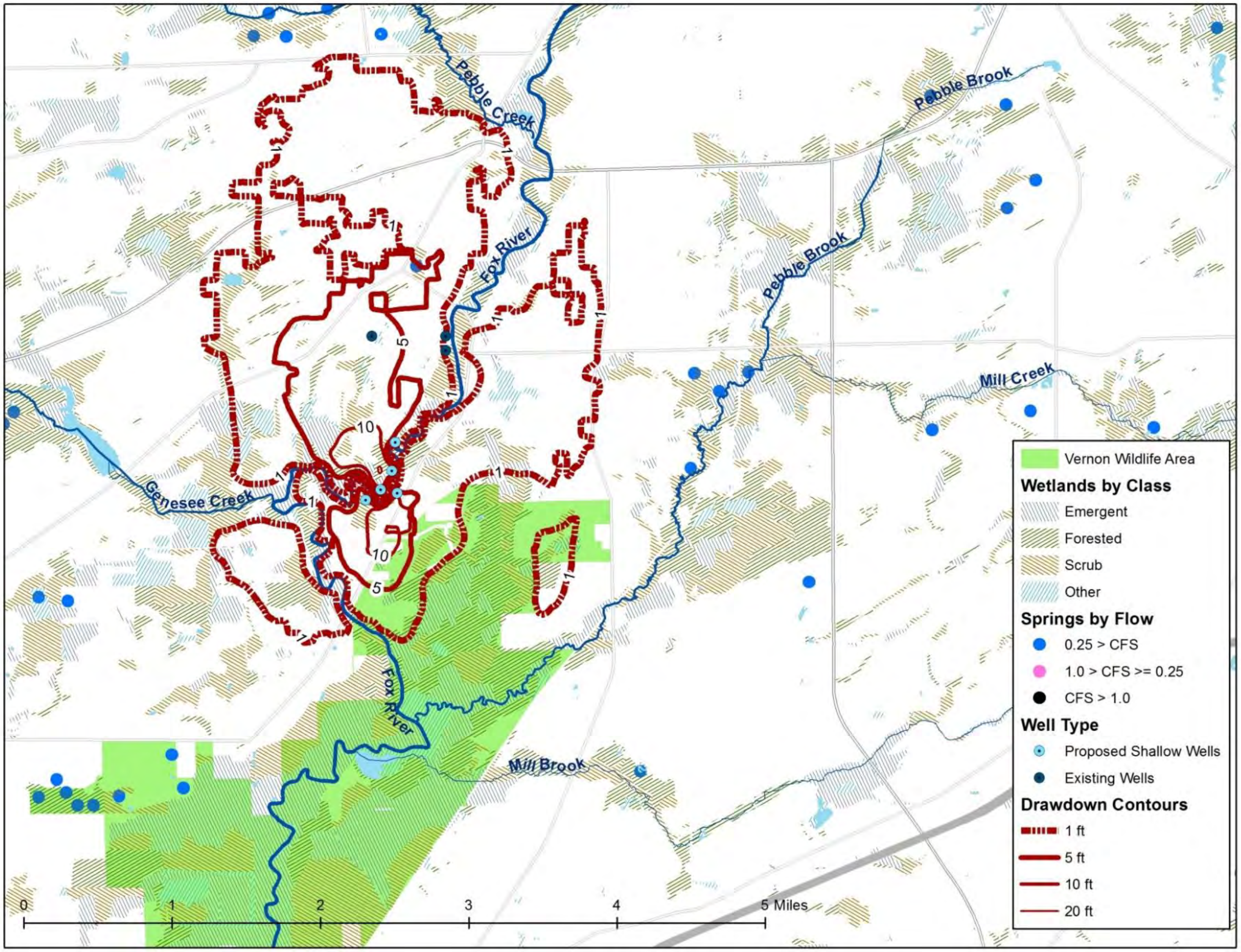
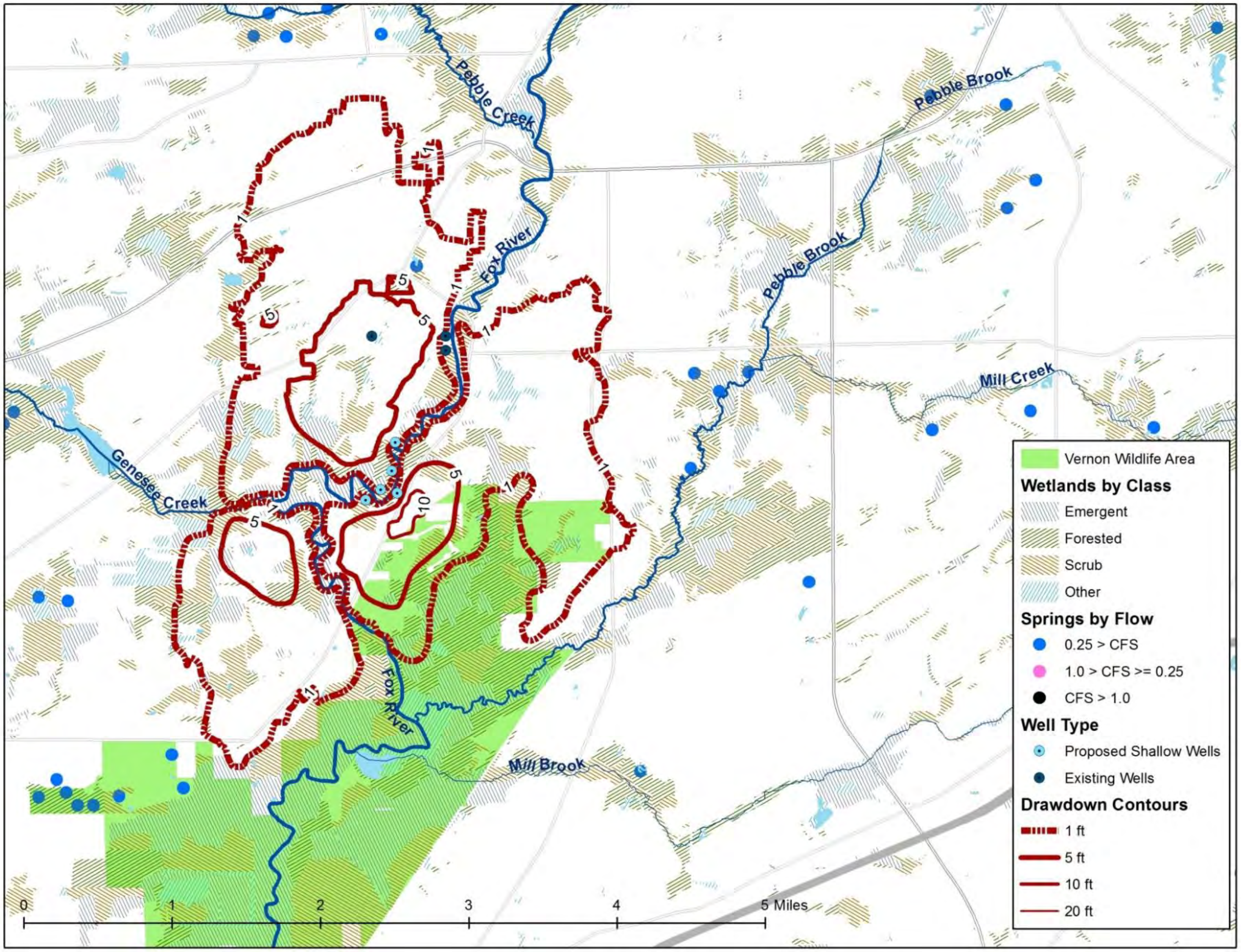


Figure 8-10. Alternative 4 - DNR Deep Aquifer and River Bank Inducement - Fine favored model



Attachment A – Well Pumping Rates and Locations

The following tables provide the pumping rates used in each scenario for each well and a brief description of how these pumping rates were selected. The model uses pumping rates up to the 2009-2013 average pumping rate for Waukesha wells 11, 12 and 13 for each of these scenarios. For example, in Alternative 1 the models use the baseline pumping rate (0.2 MGD) for Well 11 because 0.2 is less than 0.37 (4 MGD divided by 11 wells); however for well 12 the pumping rate of 0.38 MGD (3.8 MGD divided 10 wells) was used because the well 12 baseline pumping rate of 0.5 MGD is greater than 0.38 MGD. The coordinate system is NAD 1983 Transverse Mercator. Waukesha wells in the tables are noted as WK11, WK12, and WK13. New Shallow wells are noted as L-1 through L-5, indicating wells on the Lathers property and as T-1 through T-3 for wells along Pebble Brook. RBI wells are noted as FRA -1 through FRA – 4 and RBI – 1. (See Alternative 1 – Deep and Shallow Aquifer – Deep Aquifer (4.5MGD), Shallow Aquifer (4 MGD) WK11 pumping rate of 0.2 MGD determined from 2009-2013 average. The remaining 3.8 MGD was divided equally between 10 wells for a pumping rate of 0.38 MGD (Table 8-7).

Table 8-7. Alternative 1 wells and pumping rates

Well	X	Y	Stress Period 1 (MGD)	Stress Period 2 (MGD)	Stress Period 3 (MGD)
WK11	2166453.35	911303.03	0	0.2	0.2
WK12	2166453.35	911803.03	0	0.38	0.38
WK13	2163828.00	911803.00	0	0.38	0.38
L-1	2164540.61	905323.92	0		0.38
L-2	2165283.78	905934.34	0		0.38
L-3	2166022.19	905668.49	0		0.38
L-4	2165445.57	905138.00	0		0.38
L-5	2164880.49	904711.31	0		0.38
T-1	2171539.90	902609.33	0		0.38
T-2	2170772.95	902209.83	0		0.38
T-3	2169917.55	902179.23	0		0.38
		Total			**4**

Alternative 2 – Shallow Aquifer – Shallow Aquifer (5.8 MGD), River Bank Inducement (2.7 MGD) – Total average day demand from shallow aquifer of 8.5 MGD

The department used pumping rates of 0.2 and 0.5 MGD for WK11 and WK12, respectively, determined from the 2009-2013 average pumping rates. The department assumed pumping rates for WK13, L1 – 5 and T1, 2, 3, and 5 set at 0.51 MGD dividing 5.1 MGD equally between 10 wells. The department determined pumping rates for the RBI wells (FRA-1-4) by equally dividing 2.7 MGD between 4 wells for a rate of 0.675 MGD. The department used these rates to most closely match the proposed pumping volumes from the Application (Table 8-8).

Table 8-8. Alternative 2 wells and pumping rates

Well	X	Y	Stress Period 1 (MGD)	Stress Period 2 (MGD)	Stress Period 3 (MGD)
WK11	2166453.35	911303.03	0	0.2	0.2
WK12	2166453.35	911803.03	0	0.5	0.5
WK13	2163828.00	911803.00	0	0.51	0.51
L-1	2164540.61	905323.92	0	0	0.51
L-2	2165283.78	905934.34	0	0	0.51
L-3	2166022.19	905668.49	0	0	0.51
L-4	2165445.57	905138.00	0	0	0.51
L-5	2164880.49	904711.31	0	0	0.51
T-1	2171539.90	902609.33	0	0	0.51
T-2	2170772.95	902209.83	0	0	0.51
T-3	2169917.55	902179.23	0	0	0.51
T-5	2176600.68	907078.47	0	0	0.51
FRA-1	2164651.20	908028.10	0	0	0.675
FRA-2	2164532.02	907010.00	0	0	0.675
FRA-3	2164141.77	906341.06	0	0	0.675
FRA-4	2163601.27	905963.18	0	0	0.675
		Total			**8.5**

Alternative 3 – Multi-source – Shallow Aquifer (1.7 MGD), River Bank Inducement (1.5 MGD), Bedrock Sources (5.3) – Total Average day demand from Shallow Aquifer 3.2 MGD
The department used a pumping rate of 0.2 MGD for WK11 from the 2009-2013 average pumping rate. The department determined pumping rates for WK12, 13 and L1, L2 by equally dividing 1.5 MGD between 4 wells for a pumping rate of 0.375 MGD. The department determined pumping rates for RBI wells FRA-1-3 by equally dividing 1.5 MGD by 3 wells for a pumping rate of 0.5 MGD (Table 8-9).

Table 8-9. Alternative 3 wells and pumping rates

Well	X	Y	Stress Period 1 (ft3/day)	Stress Period 2 (ft3/day)	Stress Period 3 (MGD)
WK11	2166453.35	911303.03	0	0.2	0.2
WK12	2166453.35	911803.03	0	0.375	0.375
WK13	2163828.00	911803.00	0	0.375	0.375
L-1	2164540.61	905323.92	0	0	0.375
L-2	2165283.78	905934.34	0	0	0.375
FRA-1	2164651.20	908028.10	0	0	0.5
FRA-2	2164532.02	907010.00	0	0	0.5
FRA-3	2164141.77	906341.06	0	0	0.5
		Total			**3.2**

Alternative 4 – DNR-Deep Aquifer and RBI – Deep Aquifer (4.5 MGD), Shallow aquifer – River Bank Inducement wells (4 MGD)
The department used pumping rates of 0.2 MGD and 0.5 MGD for WK11 and WK12, respectively, determined from 2009-2013 average pumping rates. Pumping rate for WK13 is 0.5 MGD. The department used a pumping rate of 0.56 MGD for each of the 5 RBI wells (Table 8-10).

Table 8-10. Alternative 4 wells and pumping rates

Well	X	Y	Stress Period 1 (MGD)	Stress Period 2 (MGD)	Stress Period 3 (MGD)
WK11	2166453.35	911303.03	0	0.2	0.2
WK12	2166453.35	911803.03	0	0.5	0.5
WK13	2163828.00	911803.00	0	0.5	0.5
RBI - 1	2164724.00	906217.00	0	0	0.56
FRA-1	2164651.20	908028.10	0	0	0.56
FRA-2	2164532.02	907010.00	0	0	0.56
FRA-3	2164141.77	906341.06	0	0	0.56
FRA-4	2163601.27	905963.18	0	0	0.56
		Total			**4**

Attachment B – Pumping Rate Reductions

The following tables indicate the pumping rate reduction in each well for each alternative.

Table 8-11. Pumping rate reduction to maintain aquifer saturated thickness at 20 % of total aquifer saturated thickness. A) Alternative 1

Alternative 1 - Shallow/Deep				Coarse-favored Model		Fine-favored Model	
Name	Well	Row	Col	Qin(mgd)	Qot(mgd)	Qin(mgd)	Qot(mgd)
WK13	1	421	147	0.38	0.38	0.38	0.38
WK12	2	421	168	0.38	0.38	0.38	0.38
WK11	3	425	168	0.20	0.20	0.20	0.20
L-1	4	473	152	0.38	0.38	0.38	0.38
L-2	5	468	158	0.38	0.38	0.38	0.38
L-5	6	478	155	0.38	0.38	0.38	0.38
L-4	7	475	160	0.38	0.38	0.38	0.38
L-3	8	471	164	0.38	0.38	0.38	0.38
T-1	9	495	208	0.38	0.38	0.38	0.22
T-2	10	498	202	0.38	0.38	0.38	0.38
T-3	11	498	195	0.38	0.38	0.38	0.38
				4.00	**4.00**	**4.00**	**3.84**

b) Alternative 2

Alternative 2 - Shallow				Coarse-favored Model		Fine-favored Model	
	Well	Row	Col	Qin(mgd)	Qot(mgd)	Qin(mgd)	Qot(mgd)
WK13	1	421	147	0.51	0.50	0.51	0.50
WK12	2	421	168	0.50	0.50	0.50	0.50
WK11	3	425	168	0.20	0.20	0.20	0.20
L-1	4	473	152	0.51	0.51	0.51	0.51
L-2	5	468	158	0.51	0.50	0.51	0.37
L-5	6	478	155	0.51	0.51	0.51	0.51
L-4	7	475	160	0.51	0.51	0.51	0.49
L-3	8	471	164	0.51	0.51	0.51	0.51
T-1	9	495	208	0.51	0.51	0.51	0.21
T-2	10	498	202	0.51	0.51	0.51	0.51
T-3	11	498	195	0.51	0.51	0.51	0.51
FRA-4	12	468	145	0.68	0.68	0.68	0.68
T-5	13	459	249	0.51	0.51	0.51	0.51
FRA-3	14	465	149	0.68	0.68	0.68	0.59
FRA-1	15	452	153	0.68	0.68	0.68	0.66
FRA-2	16	460	152	0.68	0.68	0.68	0.54
				8.50	**8.48**	**8.50**	**7.79**

c) Alternative 3

Alternative 3 Multi-source				Coarse-favored Model		Fine-favored Model	
	Well	Row	Col	Qin(mgd)	Qot(mgd)	Qin(mgd)	Qot(mgd)
WK13	1	421	147	0.38	0.38	0.38	0.38
WK12	2	421	168	0.38	0.38	0.38	0.38
WK11	3	425	168	0.20	0.20	0.20	0.20
L-1	4	473	152	0.38	0.38	0.38	0.38
L-2	5	468	158	0.38	0.38	0.38	0.38
FRA-3	6	465	149	0.50	0.50	0.50	0.50
FRA-1	7	452	153	0.50	0.50	0.50	0.50
FRA-2	8	460	152	0.50	0.50	0.50	0.50
				3.20	**3.20**	**3.20**	**3.20**

d) Alternative 4

Alternative 4 DNR RBI				Coarse-favored Model		Fine-favored Model	
	Well	Row	Col	Qin(mgd)	Qot(mgd)	Qin(mgd)	Qot(mgd)
WK13	1	421	147	0.50	0.50	0.50	0.50
WK12	2	421	168	0.50	0.50	0.50	0.50
WK11	3	425	168	0.20	0.20	0.20	0.20
RBI 1	4	466	154	0.56	0.56	0.56	0.56
FRA-4	5	468	145	0.56	0.56	0.56	0.56
FRA-3	6	465	149	0.56	0.56	0.56	0.56
FRA-1	7	452	153	0.56	0.56	0.56	0.56
FRA-2	8	460	152	0.56	0.56	0.56	0.56
				4.00	**4.00**	**4.00**	**4.00**

9 Appendix C: Environmental Impacts from Existing Shallow Aquifer Wells

Impacts from Existing Shallow Wells

The department conducted additional groundwater flow modeling to evaluate the impacts to surface water from the existing shallow aquifer wells. See Appendix B for background on the groundwater modeling.

The department modeled the shallow aquifer impacts for the existing shallow aquifer pumping. Shallow aquifer pumping averaged 1.25 MGD for 2010 – 2014. This pumping rate was used in this alternative (Table 9-1).

Table 9-1 Existing water supply system.

Scenario / Alternative	Water Supply	Average Day Demand (MGD)	Infrastructure to meet demand (shallow aquifer only)
(5) Existing Water Supply System	Deep Sandstone Aquifer	5.4	
	Shallow Aquifer	**1.25**	
	- Existing wells	1.25	Waukesha wells 11, 12, 13;
	- New wells	0	

Model Setup

See Appendix B.

Stress Period 1 – Model run in steady state mode without Waukesha's shallow wells 11, 12, and 13 pumping.
Stress Period 2 – Model run in transient mode for 5 years with Waukesha's wells 11, 12, and 13 pumping at the same rate as these wells pump in stress period 3. The pumping for these wells was held constant between stress period 2 and 3 to avoid rebound scenarios in the aquifer. Wells 11 and 12 came online in 2006, Well 13 came online in 2009. The department chose a 5-year period to represent a period in which all three of these wells were in operation, prior to adding additional wells.

Stress Period 3 – Models run in transient mode for 20 years. Waukesha's wells 11, 12, and 13 pump at the same rate as in stress period 2.

Figure 23 in Appendix B indicates well locations.

Results – Maximum Drawdown

Table 9-2 Maximum drawdown with existing three shallow wells pumping.

Time Period	Maximum Drawdown – Coarse- favored (feet)	Maximum Drawdown – Fine-favored (feet)
After Stress Period 2	19 feet	23 feet
After Stress Period 3	Additional 9 feet	Additional <1 foot

Results – Streamflow depletion

Table 9-3 Impacts from existing pumping - results between stress period 1 and stress period 3

Stream	Coarse-favored model (MGD)	Fine-favored model (MGD)
Pebble Brook	0% (0.01)	0% (0.02)
Fox River	2% (1.04)	2% (1.01)
Pebble Creek	1% (0.04)	1% (0.02)
Mill Creek	0% (0.00)	0% (0.00)
Genesee Creek	0% (0.01)	0% (0.00)

Results – Wetland Impacts

Wetland acres with greater than one-foot of drawdown were calculated by intersecting the one-foot drawdown contour area in model layer 1 with the Wisconsin wetlands GIS layer[36].

Table 9-4 Wetlands in the one foot drawdown contour

Time Period	Coarse-favored model (acres)	Fine-favored model (acres)
After Stress Period 2	305	467
After Stress Period 3	Additional 135 acres	Additional 17 acres

Results – Springs

Spring ID number 680253is located in the 10 foot drawdown contour. The spring flow is recorded as 0.09 cfs in the WGNHS springs database.

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