Current Water Supply

The City of Waukesha provides water to its customers primarily from deep wells, constructed to depths of up to 2,100 feet and withdrawing water from 800 to 1,000 feet below ground. The City obtains less than 13 percent of its water supply from shallow wells in the Troy Bedrock Valley aquifer. Water supply pumping from the deep aquifer has decreased the goundwater level 500 to 600 feet in little over a century, and it continues to drop 5 to 9 feet annually. Existing groundwater levels require the City to use very large well pumps to withdraw the groundwater. Pumping water from extreme depths is energy-intensive, costly and increases the carbon footprint of the City's public water system.

The deep aquifer is hydrologically connected to the waters of the Great Lakes Basin. Extreme drawdown of the aquifer is diverting some water that would otherwise flow into the Great Lakes Basin toward wells outside the Basin. Ceasing groundwater withdrawal would help to restore natural flow conditions and provide an environmental benefit to the Waters and Water Dependent Natural Resources of the Lake Michigan Basin.

In certain parts of the deep aquifer located outside the jurisdiction of the City, precipitation helps to recharge the deep aquifer. But in the Waukesha area, a hard layer of shale above the aquifer limits groundwater recharge. Also, the water the City uses does not recharge the aquifer. After use and treatment, the water is discharged to the Fox River and ultimately finds its way to the Mississippi River and the Gulf of Mexico. The precious freshwater resource is not returned to its source—the Great Lakes and Mississippi River groundwatersheds. It is sent to the ocean and removed from the region.

As water is pumped from greater and greater depths, the quality of the source water declines. Radium and other dissolved solids are present in increasingly higher concentrations and require removal to meet drinking water standards. All the deep aquifer wells are located in developed areas of the City. Two wells have been shut down because of contamination , and another is used for emergency backup only because of high dissolved solids in the water. In addition, the City is under court order to comply with radium standards by June 30, 2018. Continuing the current practice is not an option available to the City. The deep aquifer is clearly not a reasonable or sustainable long-term source of potable drinking water.

The City's vision for the future is to provide an adequate supply of healthful water to its citizens for the long term (50 to 100 years) while effectively managing the region's water resources. In 2006, the City launched one of the most comprehensive water conservation programs in the Midwest, including a ban on daytime water sprinkling, rate structures that promote water conservation, a high efficiency toilet rebate program, and public education. But a successful water conservation program alone is not a solution to the City's water supply needs. The water saved under even the most effective conservation program is only a fraction of that needed for the future.

The Southeastern Wisconsin Regional Planning Commission, the regional planning authority, estimated the future City of Waukesha population and future water demand when the City is fully developed. The City refined the population projections and demand forecasts on the basis of extensive system operating data and determined it needs a future average annual day demand of 10.9 million gallons per day when its water service area is fully developed.

Continued and increased withdrawal from the deep and shallow groundwaters to meet present and future demands, at the cost of adverse environmental impacts to regional water resources and ecosystems, is not a sustainable solution, nor the best way to protect public health. The City of Waukesha needs a new long-term water supply.

Water Supply Alternatives

The City and others have studied extensively the water resources in the Waukesha area. The evaluations and recommendations from these and other water supply studies are summarized in this application. Numerous water sources and combinations of water supply alternatives have been evaluated, including continued use of the deep and shallow aquifers, local river supplies, local lake supplies, and wastewater reuse. Many water supplies were screened out because of poor water quality, inadequate capacity, or other reasons. Four water supply alternatives were selected for further evaluation:

- Continued use of the deep and shallow aquifer
- Use of shallow aquifer resources alone
- Use of Lake Michigan water with return flow to Lake Michigan
- Use of Lake Michigan water and the shallow aquifer with return flow to Lake Michigan

The alternatives were evaluated based on four criteria consistent with WDNR requirements: environmental impact, long-term sustainability, public health, and implementability. The evaluation is summarized below.

Water Supply Alternatives Evaluation Summary

Water Supply Alternative	Environmental Impact	Long-Term Sustainability	Public Health	Implementability
Deep and shallow aquifers	●	●	◉	●
Shallow aquifer and Fox River alluvium	●	●	◉	●
Lake Michigan	○	○	⊙	◉
Lake Michigan and shallow aquifer	●	◉	⊙	●

○ No negative impact
⊙ Minor negative impact
◉ Moderate negative impact
● Significant negative impact

The deep aquifer is not a reliable long-term water supply for the reasons given above. Focused groundwater modeling revealed that pumping the shallow aquifer, even at water quantities less than Waukesha needs, creates significant negative environmental impacts to water ecosystems both inside and outside the Great Lakes Basin. Because the shallow aquifer depends on rainwater for recharge, it is less reliable during drought conditions, when water demand is greatest. It is unlikely that the shallow aquifer could provide adequate water for maximum day demands during a drought, and even less likely it could do so without severe negative impacts to the environment. The aquifer is also more susceptible to contamination with increased risk to public health. Arsenic has already been discovered in the shallow aquifer above EPA limits.

Installing new wells in the shallow aquifer will continue to be more difficult for several reasons. First, Waukesha is located in a state-designated groundwater management area, and as a result, more requirements and restrictions could be placed on groundwater development. Second, the wellfield would be installed outside the City's boundaries. Significant land purchase/lease and controls outside the jurisdiction of the City would be required. Residents near the probable location of the wellfield have opposed high-capacity wells because of concerns about adequate water supply and impacts to wetlands, private wells, and other environmental resources.

Use of a Lake Michigan supply would cease pumpage from the deep aquifer and allow groundwater levels to recover. Increasing deep aquifer water levels would have an environmental benefit. The rising levels would provide more water to the Waters of the Great Lakes Basin. The water sent to Waukesha would be returned to Lake Michigan, thereby protecting the integrity of the Great Lakes ecosystem. There would be no measurable impact on Lake Michigan water quantity. The deep groundwater supply alternative, however, would continue to divert water from the region. With a Lake Michigan water supply, the negative environmental impacts of pumping the shallow or deep aquifer would be eliminated.

Public health would be best protected with a Lake Michigan water supply, because it would provide the most reliable source of high quality water to consumers. Another benefit is that Lake Michigan is relatively soft. The negative environmental impacts associated with home water softening of water from the deep aquifer (salt discharge to surface waters, additional water and energy use) would be eliminated, and the public would consume less sodium from its water supply.

The costs for the four alternatives are summarized below. The combination of a Lake Michigan and groundwater supply is the most expensive. Over the long term, the Lake Michigan water supply will be the most cost–effective, and also the simplest to operate and maintain.

Water Supply Alternative Cost Estimates

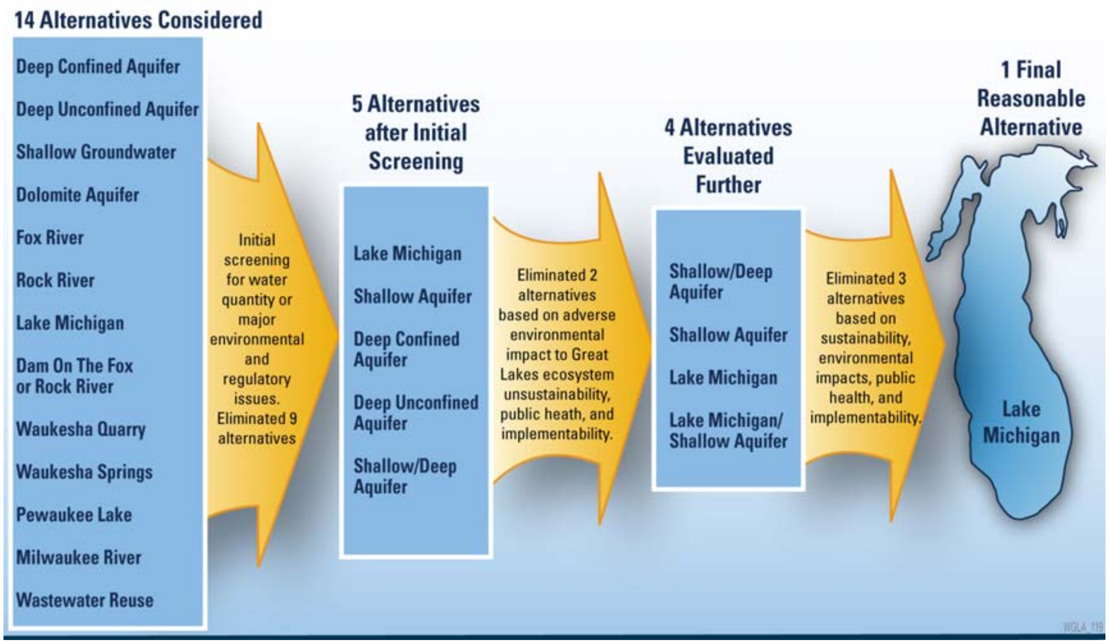
Water Supply Alternative	Capital Cost[a] ($ million)	Annual Operation and Maintenance Cost ($ million)	20-year Present Worth Cost ($ million, 6%)	50-year Present Worth Cost ($ million, 6%)
Deep and shallow aquifers	189	7.2	272	302
Shallow aquifer and Fox River alluvium	184	7.4	269	301
Lake Michigan with return flow to Underwood Creek	164	6.2	235	262
Lake Michigan and shallow aquifer	238	7.5	324	356

[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

Summary

After analyzing various water supply alternatives, it is clear that a Lake Michigan water supply, with continued water conservation and return flow, is the only reasonable solution for the City of Waukesha. It offers the most reliable, cost–effective, high-quality drinking water for the future. It protects the integrity of the Great Lakes Basin ecosystem. It more effectively manages the Waters of the Great Lakes Basin and eliminates the negative environmental impacts of using groundwater. Use of a Lake Michigan water supply will terminate pumping of the deep aquifer and help to restore the natural flow of groundwater toward Lake Michigan to benefit the Great Lakes ecosystem.

Final Water Supply Alternative Selection



There is no reasonable water supply alternative to a Lake Michigan supply within the basin in which Waukesha is located. The groundwater supply options have much greater negative environmental impacts than using Lake Michigan, and are not sustainable long-term or as protective of public health.

SECTION 1
Introduction

This application is prepared and submitted in accordance with the Great Lakes–St. Lawrence River Basin Water Resources Compact (the Compact) and the Wisconsin Compact implementing statute (§ 281.346 and 281.348, Wis. Stats.) for the purpose of gaining approval for a Great Lakes water diversion. It provides historic evidence, future water resources planning, and scientific data that support the conclusion that a Lake Michigan water supply with return flow is the only reasonable and environmentally beneficial water supply for the City of Waukesha. A Lake Michigan supply would end the City's use of the deep aquifer and provide environmental benefits to groundwaters and surface waters throughout the region while meeting the reasonable needs and protecting the public health of water utility customers. The appendixes contain technical references in support of this application.

City of Waukesha Background

The City of Waukesha is a historic community in southeastern Wisconsin, 18 miles west of Lake Michigan. Redevelopment has been central to the City's strategic plan for the community. For example, extensive revitalization of Waukesha's historic downtown has created a thriving commercial and arts district. Investments made in the downtown area have spurred the development of community resources, including local small businesses, galleries, and museums. The City looks forward to a future with well-managed growth that involves continued urban redevelopment; increased use of green infrastructure in the community; and effective management of water resources to sustain water and the natural environment for future generations.

The City of Waukesha is located in the Mississippi River Basin. It is outside the Great Lakes Basin but wholly within a county that lies partly within the Great Lakes Basin (see Exhibit 1-1). It is 1.5 miles west of the Great Lakes watershed surface water divide but 17.4 miles east of the Great Lakes groundwater divide, well within the Great Lakes groundwatershed. The City of Waukesha is eligible for a Lake Michigan diversion if the conditions of the Compact are met, including:

- The diverted water would be used solely for the City's public water supply because the City is without adequate supplies of potable water.
- The portion of diverted water that is returned to the Waters of Basin is maximized, and the portion of the returned water that is from the Mississippi River Basin is minimized.
- The City demonstrates it does not have a reasonable water supply alternative within the Mississippi River Basin, including conservation of existing groundwater supplies.
- The diversion with return flow does not endanger the integrity of the Basin ecosystem.
- The proposed diversion with return flow is reviewed and approved by the Council of Great Lakes Governors.

EXHIBIT 1-1
Wisconsin Counties Within Great Lakes Basin

Waukesha is the first community within a county that straddles the surface water divide to apply for a Great Lakes diversion for a public water supply under the terms in the Compact. Waukesha's application follows the New Berlin, Wisconsin application, which was approved under the straddling community provision of the Compact and Wis. Stat. §281.346 and §281.348.

Need for a New Water Supply

The City obtains more than 87 percent of its water supply from the deep St. Peter Sandstone Aquifer. Near and beyond the City of Waukesha, 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 by numerous other communities in Wisconsin and Illinois since the 19th century, combined with the limited recharge, has contributed to the 500- to 600-foot decline in aquifer water levels.[1] Water levels continue to drop 5 to 9 feet per year.[2] Reduced groundwater levels in southeastern Wisconsin have in turn affected regional surface waters, which now receive about 18 percent[3] less groundwater contribution as water is drawn toward the deep aquifer wells. As the aquifer level drops, water quality degrades and concentrations of radionuclides and salts increase. Radionuclides (radium-226, radium-228, and gross alpha) are naturally occurring elements that pose increased risk of cancer. To provide safe drinking water, the City treats some deep aquifer water to remove radium and blends some untreated deep aquifer water with radium-compliant water from the shallow aquifer. Increasing concentrations of total dissolved solids (TDS), also referred to as salts, is another serious water quality concern with the current deep aquifer supply. Excessive levels of TDS have prompted the City to partially plug deep aquifer wells.

The City obtains less than 13 percent of its water supply from the shallow aquifer. Pumping the shallow aquifer withdraws groundwater baseflows that would otherwise naturally feed local streams and wetlands.[4] Increasing withdrawal from the Troy Bedrock Valley shallow aquifer to meet the City's needs was simulated with groundwater modeling. Even with wells spaced so as to minimize drawdown impacts on sensitive environmental resources, shallow aquifer drawdown is estimated to be between 50 and 100 feet with baseflow reductions to wetlands and brooks, between 50 and 340 percent.[5] Additional pumping of the shallow aquifer to provide long-term water supply for the City would dramatically reduce or eliminate groundwater flows to surface waters and water dependent resources. Drawdown also reduces the availability of water for private wells and might draw contaminants from private septic systems into the public water supply.

Physical evidence, scientific research, groundwater modeling, and land use planning form the basis of a comprehensive regional water supply plan that concluded that the City of Waukesha is without an adequate supply of potable water and that no water supply alternative is as sustainable and protective of public health and natural water resources as a Great Lakes water supply.

A Great Lakes supply that recycles fresh water is sustainable (Exhibit 1-2), compared to the City's current water management strategy in which fresh water is withdrawn from local aquifers in excess of natural recharge, used, treated, and ultimately discharged the Gulf of Mexico (Exhibit 1-3).

1 SEWRPC. 2008. *Draft Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* pp.102–103.

2 Waukesha Water Utility operating data 2009.

3 USGS and WGNHS, *Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin*, March, 2007

4 SEWPRC. 2008. *Draft Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* pp. 8–14.

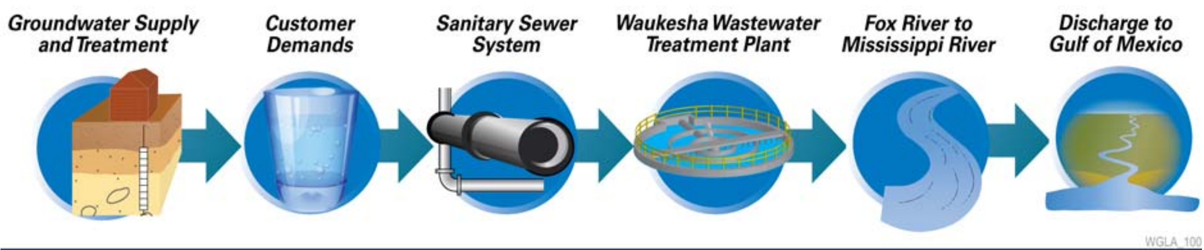
5 RJN Environmental Services, LLC. March 2010. *Results of Groundwater Modeling Study Shallow Aquifer Groundwater Source—Fox River & Vernon Marsh Area, Waukesha Water Utility.*

The City seeks to divert 10.9 million gallons per day (mgd) from Lake Michigan and to return the flow to meet the average day demand of the City's projected water supply service area at build-out. The City's planned Water Service Area was delineated by the regional planning authority, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) in accordance with Chapter NR 121, Wisconsin Administrative Code.

EXHIBIT 1-2
Proposed Supply, Treatment, and Discharge System

Long-term water supply planning studies were conducted for both the City and the region to evaluate the water supply alternatives. These studies addressed the continued use of the deep and shallow aquifer, the increased withdrawal from the shallow aquifer, local river supplies, lake supplies and wastewater reuse.

EXHIBIT 1-3
Existing Waukesha Water System Overview



A Lake Michigan potable water supply has fewer adverse environmental impacts and is more sustainable and protective of the public health than any of the alternatives considered. A Lake Michigan water supply would do the following:

- It manages water resources so they are available for future generations.
- If contributes to the recovery of groundwater and surface waters, including waters of the Great Lakes Basin.
- It ensures a long-term adequate supply of potable water.
- It provides environmental benefits to Great Lakes ecosystem by increasing flows in Underwood Creek, to restore aquatic and wildlife habitat in the watercourse that returns flow to Lake Michigan.
- It reduces energy usage and greenhouse gas emissions associated with the water supply.
- It eliminates the amount of salt, used to soften hard groundwater, that is released to the environment.
- It reduces the release of radium to the environment.

Water Conservation Leadership

In 2006, the City launched an aggressive water conservation plan. Over the past 3 years, the City accomplished reductions in water used through a ban on daytime water sprinkling, rate structures that promote water conservation, a high efficiency toilet rebate program, and educational outreach. The success of the water conservation measures has helped the City to reliably provide radium-compliant drinking water on an interim basis. Water conservation contributes to the City's water use trend, summarized in Exhibit 1-4. Between 1988 and 2008, water use decreased 31 percent, despite a corresponding 26 percent increase in population during the same period. Other leading factors in Waukesha's reduced water use is loss of local industry and decline in new development in a weak economy. Water conservation is only a partial solution to the City's water supply needs. Alone, water conservation cannot save enough water to offset the projected future water demand.

EXHIBIT 1-4
Waukesha Population and Water Use

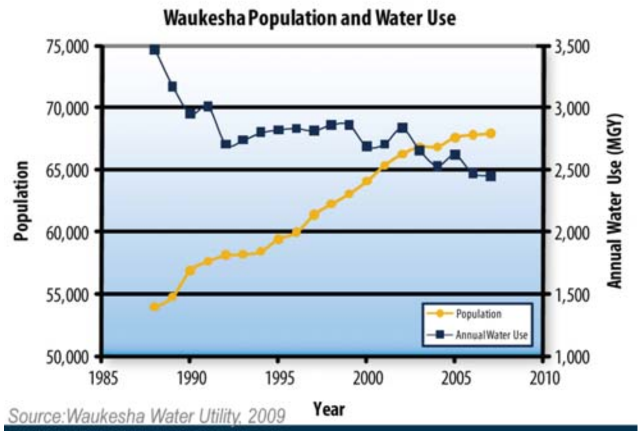
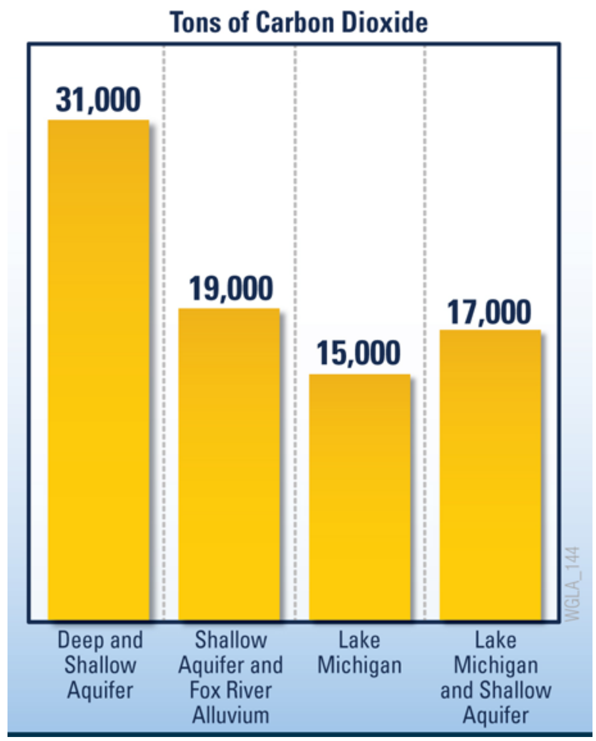


EXHIBIT 1-5
Annual Greenhouse Gas Emissions



Regional Benefits

The regional environmental benefits of ceasing deep aquifer pumping for the City's water supply, and instead using Lake Michigan water with return flow, include deep aquifer recovery and increase of groundwater flows to surface water resources in both the Great Lakes Basin and the Mississippi River Basin. The proposed return flow strategy would provide flow beneficial to habitat restoration in Underwood Creek and the Menomonee River, which supports the environmental goals for the watercourses, particularly during dry periods. Use of Lake Michigan water also reduces the need to soften groundwater to remove natural hardness. Salts used in water softening pass through conventional wastewater treatment processes and are discharged to the environment. Customers of the Waukesha Water Utility currently use nearly 5,000 tons of salt annually to soften groundwater.[6] Another significant regional environmental benefit of using Lake Michigan water is reduced energy consumption. Energy use and greenhouse gas emissions are less with a Great Lakes water supply than they are for withdrawing and treating groundwater supplies (Exhibit 1-5).

[6] CH2M HILL and Ruekert-Mielke. 2002. *Future Water Supply Report*, p. 6-3.

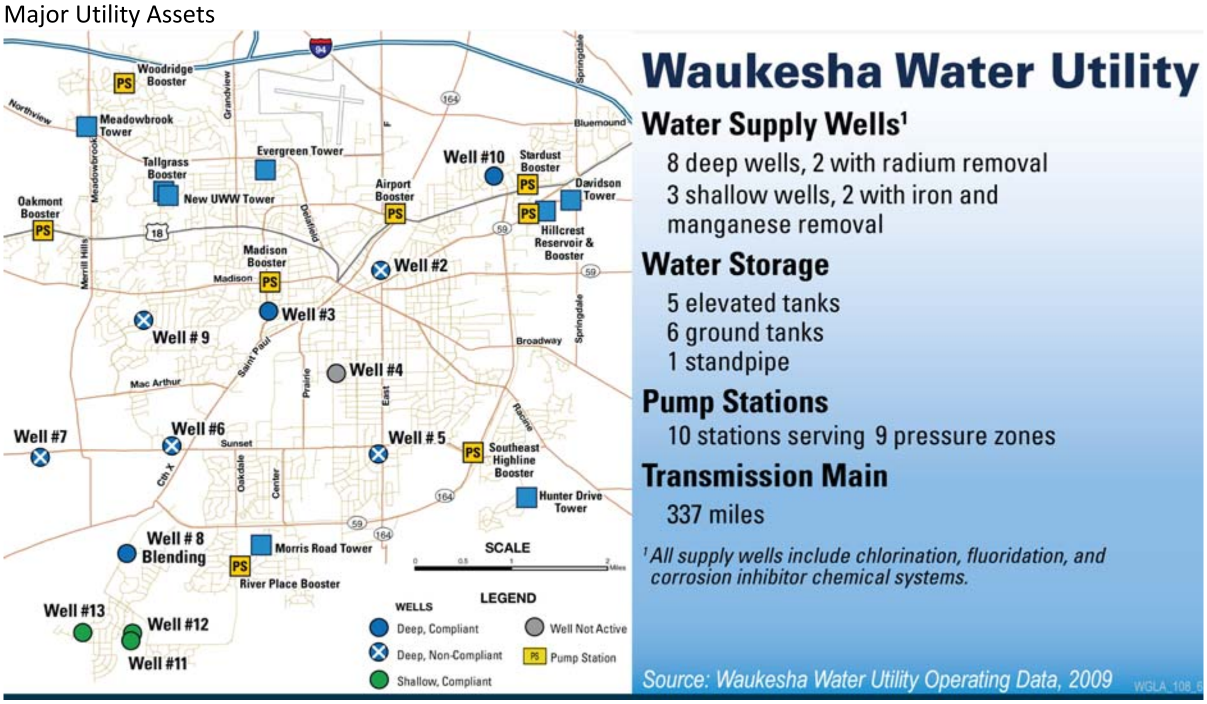
SECTION 2

Water System Overview

City of Waukesha Water System

The City of Waukesha water system comprises groundwater supply, treatment, storage, and conveyance assets (Exhibit 2-1). The City's system is a "public water supply"—a means of distributing water to the public through a physically connected system of supply, treatment, storage, and distribution facilities that serve a group of largely residential customers, and that also serves industrial, commercial and public customers. The City also maintains a water utility administration building with offices for customer service, billing, supervisory control and data acquisition system control, meter testing, fleet storage, and equipment storage. Appendix D, Water Supply Service Area Plan, contains additional water infrastructure information.

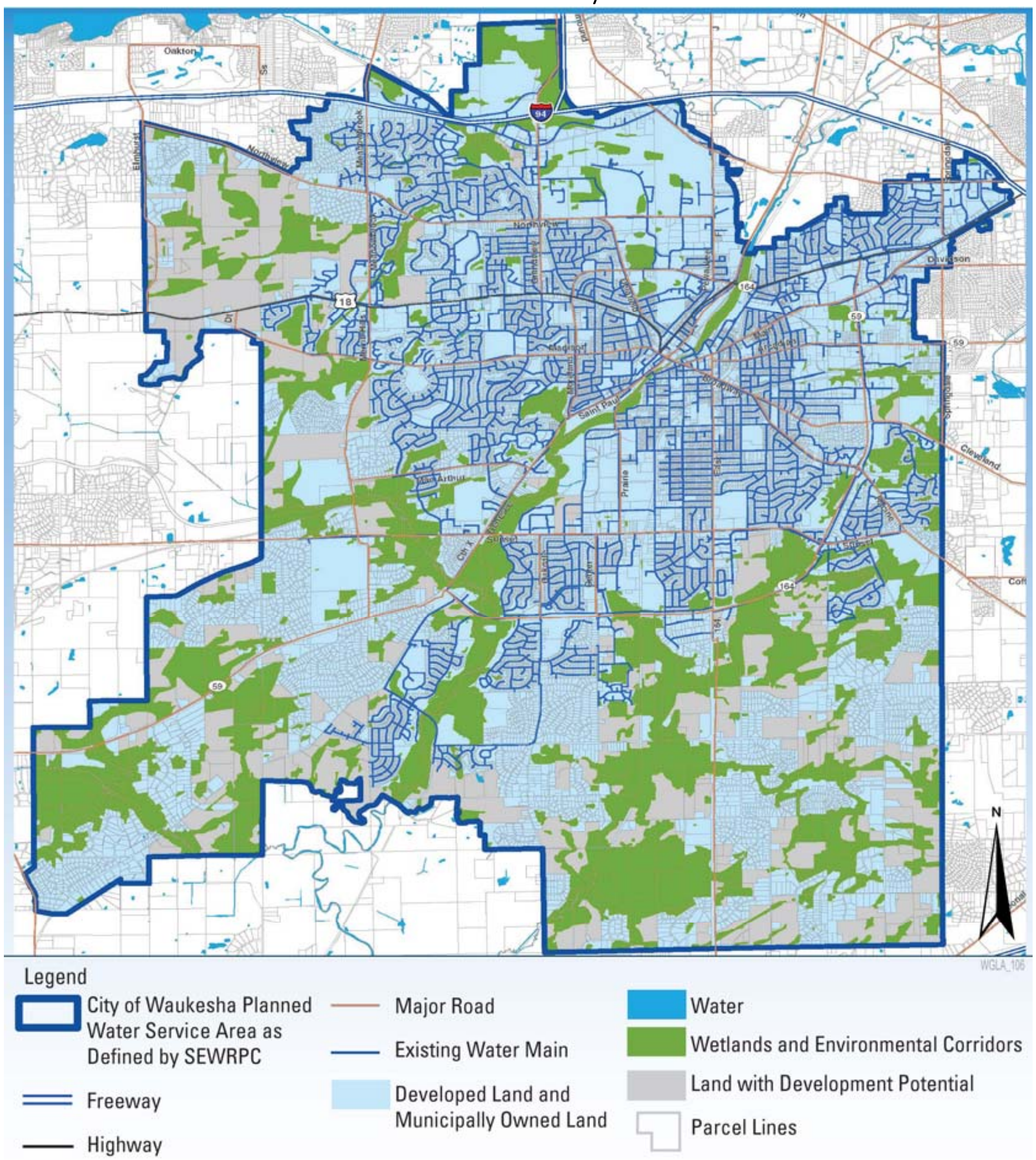
EXHIBIT 2-1
Major Utility Assets



Water Supply Service Area

To prepare a long-term water supply plan, the City studied historic water utility performance, investigated regional water quality and quantity data, undertook aggressive water conservation practices, and developed water supply projections to match the estimated needs of its water service area. The City of Waukesha's public water supply system service area was delineated by SEWRPC pursuant to its authority under Chapter NR121 Wis. Admin. Code. Exhibit 2-2 shows the planned water service area. Eighty-five percent of the planned water service area is already developed or designated as natural and environmentally sensitive areas to be preserved in a

EXHIBIT 2-2
Planned Ultimate Buildout Water Service Area for the City of Waukesha



Source: Adapted from Water Supply Service Area for the City of Waukesha and Environs, Waukesha County, Wisconsin, SEWRPC, December 2008

manner consistent with the regional land use plan.[1] Fifteen percent of the planned water service area would be available for future development.

Although there are minor differences between the City of Waukesha water and wastewater service areas, SEWRPC considers the two areas to be essentially the same.[2] The minor differences are quantified in Appendix E, Waukesha Wastewater Facility Plan Amendment, Return Flow.

[1] SEWRPC. 2008. Preliminary Draft, *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Chapter I, p. 5-6.

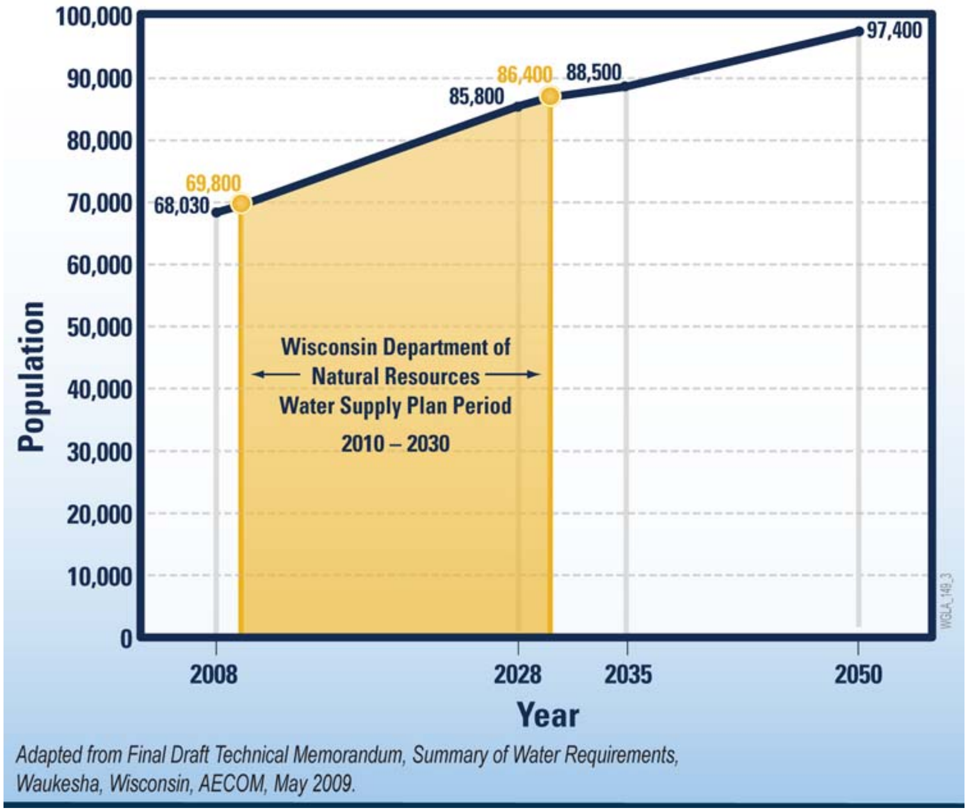
[2] SEWRPC/Philip Evenson, Executive Director. December 23, 2008. Letter to Waukesha Water Utility/Daniel S. Duchniak, P.E., General Manager. Attachment, p. 1.

Water Service Area Population Projections and Water Demand Forecasts

As part of its regional water supply plan, SEWRPC prepared population projections for the City of Waukesha water supply service area.[3, 4] To account for economic uncertainty, SEWRPC prepared regional population projections assuming low, intermediate, and high growth scenarios. SEWRPC estimated a Waukesha water supply service area population of 88,500 in 2035 under an intermediate growth scenario. This is equivalent to less than 1 percent annual increase in population.

The estimated "ultimate population" for the water supply service area is 97,400. The ultimate population projection represents a condition beyond the SEWRPC 2035 planning horizon. It occurs when all land available for development has been developed in a manner consistent with the regional land use plan. For water supply planning purposes, the City assumed the ultimate population will be reached in 2050. Exhibit 2-3 shows the population projections. The interpolated projections for the 20-year planning period (2010–2030) required under the state's new water supply plan statute (§ 281.348(3) Wis. Stats.) are also depicted.

EXHIBIT 2-3
City of Waukesha Water Supply Service Area Population Projections



SEWRPC prepared future water demand forecasts based on intermediate population projections. The demand forecasts considered water service area demographics, land use plans, and water use

3 Ibid. Chapter IV, p. 52.

4 SEWRPC/Executive Director Kenneth R. Yunker, P.E. March 17, 2009. Letter to Steven Crandall Community Development Director, City of Waukesha.

data from 2000, 2004, and 2005.[5] For the SEWRPC planning period ending in 2035, water demand forecasts were prepared using multiple factors including implementation of water conservation practices. Water conservation measures were estimated to result in 4 to 10 percent average day demand water savings, depending on the type of water supply.[6] For the Waukesha water service area, a 10 percent average day demand reduction was factored into the water demand forecasts. The reduction accomplished through conservation represents an increase over and above the current levels of water conservation. Exhibit 2-4 summarizes the SEWRPC 2035 water demand forecasts.

EXHIBIT 2-4
2035 Water Demand Forecasts

Water Use	Value
2035 Average Daily Pumpage Including 5 percent allowance for fire fighting flow and unaccounted for water and 10 percent additional water conservation	9.8 mgd
2035 Average Daily Demand Including 10 percent additional water conservation	9.3 mgd
2035 Average Daily Demand Without water conservation	10.2 mgd
2035 Maximum Day Demand Based on 1.37 peaking factor and including 10 percent additional water conservation	13.7 mgd
2035 Per Capita Water Use Based on 2035 Population of 88,500	111 gallons/capita/day

Preliminary draft *Planning Report on Regional Water Supply Plant for Southeastern Wisconsin*, Chapter IV, pp. 52, 53, 72.

The City used the SEWRPC projections, 38 years of Waukesha water system operating data, the water service area plan, and the City's water conservation and protection plan to further refine water demand forecasts for the ultimate water service area population of 97,400. Ranges of average- and maximum-day demands, developed by considering greater variability in population and water conservation effectiveness, were prepared (Exhibit 2-5). The interpolated demand forecasts for the 20-year planning period (2010–2030) required under the state's new water supply plan statute (§ 281.348(3) Wis. Stats.) are also depicted.

Two water demand factors vary between the SEWRPC and City forecasts. First, the City's amount of unaccounted-for water and fire fighting flow historically equals 4 to 7 percent of total water pumpage. For long-range planning, the City used a realistic, but conservative value of 7 percent, in lieu of the 5 percent value used in the SEWRPC plan on the basis of Waukesha's performance in 2000, 2004, and 2005 only.

Second, the City used a more conservative peaking factor to estimate maximum day demand. A peaking factor a 1.68 was used after consideration of several decades of Waukesha system performance and the inherent uncertainty of very long-range water supply plans that need to address potential impacts of climate change, including drought. The peaking factor of 1.37 used in the SEWRPC plan was based on peak flows in 2000, 2004, and 2005 only. The demand values shown are tabulated in Exhibit 2-6.

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[5] Preliminary Draft, *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin*, 2008, Chapter IV, p.7.
[6] Ibid., Chapter IV, p. 39.

EXHIBIT 2-5
City of Waukesha Water Supply Service Area Demand Projections

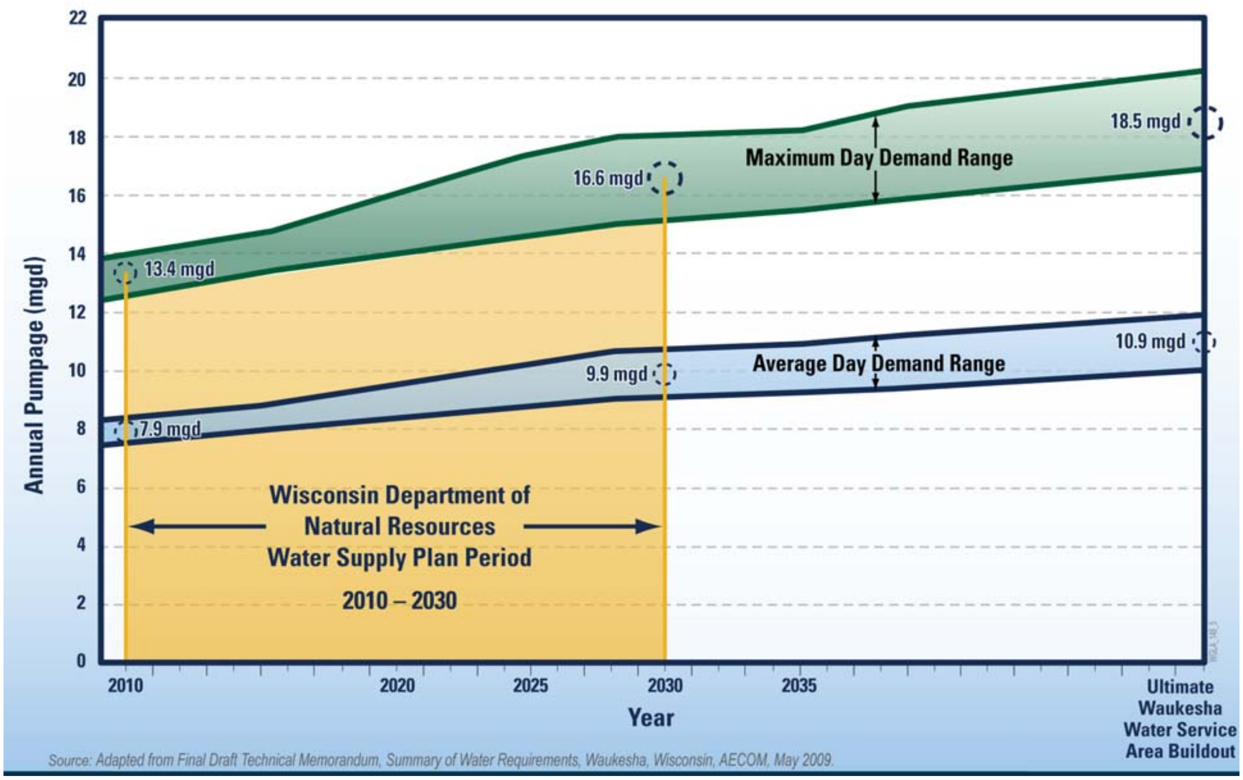


EXHIBIT 2-6
Ultimate Water Service Supply Area Water Demand Forecasts

Water Use	Value
Ultimate Average Daily Including 7 percent allowance for firefighting flow and unaccounted for water and continued water conservation	10.9 mgd
Ultimate Average Daily Demand Without water conservation	12.0 mgd
Ultimate Maximum Day Demand Based on 1.68 peaking factor and including continued water conservation	18.5 mgd
Ultimate Per Capita Water Use Based on Ultimate Population of 97,400	112 gallons/capita/day

Final Draft Technical Memorandum, Summary of Water Requirements, Waukesha, Wisconsin, AECOM, May 2009.

Waukesha Water Conservation and Efficiency

Since 2006, the City has implemented a variety of water conservation measures. These best practices, including implementation of rates that encourage water conservation, were authorized by the Wisconsin Public Service Commission. Further, the City's universal metering, leak detection and repair program, public education and landscape water controls are compliant with draft water conservation and water use efficiency rule (Wis. Admin. Code NR852.04(2)) being developed by the Wisconsin Department of Natural Resources (WDNR).

Accounting for Water

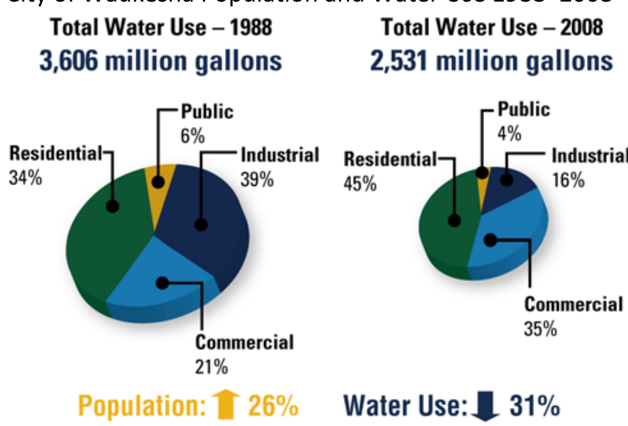
Measuring all water used is essential to ensuring wise water use. The City of Waukesha meters all water customers and monitors water use with accurate automatic flow meters that can be read remotely. The City describes water use on customer bills in terms of gallons rather than cubic feet. This small detail helps customers understand how water use relates to behavior. Also, with automatic meters, City staff routinely monitor meter records. If a dramatic change in water use is observed, the City contacts a customer to promptly address potential water waste issues.

All water utilities, including the Waukesha Water Utility have unavoidable water loss. This water loss, called unaccounted-for water, is used for fighting fires and flushing mains, or is lost through leaks in water pipes. To minimize unaccounted-for water, the City monitors the system for leaks and estimates water used for routine system flushing. Historically, the City averages 4 to 7 percent unaccounted-for water,[7] which is below the American Water Works Association-recommended benchmark of 10 percent.[8]

Water Conservation Measures

Total water use by City customers has dropped 31 percent from 1988 to 2008, despite a 26 percent population increase (Exhibit 2-7). Some of this decline in water use is attributed to industry leaving the area and the recent economic recession, but some can be attributed to the City's water conservation and protection plan. In 2006, the City implemented a comprehensive water conservation plan that successfully reduced water use. Water conservation efforts will be continued and monitored to determine which measures are the most effective. Exhibit 2-8 presents highlights of the City's plan for continued investment in water conservation.

EXHIBIT 2-7
City of Waukesha Population and Water Use 1988–2008



Source: Waukesha Water Utility

Outdoor Sprinkling Restrictions

The first conservation initiative implemented in 2006 was adoption of a sprinkling ordinance that affected all customer classes. The ordinance was targeted at reducing peak demand and reducing overall average day demand with a ban daytime sprinkling and restricted evening sprinkling.

Water bill inserts, refrigerator magnets, and press releases were used to educate the public regarding the ordinance. In 2007, street signs with sprinkler ordinance information were installed. These actions were successful in reducing the average and maximum day water demand. Comparisons show a 15 percent reduction in summer watering season water use from 2005 to 2008 (Exhibit 2-9). The baseline year of 2005 was chosen because it is the year before implementation of the conservation plan.

7 Waukesha Water Utility annual operating data submitted to Wisconsin Public Service Commission.

8 AWWA Leak Detection and Accountability Committee. 1991.

EXHIBIT 2-8

City of Waukesha Water Conservation and Protection Plan Goals

Relative Water Savings Benefit Scale: (one drop) = Minimal (two drops) = Moderate (three drops) = Major

Short-term Goals

Provide Public Education on Web Site – Teach the public why they should conserve water and how they can help, mentioning the resulting time and cost savings. Provide information on rain gardens and rain barrels.	Moderate
Continue Student Water Education – Teach Waukesha students about the water level in the aquifer, the importance of conservation, and practices their families can implement.	Major
Develop Outdoor Water Use Ordinance – Create and implement an ordinance that sets limits on sprinkling times to reduce peak water use and costs for customers.	Major
Communicate Monetary Benefits of Water Conservation – Place water conservation cost savings information in customer bills.	Moderate
Accelerate Water Main and Lateral Replacement – Continue to replace outdated mains and service laterals, helping to ensure a reduction in leaks.	Major
Promote Water Conservation – Create brochures, magnets, signage, and a public service announcement; attend events to promote conservation.	Moderate
Implement Conservation Water Rates – Develop with the Public Service Commission a water pricing structure that encourages conservation.	Major
Loop Water Mains – Have contractors loop the water mains to reduce hydrant flushing water requirements.	Minimal
Organize Regional Stakeholder Groups – Create stakeholder groups to promote regional water conservation through residential contests, commercial and industrial customer groups, regional water utility collaboration, and educational events for conservation.	Major
Recycle Filtered Backwash Water – Implement a recycling process for Wells 8, 11, and 12.	Minimal
Audit Water Use in City Buildings – Starting with City Hall, audit all city buildings to identify ways to reduce water use.	Moderate
Develop Incentives/Rebates Programs – Continue to work with the Public Service Commission to determine the feasibility and potential success of rebate programs.	Major
Implement Rain Barrel Program – Work with the Coalition to provide rain barrels for landscaping maintenance water supply.	Moderate
Become a Member of WaterSense – Gain current information on tested products to meet performance standards of plumbing fixtures for our rebate programs.	Moderate
Join Alliance for Water Efficiency – Acquire and implement best management practices for water conservation.	Moderate
Initiate Restaurant Table Tents and Other Water-saving Ideas – Work with the Coalition and Wisconsin Conference for Restaurants to develop "table tents" that explain water conservation at restaurants.	Moderate

Mid-term Goals

Continue Student Water Education Programs – Update curriculum.	Major
Continue Public Outreach Program – Provide press releases, and update brochures and materials. Update Utility Web site.	Moderate
Maintain Water System Leak Detection Program – Update Utility leak detection to identify priority areas in the system to reduce large leaks and reduce unaccounted-for flow.	Major
Implement City Water Audit – Install water-saving fixtures throughout Utility facilities.	Major
Evaluate Indoor Incentives/Rebates Programs – Evaluate rebate programs for targeted water-using appliances and fixtures.	Major
Evaluate Outdoor Incentives/Rebates Programs – Evaluate rebates for outdoor water use equipment (timers, sprayers).	Major
Evaluate Residential Audit Feasibility – Determine the feasibility of coordinating a residential water audit program with a water meter change-out program that would link to an incentive/rebate program.	Major
Review Water Use Restriction Ordinances – Review plumbing requirements in ordinances for new construction, remodeling, and retrofits, and study potential for requiring plumbing updates at time of property sale.	Major
Enhance Outreach to Commercial Sector – Provide commercial businesses (i.e., car washes, laundromats, hair salons) and retailers with information for customers about the benefits of updating indoor fixtures and outdoor watering devices.	Major
Reduce City Departments and Schools Outdoor Water Use – Identify opportunities for reduced outdoor sprinkling in parks and school fields.	Moderate
Evaluate Sewer Credit Meters – Investigate the phase-out of residential sewer credit meters to further encourage reductions in outdoor water use.	Moderate
Pilot Low-impact Development on City Properties – Add green infrastructure, such as rain gardens and permeable pavement, to City properties.	Moderate
Work with Housing Authority to Update Public Housing Plumbing – Work with Waukesha Housing Authority to update water fixtures in Waukesha public housing.	Moderate
Replace Plumbing Fixtures with Efficient Devices – Work with the Wisconsin Focus on Energy Program to update shower heads at hotels and hand sprayers at restaurants.	Major
Form Regional Source Water Protection Planning Committee – Work with surrounding utilities to better coordinate source water protection.	Minimal
Communicate Monetary Benefits of Water Conservation – Place individual account water use information on the internet and on water bills.	Moderate
Fix a Leak Week in March – Get involved with EPA's Fix a Leak Week by including dye tablets and a brochure in all water bills.	Major

Long-term Goals

Implement Unidirectional Flushing – Update the flushing program to maximize velocities in the main for flushing, thereby reducing the amount of water needed to clean the water mains.	Minimal
Implement Smart Growth Land Use Planning and Zoning – Work with other entities (surrounding communities, developers, businesses) to develop Low-impact Development Practices to prevent pollution from entering the Fox River. Consider revision of Comprehensive Plan and zoning ordinances to encourage infiltration of stormwater into the ground.	Minimal
Audit Commercial and Industrial Sectors Water Use – Work with commercial and industrial customers to identify areas to reduce water use and save customers' money.	Major
Evaluate Gray Water Systems – Investigate reuse of the City's wastewater after it is returned to the Lake Michigan watershed. Reuse may involve "gray" water separation or redirection of treated wastewater for regional aquifer recharge.	Major

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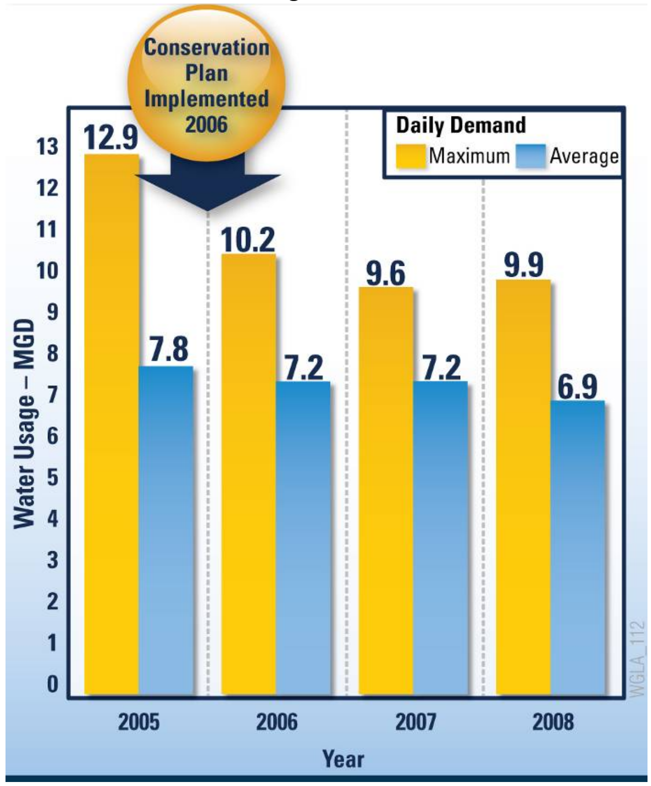
Conservation Water Rates

Waukesha adopted a conservation (inclining) rate structure for residential customers in 2007, becoming the first city in the state to charge customers more per gallon as water use increases. The City recently strengthened and expanded the conservation water rate model to include increasing the cost in each rate tier and reducing the amount of water allowed before reaching the next tier. Exhibit 2-10 summarizes the single-family residential rates before and since water conservation rates were implemented.

EXHIBIT 2-9
Water Reduction Following Water Conservation Measures



The Utility has focused on residential users because they represent the largest customer class with the most significant fluctuations in water use. Water rates for commercial and industrial customers have increased by larger percentages than for residential customers. To date, nonresidential customers have realized major water use reductions through individual conservation efforts and collaboration with City officials. Because 20 percent of the industry and commercial business class uses 80 percent of the water,[9] a few key changes with a small number major water users has resulted in significant water savings.

EXHIBIT 2-10
City of Waukesha Water Conservation Rates

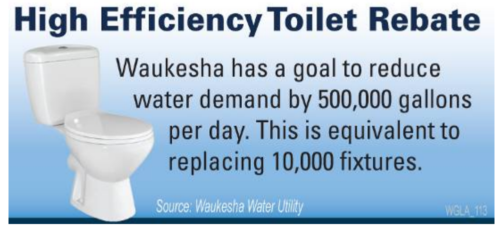
Quarterly Use (gal.)	Current Rate ($ / 1,000 gal.)
Tier 1: 0 to 10,000	2.05
Tier 2: 10,001 to 30,000	2.65
Tier 3: over 30,000	3.40
Quarterly Use (gal.)	**2007 Rate ($ / 1,000 gal.)**
Tier 1: 0 to 30,000	1.95
Tier 2: 30,001 to 40,000	2.20
Tier 3: over 40,000	2.70
Quarterly Use (gal.)	**Pre-Conservation Rate ($ / 1,000 gal.)**
Tier 1: 0 to 40,000	1.69
Tier 2: 75,000 – 1,425,000	1.14
Tier 3: over 1,425,000	1.02

Water Conservation Education in Public Schools

The hallmark of the City's water conservation public outreach program is its contribution to the environmental education curriculum in the City of Waukesha. Fifth- and ninth-grade students are taught about water conservation by Waukesha Water Utility staff. By visiting water facilities, operating tabletop groundwater models, and collaborating with teachers, the City has introduced water conservation to more than 17,000 students.[10]

9 Waukesha Water Utility annual operating data. 2009.
10 Waukesha Water Utility. 2009. Annual educational program data.

Toilet Rebate Program



After the City's measurable success with outdoor water use reduction, more attention was focused on indoor water use. Toilets are the largest user of residential water, accounting for 26.7 percent of the water used in an average home.[11] Toilet replacement is one the most effective ways to reduce indoor water use. The toilet rebate program was launched in October 2008, with a goal of saving 500,000 gallons per day by replacing old high-flow toilets with new high-efficiency toilets.

Regional Conservation Coalition

In 2006, leaders from the City of Waukesha and Waukesha County created the Waukesha County Water Conservation Coalition. Water supply is a regional issue and cooperation among the area's water users will improve the results of conservation initiatives. The coalition of business, government, education, and local stakeholder groups, collaborated on countywide messages on water conservation.

Waukesha County Water Conservation Coalition:

- Initiated rain barrel distribution to increase outdoor use of stormwater instead of drinking water
- Created restaurant table tents that say, "Water served upon request. By reducing water waste and washing chemical use, our restaurant is protecting the environment. Thank you for your cooperation and helping us do the right thing."
- Sponsored a residential water conservation contest with prizes going to greatest water use reductions

Active Member of Water Conservation Advocacy Organizations

The Utility is a member of leading national advocacy organizations to promote best water management strategies. Associations with the following key partners have enabled the City to bring innovative water conservation best practices to their customers:

WaterSense, a partnership program sponsored by the U.S. Environmental Protection Agency, makes it easy for all Americans to save water and protect the environment. The Utility is a partner of the program that promotes water efficiency and enhances the market for water-efficient products. The WaterSense label denotes quality, water-efficient products, the same way EnergyStar promotes energy-efficient appliances.

Alliance for Water Efficiency serves as a national voice on water efficiency, and the Utility is a sponsor. Headquartered in Chicago, the Alliance for Water Efficiency promotes the efficient and sustainable use of water.

Waukesha Water Consumptive Use

"Consumptive use" means a use of water that results in the loss of or failure to return some or all of the water to the basin from which the water is withdrawn because of evaporation, incorporation into products, or other processes. (§ 281.346(1)(e), Wis. Stats.). Public water suppliers can calculate their consumptive use coefficients following the USGS Winter Base-Rate Method.[12]

[11] Amy Vickers. 2001. *Handbook of Water Use and Conservation*.

[12] USGS, Kimberly H. Shaffer. 2009. Scientific Investigations Report: 2009-5096.

Based on water utility data over the past 10 years, the City of Waukesha annual average consumptive use is 8 percent (Exhibit 2-11). By comparison, the USGS found consumptive use in the Great Lakes can range as high as 74 percent for the domestic and public sector, with an average between 12 to 15 percent.[13, 14]

EXHIBIT 2-11
Waukesha Water Utility seasonal and Annual Consumptive-Use Coefficients Computed Using the Winter-Base-Rate Method

Year	Spring	Summer	Fall	Annual
1999	8	18	6	9
2000	6	12	2	5
2001	6	22	5	9
2002	6	24	8	10
2003	3	20	7	8
2004	5	16	10	8
2005	5	26	11	12
2006	5	16	3	6
2007	8	19	6	9
2008	5	14	3	6
2009	4	14	3	5
25th percentile	5	15	3	6
Median	6	17	6	8
75th percentile	6	21	7	9
Average (1999–2009)	6	18	6	8

Note: The consumptive-use coefficient is a percentage, rounded to the whole number.

13 USGS. 2008. Consumptive Water Use in the Great Lakes Basin. Fact Sheet 2008-3032, page 3.

14 USGS. 2007. *Consumptive Water Use Coefficients for the Great Lakes Basin and Climatically Similar Areas.* Scientific Investigations Report 2007-5197, page 25.

Waukesha Water Supply Sources

The City of Waukesha's current source of water supply is groundwater. The City of Waukesha has 11 functional wells, 8 in the deep aquifer and 3 in the shallow aquifer (Exhibit 3-1). Approximately 87 percent of Waukesha's supply is from the deep St. Peter Sandstone aquifer, which has severely declining water levels and significant water quality issues. About 13 percent of Waukesha's supply is from the shallow Troy Bedrock Valley aquifer, which feeds sensitive surface water resources and also has water quality issues.

EXHIBIT 3-1
Waukesha Water Utility Supply Wells

Well No.	Well Depth (ft)	Capacity (mgd)
1	Abandoned because of contamination	N/A
2	1,835	1.15
3	1,995	1.40
4	Abandoned because of contamination	N/A
5	2,120	1.44
6	2,075	2.59
7	1,658	1.08
8	2,024	2.16
9	1,730 (backup service only)	1.94
10	2,145	3.74
11	127	0.47
12	149	0.90
13	105	1.01

With the passage of the Great Lakes–St. Lawrence River Basin Water Resources Compact, Lake Michigan became a potential source of water supply for the City of Waukesha. Because the City lies wholly within a county that is partially in the Basin, the City may apply to withdraw Lake Michigan water for public water service and return treated water to the Great Lakes Basin.

To understand why the City is without adequate supplies of potable water, the potential sources of supply are discussed below. Specific water supply alternatives to meet the City's needs are presented and evaluated in Section 4.

Deep St. Peter Sandstone Aquifer

The City's deep aquifer wells are constructed to depths of greater than 2,100 feet and withdraw water from 800 to 1,000 feet below ground. Since the 1840s, the aquifer has served as a source of water supply for many communities in Wisconsin and Illinois. Today deep aquifer water supply pumping in southeastern Wisconsin results in additional groundwater level declines of 5 to 9 feet per year.[1]

The dramatic drawdown of the aquifer (an estimated 500 to 600 feet in the confined aquifer since the nineteenth century[2]) is in part attributed to the Maquoketa shale confining layer, a geological feature that limits the recharge of the aquifer by rain and snow (Exhibit 3-2).

Not all of the St. Peter Sandstone aquifer is confined. Parts of the aquifer are unconfined but located outside the jurisdiction of the City. In the unconfined part of the aquifer in southeastern Wisconsin, groundwater levels have declined more than 100 feet. The largest capacity wells in that area supply the City of Oconomowoc and had an average annual flow of 1.8 mgd.[3, 4] In addition to

1 Waukesha Water Utility operating data.

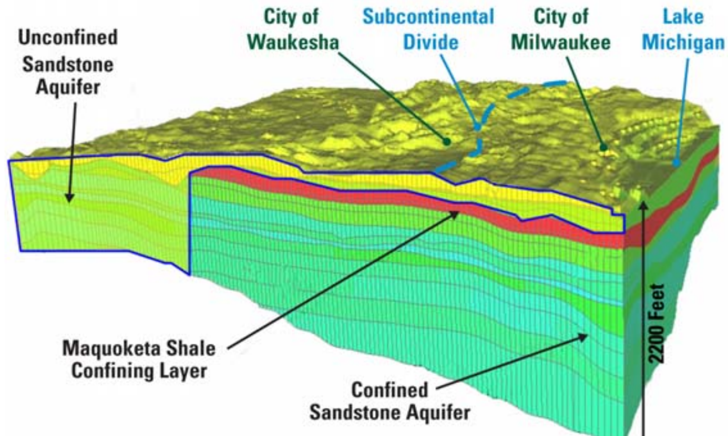
2 SEWRPC. 2008. *Draft Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* p.102–103.

3 SEWRPC. 2008. *Draft Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Chapter II, p. 107

4 Utility operating data, City of Oconomowoc. 2009.

significant drawdown and associated environmental impacts, the installation of more wells to meet the City's needs will undoubtedly result in legal challenges because Wisconsin law protects against municipal withdrawal of large amounts of water from a particular area and transporting that water to other locations for its use. Installation of hsigh capacity wells in the unconfined aquifer would interfere with other communities' and land owners' beneficial use of the water and would expose the City to numerous damage claims from other municipalities and homeowner associations.[5]

EXHIBIT 3-2
Hydrogeology of Southeastern Wisconsin



Source: Adapted from Ken Bradbury, Wisconsin Geological and Natural History Survey

The deep aquifer is not an adequate source of supply for the City because pumping exceeds the rate at which the aquifer can be renewed. The quantity of available groundwater is decreasing. The deep aquifer is not a reliable, adequate source of supply for the future.

Waukesha's Water Supply Linkage to Great Lakes Basin

The drawdown of the deep sandstone aquifer and continued pumping are also having a measurable impact on the Great Lakes Basin. The U.S. Geological Survey (USGS), the Wisconsin Geological and Natural History Survey (WGNHS), and other leading researchers in Wisconsin and Illinois have conducted extensive modeling and studies of the deep sandstone aquifer. USGS recently determined that most of water withdrawn from southeastern Wisconsin over the last 136 years was not derived from groundwater storage but rather from captured baseflow.[6] Baseflow is groundwater that under natural conditions would discharge to streams and lakes, including Lake Michigan. Because of pumping, groundwater has been diverted to wells instead of supplying water to surface water resources.

Groundwater pumping has also moved the groundwater divide—the boundary that defines the flow of groundwater toward Lake Michigan or to the Mississippi River—farther to the west (Exhibit 3-3). The natural hydrogeology has been altered so that the deep aquifer, which historically fed the Lake Michigan Basin with groundwater, now draws water from the Lake Michigan Basin. Even though the City's wells are outside the Great Lakes surface water divide, they withdraw water from both the Mississippi River Basin and the Great Lakes Basin. The USGS estimates that 30 percent of the 33 mgd of water pumped by the deep aquifer wells in southeastern Wisconsin originates from inside the Lake Michigan Basin.[7]

Reducing or eliminating pumping of the deep sandstone aquifer would have a significant positive effect on groundwater levels. Measurements taken after other communities have replaced deep aquifer groundwater supplies with a Lake Michigan supply indicate recovery of the aquifer. In areas of northeastern Illinois, where groundwater withdrawal has ceased because communities

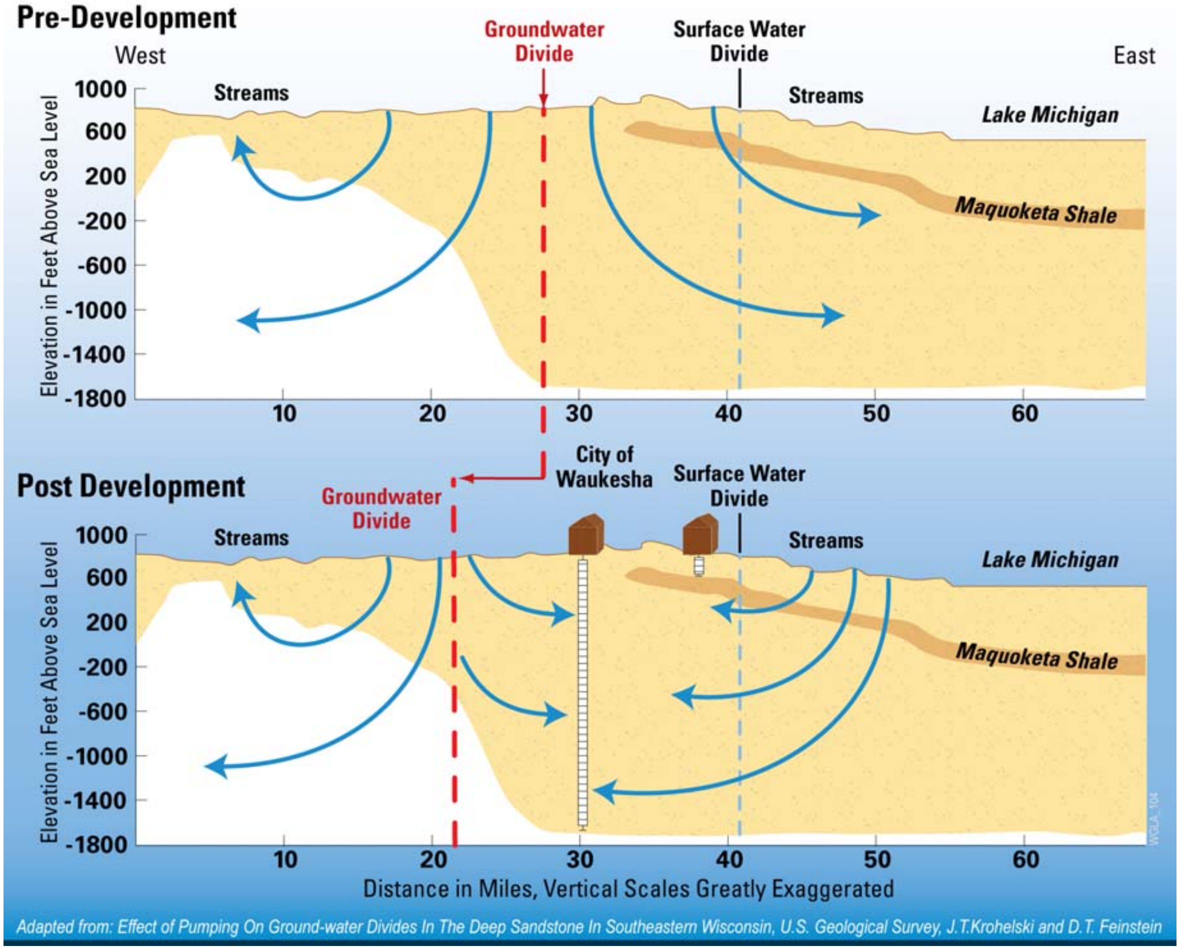
[5] State v. Michaels Pipeline Construction Inc., 63 Wis.2d 278, 292 (1974).

[6] USGS. March 2007. *Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin.*

[7] D. T. Feinstein, USGS. October 2006.*Where do the deep wells in southeastern Wisconsin get their water?*

EXHIBIT 3-3

Flow of Groundwater in the St. Peter Sandstone Aquifer



Adapted from: Effect of Pumping On Ground-water Divides In The Deep Sandstone In Southeastern Wisconsin, U.S. Geological Survey, J.T.Krohelski and D.T. Feinstein

have converted from the deep St. Peter Sandstone aquifer to a Lake Michigan supply, groundwater levels at former pumping centers recovered more than 100 feet.[8] For southeastern Wisconsin, the USGS estimated that if all pumping of the deep aquifer ceased in year 2000, the aquifer would similarly recover over this century. Specifically, USGS estimates that :[9]

- To replace 50 percent of the water drawn out of storage, it would take 13 years for the shallow portion and 9 years for the deep portion of the aquifer to recover.
- To replace 90 percent of the water drawn out of storage, it would take 100 years for the shallow portion and 70 years for the deep portion of the aquifer to recover.

Based upon the available scientific evidence, it has been shown that the City's groundwater supply is derived in part from groundwater that is interconnected hydrologically to the Lake

[8] S. L. Burch. 2002. *A Comparison of Potentiometric Surfaces for the Cambrian-Ordovician Aquifers of Northeastern Illinois, 1995 and 2000.* Illinois State Water Survey Data/Case Study 2002-02.

[9] USGS. March 2007. *Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin.*

Michigan Basin. Ceasing groundwater pumping of the deep aquifer will reduce amount of groundwater withdrawn from the Lake Michigan Basin. [10]

Deep Aquifer Groundwater Quality

As water is pumped from greater depths, naturally occurring contaminants, primarily radium and total dissolved solids (TDS), are present in progressively higher concentrations. These contaminants require removal to meet drinking water standards. The City's groundwater supply has radium levels up to three times the United States Environmental Protection Agency's (USEPA's) drinking water maximum contaminant level (MCL) of 5 picocuries per liter (piC/L). The naturally occurring radioactive isotopes radium-226 and radium-228 are present in the aquifer because of parent elements in the sandstone. The radioactive isotopes are known to be carcinogenic. The concentration of radium in the City's groundwater supply is as high as 15 piC/L, among the highest in the country for a potable water supply.

To provide drinking water that meets the radium standard on a weighted average basis, the City treats some deep aquifer water to remove radium and blends some untreated deep aquifer water with radium-compliant water from the shallow aquifer. The City has until 2018 to complete the capital investments needed to meet the radium standard at all times at each entry point to the water system. Treatment to remove radium from drinking water creates a high radium concentration waste stream. WDNR requires the waste stream radium concentration to be minimized prior to disposal to the wastewater treatment plant. Radium levels are also regulated in the wastewater treatment plant residual sludge.

USEPA regulates TDS as a secondary drinking water standard of 500 mg/L. For the City of Waukesha, continued use of the deep aquifer eventually may require treatment to remove TDS. TDS concentrations in the City's wells range from 300 to 1,000 mg/L. To mitigate the high TDS concentrations, wells can be partially blocked, but plugging reduces well capacity by as much as 35 percent.[11] TDS can be removed by desalination treatment. Desalination is a costly and energy-intensive process that would be necessary for the long-term continued use of the deep wells. Desalination produces a waste stream with a concentration of salts. These salts ultimately pass through the wastewater treatment plant and are released to the environment.

Waukesha County is a state-designated groundwater management area. This is a critical consideration in the expansion of the City's groundwater supplies. Waukesha County is one of two groundwater management areas because its groundwater potentiometric surface has been reduced 150 feet or more from the level at which the potentiometric surface would be if no groundwater had been pumped.[12] Consequently, high capacity groundwater withdrawals may not be permitted if proposed wells impair the water supply of another public utility or cause significant environmental impacts.[13] Given aquifer conditions and the presence of Vernon Marsh Wildlife Area and Pebble Brook (a Class II trout stream), it would be a challenge to locate shallow wells in the Troy Bedrock Valley aquifer in a manner that does not impair other wells or affect the environmental adversely.

In addition to naturally occurring contaminants, deep aquifer wells are susceptible to pollution. Two of the City's deep wells are no longer in service because they are contaminated by a local landfill. While removing contaminants from the deep aquifer water is technically feasible, the

[10] Ibid.

[11] Waukesha Water Utility operating data for Well 9, 2000 and 2006.

[12] Wis. Stat. § 281.34(9)

[13] Ibid.

deep aquifer is not a reasonable source of supply because the quantity of available water is declining and will be more limited in the future. In addition, continued deep aquifer pumping results in significant cumulative impacts.

Cumulative Impacts of Deep St. Peter Sandstone Aquifer Pumping

The City's deep aquifer pumping contributes to the following cumulative impacts:

- Continued significant decline of groundwater levels
- Baseflow reduction of 12 percent to surface water resources, as water is drawn toward deep wells[14]
- Reversal of the natural flow system causing more than 10 times the water that once flowed east toward Lake Michigan through the deep aquifer in southeastern Wisconsin to now converge from all directions on pumping centers[15]
- Diversion of as much as 30 percent of the water replenishing the deep aquifer from the Great Lakes Basin[16]
- Ultimate discharge of water from the Great Lakes Basin to the Mississippi River Basin

Shallow Troy Bedrock Valley Aquifer

The City draws about 13 percent of its water supply from the shallow aquifer (Troy Bedrock Valley formation) overlying the Maquoketa shale. That formation is a source of water supply for the Village of Mukwonago and the City of Muskego; it is also hydraulically connected to sensitive environmental resources including the Vernon Marsh Wildlife Area, Pebble Brook (a Class II trout stream), and Pebble Creek. Because of quantity and quality concerns with the deep aquifer, the City has considered the shallow aquifer as a greater source of supply.

To estimate the impacts of the City significantly increasing its withdrawal from the shallow aquifer, hydrogeologic modeling was conducted with the Troy Bedrock Valley Aquifer Model.[17] The model predicted groundwater level drawdown and the baseflow reduction index if additional City wells are in service. Baseflow is groundwater that discharges to, or feeds, surface water bodies. The groundwater discharge is the inflow that keeps surface waters flowing during dry periods. Estimating the loss of baseflow from groundwater pumping is critical to understanding whether the shallow aquifer is a sustainable water supply. To quantify impacts on baseflow, a baseflow reduction index was used in regional water supply planning studies.[18, 19]

$$\text{baseflow reduction index} = [(\text{net baseflow}_{2005} - \text{net baseflow}_{1900})/\text{net baseflow}_{1900}] \times 100$$

where net baseflow is surface water flow_{out} – surface water flow_{in}.

Although the wells needed to meet the City's demands in the model were spread over an extensive area and located at least 1,300 feet from sensitive water resources, additional shallow aquifer withdrawal resulted in severe drawdown at the wells of up to 50 to 100 feet and reduction

14 USGS. March 2007. *Groundwater in the Great Lakes Basin: The Case of Southeastern Wisconsin*

15 D. T. Feinstein, USGS. October 2006. *Where do the deep wells in southeastern Wisconsin get their water?*

16 Ibid.

17 SEWRPC. January 2010. *Southeastern Wisconsin Regional Planning Commission Report No.188.*

18 SEWRPC. *A Regional Water Supply Plan for Southeastern Wisconsin*, pp 38–50.

19 Cherkauer, p. 11.

of baseflow to surface waters ranging from 17 to 340 percent.[20] For reference, the historical baseflow reduction index for Waukesha County from 1920 to 2000 is less than 10 percent.[21]

Shallow Aquifer Groundwater Quality

Groundwater from the shallow aquifer requires treatment to meet secondary drinking water standards of 0.3 mg/L for iron, 0.05 mg/L for manganese, and primary standard of 10 ppb for arsenic. Given the results of the Troy Bedrock Valley aquifer modeling, there is also evidence that both the Fox River water and groundwater could be impacted by contaminants from septic waste disposal systems that would be drawn into shallow wells. To address these contaminants, conventional surface water treatment is needed to provide safe drinking water.

Expansion of the Troy Bedrock Valley aquifer supply is not a reasonable water source because withdrawing the quantity of water needed by the City would have a devastating cumulative impacts on state-protected water resources.

Cumulative Impacts of Shallow Troy Bedrock Valley Aquifer Pumping

Additional shallow aquifer pumping by the City would contribute to the following cumulative impacts:

- Significant decline of groundwater levels
- Baseflow reduction indices ranging from 17 to 340 percent for surface waters including the Vernon Marsh Wildlife Area and the Pebble Brook Class II trout stream
- Over 400 existing private wells could be impacted by the City pumping as little at 6.4 mgd from the shallow aquifer to meet the public water system demand[22]

Water Conservation Practices

Water savings from conservation is an important element in the City's long-range water supply plan. Based on the effectiveness of current water conservation measures and projected water use across various customer classes over the water supply planning period, and beyond, it is estimated that another 10 percent water savings may be gained through conservation, but that additional volume resulting from increased conservation efforts—about 1 mgd—would not be sufficient to offset the need for a new adequate supply of potable water.

Lake Michigan

The Compact encourages adaptive water management and conservation of Great Lakes Basin water resources. Goals of the Compact include protection, conservation, restoration, improvement, and effective management of the Waters and Water Dependent Natural Resources of the Basin. The City of Waukesha may be successful in an application for a Lake Michigan diversion if the conditions of the Compact are met, including:

- The diverted water will be used solely for the City's public water supply because the City is without adequate supplies of potable water.
- The diverted water returned to the Great Lakes Basin is maximized, and the returned water that is from the Mississippi River Basin is minimized.

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[20] *Results of Groundwater Modeling Study Shallow Aquifer Groundwater Source, Fox River & Vernon Marsh Area, Waukesha Water Utility,* RJN Environmental Services, April 2010.

[21] Cherkauer, p. 13.

[22] RJN Environmental Services.

- The City does not have a reasonable water supply alternative within the Mississippi River Basin, including conservation of existing groundwater supplies.
- The diversion with return flow does not endanger the integrity of the Great Lakes Basin ecosystem.

In preparation for the passage of the Great Lakes Compact, the City participated in a case study that arrived at several critical conclusions about a potential diversion for the City.[23] Chief among these was that changing sources from the current groundwater supply to a withdrawal from Lake Michigan was found to provide an improvement to the groundwater resources of the Great Lakes Basin through ceasing groundwater pumping. Further, a Lake Michigan withdrawal has no measureable effect on the Basin.

Cumulative Impacts of Lake Michigan Supply

Switching from a groundwater to a Lake Michigan supply would have the following cumulative impacts:

- Assist in the recovery of both surface water and groundwater resources.
- Assist in the restoration of the natural flow system wherein the deep aquifer feeds the Waters of the Great Lakes.
- Eliminate the diversion of water from the Lake Michigan groundwatershed to the Mississippi River Basin.
- Result in no impact on Lake Michigan water level for the proposed diversion of 10.9 mgd with return flow.
- Prevent radium in wastewater treatment plant sludge from being discharged into the environment
- Reduce the release of salts, used to soften hard groundwater, into the environment.

Combined Lake Michigan and Groundwater

To limit the Great Lakes diversion to the smallest reasonable quantity, a combination of Lake Michigan water and shallow aquifer water was evaluated by the City. An alternative with deep aquifer water and Lake Michigan water was not developed. One reason is that Illinois and Wisconsin are both supportive of the goal of eliminating the use of the deep St. Peter Sandstone aquifer. The goal is to enhance recovery of the deep aquifer. Another reason for not combining water sources is related to the practical public water system operating challenges of continuously meeting water quality regulations and system pressure requirements. See Section 4 for additional discussion. Under the shallow aquifer/Lake Michigan supply alternative, also discussed in Section 4, return flow to the Great Lakes Basin would consist of both Lake Michigan water and Mississippi River Basin groundwater. It is not evident that this alternative meets the intent of the Compact to protect the Basin ecosystem by minimizing the return of water from outside the Great Lakes Basin.

[23] CH2M HILL, Ruekert & Mielke, et al. 2003. *Case Study Report—Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply*, p. ES-5.

Waukesha Does Not Have Adequate Supplies of Potable Water

The City of Waukesha lacks an adequate supply of potable water, because the groundwater supply in the deep aquifer is severely depleted and is not reliable over the long term. The quantity of water that can be withdrawn from the shallow aquifer for potable water supply is limited because pumping would severely reduce the quantity of water available for local streams, brooks, and wetlands. The City does not have an adequate supply of potable water. The only reasonable water supply for the City is a Lake Michigan supply with continued water conservation and return flow, in accordance with the requirements of the Compact. A Lake Michigan supply for the City is sustainable, protective of public health, and results in more effective management of the Waters of the Great Lakes Basin.

Introduction

The City and others have studied extensively the water resources in the Waukesha area.[1, 2, 3] The evaluations and recommendations from the various studies are summarized in this application.

The Compact (Section 4.9.3(d)) requires a community in a straddling county applying for a diversion to show that: "There is no reasonable water supply alternative within the basin in which the community is located, including conservation of existing water supplies." Further, Wisconsin Statute § 281.344(ps) states:

> "A reasonable water supply alternative means a water supply alternative that is similar in cost to, and as environmentally sustainable and protective of public health as, the proposed new or increased diversion and that does not have greater negative environmental impacts than the proposed new or increased diversion."

In this application, water supply alternatives have been evaluated based on the following criteria:

- Environmental impact
- Long-term sustainability to provide the public with adequate supplies of potable water
- Protection of public health
- Implementability

Costs of the alternatives were also estimated.

This evaluation determined the water supply alternative that would best protect, conserve, restore and improve waters and water dependent natural resources of the Great Lakes Basin.

Previous Studies of Water Supply Alternatives

Extensive studies have investigated various water supply alternatives for the City of Waukesha. The results and conclusions from a few of those studies are summarized in this Section. These studies helped identify the alternatives analyzed in this application.

Future Water Supply Study

In March 2002, the City of Waukesha water utility completed a future water supply study.[4] Stakeholders in this study included representatives from the water utility, City of Waukesha, WDNR, SEWRPC, USGS, the WGNHS, and the University of Wisconsin–Madison. The study looked at the following 14 water supply sources and combinations of them:

- Deep aquifer near Waukesha (confined)
- Deep aquifer west of Waukesha (unconfined)
- Shallow groundwater south of Waukesha
- Lake Michigan
- Dam on the Fox or Rock River
- Waukesha quarry

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[1] CH2M HILL and Ruekert & Mielke. 2002. *Future Water Supply Report for the Waukesha Water Utility.*

[2] SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Preliminary Draft.

[3] Douglas S. Cherkauer. 2009. *Groundwater Budget Indices and their Use in Assessing Water Supply Plans for Southeastern Wisconsin,* Technical Report 46, Preliminary Draft. Department of Geosciences, University of Wisconsin—Milwaukee.

[4] CH2M HILL and Ruekert & Mielke. 2002. *Future Water Supply Report for the Waukesha Water Utility.*

- Shallow groundwater west of Waukesha
- Dolomite aquifer
- Fox River
- Rock River
- Waukesha springs
- Pewaukee Lake
- Milwaukee River
- Wastewater reuse

The study eliminated nine water supply sources for the primary reasons listed in Exhibit 4-1. Additional detail can be found in the Future Water Supply Study report, Appendix C.[5]

EXHIBIT 4-1
Water Supply Alternatives Eliminated

Potential Water Supply Source	Primary Reason for Not Being a Reasonable Alternative
Dolomite Aquifer	Insufficient water in the aquifer to meet the needs of the City of Waukesha.
Fox River	Inability to provide a reliable supply during dry periods, when public water supply is most needed.
Rock River	Inability to provide a reliable supply during dry periods, when public water supply is most needed.
Dam on the Fox or Rock River	Environmental impacts, regulatory issues, and public/property concerns.
Waukesha Quarry	Inadequate supply, water quality contamination potential, used for other purposes.
Waukesha Springs	Insufficient water in the aquifer to meet the needs of the City of Waukesha.
Pewaukee Lake	Insufficient water to meet the needs of the City of Waukesha, negative environmental impacts, property owner concerns.
Milwaukee River	Poor quality, environmental impacts.
Wastewater Reuse	Public health and perception, water quality concerns, treatment requirements, limited supply, seasonal demand, regulatory issues.

The water supply alternatives that passed the initial screening process included:

- Deep confined aquifer
- Deep unconfined aquifer
- Shallow groundwater near Waukesha
- Shallow groundwater and deep confined aquifer
- Lake Michigan

These remaining alternatives, and combinations of them, were evaluated by a broad group of stakeholders using the following criteria:

- Sustainability and reliability as a long-term, high-quality water supply
- Regulations, environmental impacts, and land and legal requirements
- Political issues and public acceptance
- Operational and maintenance requirements
- Schedule for implementation
- Infrastructure requirements

A brief summary of the results follows. Refer to the Future Water Supply report,[6] Appendix C, for details.

5 Ibid.
6 Ibid.

Continued use of the deep confined aquifer (current water supply for Waukesha) was ranked lowest because:

- It is not sustainable over the long term due to drastically declining water levels and water quality requiring extensive treatment (radium and total dissolved solids removal)
- Negative environmental impacts to the deep aquifer, shallow aquifers, surface water and hydrologically connected waters of the Great Lakes Basin
- Potential negative public health impacts from radium and high dissolved solids in the water
- It also had the highest cost for facilities and long term operations and maintenance

The deep unconfined aquifer alternative, far west of Waukesha, also was ranked low because:

- Negative impacts to the surrounding groundwater and surface water environment due to groundwater table drawdown and water budget depletion
- Negative impacts to other water users currently using this source
- Poor public acceptance and potential lawsuits
- Extensive infrastructure requirements due to the distance from Waukesha
- High costs for facilities and long term operations and maintenance

With the deep aquifer alternatives ranking lowest, the Future Water Supply Study report recommended further evaluation of the highest ranked alternatives:

- Lake Michigan
- Shallow aquifer sources

Key recommendations relating to the Lake Michigan alternative included evaluating diversion permit requirements and identifying a Lake Michigan water provider. The alternatives analysis noted that the Lake Michigan alternative provided the most reliable and highest quality source of water for Waukesha, a reasonable water supply.

For the shallow aquifer alternatives, the report recommended evaluating sustainable capacities from the aquifers, environmental impacts of extracting additional shallow groundwater, land issues, and impacts on other shallow aquifer users. Evaluation of these items was not in the scope of the Future Water Supply study. However, subsequent reports addressed these issues.[7]

SEWRPC Report Further Evaluates Water Supply Alternatives

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) is the official regional planning agency for the seven-county Southeastern Wisconsin Region, including Waukesha County. SEWRPC is charged by law with making and adopting a comprehensive plan for the physical development of the region. In 2008, SEWRPC released a draft report titled, *A Regional Water Supply Plan for Southeastern Wisconsin* (Appendix I). This plan is an extensive evaluation of water supply alternatives for the seven-county area, including the City of Waukesha, to the year 2035.

Water supply alternatives were evaluated on the basis of five overall objectives:

1. Support of existing land use patterns

[7] SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin*, Preliminary Draft.

2. Conservation and wise use of the surface water and groundwater supplies
3. Protection of public health, safety, and welfare
4. Economical and efficient systems
5. Responsive and adaptable plans

Each objective had several sub-objectives or standards. Two key standards under Objective 2 were as follows:

- Manage the use of the deep and shallow aquifers so as to minimize ecological impacts on the surface water system of the region.

- Use groundwater and surface water for water supply purposes in a manner that minimizes negative impacts to the water resources, including lakes, streams, springs, and wetlands.

Similar to the Future Water Supply Study, the SEWRPC study screened alternative water supplies and ultimately identified similar water supply alternatives. The water supply alternatives evaluated for the region included the following:

- Lake Michigan
- Shallow aquifers
- Deep aquifer
- Shallow aquifers and artificial recharge using rainwater and wastewater treatment plant effluent
- Deep aquifer and artificial recharge using treated Lake Michigan water
- Combinations of these alternatives

Extensive groundwater and surface water modeling was conducted in the evaluation of these alternatives. Major findings include the following:

- Continued increased pumping of the deep aquifer would continue to draw down groundwater levels, create poorer water quality (higher concentrations of radium and TDS), increases negative impacts on surface waters and hydrologically connected waters of the Great Lakes Basin, and increase the water budget deficits.

- Increased pumping of the shallow aquifer would reduce baseflows to surface waters, produce water budget deficits, and have negative environmental impacts on sensitive surface water ecosystems, such as Vernon Marsh, Pebble Brook, and Pebble Creek (a high quality trout stream)[8] near Waukesha.

- Shallow aquifer recharge with rainfall or treated wastewater infiltration would increase baseflows, but would create land use concerns and public health concerns due to contamination, and require overcoming regulatory hurdles along with constructing extensive, costly facilities.

- A Lake Michigan supply to some straddling communities and counties west of the subcontinental divide (with return flow) would reduce the ecological stress on the deep aquifer, shallow aquifer, and associated waters and water dependent natural resources of the Great Lakes Basin compared to the other alternatives.

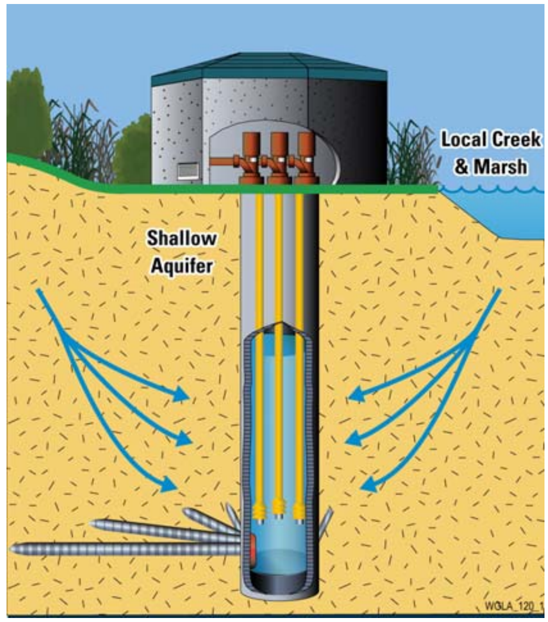
- The amount of chlorides and sodium discharged into the environment by home water-softening devices would increase greatly under any groundwater alternative. The SEWRPC report estimated that eliminating groundwater softening by providing Lake Michigan water to

[8] WDNR, Wisconsin Trout Streams, PUB-FH-306, 2002.

some communities east and west of the divide (including Waukesha) would eliminate 5.2 million pounds of chlorides discharged to the Cedar Creek, Milwaukee River, and Lake Michigan environments.[9]

- Shallow groundwater supplies are more susceptible to contamination than a Lake Michigan supply. This could result in an increased risk to public health and the need for advanced water treatment facilities that would increase costs, energy use, and greenhouse gas emissions.

EXHIBIT 4-2
A Shallow Aquifer Water Supply Affects Surface Waters and Groundwaters



Comparing alternatives under which the City of Waukesha obtains a Lake Michigan water supply with return flow to alternatives using current or new groundwater supplies (deep and shallow aquifers), **SEWRPC concluded that the Lake Michigan alternative "offers advantages related to a greater improvement in the deep aquifer long-term sustainability, reductions in chloride discharges to the surface waters, and improvement in groundwater-derived baseflow inputs to the surface water system." On that basis, SEWRPC issued a draft recommendation for the City of Waukesha to change to a Lake Michigan water supply.** This recommendation was reviewed, and 32 experts in the region concurred.[10]

A 2009 study provided further groundwater/surface water modeling of the SEWRPC alternatives, with projections to 2035.[11] The study evaluated alternatives for the City of Waukesha similar to those in the SEWRPC Regional Water Supply Plan. The analysis showed that a Lake Michigan water supply for the City of Waukesha would improve the deep aquifer water levels and eliminate its negative impacts on the shallow aquifer and surface water baseflow reductions in the whole region. **A Lake Michigan supply to Waukesha would also increase deep aquifer flows to the Lake Michigan Basin, since they are hydrologically connected.**[12, 13, 14] The study issued cautions against Waukesha's or other similarly situated communities reliance on a future groundwater supply west of the divide, noting that groundwater levels and environmental impacts would worsen.[15]

These studies evaluated alternatives up to 2035, only 25 years from now.[16, 17] This is a relatively limited planning period, given that water supply planning typically looks out 50 years and more. A

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[9] SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Preliminary Draft.

[10] http://www.sewrpc.org/SEWRPC/DataResources/CommissionAdvisoryCommittees/RegionalWaterSupplyPlanningAdv.htm

[11] Cherkauer. 2009.

[12] USGS. *Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin*, March, 2007.

[13] D. T. Feinstein, USGS. October 2006. *Where do the deep wells in southeastern Wisconsin get their water?*

[14] CH2M HILL, Ruekert & Mielke, et al. 2003. *Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply.*

[15] Cherkauer. 2009.

[16] SEWRPC. 2008.*Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Preliminary Draft.

[17] Cherkauer. 2009.

community water supply must be sustainable in the long term, or the capital, operations, and environmental costs of development are too high to make it reasonable. Developing a short-term water supply puts communities at risk of paying twice for the large capital costs involved.

Water Supply Alternatives Studied, But Not Pursued

Artificial Recharge

Some of the SEWRPC groundwater alternatives assume that the shallow aquifer will be artificially recharged with rainwater infiltration facilities, or that treated wastewater effluent will be artificially recharged into the shallow aquifer. By artificially increasing the amount of water infiltrating into the shallow aquifer, surface water baseflow reduction can be decreased. However, SEWRPC noted several issues and concerns:

- WDNR regulations do not allow using treated wastewater effluent to recharge a potable drinking water aquifer. A high level of treatment would be required for this to be considered. Capital and operating costs would be very high. SEWRPC estimates capital costs of advanced wastewater treatment alone would be $12.6 million for 1 mgd.[18] Transmission mains from the Waukesha wastewater plant to recharge areas would add another $4 million.
- Large land areas are required for artificial recharge, with significant costs and public concerns. An important issue is who owns and controls the use on these lands. SEWRPC estimated more than 100 acres would be needed for Waukesha to implement artificial recharge, even if it relies on the deep aquifer for more than half of its water supply.[19]
- Water which is artificially recharged is more vulnerable to contamination, which might increase the cost of treatment and risk to public health.
- The long-term feasibility of artificial recharge is unknown. Long-term soil permeability for effective recharge might be compromised in the long term. Plugging of the aquifer would reduce effectiveness over time. Restoration or decommissioning of facilities would add to costs.
- Rainfall recharge will be subject to drought constraints.

Because of the issues above, artificial groundwater recharge was not considered in this application.

Unconfined Deep Aquifer

The Future Water Supply Study evaluated a deep unconfined aquifer alternative west of Waukesha, but the SEWRPC did not. SEWRPC assumed that groundwater supplies will be located within 1 mile of the 2035 utility service area to minimize public concerns and municipal boundary issues.[20]

Installing high capacity wells in the unconfined aquifer west of the Maquoketa shale presents not only logistical but also definite legal problems. Installation of high capacity wells in an unconfined aquifer could result in legal challenges and expose the City to numerous damage claims from lake area homeowners and municipalities and would be a source of continuing controversy in the region. Under Wisconsin law, the City could be liable if its withdrawal of water caused unreasonable harm through lowering the water table for residential and municipal wells

[18] SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Preliminary Draft.
[19] Ibid.
[20] SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Preliminary Draft.

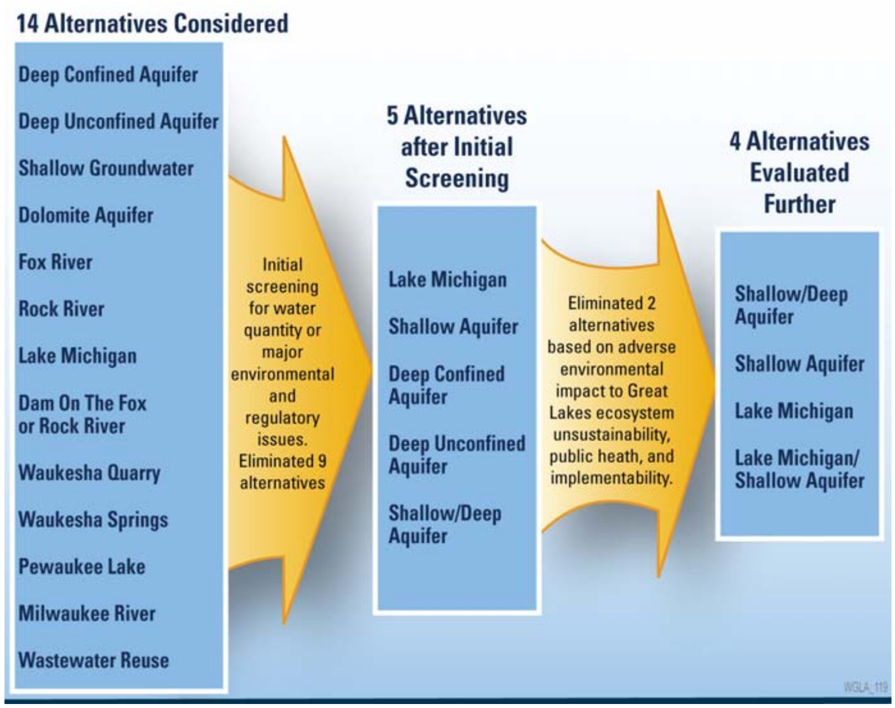
in the area (State v. Michels Pipeline Construction, Inc., 63 Wis.2d 278, 217 N.W.2d 339). The City could be liable if its withdrawal of groundwater had a direct and substantial effect upon the water of a watercourse or lake (i.e., effects to base flow or lake levels). Damages could include the cost of new wells, deepening existing wells, the cost of water treatment as water quality declines and replacement of well pumps. Additionally, groundwater protection legislation has been recently introduced (on March 12, 2010), which would require environmental review of proposed high capacity wells located in a groundwater management area, even before WDNR approves or develops a groundwater management plan for the area. For these and other reasons detailed in the Future Water Study, the unconfined deep aquifer west of the Maquoketa shale was screened out as a reasonable water supply.

As discussed previously, two significant reasons that the deep unconfined aquifer was ranked low in the Future Water Supply study is negative impact to the groundwater and surface water environment and negative impacts on other water communities using the same aquifer. Near Oconomowoc, the deep unconfined aquifer has dropped about 100 feet in the last 100 years.[21] This has occurred with the small pumping demands of Oconomowoc of around 1 to 2 mgd. Increasing the water pumped out of that aquifer by a factor of 5 to 10 or more will have significant impacts not only on the aquifer drawdown and surrounding water ecosystems, but on municipal and private wells in the area.

Water Supply Alternatives Evaluation

Extensive evaluations of water supply alternatives for the City of Waukesha and the region have previously been conducted. This application requests the use of Lake Michigan water. To be eligible for Lake Michigan water, the City must show that there is no reasonable water supply alternative within the basin the City is located in. For this application, the City compared its Lake Michigan request to the top ranked water supply alternatives. The water supply alternatives were chosen based on the screening done in previous studies.[22] Exhibit 4-3 summarizes the alternatives screening.

EXHIBIT 4-3
Water Supply Alternative Screening



21 SEWRPC. 2008, Figure 7.
22 SEWRPC. 2008; CH2M HILL et al. 2002.

The water supply alternatives include:

- Deep and shallow aquifer
- Shallow aquifer and Fox River alluvium
- Lake Michigan
- Lake Michigan and shallow aquifer

A general description of each alternative is provided, along with comparisons to the following evaluation criteria:

- **Environmental Impacts**
  - Impact on ground and surface waters of the Great Lakes Basin
  - Impact on ecosystems flora and fauna
  - Greenhouse gas emissions
- **Long-Term Sustainability**
  - Reliability during droughts and infrastructure failures
  - Ability to provide adequate supplies of potable water to the public for generations without negative environmental impacts
- **Public Health**
  - Quality of the water for human consumption
  - Potential for contamination
- **Implementability**
  - Infrastructure requirements
  - Operation and maintenance requirements
  - Land requirements, legal issues, easements, public impact

Each alternative was rated by the following categories:

○ No negative impact
⦿ Minor negative impact
◉ Moderate negative impact
● Significant negative impact

Water Supply Alternative 1: Continued Use of Deep and Shallow Aquifers

Alternative 1 consists of continued use of the deep aquifer (St. Peter sandstone) and shallow aquifer south of Waukesha (Troy Bedrock Valley). The future average annual water usage would be 10.9 mgd based on water demand projections (Section 2).

To meet a future maximum day demand of 18.5 mgd, infrastructure would be in place for 7.6 mgd firm capacity from the deep wells and 10.9 mgd from the shallow wells. The maximum capacity from shallow wells would be achieved by relying upon the current 1.2 mgd firm capacity from existing wells 11,12,13, plus developing an additional 9.7 mgd firm capacity (capacity with the largest well out of operation) by installing 14 new wells south of Waukesha near Vernon Marsh in the Troy Bedrock Valley aquifer.

Water from the shallow wells would need to undergo treatment for iron, manganese and microorganism removal. The recent discovery of arsenic in the shallow aquifer at future well sites means arsenic treatment would be required as well. The shallow well water would be pumped from the wells to a new treatment plant. A new pump station would convey treated water to the

City of Waukesha and connect with the water distribution system and Hillcrest reservoir, the largest reservoir in Waukesha used as a point to deliver water to the City.

Exhibit 4-4 shows the facilities for Alternative 1. For the purposes of this alternative, the capacity of the City's deep wells was estimated to decrease 30 percent in the future. Waukesha's deep wells vary in age from 30 to 75 years. Several wells have been abandoned because of contamination and decreasing capacity. One well had TDS concentrations greater than 1,000 mg/L and was rehabilitated to reduce the TDS (blocking off part of the well hole). In doing so, the well capacity was reduced over 35 percent. The Future Water Supply Study warned that many of the wells were not constructed to current well codes and could experience physical failures such as casing leaks or borehole collapse, which would require extensive rehabilitation or replacement.[23]

Capacity is also expected to decrease from the deep wells because the groundwater elevation continues to drop. Currently it is over 600 feet below predevelopment levels. This declining water level causes water quality problems (increased TDS, radium, and gross alpha levels). As a result, treatment would be installed at the three largest deep wells (No. 6, 8, 10) to reduce TDS and radium. Since the deep wells are on small lots, adjacent residential property would need to be purchased and homes demolished to make room for the additional treatment facilities. It was assumed that the three deep wells will have their own treatment facility, and that water from the remaining deep wells and shallow wells will be blended at the Hillcrest reservoir. Treatment to remove TDS would produce a concentrated salt waste stream equal to about 7.5 percent of the water pumped (assuming 25 percent bypass). The lost capacity would be made up with shallow wells. This is consistent with the Future Water Supply Study.[24]

Environmental Impacts

Deep Aquifer

Studies have shown that the deep aquifer is hydrologically connected to the waters of the Lake Michigan Basin.[25] Before development, the deep groundwater below southeast Wisconsin flowed toward Lake Michigan. Pumping water from the deep aquifer reduces the amount of water that would flow to the waters of the Lake Michigan Basin, and actually reverses the flow so that it is away from Lake Michigan.[26] The USGS estimates that 30 percent of the 33 mgd of water currently pumped by the deep aquifer wells in Southeast Wisconsin originates from inside the Lake Michigan Basin.[27] The largest pumping center with the highest drawdown is in Waukesha County.[28]

Reducing the amount of water that would have flowed into the Lake Michigan Basin by deep aquifer pumping has negative environmental impacts on the waters of the Lake Michigan Basin. By stopping deep aquifer pumping in Waukesha alone, an improvement in the hydrology and hydrogeology of the waters of the Lake Michigan Basin can be realized.[29]

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[23] CH2M HILL and Ruekert & Mielke. 2002. *Future Water Supply Report for the Waukesha Water Utility.*

[24] Ibid.

[25] USGS. March 2007. *Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin*; D. T. Feinstein, USGS. October 2006. *Where do the deep wells in southeastern Wisconsin get their water?*; CH2M HILL, Ruekert & Mielke, et al. 2003. *Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply.*

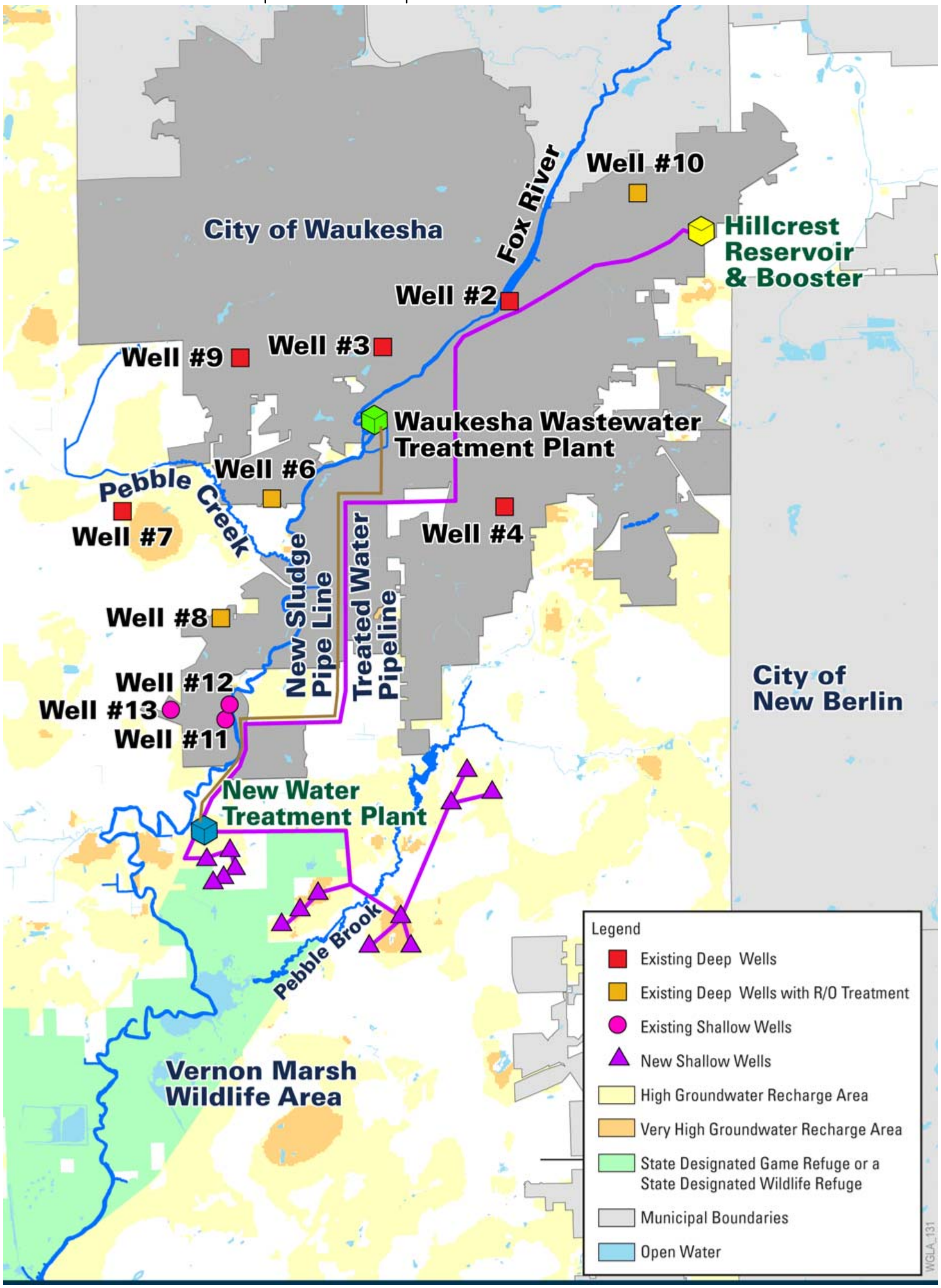
[26] D.T. Feinstein, USGS. October 2006. *Where do the deep wells in southeastern Wisconsin get their water?* http://wi.water.usgs.gov/glpf/index.html

[27] Ibid.

[28] Ibid.

[29] CH2M HILL, Ruekert & Mielke, et al. 2003. *Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply.*

EXHIBIT 4-4
Facilities for Alternative 1: Deep and Shallow Aquifers



In addition, water pumped from the deep aquifer removes water that would otherwise be available to local surface water resources. The USGS and WGNHS indicate that 70 percent of water pumped from the deep aquifer would have gone to inland surface waters. The remaining 30 percent originates from inside the Lake Michigan Basin and 4 percent of that is contributed by Lake Michigan.[30] Reducing natural flows to surface waters by pumping the deep aquifer has negative environmental impacts both inside and outside the Lake Michigan Basin.

Adverse environmental impacts are also occurring because of the depletion of the deep aquifer. Recharge is limited for the deep aquifer near Waukesha because of the shale confining layer, causing continued depletion of the aquifer along with increasing TDS and radionuclides. In addition, dropping groundwater levels can expose sulfide minerals to oxygen and increase arsenic levels. This oxygen can also provide conditions for growth of pathogenic microorganisms in wells, which as occurred in a number of deep wells.[31] Changing the physical and biological nature of the aquifer creates negative environmental impacts.

Shallow Aquifer

Pumping the shallow aquifer can cause negative environmental impacts on ground and surface water resources. SEWRPC estimates that about 85 percent of water extracted from the shallow aquifer is diverted or extracted from surface waters.[32] This would negatively affect sensitive and valuable environmental areas near Waukesha, such as Pebble Brook, Pebble Creek (a trout stream), and Vernon Marsh. SEWRPC estimated parts of Vernon Marsh and Pebble Creek could see the baseflow decrease more than 25 percent if the City of Waukesha continues using a combination of deep and shallow groundwater, with artificial recharge.[33] A subsequent study estimated significant baseflow reductions would occur near Waukesha even if only 3.9 mgd of shallow groundwater was pumped and artificial recharge was used.[34] Under Alternative 1, Waukesha would need a maximum of 10.9 mgd of shallow aquifer water without artificial recharge, so the negative impacts to baseflow reduction and groundwater/surface water ecosystems would be much greater.

For this application, the recently completed Troy Bedrock Valley groundwater model[35] was used to simulate shallow aquifer groundwater drawdown and baseflow reduction for Alternative 1. Although a maximum day pumpage of 10.9 mgd may need to be extracted from the shallow aquifer, an annual average well pumpage of 6.4 mgd was the withdrawal amount modeled.

The results on groundwater drawdown are shown in Exhibit 4-5.[36] The results show significant shallow aquifer drawdown (about 50 feet) near the wells. Water levels would also be lower in a large portion of the Vernon Marsh and near Pebble Brook. A groundwater drawdown of 1 foot is significant in a wetland as it may affect root structures of aquatic plants. In addition, there are many private wells in the drawdown area that could be affected, along with potential contamination from associated septic tanks.

Water extracted from the ground reduces the water that would naturally flow to wetlands, lakes and streams (base flow). The model estimated that base flow would be reduced as shown below

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30 D. T. Feinstein, USGS. October 2006. *Where do the deep wells in southeastern Wisconsin get their water?* http://wi.water.usgs.gov/glpf/index.html

31 CH2M HILL with Ruekert & Mielke. 2002. *Future Water Supply Report for the Waukesha Water Utility.*

32 SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin*, Preliminary Draft.

33 Ibid.

34 Cherkauer. 2009.

35 Troy Bedrock Valley Aquifer Model. Memorandum Report Number 188. Prepared by Ruekert & Mielke for SEWRPC. Reviewed by Dr. Kenneth R. Bradbury – Wisconsin Geological and Natural History Survey. January 2010.

36 RJN Environmental Services, LLC. March, 2010. Results of Groundwater Modeling Study Shallow Groundwater Source, Fox River & Vernon Marsh Area. Reviewed by Dr. Kenneth R. Bradbury – Wisconsin Geological and Natural History Survey.

with this alternative.[37] This baseflow reduction can have significant negative environmental impacts to the water ecosystems. Not only would groundwater be intercepted and not reach surface waters, under this scenario water also would be drawn from the Fox River. Appendix N, Environmental Report, contains additional information on the environmental impacts.

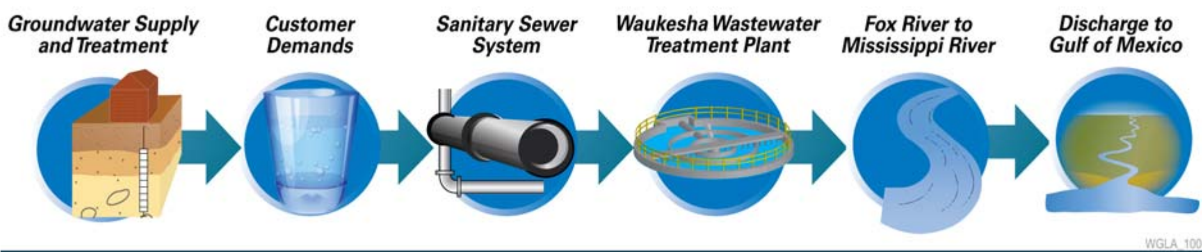
Resource	Baseflow Reduction (%) from pumping 17 shallow wells for a total of 6.4 mgd
Fox River	142
Pebble Brook	61
Vernon Marsh	7
Mill Brook	29
Pebble Creek	9

Water transmission mains extending from the shallow aquifer wellfield to the treatment plant, and from the treatment plant to Waukesha, would have environmental impacts during construction. Appendix N contains additional information on environmental impacts.

Deep and Shallow Aquifers Combined

Water is not returned to its source when deep or shallow groundwater is pumped and discharged to surface water. Water is transferred out of the Great Lakes and Mississippi river ecosystem and eventually to the ocean (Exhibit 4-6). This results in less water in the Great Lakes and Mississippi river watersheds and associated negative environmental impacts. One of the decision making standards of the Compact (4.11.1) states “All Water withdrawn shall be returned, either naturally or after use to the Source watershed less allowance for Consumptive Use.” Since the deep aquifer and the waters of the Lake Michigan Basin are hydrologically connected, pumping the deep aquifer and discharging the water into the Fox River does not comply with this Compact decision-making standard.

EXHIBIT 4-6
Groundwater Supply Water Cycle

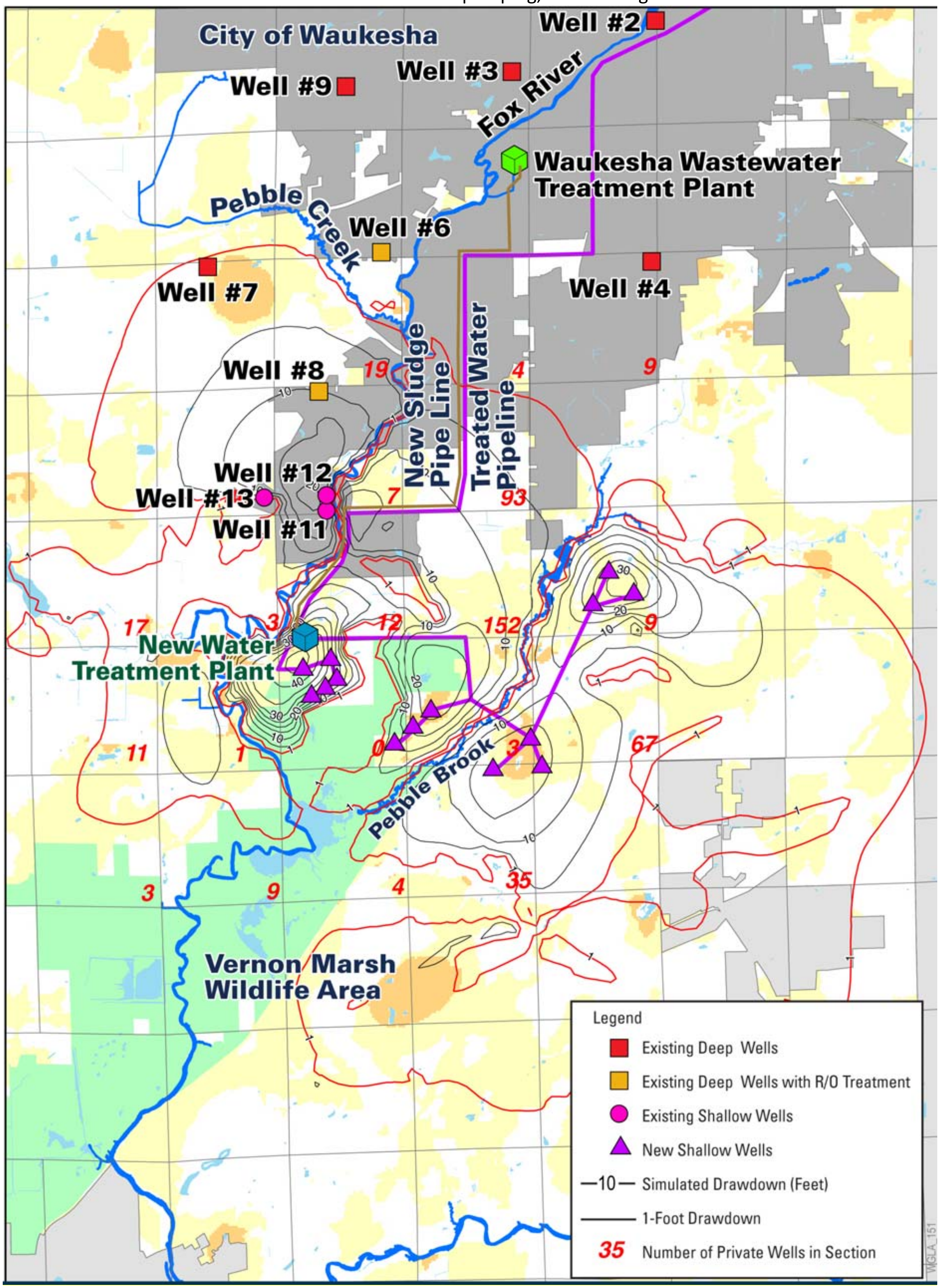


Both the deep and shallow groundwaters are hard, requiring use of home water softeners. Continued and expanded use of water softeners increases salt discharge into the environment. It is estimated that Waukesha discharges 7.4 million pounds of salt into the Fox River each year from home water softeners. Water use also increases with the use of home water softeners. It is estimated that each household water softener produces 40 gallons of salty wastewater per regeneration. TDS removal treatment concentrates salts that also are discharged into the environment and increases wastewater volumes. Continued use of hard groundwater would increase water and energy use while degrading conservation efforts.

[37] Ibid.

EXHIBIT 4-5

Groundwater Drawdown – Alternative 1 with 17 wells pumping, total 6.4 mgd



Finally, it is estimated that Alternative 1 would discharge 31,000 tons of greenhouse gases per year (carbon dioxide equivalent) through pumping from aquifers, water treatment, and pumping from the wellfield to Waukesha. That is equivalent to powering about 3,000 homes for a year.[38]

Considering the environmental impacts of Alternative 1, a rating of "significant negative impact" was applied.

Long-Term Sustainability

The City seeks Lake Michigan water because its current water source is not sustainable.

The deep aquifer water levels are very low and dropping. Water quality is degrading and radium and TDS levels are increasing. Two wells have recently been abandoned due to contamination from outside sources. Capacity in some wells is decreasing due to the ever increasing depth that water needs to be pumped from (over 600 feet from the surface now and dropping 5 to 9 feet per year). In order to continue withdrawing water, the existing pumps may need to be replaced with larger and different type (submersible) pumps to draw water from lower levels. This will increase costs and energy.

The deep wells are 30 to 75 years old and have some of the largest pumps of their kind which have to be custom built. If a failure occurs with the pumping equipment, it could be many months before repairs can be made. This situation has occurred on Waukesha's well 10 recently. This situation reduces reliability and sustainability of the water supply.

Current deep aquifer pumping could be reduced by using more shallow groundwater. That would slow the drawdown but may not eliminate it. The amount of deep aquifer pumping by other communities (about 75 percent of the total deep aquifer usage in southeastern Wisconsin) would also greatly affect drawdown.

Using the shallow groundwater as a replacement for the deep aquifer pumping would not be sustainable. As described above, pumping for average day water demands result in significant groundwater drawdowns and baseflow reduction, causing negative environmental impacts to wetlands, streams, lakes and rivers. This negative impact will increase during drought periods and when water demands are higher. As the shallow aquifer depends on rainwater for recharge, it is less reliable during drought conditions, when water supply is needed most. It is unlikely that the shallow aquifer could provide adequate water for maximum day demands during a drought, and even less likely if it could do so without severe negative impacts to the environment.

The deep aquifer is not significantly affected by drought, since the shale confining layer above the aquifer limits recharge near Waukesha. Having two sources of water is more reliable than having only one.

It should also be noted that treatment requirements for the deep and shallow aquifers would require more water to be pumped because the treatment process itself uses water. This would require more water to be pumped out of the ground to meet demand and thus decrease water efficiency. Treatment of all the water supply in multiple treatment plants is required. This would increase operation and maintenance efforts and costs, plus produce a salty liquid waste stream.

Considering the long-term sustainability of Alternative 1, a rating of "significant negative impact" was applied.

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[38] US Energy Information Administration. http://tonto.eia.doe.gov/ask/electricity_faqs.asp#electricity_use_home

Public Health

The deep aquifer exceeds the radium and gross alpha regulations. While drinking water regulations can be met with proper treatment, if there is a malfunction in the treatment process or if new contaminants appear, the public may be exposed to these contaminants. One of Waukesha's deep wells has already been contaminated from outside sources in recent years and shut down, and another deep well has been shut down due to potential contamination from a nearby landfill. Similar contamination may occur in the future requiring abandoning the wells or installing expensive treatment. The deep wells are mainly located within City limits, so there are numerous sources of contamination present.

In addition, the deep groundwater is high in TDS, mainly from calcium, magnesium, carbonates, chlorides and sulfate. Home softening takes out calcium and magnesium, but adds sodium. Sodium has been identified as an item to limit if you have certain health conditions such as heart disease. The shallow groundwater is also high in TDS.

Shallow aquifers are more susceptible to contamination than deep confined aquifers and large surface water bodies. Without a confining layer, the porous sand and gravel of shallow aquifers can quickly pass contaminants into the drinking water. Preventing a potential source of contamination (i.e., industry, gas station) from locating near the wellfield is difficult, particularly when the wellfield is located outside of a municipality's borders. The proposed shallow wellfield here will be located outside of the City limits, and, as a result, the City would have limited zoning control to enforce a wellhead protection ordinance to protect the well. A wellhead protection program is required by WDNR to protect municipal wells from contamination. Buying large tracts of land or trying to influence land use zoning around the wellfield is possible, but costly and the effectiveness is uncertain.

Arsenic was recently detected in a future shallow aquifer wellfield site near Waukesha. The future shallow wells may exceed arsenic regulations and would require treatment. In addition, City pumping of wells located in the shallow could impact private wells. Private wells may run dry or encounter water quality problems due to additional shallow aquifer pumping. If this should occur, new wells or deeper wells would be needed. Exhibit 4-5 shows the number of private wells that may be affected by a shallow wellfield. Private wells are often located near septic systems. These septic systems could be another source of contamination such as pathogenic microorganisms or nitrate, in situations where groundwater pumping pulls the contaminants towards the well.

With the Lake Michigan proposal, the deep aquifer would no longer be used and the potential public exposure to radionuclide and other contaminants would be eliminated. In addition, water resources, private wells and municipalities on groundwater near Waukesha would not be affected if Waukesha obtains a Lake Michigan water supply. Home softening would no longer be needed, and the water would contain much less sodium and TDS than a groundwater supply, making it healthier to consume.

Considering the public health impacts of Alternative 1, a rating of "moderate negative impact" was applied.

Implementability

The City's ability to implement Alternative 1, which requires the installation of 14 new shallow wells, would be difficult for several reasons.

First, Waukesha is part of a groundwater management area, and as a result, more requirements and restrictions could be placed on groundwater development. Additionally, groundwater protection legislation has been recently introduced (on March 12, 2010). The legislation would require environmental review of proposed high capacity wells located in a groundwater management area before WDNR approves or develops a groundwater management plan for the area.

Second, the shallow aquifer wellfield would be installed outside the City's boundaries. Significant land purchase/lease and controls outside the city limits would be required. Residents near the shallow aquifer wellfield have opposed high-capacity wells because of concerns about adequate water supply and impacts to wetlands, private wells, and other environmental resources.

Installation of wells in the unconfined aquifer may create legal challenges and expose the City to numerous damage claims from lake area homeowners and municipalities and would be a source of continuing controversy in the region. The City, for example, could be liable if its withdrawal of water causes unreasonable harm through lowering the water table for residential and municipal wells in the area. The City could also be liable if its withdrawal of groundwater had a direct and substantial effect upon the water of a watercourse or lake (i.e., effects to base flow or lake levels).

If new wells need to be installed in the future because of declining water levels in existing wells or the need to locate wells farther from surface water resources, wells may need to be located a greater distance from Waukesha. Locating wells further from Waukesha would increase costs, energy usage, and legal/public concerns. The environmental and legal impacts described above would become more severe.

If the new shallow wells can be built, a new water treatment plant would be required to remove iron, manganese, arsenic and microorganisms. If new contaminants are discovered, additional treatment would need to be constructed. A new pump station and transmission pipes are required to convey the treated water to the Hillcrest reservoir in Waukesha and throughout the City. The water treatment plant would be located outside the City limits and require land purchase or lease. The new wells, water plant, and pump station would require ongoing operation and maintenance.

Water transmission mains would need to be constructed from the shallow aquifer wellfield to the treatment plant, and from the treatment plant to Waukesha. This would require easements, and construction through rural and urban conditions.

Additional treatment for the water still pumped from the deep aquifer would result in significantly increased operation and maintenance requirements. If TDS is removed with reverse osmosis (RO) treatment, it would consist of pretreatment to condition the water, RO treatment with membranes, aeration to remove dissolved gases, and chemical addition for corrosion control and disinfection. It is assumed that the concentrated waste brine and chemical cleaning waste solution can be discharged to the sewer. This may cause TDS increases in the wastewater plant influent. In addition, residential housing would need to be bought and demolished to make room for the treatment facilities at the three well sites. This may require legal condemnation procedures.

Some of the deep aquifer water supply would be softened by RO, but the shallow aquifer supply would still be hard. Blending the different waters before distribution would be required to mitigate water quality issues (red water, corrosion) that could lead to customer complaints. However, this requires additional piping in the water distribution system to blend waters from different sources.

Considering the implementability of Alternative 1, a rating of "significant negative impact" was applied. Exhibit 4-7 summarizes the criteria for Alternative 1.

EXHIBIT 4-7
Water Supply Evaluation: Alternative 1

Water Supply Alternative	Environmental Impact	Long-term Sustainability	Public Health	Implementability
Deep and shallow aquifers	●	●	◉	●

○ No negative impact
⊙ Minor negative impact
◉ Moderate negative impact
● Significant negative impact

Water Supply Alternative 2: Shallow Aquifer and Fox River Alluvium

Alternative 2 uses the shallow aquifer south of Waukesha for Waukesha's entire water supply. The future average annual water usage would be 10.9 mgd based on water demand projections (Section 3). To meet a future maximum day demand of 18.5 mgd, infrastructure would be built for 4.5 mgd of firm capacity through 4 new wells along the Fox River south of Waukesha, in what is called the Fox River alluvium. Another 12.8 mgd firm capacity would be obtained through 14 new wells in the Troy Bedrock Valley south of Waukesha and adjacent to Vernon Marsh. The remaining 1.2 mgd firm capacity would be obtained from Waukesha's existing shallow wells 11 through 13.

The wells would pump water to a central treatment plant south of Waukesha. The water would be treated for iron, manganese, arsenic and microorganism removal. A pump station and pipelines would convey treated water to the Hillcrest reservoir in Waukesha and through the distribution system. Exhibit 4-8 shows the facilities for Alternative 2.

Environmental Impacts

Pumping the shallow aquifer can cause negative environmental impacts on groundwater and surface water resources (see Alternative 1 discussion). Alternative 2 would have greater negative environmental impacts than Alternative 1, since almost twice the amount of shallow groundwater would be pumped. The Troy Bedrock Valley aquifer south of Waukesha has several sensitive environmental areas (Vernon Marsh, Pebble Creek). Appendix N, Environmental Report, contains additional information on environmental impacts.

For this application, the recently completed Troy Bedrock Valley groundwater model[39] was used to simulate shallow aquifer groundwater drawdown and baseflow reduction for Alternative 2. Although the City may need to extract a maximum day pumpage of 18.5 mgd from the shallow aquifer occasionally, only the annual average well pumpage of 10.9 mgd was modeled to simulate a future average day water demand. The results on groundwater drawdown are shown in Exhibit 4-9.[40] The results show significant shallow aquifer drawdown (105 feet) near the wells. Water levels would also be lowered in a large portion of the Vernon Marsh and near Pebble Brook. A groundwater drawdown of 1 foot is significant in a wetland as it may affect root structures of aquatic plants. The model estimated that base flow would be reduced 346 percent to the Fox River and 58 percent to Pebble Brook in this alternative. This would have very significant negative environmental impacts to the water ecosystems and is not sustainable.

[39] Ruekert & Mielke, for SEWRPC. January 2010. Troy Bedrock Valley Aquifer Model. Memorandum Report Number 188. Reviewed by Dr. Kenneth R. Bradbury, Wisconsin Geological and Natural History Survey.

[40] RJN Environmental Services, LLC. Results of Groundwater Modeling Study Shallow Groundwater Source, Fox River & Vernon Marsh Area. March, 2010. Reviewed by Dr. Kenneth R. Bradbury, Wisconsin Geological and Natural History Survey.

EXHIBIT 4-8
Facilities for Alternative 2: Shallow Aquifer and Fox River Alluvium

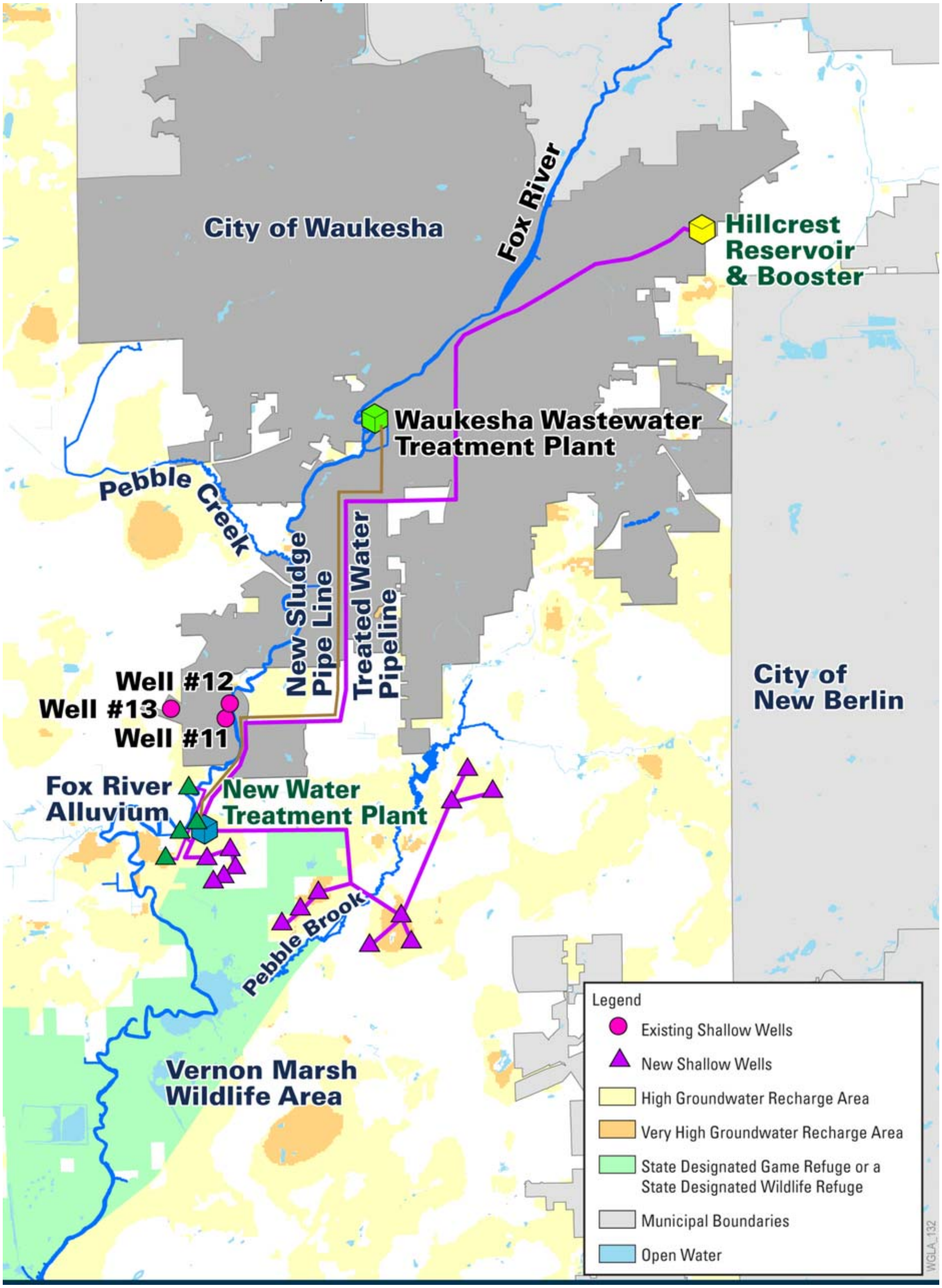
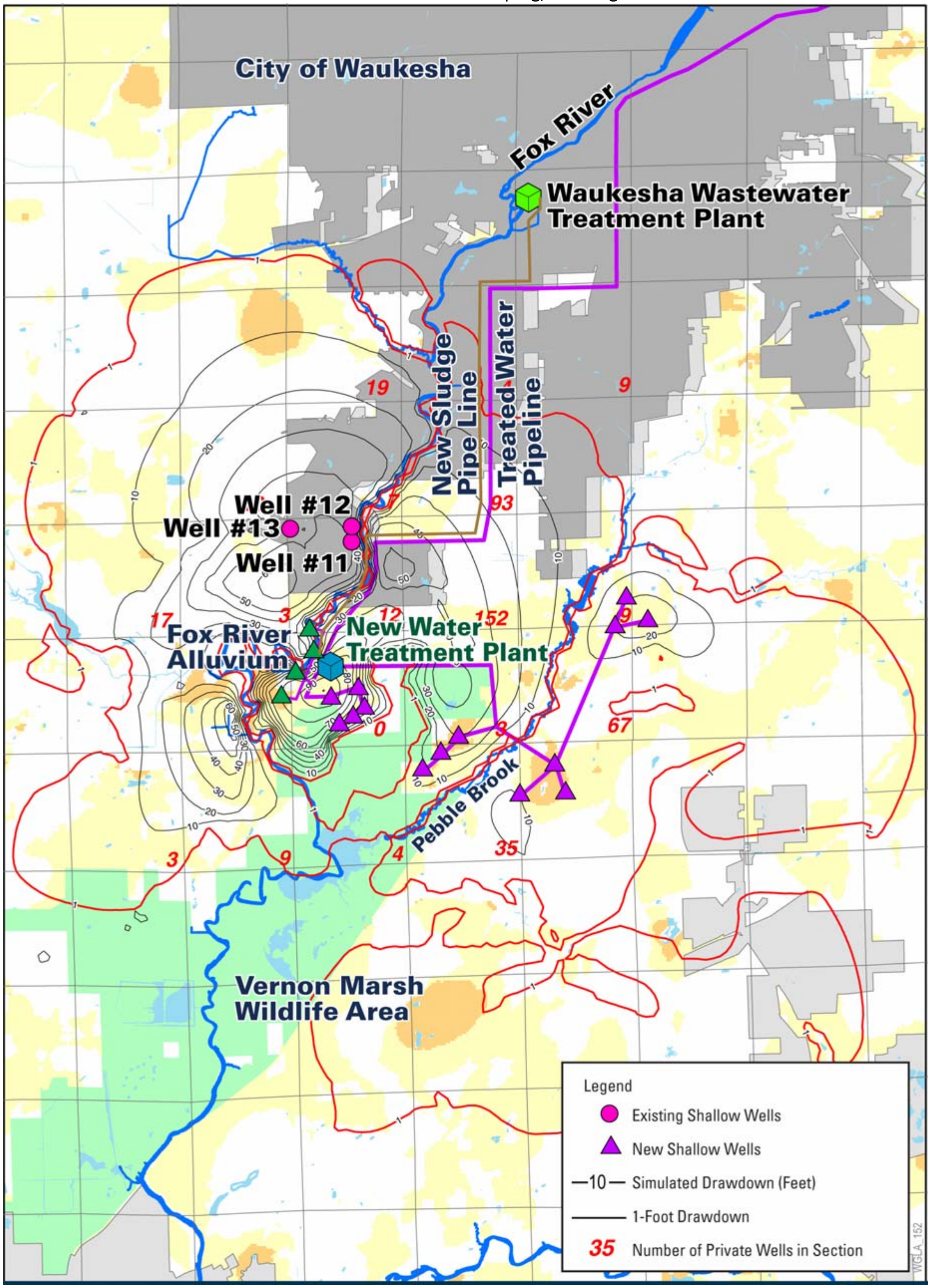


EXHIBIT 4-9
Groundwater Drawdown – Alternative 2 with 12 Wells Pumping, 10.9 mgd



Drawdown in the shallow aquifer can be reduced by spreading more wells out over a larger area and reducing the capacity of each well. Exhibit 4-10 shows the groundwater drawdown if the number of shallow wells increases from 12 to 28 and the wellfield land area is nearly doubled.

Although this reduces the drawdown from a maximum of 105 to 55 feet, there is a larger area affected by reduced groundwater levels. Base flow reduction decreases from 346 percent to 156 percent in the Fox River, but increases in the other resources as shown below.[41] Spreading the wells over a larger area and reducing the pumping from each well still would have a very significant negative impact on the baseflow to sensitive wetlands and streams.

Resource	Baseflow Reduction (%) from pumping 28 shallow wells for a total of 10.9 mgd
Fox River	156
Pebble Brook	82
Vernon Marsh	51
Mill Brook	94
Pebble Creek	10

This modeling of the shallow aquifer shows that development of a wellfield for a City the size of Waukesha would be very difficult from an environmental impacts standpoint.

On a much smaller scale, the Village of Mukwonago installed a single shallow groundwater well in the southern area of the Vernon Marsh wildlife area and monitored the effects to a nearby marsh and calcareous fen, a rare Wisconsin wetland. According to the WDNR, the well appears to have created a cone of depression that is affecting the fens, along with the endangered plant species that depend on the groundwater supply.[42, 43] The long-term impacts of pumping this well are being evaluated by WDNR.

A benefit of Alternative 2 is that Waukesha's deep aquifer pumpage would be eliminated, and therefore deep aquifer water levels would increase under Waukesha. The amount of the actual increase in water levels in the deep aquifer would depend on how many other communities continue to use it. If enough communities reduce deep aquifer pumping, increasing deep aquifer levels would have an environmental benefit.[44, 45, 46]

If shallow groundwater is used as the City's water source, return flow would not remain in the region. Instead, treated wastewater would be discharged to the Fox River and transferred out of the Great Lakes and Mississippi River ecosystem, eventually discharging to the ocean (Exhibit 4-6). This would result in less water in the Great Lakes and Mississippi River watersheds and associated negative environmental impacts.

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41 Ibid.

42 Letter to City of Waukesha Common Council from Brian Glenzinski, Vernon Marsh Wildlife Area Property Manager, WDNR. July 18, 2006.

43 Lisa Gaummitz, T. Asplund, and M. R. Matthews. June 2004. "A Growing Thirst of Groundwater." Wisconsin Natural Resources.

44 http://wi.water.usgs.gov/glpf/cs_pmp_src.html.

45 SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Preliminary Draft.

46 Douglas Cherkauer. 2009. *Groundwater Budget Indices and their Use in Assessing Water Supply Plans for Southeastern Wisconsin,* Technical Report 46, Preliminary Draft. Department of Geosciences, University of Wisconsin—Milwaukee.

If shallow groundwater is used, customers would continue to use home water softeners as shallow groundwater is hard. Negative environmental impacts associated with home water softening (salt discharge to surface waters, additional water and energy use) are similar to those under Alternative 1.

In order to use the shallow aquifer wellfield, the City would be required to construct water transmission mains from the shallow aquifer wellfield to the treatment plant, and from the treatment plant to Waukesha. This construction would have environmental impacts as discussed in Appendix N.

Alternative 2 would discharge 19,000 tons of greenhouse gases (carbon dioxide equivalent) annually through pumping from aquifers, water treatment, and pumping from the wellfield to Waukesha.

Considering the environmental impacts of Alternative 2, a rating of “significant negative impact” was applied.

Long-Term Sustainability

This alternative relies on multiple wells spread out over a large area. All wells would draw from the same aquifer. Relying upon one aquifer is less reliable than relying upon two aquifers as Alternative 1 does.

The shallow aquifer is dependent on rainwater for recharge and is less reliable during drought conditions, when water supply is needed most. Given the modeling of the shallow aquifer conducted at average day conditions, it is unlikely that this shallow aquifer could provide the City’s maximum water demand during a drought. Furthermore, the negative impacts of groundwater drawdown and baseflow reduction at average day water demand conditions as demonstrated by the model would be worse in a drought situation. Pumping the shallow aquifer for the City’s maximum water demand during a drought could result in severe negative impacts to the environment.

Treatment requirements for the shallow aquifers would also reduce the amount of water available to customers because the treatment requirements would require water and produce waste streams. However, the waste streams would only be about 2 to 3 percent of pumped water, much less than the TDS removal treatment in Alternative 1. Treatment of all the water supply in one treatment plant would reduce operation and maintenance efforts and costs compared to the multiple treatment plants in Alternative 1, but reduce reliability because there is only one treatment plant.

Considering the long-term sustainability of Alternative 2, a rating of ”significant negative impact” was applied.

Public Health

Shallow aquifers are more susceptible to contamination than deep confined aquifers and large surface water bodies. Contaminants may be undetected for some time, exposing the public to health risks. Proper drinking water treatment can meet regulations as long as new contaminants are known before the water treatment plant is designed. If new contaminants are undetected or there is a malfunction in the treatment process, contaminants may be exposed to the public.

In addition, the Fox River alluvium may have exposure to additional contaminants from the Fox River. The Fox River is listed as impaired for PCBs[47] and is known to contain compounds that may be regulated in the future such as endocrine disrupters.

WDNR requires a wellhead protection program to protect municipal wells from contamination. Waukesha would have no zoning control to enforce the wellhead protection ordinance because the shallow wellfield is outside the City limits. Preventing a potential source of contamination such as a gas station or industry from locating near the wellfield will be difficult without owning the land. Buying large tracts of land or influencing land use and zoning on surrounding properties is possible, but costly and the effectiveness is uncertain.

Other wells in the influence of the new wellfield may run dry or encounter water quality problems due to additional shallow aquifer pumping. Exhibit 4-10 shows the number of private wells that may be affected by a shallow wellfield. Private wells are associated with septic systems as well. These septic systems under the influence of a wellfield cone of depression could be sources of contamination such as pathogenic microorganisms or nitrate.

Groundwater is high in TDS, mainly from calcium, magnesium, carbonates, chlorides and sulfate. Home softening takes out calcium and magnesium, but adds sodium. Sodium has been identified as an item to limit if people have certain health conditions such as heart disease.

Under Alternative 2, the deep aquifer would no longer be used, and potential public exposure to radionuclide and other contaminants would be eliminated.

Considering the public health impacts of Alternative 2, a rating of “moderate negative impact” was applied.

Implementability

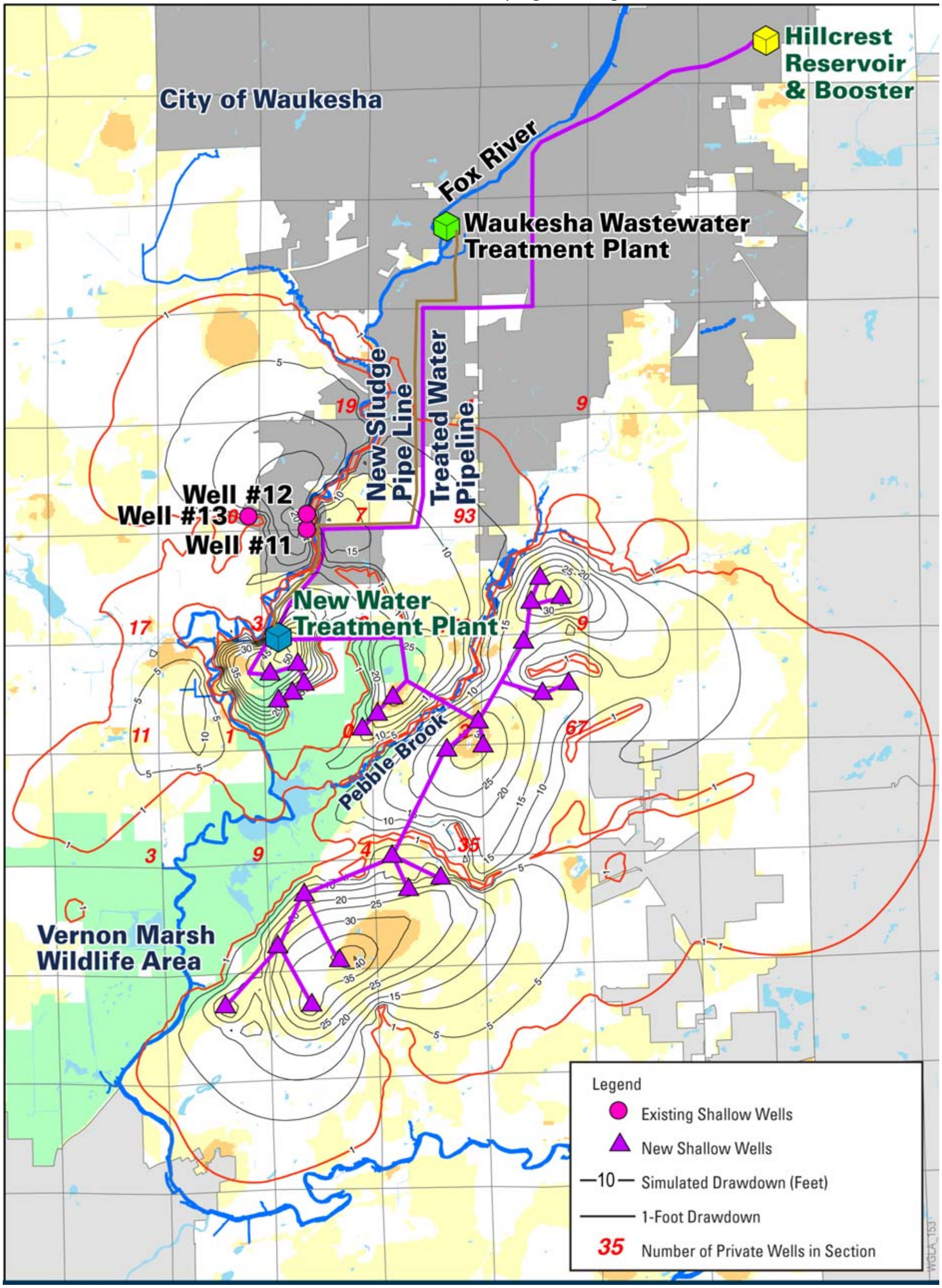
For the Troy Bedrock Valley and Fox River alluvium wellfields, significant land purchase/lease and controls outside the city limits would be required. Local residents have opposed high-capacity wells because of concerns about adequate water supply and impacts to wetlands, private wells, and other environmental resources. Installation of wells an unconfined aquifer may create legal challenges and expose the City to damage claims from lake area homeowners and municipalities and would be a source of continuing controversy in the region. The City, for example, could be liable if its withdrawal of water causes unreasonable harm through lowering the water table for residential and municipal wells in the area. The City could also be liable if its withdrawal of groundwater had a direct and substantial effect upon the water of a watercourse or lake (i.e., effects to base flow or lake levels).

Because the Waukesha area is part of a groundwater management area, more requirements and restrictions could be placed on groundwater development. Additionally, groundwater protection legislation has been recently introduced in Wisconsin by the relevant committee chairs (on March 12, 2010). The legislation would require environmental review of proposed high capacity wells in a groundwater management area before WDNR approves or develops a groundwater management plan for the area.

The legal issues with siting new wells and impacting other entities discussed in Alternative 1 would be much greater in Alternative 2 because the City would be installing nearly twice as many wells and they would cover a larger land area. This land is outside the Waukesha municipal boundaries.

[47] http://dnr.wi.gov/org/water/wm/wqs/303d/303d.html

EXHIBIT 4-10
Groundwater Drawdown – Alternative 2 with 28 Wells Pumping, 10.9 mgd



A new water treatment plant, pump station, and transmission pipes would be required to convey the treated water to the Hillcrest reservoir in Waukesha and through the distribution system. The treatment plant would be located outside the City limits and require land purchase or lease. The new wells, water plant, and pump station would require additional operations and maintenance. Water transmission mains from the shallow aquifer wellfield to the treatment plant, and from the treatment plant to Waukesha would require, easements, and construction through rural and urban conditions.

Treatment of all the water supply in one treatment plant would reduce operation and maintenance efforts and costs compared to the multiple treatment plants in Alternative 1, but reduce reliability because there is only one treatment plant.

If well capacity decreases due to declining water levels or wells need to be located a greater distance from surface water resources, wells may need to be located a greater distance from Waukesha, which would increase costs, energy, and public concerns. The environmental and legal impacts described above would still be present, and may increase.

Considering the implementability of Alternative 2, a rating of “significant negative impact” was applied. Exhibit 4-11 summarizes the criteria for water supply Alternatives 1 and 2.

EXHIBIT 4-11
Water Supply Evaluation: Alternatives 1 and 2

Water Supply Alternative	Environmental Impact	Long-Term Sustainability	Public Health	Implementability
Deep and shallow aquifers	●	●	◉	●
Shallow aquifer and Fox River alluvium	●	●	◉	●

○ No negative impact
⊙ Minor negative impact
◉ Moderate negative impact
● Significant negative impact

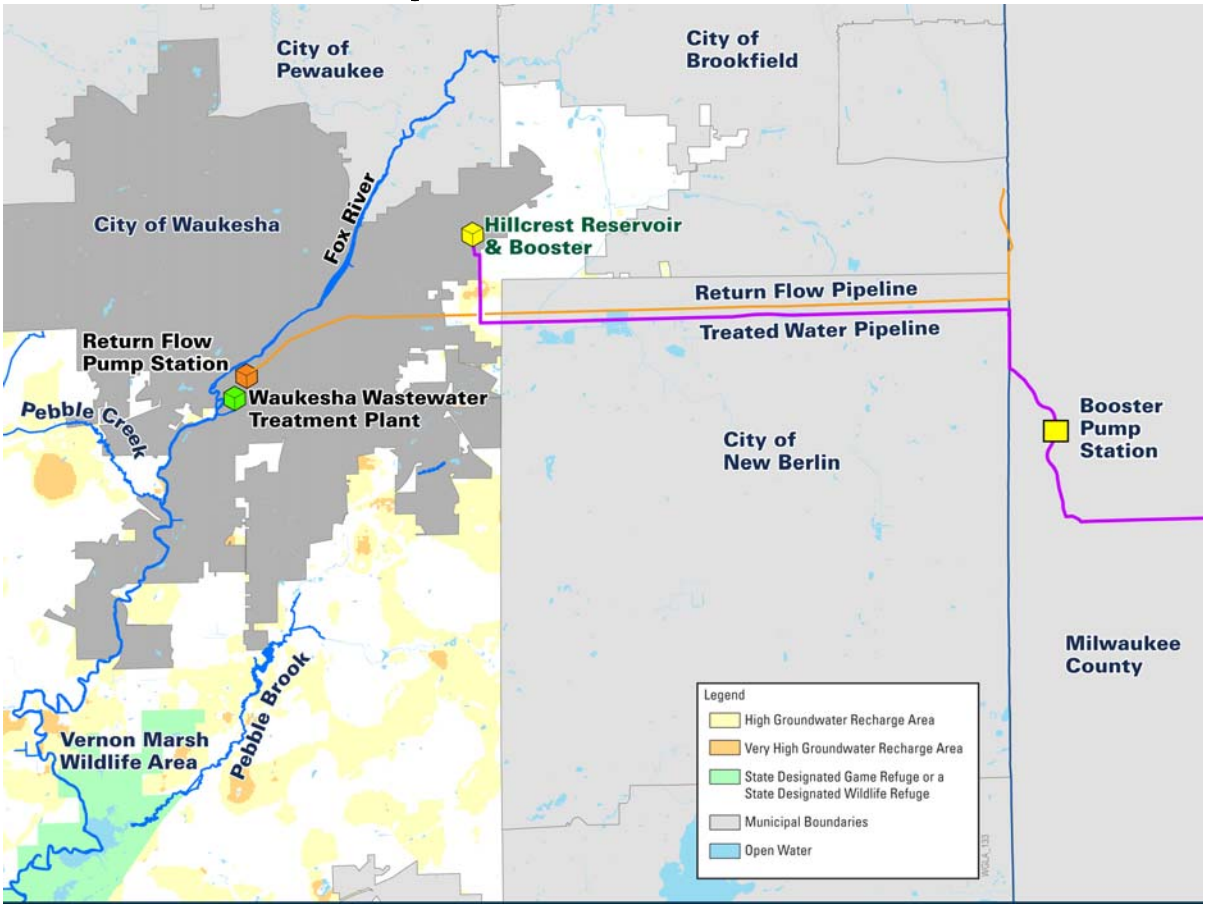
Water Supply Alternative 3: Proposal to Use Lake Michigan Water

This application seeks authority to obtain water supply from Lake Michigan. The City seeks to obtain treated potable drinking water from a Lake Michigan water utility, and convey it to Waukesha through a transmission pipeline and booster pump station to the Hillcrest reservoir in Waukesha (Exhibit 4-12). This application seeks to withdraw 10.9 mgd of water on a future average day, and 18.5 mgd on a future maximum day; the same as the other alternatives. Water used by Waukesha would be returned to the Lake Michigan watershed.

To estimate infrastructure requirements and costs, Alternative 3 assumes connection to Milwaukee’s water system at a large transmission main near 60th Street and Howard Avenue. Milwaukee is the closest Lake Michigan water utility to Waukesha and has excess capacity to provide water. Other options for a Lake Michigan water supply include the Cities of Oak Creek or Racine. The Lake Michigan water supplier would be determined after negotiations with the various cities.

There are several options for a return flow pipeline, all starting at the Waukesha wastewater treatment plant with a pump station. Discharge location options include Underwood Creek, Root River, and Lake Michigan through an outfall. The Underwood Creek location has the shortest distance and is the preferred alternative.

EXHIBIT 4-12
Facilities for Alternative 3: Lake Michigan



Environmental Impacts

If Lake Michigan water is obtained, the City would cease pumping the deep aquifer and groundwater levels would begin to increase. Using the Southeastern Wisconsin Regional Groundwater Model and assuming Waukesha stops pumping from the deep aquifer, the deep aquifer cone of depression may recover 100 feet over time.[48] SEWRPC estimates deep aquifer water levels could rise as much as 270 feet if deep aquifer pumping ceased in several communities, including Waukesha.[49] Ceasing deep aquifer pumping in northeastern Illinois allowed water levels to rise 300 feet between 1980 and 2000 at Villa Park and Elmhurst, Illinois.[50] Similar aquifer recovery is becoming evident near Green Bay, Wisconsin, where Brown County water utilities stopped pumping the deep aquifer and started using Lake Michigan water.

Increasing deep aquifer water levels would result in an environmental benefit because more water would be provided to the waters and water dependant natural resources of the Lake

48 CH2M HILL, Ruekert & Mielke, et al. 2003. *Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply.*

49 SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Preliminary Draft.

50 S. L. Burch. 2002. *A Comparison of Potentiometric Surfaces for the Cambrian-Ordovician Aquifers of Northeastern Illinois, 1995 and 2000.* Illinois State Water Survey Data/Case Study 2002-02.

Michigan Basin.[51] A 2003 study concluded that ceasing groundwater pumping from Waukesha's deep wells would have a beneficial effect on streams and wetlands and help restore the natural flow regimes toward, rather than away from Lake Michigan.[52] This has a significant benefit to the waters and water dependent natural resources of the Lake Michigan Basin. In addition, water sent to Waukesha is returned to Lake Michigan (Exhibit 4-13). This preserves the waters and water dependent natural resources of the Lake Michigan Basin and protects the integrity of the Great Lakes ecosystem. There is no measurable impact on Lake Michigan water quantity.[53]

In contrast, a groundwater supply alternative diverts water from the region.

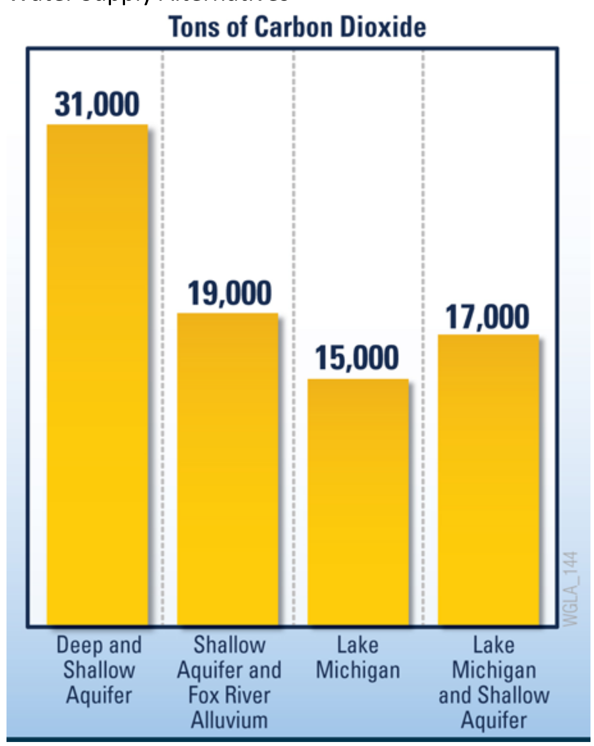
Current and future negative environmental impacts of pumping deep and shallow groundwater and reducing baseflows would be eliminated, thus protecting sensitive and valuable environmental areas such as Pebble Brook, Pebble Creek, and Vernon Marsh.

Another benefit of using Lake Michigan water is that it is relatively soft and customers do not need home water softeners. The negative environmental impacts associated with home water softening (salt discharge to surface waters, additional water and energy use) would be eliminated under Alternative 3.

It is estimated that Alternative 3 would discharge 15,000 tons of greenhouse gases per year (carbon dioxide equivalent) through pumping from Milwaukee and returning the water to the Great Lakes Basin. This is less than the deep and shallow aquifer alternatives (Exhibit 4-14). Using the Lake Michigan alternative would save enough electricity to power about 1,600 homes for a year compared to the current water supply sources (Alternative 1).[54]

EXHIBIT 4-13
Lake Michigan Water Cycle

EXHIBIT 4-14
Greenhouse Gas Emissions from Water Supply Alternatives



[51] D.T. Feinstein, USGS. October 2006. *Where do the deep wells in southeastern Wisconsin get their water?* http://wi.water.usgs.gov/glpf/index.html

[52] CH2M HILL, Ruekert & Mielke, et al. 2003. *Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply*.

[53] Ibid.

[54] US Energy Information Administration. http://tonto.eia.doe.gov/ask/electricity_faqs.asp#electricity_use_home

Water transmission mains from a Lake Michigan supplier to Waukesha, the booster pump stations, and return flow pipelines from the Waukesha wastewater plant to Underwood Creek would have environmental impacts during construction (see Appendix N, Environmental Report). However, existing utility corridors would be used for pipeline routing where possible to minimize environmental impacts.

Overall, the City believes a Lake Michigan water supply results in a net environmental benefit compared to using a groundwater supply. This is consistent with SEWRPC's conclusion that the Lake Michigan alternative "offers advantages related to a greater improvement in the deep aquifer long-term sustainability, reductions in chloride discharges to the surface waters, and improvement in groundwater-derived baseflow inputs to the surface water system."[55]

Considering the environmental impacts of Alternative 3, a rating of "no negative impact" was applied. There is actually an environmental benefit to the waters and water dependent natural resources of the Lake Michigan Basin because groundwater pumping would be eliminated, and as a result baseflow to surface waters would increase. In addition, there would be less of a need for water softening and salt discharge into the environment would decrease.

Long-Term Sustainability

Lake Michigan would provide Waukesha with an adequate quantity of high-quality water. The water source would provide long-term sustainability indefinitely because the water used would be recycled to its source. Lake Michigan is also a reliable water source because it is much more resistant to drought conditions than groundwater.

Using a Lake Michigan water supply also restores the hydrologic conditions and functions of the source watershed by stopping deep aquifer pumping and restoring flow toward, rather than away from Lake Michigan. This improves the long-term reliability and sustainability of the water resources in the region.

The infrastructure needed to provide Lake Michigan water is less than that for groundwater because no additional treatment or wellfields are needed. Existing treatment and pumping infrastructure from a Lake Michigan suppler would be used. In addition, long term operation and maintenance of pipelines and pump stations are simpler and less expensive than those of wellfields and water treatment plants.

Waukesha would maintain their shallow wells as an emergency backup to the Lake Michigan supply. This will increase reliability.

Considering the long-term sustainability of Alternative 3, a rating of "no negative impact" was applied.

Public Health

Treated Lake Michigan water is high quality and safe. Millions of people are provided with drinking water from Lake Michigan. Contamination is possible, as with all supplies, but the large size and high quality of Lake Michigan water makes this a rare occurrence. Lake Michigan water suppliers have some of the most stringent water quality programs and advanced treatment processes to assure high quality water.

The deep aquifer would no longer be used, and potential public exposure to radionuclide and other contaminants is eliminated. Private wells and municipalities on groundwater near Wau-

[55] SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin*, Preliminary Draft.

kesha would not be adversely affected if Waukesha obtains a Lake Michigan water supply because Waukesha would no longer be pumping groundwater. Home softening would no longer be needed, and the water would contain much less sodium and TDS than a groundwater supply, making it healthier to consume.

Considering the public health impacts of Alternative 3, a rating of "minor negative impact" was applied.

Implementability

Alternative 3 requires an agreement with a Lake Michigan water supplier to provide water. Waukesha has letters from three Lake Michigan water utilities willing to negotiate a contract. It would also require approval from the Governors of the Great Lakes States under the terms of the Compact.

Land purchase requirements would be less than a groundwater alternative, because no treatment plant or wellfield are required. Land use issues for wellhead protection, well and treatment plant siting are eliminated. Public concerns over impacts to groundwater levels and long-term wetland impacts are also eliminated.

A new pump station and transmission pipe would be required to convey the treated drinking water to the Hillcrest reservoir in Waukesha. A new pump station and transmission pipe would be required to convey treated wastewater from the wastewater treatment plant to Underwood Creek. The drinking water pump station would be located outside the City limits and require land purchase or lease. Water transmission mains to and from Waukesha would require routing studies, easements, and construction through rural and urban conditions. There are no treatment plants or wellfields for Waukesha to operate with Alternative 3, making operation and maintenance of the water utility much simpler than that of a groundwater alternative.

Considering the implementability of Alternative 3, a rating of "moderate negative impact" was applied. Exhibit 4-15 summarizes the criteria for water supply Alternatives 1, 2, and 3.

EXHIBIT 4-15
Water Supply Evaluation: Alternatives 1, 2, and 3

Water Supply Alternative	Environmental Impact	Long-Term Sustainability	Public Health	Implementability
Deep and shallow aquifers	●	●	◉	●
Shallow aquifer and Fox River alluvium	●	●	◉	●
Lake Michigan	○	○	⊙	◉

○ No negative impact
⊙ Minor negative impact
◉ Moderate negative impact
● Significant negative impact

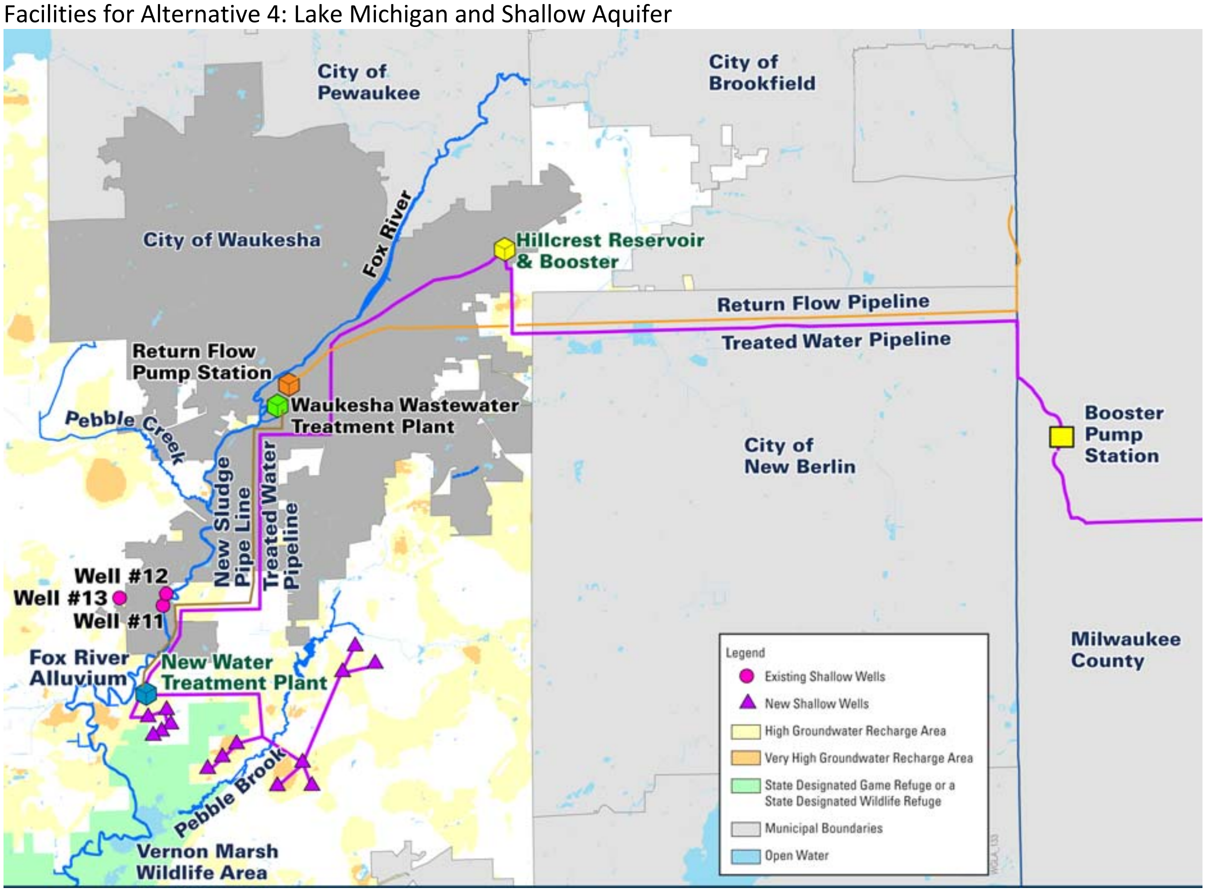
Water Supply Alternative 4: Lake Michigan and Shallow Aquifer

Alternative 4 consists of obtaining about 40 percent the City's required potable water (4.5 mgd average day demand, 7.6 mgd maximum day demand) from a Lake Michigan water utility and the other 60 percent (6.4 mgd average day demand, 10.9 mgd maximum day demand) from the shallow aquifer in the Mississippi River Basin. The shallow aquifer supply quantity is the same as in Alternative 1. This amount of shallow aquifer water caused significant negative environmental impacts on water resources, so using a higher amount of shallow aquifer water and less Lake Michigan water was not deemed reasonable for the purposes of this alternative. A slightly higher or lower amount of shallow aquifer water would not significantly change the results of this alternative analysis.

The Lake Michigan supply would be conveyed to Waukesha through a transmission pipeline and booster pump station to the Hillcrest reservoir in Waukesha. Additional distribution system piping would convey water through the City. Water used by Waukesha would be returned to the Lake Michigan watershed via Underwood Creek.

The supply from the shallow aquifer would be provided by existing and new wells. Existing shallow wells 11 through 13 would provide firm capacity for 1.2 mgd. The remaining 9.7 mgd would come from 14 wells in the Troy Bedrock Valley south of Waukesha. These wells would be combined into a central water treatment plant and the treated water pumped to the Hillcrest reservoir in Waukesha for blending with Lake Michigan water. The facilities are shown in Exhibit 4-16.

EXHIBIT 4-16
Facilities for Alternative 4: Lake Michigan and Shallow Aquifer



Environmental Impacts

Current and future negative environmental impacts of pumping the shallow aquifer would be the same as Alternative 1. Groundwater drawdown would negatively affect sensitive and valuable environmental areas such as Pebble Brook, Pebble Creek, and Vernon Marsh, and the reduction in baseflow to these water resources would negatively impact ecosystems.

Home water softening would continue because although Lake Michigan water is relatively soft the shallow groundwater is hard. Blending the two waters will reduce the hardness, but hardness will still be relatively high and a significant reduction in home softener use is not anticipated. The negative environmental impacts associated with home water softening (salt discharge to surface waters, additional water and energy use) would remain.

It is estimated that Alternative 4 would discharge 17,000 tons of greenhouse gases per year (carbon dioxide equivalent). Greenhouse gases would be produced by the pumping needed to convey water from and back to Lake Michigan. In addition, pumping from the shallow aquifer, treating the water and pumping the water to Waukesha uses energy and produces greenhouse gases. This alternative produces more greenhouse gases than the Lake Michigan Alternative 3 (see Exhibit 4-14).

Water transmission mains from a Lake Michigan supplier to Waukesha, the booster pump stations, and return flow pipelines from the Waukesha wastewater plant to Underwood creek would have environmental impacts during construction (see Appendix N). Existing utility corridors would be used for pipeline routing where possible to minimize environmental impacts. Developing the shallow aquifer wellfield, pipelines, treatment plant and pump station would also have environmental impacts during construction.

Considering the environmental impacts of Alternative 4, a rating of "significant negative impact" was applied.

Long-Term Sustainability

Lake Michigan as a drinking water source for Waukesha provides adequate quantity, high-quality, and long-term reliability indefinitely by allowing water to be recycled to its source. Alternative 4 also restores the hydrologic conditions and functions of the source watershed by stopping deep aquifer pumping and restoring flow toward, rather than away from Lake Michigan.

Lake Michigan water is much more resistant to drought conditions than groundwater. During a drought Waukesha could rely more on Lake Michigan and less on the shallow aquifer, increasing reliability. The infrastructure needed to provide Lake Michigan water is similar to Alternative 3, with the main difference being a smaller pipe. In addition, a shallow aquifer wellfield, treatment plant, pump station and pipeline are needed. Waukesha would have to maintain not only the Lake Michigan supply, but also the shallow aquifer supply. Blending the two waters would require attention to water chemistry so customers are receiving consistent water quality and distribution system corrosion is minimized.

Considering the long-term sustainability of Alternative 3, a rating of "moderate negative impact" was applied.

Public Health

Treated Lake Michigan water is high quality and safe. Millions of people are provided with drinking water from Lake Michigan. Contamination is possible, as with all supplies, but the large size and high quality of Lake Michigan makes this a rare occurrence. Lake Michigan water suppliers have some of the most stringent water quality programs and advanced treatment processes to assure high quality water.

The deep aquifer would no longer be used, and potential public exposure to radionuclide and other contaminants is eliminated.

The contamination and wellhead protection issues with the shallow aquifer remain (see Alternative 1). Private wells will be affected by the shallow aquifer pumping and septic systems may contribute contaminants into the water supply. However, if a contamination issue should occur, Waukesha could rely more on the Lake Michigan water supply.

Home softening would still be needed, so the increased sodium and TDS would still be present.

Considering the public health impacts of Alternative 3, a rating of "minor negative impact" was applied.

Implementability

Alternative 4 still requires an agreement with a Lake Michigan water supplier to provide water, and approval from the Governors of the Great Lakes states under the terms of the Compact. Since a large portion of Waukesha's water supply would come from shallow groundwater and be blended with Lake Michigan water, minimizing out of Basin return water to comply with section 4.9.3(b) of the Compact would not be possible. This would apply even if a much smaller amount of groundwater were used with a Lake Michigan water supply.

A Lake Michigan supply will have the same issues and requirements of pipeline routing studies, easements, land purchase and construction through rural and urban conditions.

Land purchase and easement requirements for the shallow aquifer supply would be similar to Alternative 1. Land use and legal issues for wellhead protection, well and treatment plant siting remain. Public concerns over impacts to groundwater levels and long-term wetland impacts are also still present.

In Alternative 4, Waukesha would operate and maintain the Lake Michigan supply in addition to the shallow aquifer wellfield, treatment plant and pumping/pipelines. This will make operation and maintenance of the water utility more complex than that of a Lake Michigan alternative.

Considering the implementability of Alternative 3, a rating of "significant negative impact" was applied. Exhibit 4-17 summarizes the criteria for water supply Alternatives 1, 2, 3, and 4.

EXHIBIT 4-17
Water Supply Evaluation: Alternatives 1, 2, 3, and 4

Water Supply Alternative	Environmental Impact	Long-Term Sustainability	Public Health	Implementability
Deep and shallow aquifers	●	●	◉	●
Shallow aquifer and Fox River alluvium	●	●	◉	●
Lake Michigan	○	○	⊙	◉
Lake Michigan and shallow aquifers	●	◉	⊙	●

○ No negative impact
⊙ Minor negative impact
◉ Moderate negative impact
● Significant negative impact

Using the deep aquifer with Lake Michigan water instead of the shallow aquifer will have similar results and impacts. However, since the deep aquifer will continue to be pumped, the benefit of increasing water levels and restoration of the natural groundwater flow toward Lake Michigan will not be realized. In addition, the old deep wells are less reliable. The wells are 30 to 75 years old and have some of the largest pumps of their kind which have to be custom built. If a failure occurs with the pumping equipment, it could be many months before repairs can be made. This situation has occurred on Waukesha's well 10 recently. The deep wells also have more water quality issues than new shallow wells with treatment. Radium treatment facilities will be over half their expected life when a Lake Michigan supply is finished, and will require replacement in the near future. Additional treatment for TDS removal in the future will be a large expense in both capital and operating costs (See Alternative 1). Other issues with using the deep aquifer for a portion of Waukesha's water supply are explained in the Alternative 1 description. For these reasons, a Lake Michigan and deep aquifer supply alternative was not developed in detail.

Combinations of Water Supply Sources

In general, water utilities rarely have more than two primary water supply sources. A main principal of public drinking water supply is to obtain the water supply source with the highest quality and most reliability. If this water supply does not have adequate quantity, the next highest quality water supply source is obtained. Using multiple sources of water is possible when necessary, but increases costs along with operational and maintenance complexity. Impacts to the environment can increase if unsustainable sources are tapped, and public health protection can decrease if lower quality water sources are used.

For example, a quarry north of Waukesha was evaluated as a potential water source, but screened out due to inadequate capacity (2 mgd) and contamination concerns.[56] Using this 2 mgd quarry capacity to supplement a deep and shallow aquifer supply instead of obtaining an additional 2 mgd from the shallow aquifer would actually increase the capital cost about $19 million. Under this example, having three sources of water (deep aquifer, shallow aquifer, quarry) instead of two (deep and shallow aquifer) would increase costs and operational complexity, and also increase risk to public health by using a poorer quality water source.

Summary of Water Supply Alternatives

Major studies previously conducted by the City of Waukesha[57] and others[58, 59] thoroughly evaluated the water supply alternatives for the City of Waukesha. Through these studies, potentially feasible water supply options were identified. This application analyzes four alternatives for Waukesha's water supply:

- Deep and shallow aquifers
- Shallow aquifer and Fox river alluvium
- Lake Michigan
- Lake Michigan and shallow aquifer

Each alternative was evaluated against four criteria:

- Environmental impact
- Long-term sustainability
- Public health
- Implementability

Exhibit 4-18 summarizes the water supply alternatives evaluation results. The evaluation results show the Lake Michigan alternative (Alternative 3) has the most environmental benefit for

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56 CH2M HILL and Ruekert & Mielke. 2002. *Future Water Supply Report for the Waukesha Water Utility.*

57 Ibid.

58 SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin*, Preliminary Draft.

59 Cherkauer. 2009.

the waters and water dependent natural resources of the Lake Michigan Basin, is the most reliable and sustainable in the long term, provides excellent public health protection, and is implementable. A Lake Michigan water supply also provides higher quality potable water to consumers. Exhibit 4-19 shows the total dissolved solids in each water supply. The much lower total dissolved solids in the Lake Michigan water supply not only eliminates the need for home softening; it also is more healthy for consumers and the environment, and better for many industrial and commercial uses.

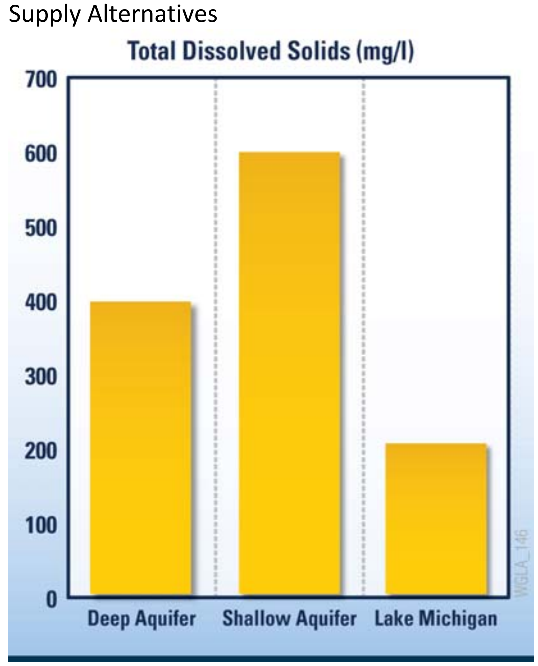
EXHIBIT 4-18
Water Supply Alternatives Evaluation Summary

Water Supply Alternative	Environmental Impact	Long-Term Sustainability	Public Health	Implementability
Deep and shallow aquifers	●	●	◉	●
Shallow aquifer and Fox River alluvium	●	●	◉	●
Lake Michigan	○	○	⊙	◉
Lake Michigan and shallow aquifers	●	◉	⊙	●

○ No negative impact
⊙ Minor negative impact
◉ Moderate negative impact
● Significant negative impact

Estimated costs for each alternative are summarized in Exhibit 4-20. These cost estimates were prepared for guidance in comparing alternatives based on information available at the time of the estimate. Detailed engineering design has not been done. The final cost estimate of any project will depend on market conditions, site conditions, final project scope, schedule, and other variable factors. As a result, final project costs may vary from the estimates presented here.

EXHIBIT 4-19
Water Quality Comparison between Water Supply Alternatives



The cost comparison of the alternatives shows that the Lake Michigan water supply is the most cost-effective in the long term. There is no cost advantage of a groundwater supply or combination groundwater/Lake Michigan supply over a Lake Michigan supply. The combination of a Lake Michigan and groundwater supply (Alternative 4) is the most expensive. The lake Michigan supply is also the simplest to operate and maintain. Capital, operation, and maintenance cost details are in Appendix M, Cost Estimates Update.

The groundwater supply alternatives are not reasonable alternatives under the Wisconsin Compact implementing statute (§281.346(1) (ps), Wis. Stats.). Under Wisconsin law, "a reasonable water supply alternative means a water supply alternative that is similar in cost to, and as environmentally sustainable and protective of public health as, the proposed new or increased diversion and that does not have greater negative environmental impacts than the proposed new or increased

EXHIBIT 4-20
Water Supply Alternative Cost Estimates

Water Supply Alternative	Capital Cost[a] ($ million)	Annual Operation/Maintenance Cost ($ million)	20 yr. Present Worth Cost ($ million, 6%)	50 yr. Present Worth Cost ($ million, 6%)
Deep and shallow aquifers	189	7.2	272	302
Shallow aquifer and Fox River alluvium	184	7.4	269	301
Lake Michigan with return flow to Underwood Creek	164	6.2	235	262
Lake Michigan and shallow aquifer	238	7.5	324	356

[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

diversion." Compared to a Lake Michigan water supply, the groundwater supply alternatives create greater negative environmental impacts, are less sustainable, less protective of public health and are more expensive.

Exhibit 4-21 compares the water supply alternatives to some of the Great Lakes Compact criteria.

EXHIBIT 4- 21
Great Lakes Compact Requirements and Water Supply Alternatives

	Lake Michigan with Return Flow to Underwood creek	Shallow Aquifer	Shallow / Deep Confined Aquifer
All water withdrawn shall be returned to the Source watershed, minus consumptive use (4.11.1)	✓		
No significant individual or cumulative negative impact to the quantity or quality of the waters and water dependent natural resources and the applicable source watershed (4.11.2)	✓		
Environmentally sound and economically feasible water conservation measures (4.11.3)	✓	✓	✓
The supply potential of the water source, considering quantity, quality, reliability and safe yield of hydrologically interconnected water sources (4.11.5(d))	✓		
Not endanger the integrity of the Basin Ecosystem (4.9.3(e))	✓		
Restoration of hydrologic conditions and functions of the Source Watershed (4.11.5(f))	✓		
In compliance with all applicable laws and agreements (4.11.4)	✓	✓	✓
Protection of the integrity of the Great Lakes (4.5.1(d))	✓		
Protect, conserve, restore, improve and effectively manage the Waters and Water dependent natural resources of the Basin (1.3.1(f) and 1.3.2(a))	✓		

Summary

An analysis of Waukesha's water supply alternatives demonstrates that a Lake Michigan water supply is the only reasonable solution for the Waukesha Water Utility (Exhibit 4-22). It provides the most reliable, cost-effective, and high quality drinking water for the future. It protects the integrity of the Great Lakes Basin ecosystem. A Lake Michigan water supply will result in termination of deep aquifer pumping which will restore the natural flow regime of the groundwater towards the Lake Michigan Basin instead of away from it. This will eliminate negative environmental impacts of using groundwater and improve the Great Lakes water and water-related ecosystems.

EXHIBIT 4-22
Final Water Supply Alternative Selection

This analysis also demonstrates that that there is no reasonable water supply alternative to a Lake Michigan supply within the basin in which Waukesha is located. The groundwater water supply options have much greater negative environmental impacts than using Lake Michigan, are not sustainable long-term and are not as protective of public health.

The Compact and Wisconsin Statute Section 281.346 require return flow to the source watershed equal to the amount of water diverted from the Great Lakes, less an allowance for the volume of water consumed. It also requires that the return flow protect the chemical, physical, and biological integrity of the Great Lakes. The City of Waukesha has developed a return flow management plan to meet those requirements, with a goal to exceed the requirements of the Compact and Wisconsin Statute by returning 100 percent of the withdrawn water over a management period. The return flow management plan will provide environmental benefits to the source watershed by returning flow to a Lake Michigan tributary that is flow-limited during baseflow and low flow periods.

This section addresses the requirements of the Compact set forth in Sections 4.9(3)(b), 4.9(3)(e), 4.9(4)(c) and 4.9(4)(d). It also addresses the Wisconsin Statutes Section 281.346(4)(e)1c and e and 281.346(4)(f)3-5.

Return Flow Management Plan

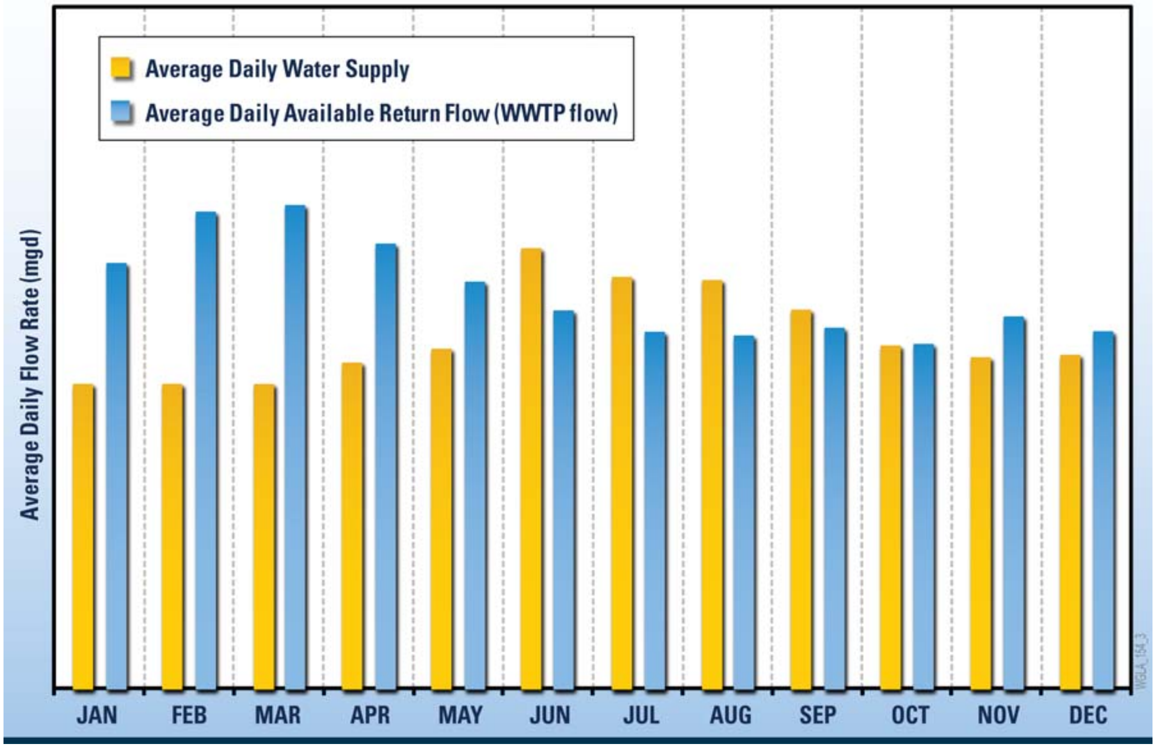
The City of Waukesha's goal is to return 100 percent of the water withdrawn from Lake Michigan.

The City of Waukesha will meet the requirements of the Compact by returning the volume of water withdrawn from Lake Michigan, less consumptive use (Compact Section 4.9(4)c, Wisconsin Statute Section 281.346(4)(f)3). The City of Waukesha also has a goal of returning 100 percent of the water supplied from Lake Michigan to ensure that its withdrawal will not individually or cumulatively create an adverse impact to the water quantity within Lake Michigan (Compact Section 4.9(4)d, Wisconsin Statute Section 281.346(4)(f)5). To accomplish the 100 percent return flow goal, a management plan has been developed using an innovative precedent of using treated wastewater as an environmental resource to balance the return and withdrawal volumes, and for supporting flow restoration and other watershed goals for the Lake Michigan tributary.

The return flow will come from the City of Waukesha Wastewater Treatment Plant (WWTP). The WWTP is an advanced facility with primary, secondary, and tertiary treatment (dual media sand filters), and ultraviolet light disinfection processes. It produces a high quality effluent that is discharged to the Fox River, in the Mississippi watershed. The Fox River has a small watershed area at the City of Waukesha, and the WWTP provides a significant contribution to the flow in the Fox River during periods of low river flow. The WWTP maintains high quality treatment standards to protect the river water quality. The City of Waukesha will continue to use the treatment facility and at least maintain its high-quality treatment standards for future return flow.

Water supply rates change throughout the year because of changes in demand, with the greatest water usage generally occurring during hot and dry periods. For example, water consumption is greater during the summer, when the temperatures are high and precipitation is low, than it is in the winter. Return flow from the WWTP also varies throughout the year, but it does not always follow the same variation as the water supply. During periods of high water demand (e.g., July and August), return flow from the WWTP often is less than the water supply. Exhibit 5-1 shows how the water supply and an available return flow (from the WWTP) would have varied seasonally during 2005. Year 2005 was used to demonstrate this because it was a year when there were several months when the water supply was greater than the available return flow.

EXHIBIT 5-1
Example of Variability between a Water Supply and Available Return Flow Volume for Example Year 2005



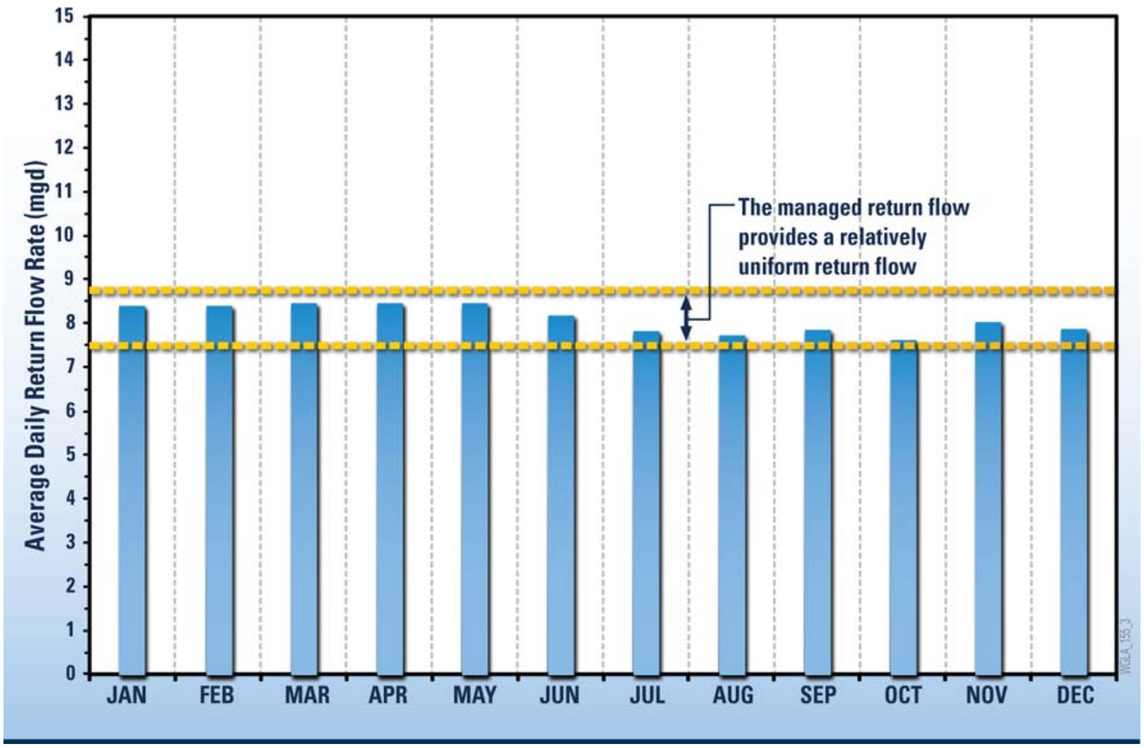
Return Flow Rates

To achieve 100 percent return volume and to balance the periods when the water withdrawal is greater than the available return flow, the return flow management plan will use a period of time to track water withdrawal and return volumes. The return flow will at least meet the Compact requirement of returning the withdrawn water, less consumptive use. To account for summer days when water withdrawal is greater than the available return flow, slightly more water will be returned during spring, fall, and winter when the available return volume typically is greater than the demand (Exhibit 5-1). This will provide a total water balance of 100 percent return over a management period.

The return flow will meet the Compact requirement of returning the withdrawn water, less consumptive use.

As required by the Compact Section 4.9(4)(c) and Wisconsin Statute Section 281.346(4)(f)3, the *minimum* daily return flow rate will be the water withdrawn less consumptive use, which at some times (summer) is the available flow rate from the WWTP. As discussed in Section 2, the City of Waukesha has an average consumptive use of about 8 percent. The *maximum* daily return flow rate will not exceed 115 percent of the average water withdrawal; that is the maximum daily return flow rate will not be more than 15 percent more than the average withdrawal. With return flow not exceeding 115 percent of the average daily withdrawal, the City of Waukesha will balance the amount of return flow with the amount of water withdrawn, allowing the City to provide a return flow rate very close to the withdrawal rate. This approach will provide a uniform return flow rate that will prevent large fluctuations in the return volume and excessive “banking” of volume during the management period. Exhibit 5-2 demonstrates the range of return flow rates following the management plan for 2005. As shown, the managed return flow provides a relatively uniform return flow rate throughout the year.

EXHIBIT 5-2
Return Flow in Example Year 2005: Following the Management Plan for Controlling the Minimum and Maximum Return Flow Rates



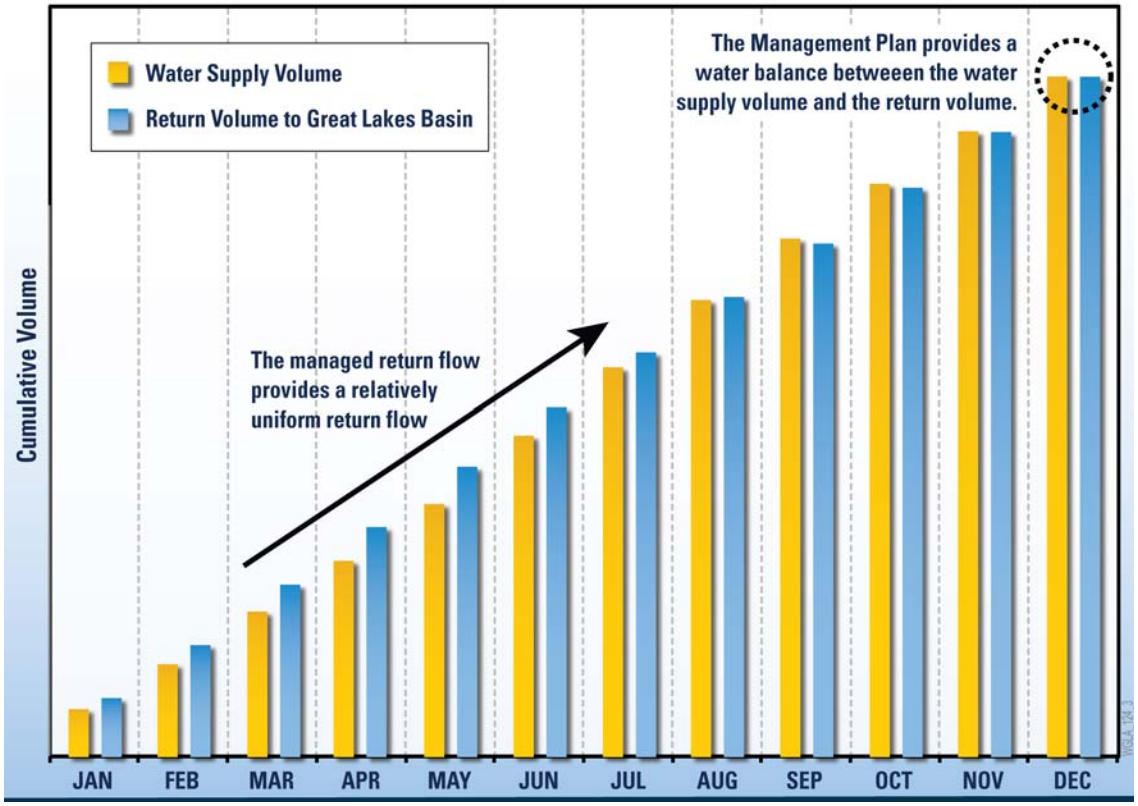
When the available return flow rate (WWTP flow) exceeds 115 percent of the water withdrawal rate, the excess flow from the WWTP will be conveyed through the existing outfall to the Fox River. Exhibit 5-3 summarizes the management plan.

EXHIBIT 5-3
Summary of the Return Flow Management Plan

Average Daily Return Flow to Lake Michigan Source Watershed		Receiving Water Body for Return Flow Exceeding the Maximum
Minimum Return Flow	Maximum Return Flow	
Available flow from the WWTP (water withdrawal, less consumptive use)	Average daily water withdrawal + 15%	Fox River

To demonstrate how the management plan would provide return flow, the water supply and available return flows (WWTP flows) were modeled for the most recent period of record, between years 2002 and 2009. Over this period the management plan provided 100 percent return of the withdrawn volume each year, including 2005 when there were several months when the water supply was greater than the available return volume (i.e., a year when obtaining 100 percent return flow would be more difficult). As shown in Exhibit 5-4, the return and withdrawal volumes fluctuate throughout example year 2005, and at the end of the year there is a water balance between the withdrawal and return volumes (i.e. at the end of the year, the cumulative water withdrawn is equal to the return volume). Because the management plan allows the return flow rate to be relatively uniform (Exhibit 5-2) and very close to the withdrawal volume (Exhibit 5-4), the average daily variations between the withdrawal and return flow rates will be limited. This uninterrupted flow will allow the return flow to be used as a resource to enhance the fisheries and aquatic habitat in a Lake Michigan tributary while protecting the streambed geomorphic stability.

EXHIBIT 5-4
Example of 100 Percent Return during Example Year 2005



Management Plan Period

The City of Waukesha will monitor the withdrawal and return flow rates on a daily basis to ensure that the minimum requirement of the Compact is met: returning the withdrawn water, less consumptive use. The City also proposes using a 5-year rolling average to track water withdrawal and return flow rates to achieve its goal of 100 percent return flow. The 5-year management period will be used to provide 100 percent return flow because there could be periods in the future with extended drought, when available return flow from the WWTP is less than the water withdrawal (when only the minimum Compact requirement of returning the withdrawn water, less consumptive use, is achieved). By using the 5-year rolling average, drought periods can be balanced with wet or normal precipitation periods, to provide a 100 percent return flow and a water balance between the withdrawal and the return volumes. As noted, because the average return flow rate is similar to the average withdrawal flow rate, the management plan will minimize daily variations between the two and will prevent "banking" excessive volume to account for days when available return flow is much less than the withdrawal.

Minimizing Out-of-Basin Water in Return Flow

The City of Waukesha operates a separate sanitary sewer collection system that conveys wastewater from the sanitary sewer service area (see Appendix E) to the WWTP. The City will continue to operate this system for the proposed Lake Michigan water supply and return flow. As required by the Compact Section 4.9(4)(c)i and Wisconsin Statute Section 281.346(4)(f)4a, the return flow will consist only of flow from the WWTP that originates within the sanitary sewer service area (see Appendix E) served by the City of Waukesha WWTP. Sources of return flow outside that area will not be used for return flow.

The City of Waukesha has been implementing an aggressive infiltration and inflow (I&I) reduction program to reduce the amount of clear water entering the sanitary sewer collection system (Waukesha has only a separate sanitary sewer system). As in all communities with sanitary sewer collection systems, some I&I is observed in the City of Waukesha during wet periods and storms. The I&I contributes to the collection system flows during those times, and subsequently receives the same treatment at the WWTP as the sanitary flow. The City's collection system and WWTP have adequate conveyance and treatment capacity to treat the I&I, but the City has continued the I&I reduction program to minimize treatment costs and to minimize the I&I that could be part of the return flow.

Over the past several years, projects that have contributed to reducing I&I include televising, smoke testing, and dye tracing of sewer pipes and structures; replacing sewer laterals, cracked pipes, and manholes; lining and sealing manholes and sewers; and identifying and correcting sump pump and foundation drain connections to the sanitary sewer. The City continues to investigate I&I throughout the collection system to prioritize projects that provide the most efficient I&I reduction.[1] Those efforts include sewer system modeling, in-pipe flow monitoring, sewer televising and smoke testing, and conducting a sewer system evaluation survey. The I&I reduction program will contribute to minimizing out-of-basin water in the return flow.

The return flow management plan will also contribute to minimizing out-of-basin water in the return flow. Because I&I contributes to WWTP flows that are greater than the withdrawn water, the maximum return flow rate will not include the WWTP flows where I&I have the greatest contribution. Instead, the return flow rate will not exceed 15 percent more than the average withdrawal (as discussed under "Return Flow Management Plan"). By limiting the return flow rate, I&I contributions above that amount will not contribute to return flow, and the out-of-basin water (I&I) will be minimized. The WWTP flows exceeding the maximum return flow will continue to the Fox River, which is within the surface watershed where the I&I occurs.

By using the City of Waukesha sanitary sewer system, the I&I reduction program, and the return flow management plan as discussed above, the Compact Sections 4.9(3)b and Wisconsin Statute Sections 281.346(4)(e)1c and 281.346(4)(f)4a requirements are met for minimizing the amount of water from outside the Great Lakes Basin that will be returned.

Return Flow Alternatives

Five alternatives were considered for return flow to the Lake Michigan source watershed. The alternatives include return flow to:

- Underwood Creek, a tributary to the Menomonee River that flows to Lake Michigan
- Root River, a tributary to Lake Michigan
- Direct to Lake Michigan
- The Milwaukee Metropolitan Sewerage District (MMSD) sewer system and water reclamation facility, which would then return flow to Lake Michigan. Two subalternatives were considered for return flow to MMSD.

Each alternative includes a corridor for the return flow pipeline and associated infrastructure along the pipeline alignment (e.g., pump station, service manholes). The Compact Sec-

[1] Donohue & Associates. (2010; in press). *Sanitary Sewer Master Plan—Phase I.*

tion 4.9(4)d and Wisconsin Statute Section 281.346(4)(f)5 requires that the return flow result in no significant adverse individual or cumulative impacts to the quantity or quality of the Great Lakes Basin. Therefore, the pipeline corridors and the return flow discharge locations were selected to protect public health and safety, to provide long-term and sustainable return flow, to minimize environmental impacts, to provide feasible implementation (an alignment that is constructible), to use previously disturbed areas and existing utility corridors, to be consistent with the SEWRPC alignments, to allow the return flow to be used as an environmental resource to the Lake Michigan Basin, and to minimize cost.

The return flow alignments selected follow previously disturbed areas including streets and alleys, bike paths, active and abandoned railroad corridors, utility corridors, and city and county lands. The alignments are discussed below for each return flow alternative. The alignments were developed to a limited level of detail that allows for screening and comparison of alternatives. The concepts do not include the details that will be identified and evaluated in subsequent engineering design phases for the actual project.

Similar infrastructure (a pump station and a pipeline of varying length depending on the alternative) was included for each alternative. Based on the above criteria, return flow to Underwood Creek is the preferred alternative because it protects public health, it has the least environmental impact, it occurs exclusively in previously disturbed areas, it is consistent with SEWRPC's recommended alignment, it will allow the return flow to provide an environmental resource benefit within Underwood Creek, and it is the least costly alignment.

Regardless of the return flow discharge location, the return flow will meet the Compact Section 4.9(4)c and Wisconsin Statute Section 281.346(4)(f)4b requirements of preventing introduction of invasive species into the Great Lakes Basin. This will be accomplished because the City of Waukesha WWTP will prevent invasive species from entering the return flow pipeline, and because the pipeline is only proposed to be connected to only the WWTP and the return flow discharge location.

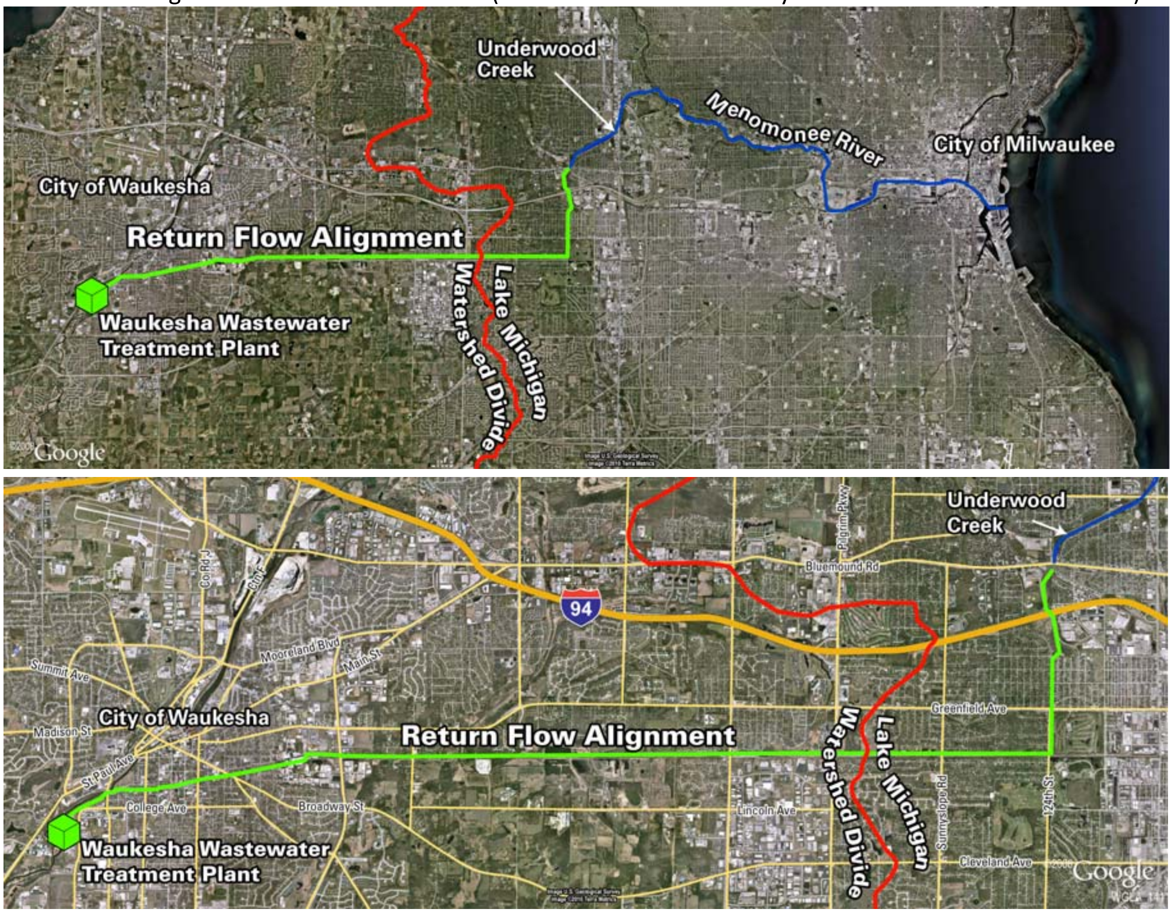
Each alternative is discussed below with additional information and evaluation details included in Appendixes E and N. Because Underwood Creek is the preferred return flow location, it is discussed in detail.

Return Flow to Underwood Creek

Return flow to Underwood Creek is expected to occur in Waukesha County, near the crossing of Underwood Creek and Bluemound Road. At that location, Underwood Creek flows about 2.6 river miles to its confluence with the Menomonee River in Wauwatosa before flowing another 10 river miles to Lake Michigan in the City of Milwaukee.

A screening level layout was developed for the return flow pipeline (Exhibit 5-5). It begins at the City of Waukesha WWTP, and proceeds north and east through a City park and along an alley and minor streets for about 1.3 miles. The pipeline continues east for another 1.3 miles following an abandoned railroad corridor planned for a future recreational trail, where it joins with an utility corridor and bike trail and runs for another 7 miles. The pipeline continues north 1.9 miles along a street and bike path until it ends near the confluence of the north and south branch of Underwood Creek. The return flow discharge elevation is expected to be located at an elevation similar to the bed elevation of Underwood Creek, where the detailed design of the structure will meet the requirements of Wisconsin Statute Section 281.346(4)(f)4c.

EXHIBIT 5-5
Return Flow Alignment to Underwood Creek (creek and river shown only downstream of the return flow)



Environmental Resources

EXHIBIT 5-6
Summary of Potential Environmental Impacts for an Underwood Creek Return Flow

Resource Type	Potential Temporary Impact of Pipeline Corridor
Stream crossings	17
Water body crossings	8
Water body crossing (acres)	0.15
Wetlands (acres)	9.4[a]

[a]For an outfall near Bluemound Road. The impacts are about 5.0 acres for a discharge 0.9 mile upstream.

The return flow pipeline follows corridors that are previously disturbed, and it avoids environmental resources, such as wetlands, stream crossings, and other similar land use categories as much as possible. Some areas of the alignment will have temporary (short-term) impacts to these resources because of the construction-related activities associated with building the pipeline, but there will be no significant adverse short-term impacts. There will also be no long-term significant adverse impacts because the return flow alignment follows an alignment previously disturbed with existing development (e.g. bike path, utility corridor). The impacts to environmental resources (Appendix N) were analyzed for the return flow pipeline corridor, and the Underwood Creek return flow had the least impact of all alternatives. A 75-foot-wide corridor was used along the centerline of the pipeline alignment to assess and compare impacts between alternatives. Exhibit 5-6 summarizes the impacts for the corridor.

The estimated total temporary wetland impacts related to construction are 9.4 acres within the pipeline corridor between the City of Waukesha WWTP and the outfall to Underwood Creek.

Most of the impacts occur in the last 0.9 mile of the alignment, where about 5.3 acres of land are classified as wetlands. This area has been disturbed in the past when the creek was lined with concrete and when a pedestrian trail was recently constructed. The pipeline corridor is located along the pedestrian trail to minimize wetland impacts, but some temporary impacts are estimated for a return flow outfall near Bluemound Road. To reduce these impacts, the outfall could be located upstream of Bluemound Road 0.9 mile. This would reduce the total potential temporary construction impacts from 9.4 acres to about 5.0 acres.

The return flow *discharge* will not adversely impact the environmental resources along the pipeline corridor, but the discharge was analyzed for potential effects on resources within Underwood Creek, Menomonee River, and Lake Michigan. These effects are summarized below.

Flow, Geomorphology, and Habitat

Downstream of the return flow outfall, Underwood Creek is mostly concrete-lined, but in 2009 a 2,400-foot-long segment of lining was removed and rehabilitated with natural channel design features.[2] The rehabilitated creek provides improved habitat because the bottom substrate is coarse grained sediments (gravel and cobbles); it provides various habitat features such as riffles, runs, pools, and glides; it meanders and includes other habitat features like rock boulders; the vegetation will overhang the channel once it is mature; and the creek is reconnected with its floodplain. A preliminary design for rehabilitating an additional 4,400-foot section of creek is complete.[3] When construction is completed it is expected to provide similar environmental resource benefits.

The Underwood Creek design engineers conducted a hydraulic and geomorphic analysis for a City of Waukesha return flow. This analysis used a 20-cfs (12.9-mgd) return flow rate, which provides a conservatively high estimate because it is about 18 percent more than the future average day water demand. The analysis assessed the impacts of return flow to the creek geomorphic stability and concluded that the return flow will have a negligible effect on the geomorphic stability of the rehabilitated creek.[4]

The Underwood Creek watershed is a predominantly urban area. Flow in the creek fluctuates from no flow during dry periods and winter, to high flows during rain events. With the addition of return flow, the return flow would subsequently fluctuate between all the flow in Underwood Creek (e.g., during dry periods) to providing a very small portion of flow during storms. For example, a 20-cfs return flow is only 1.5 to 2.0 percent of the 2-year creek flow (for locations in the creek downstream of the potential return flow location) and 0.29 to 0.76 percent of the 100-year flow.[5]

Return flow effects on the flow in the Menomonee River are similar to Underwood Creek. The Menomonee River is downstream of Underwood Creek, and therefore the river has a much larger watershed and flow rate. Because of this, the return flow is even less of a fraction of the river flow and similar to Underwood Creek, the return flow is also expected not to affect the geomorphic stability of the river. Comparing the same frequency storm events for the river, a 20-cfs return flow is only 0.30 to 0.59 percent of the 2-year flow (for locations in the river downstream of the potential return flow location) and 0.11 to 0.21 percent of the 100-year flow.[6]

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[2] MMSD. 2008. "Watercourse: Underwood Creek Rehabilitation and Flood Management—Phase 1." Designed by Short Elliott Hendrickson, Inc. (SEH).

[3] SEH. 2009. "Underwood Creek Effluent Return Evaluation". Technical memorandum dated July 23, 2009, page 2.

[4] SEH. 2009. "Underwood Creek Effluent Return Evaluation," pages 2, 5.

[5] SEH. 2009. Underwood Creek HEC-RAS Model. Underwood Creek Rehabilitation and Flood Management Project.

[6] MMSD. 2001. Menomonee River HEC-RAS Model. Phase I Watercourse System Management Project. Modified for newer HEC-RAS model v3.1.3.

A habitat assessment was also completed for Underwood Creek and Menomonee River to determine the changes in habitat that could result from return flow to Underwood Creek. The return flow increases the average velocity, cross sectional flow area, shear stress, and the wetted perimeter in the creek and river. The increases are not expected to have a significant effect on the in-stream habitat, but they are expected to benefit the habitat within the creek by reducing the potential for fine sediments to fill the coarse sediment substrate (embeddedness), providing deeper pools and riffles for more functional fish passage, and providing more wetted perimeter to support a greater benthic macroinvertebrate community. Return flow will provide the greatest benefit to in-stream habitat during periods when Underwood Creek has low or no flow. Return flow will eliminate the no flow conditions, and will augment low baseflow flow to provide improved habitat. The return flow is expected to have similar but less significant benefits for the Menomonee River, because the river flow is greater than the creek flow. Appendix L contains additional details of the habitat analysis that was completed for this Application.

Based on the above analysis, the return flow will not adversely impact the physical integrity of Underwood Creek or Menomonee River (as required by the Compact Section 4.9(4)d and Wisconsin Statute Sections 281.346(4)(f)4m and 281.346(4)(f)5).

Fisheries

Fisheries data for the Menomonee River watershed show an apparent net gain of fish species within the watershed. For example, 10 new species have been identified since 1986, and the most recent fishery surveys conducted by the USGS in 2004 and 2007 identified that 12 of the 20 species found in the Menomonee River watershed occurred within Underwood Creek.[7] Underwood Creek is predominantly a concrete channel with little habitat for fish, but the creek provides minimal substrate for macroinvertebrates. The part of the concrete channel removed in 2009 and rehabilitated to a meandering stream channel has numerous pools and riffles, and a substrate composed of gravel, sand, and silt.

Underwood Creek, along with most streams in the Menomonee River watershed, is a warmwater habitat, with an imbalance of number and type of species indicative of a poor quality fishery. Although macroinvertebrate communities within the watershed improved substantially since 1993, the USGS macroinvertebrate data collected in 2007 concluded that Underwood Creek and the Menomonee River range from fairly poor to fair to good, in terms of relative quality based on the presence of specific macroinvertebrates.

With the potential presence of two state-listed threatened fish species in the Menomonee River watershed, there appear to be areas of good river quality within limited parts of the watershed. The poor quality of the fish communities in the watershed is caused mostly by habitat loss. The rehabilitated channel of Underwood Creek contains habitat features that fish and macroinvertebrates can use. Although habitat conditions in Underwood Creek are limiting for the fish and benthic communities, those conditions could be improved by providing more or higher quality habitat. Because return flow is expected to improve habitat, the fish and macroinvertebrate communities would also be expected to improve.

One example of improving fisheries with effluent flow from a WWTP is in southeast Michigan, where the Ypsilanti Community Utilities Authority (YCUA) WWTP uses wastewater effluent as an environmental resource. In 1995, the Lower Rouge River near Detroit began receiving flow augmentation from YCUA effluent. Since then, the Lower Rouge River has been able to support

[7] SEWRPC. 2007. *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds.* Planning Report No. 50. pp. 200–14. Data compilation from MMSD, USGS, and WDNR.

an improved fishery, with the potential for up to 29 species and angling opportunities for 7. Baseflow enhancement has dramatically increased the fishery potential of the Lower Rouge, where the YCUA flow augmentation demonstrates that baseflow enhancement to low flow systems may be a particularly useful tool to enhance sport fish populations.[8] Following a similar precedence for the City of Waukesha, return flow could provide similar opportunities to improve public and natural resources, and provide benefits beyond just maintaining a water balance in Lake Michigan. Underwood Creek experiences extended periods of very low flows and periods of no flow (i.e., a dry creek). Flow augmentation with return flow would eliminate dry periods and could enhance the baseflow in Underwood Creek and Menomonee River to support an improved fishery. Return flow to the creek provides natural resource benefits as it flows on the surface towards Lake Michigan. In contrast, when conveyed in a pipe (e.g., return flow direct to Lake Michigan), the flow does not have an opportunity to provide an environmental benefit.

Flooding

The City of Waukesha will manage the return flow to meet regulatory floodplain management requirements and not to cause additional flood damage downstream of the return flow discharge. The Underwood Creek and Menomonee River watersheds in the Milwaukee area are highly developed with existing residential and commercial buildings very near, and sometimes within, the 100-year flood plain. During a flood in the watershed, floodwaters rise and then subside quickly. To protect downstream properties, conveying floodwaters to the Milwaukee County Grounds floodwater management facility is estimated to last only 6 hours for the 100-year return period storm.[9]

To protect public and private property, there have been significant and ongoing investment in flood control projects. For example, downstream of the return flow location, the MMSD has invested $48 million in the Hart Park flood control project, completed in 2007,[10] and $99 million in the County Grounds flood control project, to be completed in 2010.[11] Other projects have been completed or are planned elsewhere in the watershed. Each project contributes to providing flood protection to neighboring and downstream residents. Although return flow is a very small percentage of flow during a flood, if an extreme flood condition threatens personal property or public investments, return flow would be temporarily paused. This will not affect the City of Waukesha's goal of providing 100 percent return flow because based on the duration of flooding events, the paused return flow is not anticipated to be significant.

Water Quality

The City of Waukesha will provide return flow with water quality that not only meets but also exceeds the discharge requirements stipulated by the Wisconsin Pollutant Discharge Elimination System (WPDES). The City of Waukesha will also meet future water quality effluent standards that are at least as stringent as those currently imposed.

The WDNR has provided the City of Waukesha with proposed effluent limits for discharge to a Lake Michigan tributary.[12] Effluent limits for two other in-basin municipal dischargers to Lake Michigan tributaries were obtained for comparison purposes. The WDNR-proposed effluent limits for the City of Waukesha are more stringent than the other Lake Michigan tributary dischargers

[8] Michael Wiley, P. Seelbach, and S. Bowler. 1998. *Ecological Targets for Rehabilitation of the Rouge River.* School of Natural Resources and Environment. University of Michigan. Final Report, April 30. Page 7, 13, and 18.

[9] HNTB. 2006. *Environmental Assessment Milwaukee County Grounds Floodwater Management Facility and Underwood Creek Rehabilitation Projects.*

[10] MMSD. http://v3.mmsd.com/hartparkproject.aspx. Accessed January 13, 2010.

[11] MMSD. http://v3.mmsd.com/milwaukeecogrounds.aspx. Accessed January 13, 2010.

[12] WDNR letter from Duane Schuettpelz. October 16, 2008.

(Exhibit 5-7). Because the City is committed to maintaining high quality effluent from their WWTP, the return flow will meet WPDES requirements with any alternative return flow location.

EXHIBIT 5-7
Comparison of WDNR-Proposed WPDES Limits to
Historical WWTP Performance and Other Lake Michigan Tributary Dischargers

	City of Waukesha Potential Return Flow			
Water Quality Parameter	WDNR-Proposed Limit for Lake Michigan Tributary Return	Waukesha Historic Average[a]	Lake Michigan Tributary WWTP Discharger #1[b]	Lake Michigan Tributary WWTP Discharger #2[c]
Biological oxygen demand, mg/L	≤ 5.0 to ≤ 10.0	1.8	≤ 10.0 to ≤ 15	≤ 30.0 monthly avg.
Total suspended solids, mg/L	≤ 5.0 to ≤ 10.0	1.2	≤15.0	≤ 30.0 monthly avg.
Dissolved oxygen, mg/L	≥ 7.0	9.2	≥ 6.0	≥ 6.0
Phosphorus, mg/L	≤ 1.0	0.16	≤ 1.0	≤ 1.0
Ammonia (NH_3-N), mg/L	Likely lower than current range of 2.0 to 6.0	< 1.0	3.3 to 6.4 monthly avg.	6.3 to 12.0 monthly avg.

[a]October 1, 2002, to August 31, 2009.
[b]WPDES Permit No. WI-0020222-08-0
[c]WPDES Permit No. WI-0020184-08-0

The City of Waukesha WWTP has water quality limits for several other parameters, including chlorides, which the WDNR has indicated would continue to be regulated.[13] As noted in Section 4, a Lake Michigan water supply will eliminate the need for Utility customers to soften water with salt. As a result, the chloride concentration from WWTP-treated return flow is expected to decrease in the future.

The temperature of the WWTP discharge varies seasonally, with the warmest month of August averaging 70°F (21.3°C) and the coolest month of February averaging 53°F (11.5°C). This type of seasonal variation is typical at municipal WWTPs. The current discharge to the Fox River meets temperature requirements and consequently, return flow temperatures will meet temperature requirements (Wisconsin Statute Section 281.346(4)(f)4m).

Underwood Creek and Menomonee River Water Quality

Underwood Creek is classified as a warm water fishery under the WDNR fish and aquatic life standards, but it has a variance in Milwaukee County for dissolved oxygen and fecal coliform.[14] The Menomonee River downstream of Underwood Creek is also classified as a warm water fishery under the WDNR fish and aquatic life standards, but it has the same dissolved oxygen and fecal coliform variances from Honey Creek to the mouth of the river (about 5 miles downstream of the proposed return flow location).[15]

A reach of Underwood Creek in Waukesha County, upstream of the proposed return flow discharge location, is proposed to be included on the 2010 303(d) list for fecal coliform as a recreational restriction.[16] Similarly, the last 2.67 miles of the Menomonee River is proposed to be included on the 2010 303(d) list for fecal coliform as recreational restrictions. The Menomonee River is currently

13 Ibid.
14 NR 104.06(2) Water Quality Standards for Wisconsin Surface Waters.
15 Ibid.
16 http://dnr.wi.gov/org/water/wm/wqs/303d/303d.html accessed January 19, 2010.

on the 303(d) list in the same stretch of river for PCBs from contaminated sediment, *E. coli* bacteria for recreational restrictions, total phosphorus for low dissolved oxygen, and unspecified for chronic aquatic toxicity. These listings were all made in 1998.[17] More recently, SEWRPC completed a detailed analysis of water quality in the Menomonee River and found that the dissolved oxygen variance standard was always met for the 11-year period of record analyzed.[18]

Water quality in Underwood Creek and the Menomonee River was extensively studied in SEWRPC's *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds*. Findings for the 11-year period of record under SEWRPC's existing condition scenario are summarized below for three points closest to the proposed return flow location. Additional water quality analysis was completed for the current conditions in Underwood Creek and Menomonee River, and for conditions with return flow (Appendix H).

Fecal Coliform. Underwood Creek and Menomonee River sometimes meet fecal coliform standards during the summer recreational season. The overall compliance for the single sample standard is met 67 to 86 percent of the time. The geometric mean fecal coliform concentration for the summer season ranges from 351 to 496 cells/100 mL.[19]

The historical performance at the City of Waukesha WWTP for the summer recreation season (May through October) had geometric mean fecal coliform concentration ranging from 2 to 49 cells/100 mL. Because the return flow fecal coliform concentration is much lower than the existing conditions and water quality standards in Underwood Creek and Menomonee River, the average fecal coliform concentration with return flow will improve. To provide this improvement with return flow, and because portions of Underwood Creek and Menomonee River are proposed to be listed on the 303(d) list for fecal coliform, the City of Waukesha is proposing to disinfect the return flow to protect (and improve) the chemical and biological integrity of Underwood Creek, Menomonee River, and Lake Michigan.

Dissolved Oxygen. The SEWRPC study predicted that Underwood Creek and Menomonee River comply with the standards of maintaining 5 mg/L of dissolved oxygen (2 mg/L for variance standard). The City of Waukesha WWTP historical performance for average dissolved oxygen concentration ranges from 7.9 to 10.5 mg/L. Because the return flow concentration is greater and has a very low concentration of biological oxygen demand, the average dissolved oxygen concentration in Underwood Creek and the Menomonee River would be expected to continue to meet water quality standards.

Total Phosphorus. Underwood Creek and Menomonee River meet the SEWRPC planning level goal of 0.1 mg/L 66 to 84 percent of the time. The City of Waukesha WWTP historical performance for monthly average phosphorus concentration ranges from 0.10 to 0.24 mg/L. Phosphorus concentration in Underwood Creek and the Menomonee River is expected to increase as a result of return flow, but the effect of the increased concentration is expected to be minimal as described below in "Return Flow Water Quality Modeling" and in Appendix H.

Total Suspended Solids. The average total suspended solids in Underwood Creek and the Menomonee River are always less than the total suspended solids reference background concentration of 17.2 mg/L used in the SEWRPC modeling. The City of Waukesha WWTP historical performance for total suspended solids concentration ranges from 0.9 to 1.8 mg/L. Because the

[17] Ibid.

[18] SEWRPC. 2007. *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds,* Appendix N, Planning Report Number 50.

[19] Ibid.

return flow total suspended solids are much lower than the background concentration, the average total suspended solids concentration is expected to improve in Underwood Creek and the Menomonee River as a result of return flow.

Return Flow Water Quality Modeling

Underwood Creek Water Quality. Water quality modeling was conducted for the Underwood Creek return flow alternative. Modeling included existing conditions in Underwood Creek with expected Waukesha return flow concentration and also a "worse case" scenario having high flows and higher concentrations in the discharge (but still within permit limits). Appendix H contains the detailed water quality modeling conclusions and also the detailed findings.

The water quality modeling found that average water quality improved or continued to meet water quality standards or background reference concentrations for three of four water quality parameters (fecal coliform, dissolved oxygen, and total suspended solids). For the fourth water quality parameter (phosphorus), concentrations increased and were more frequently higher than the planning level goal used in the SEWRPC modeling (0.1 mg/L). However, the modeling results indicate that with return flow, nuisance algae growth will decrease in Underwood Creek and Menomonee River. The WDNR is developing new phosphorus standards that are intended to prevent in-stream algae and plant growth to the extent that is detrimental to fish and aquatic life as determined by intensive field studies.[20] The proposed standards would further reduce the phosphorus discharge concentration in the return flow. The WDNR is hosting public comment hearings for the new standard in April 2010, with the intent of finalizing the standard in 2010. The City of Waukesha will provide return flow with water quality that meets effluent requirements, regardless of the discharge location.

Lake Michigan Water Quality. The return flow is ultimately conveyed to Lake Michigan. Consequently, water quality information was reviewed for overall water quality parameter loadings from the greater Milwaukee watersheds tributary to Lake Michigan. SEWRPC compiled total annual water quality parameter loadings for all the greater Milwaukee watersheds.[21] The contribution of the City of Waukesha return flow loadings was calculated using the information from the water quality modeling documented in Appendix H and then compared to the SEWRPC annual average load findings. The analysis indicates the following:

- Fecal coliform contribution in the return flow under very conservative "worst case" conditions is only 0.20 percent of all fecal coliform loading from the greater Milwaukee watersheds.
- Total suspended solids contribution in the return flow under very conservative "worst case" conditions is only 0.21 percent of all total suspended solids loading from the greater Milwaukee watersheds.
- Phosphorus contribution in the return flow is only 1.23 percent of all phosphorus loading even under "worst case" conditions and only 0.62 percent of all phosphorus loading when considering the City of Waukesha's WWTP historic performance. These contributions could be even less because the WDNR is considering new phosphorus regulations that could require more stringent phosphorus discharge limitations.

As required by the Compact Section 4.9(4)d and Wisconsin Statute Sections 281.346(4)(f)4m and 281.346(4)(f)5, the return flow water quality will not have a significant adverse impact on

[20] http://www.dnr.wi.gov/org/nrboard/2010/March/03-10-3A5.pdf. Page 2. Accessed March 12, 2010.

[21] SEWRPC. 2007. *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds,* Tables 54–56. Planning Report Number 50,

the Lake Michigan Basin. For some parameters, such as Fecal Coliform, the return flow will allow Underwood Creek and Menomonee River to meet their water quality standards more often.

Cost Estimate

Exhibit 5-8 summarizes the screening-level cost estimate, based on return flow to the creek through a pump station at the City of Waukesha WWTP, a pipeline, and an outfall to the creek. Appendixes E and M contain additional information. These cost estimates were prepared for guidance in comparing alternatives based on information available at the time of the estimate. Detailed engineering design has not been completed. The final cost estimate of any project will depend on market conditions, site conditions, final project scope, schedule, and other variable factors. As a result, final project costs may vary from the estimates presented here.

EXHIBIT 5-8
Screening Level Cost Estimate for Return Flow to Underwood Creek

Return Flow Alternative	Capital Cost[a]	Annual Operations and Maintenance	20-Year Present Worth	50-Year Present Worth
Underwood Creek	$56,174,000	$119,000	$57,539,000	$58,050,000

[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

Return Flow to Root River

The Root River flows through parts of Milwaukee and Racine counties, and into Lake Michigan at Racine, Wisconsin. The river has more natural channel (e.g., natural bottom substrate and vegetated river banks) than does Underwood Creek, and it has a mixture of land uses between its headwaters and Lake Michigan. The headwaters of the Root River are heavily urbanized, the middle reaches are primarily agriculture and lower density development, and the lower parts of the watershed near Lake Michigan are heavily urbanized.

The conceptual pipeline alignment for return flow to the Root River is the same as the pipeline for Underwood Creek for about the first 9.6 miles. Where the Underwood Creek pipeline heads north toward Underwood Creek, the Root River pipeline would head southeast for 6 miles toward the Root River (Exhibit 5-9) following streets, a parkway, and a bike trail.

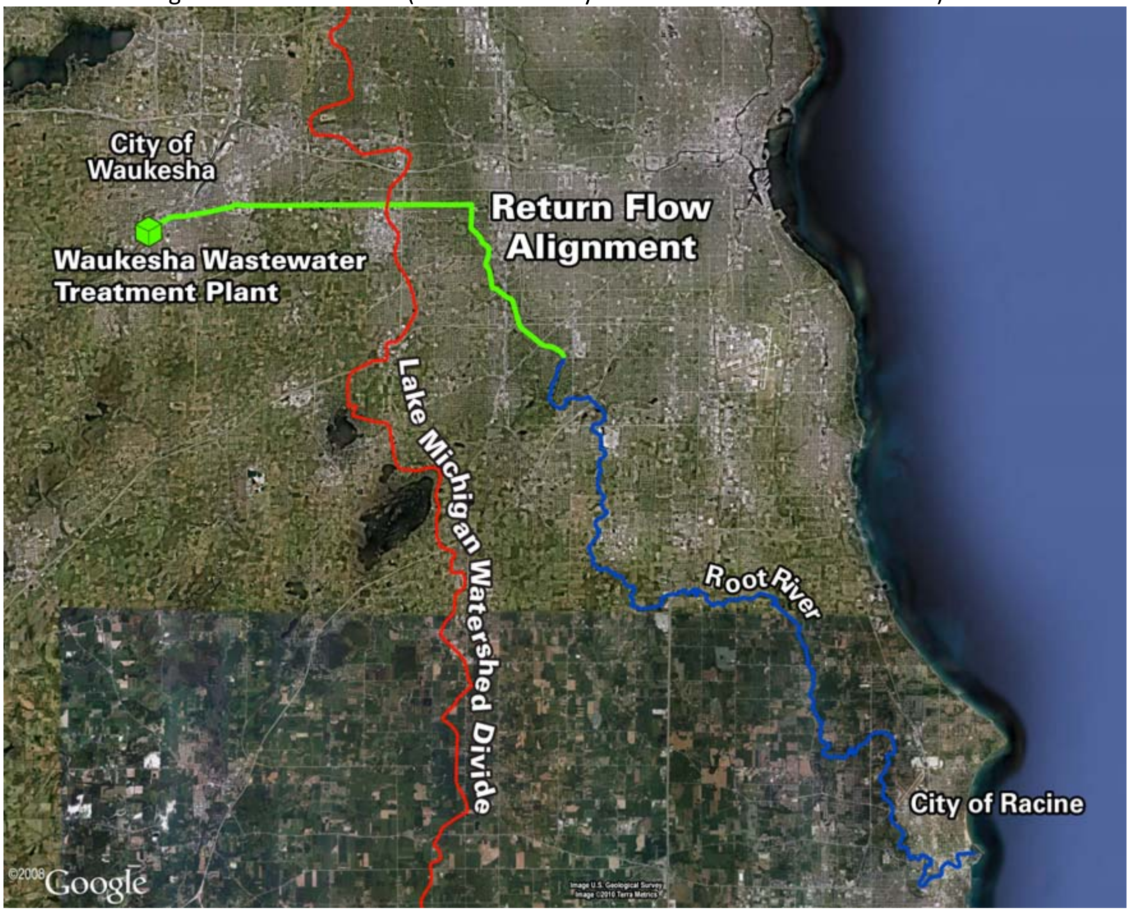
The outfall location is farther downstream than the location considered by SEWRPC.[22] This downstream location was chosen to allow for a watershed size and river flow rate similar to that of the Underwood Creek outfall location (i.e., the SEWRPC outfall location was farther upstream on the Root River, where the watershed was smaller). Having similar watershed areas allows the Root River and Underwood Creek return flow locations to be more readily compared for a resulting return flow discharge.

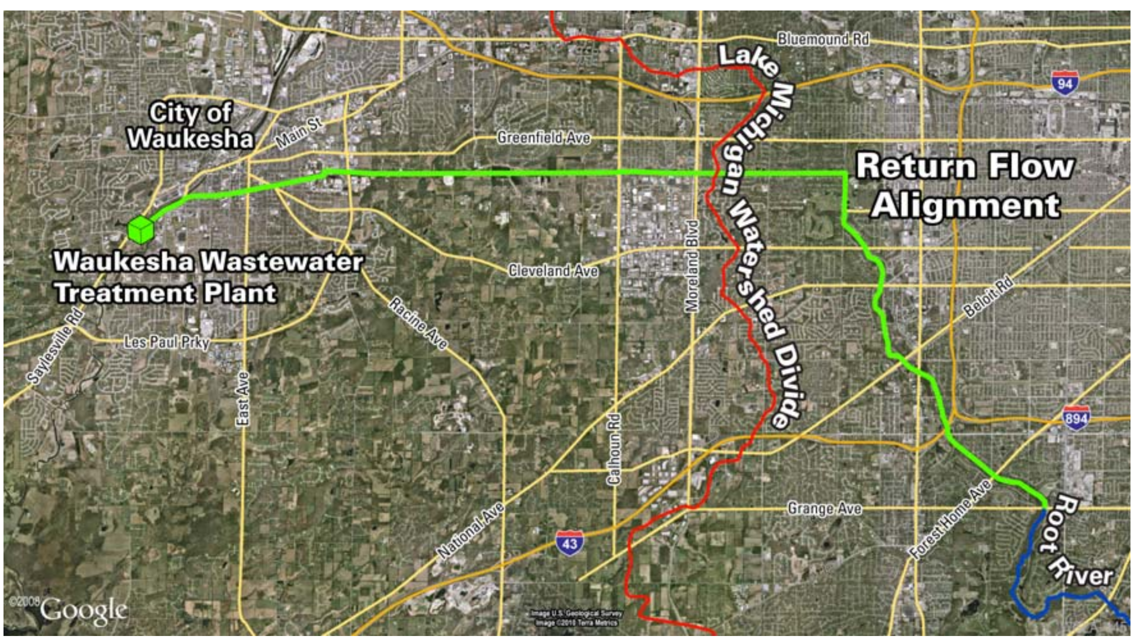
Environmental Resources

Similar to the Underwood Creek alignment, the Root River alignment follows corridors that are previously disturbed and avoids such environmental resources as wetlands and stream crossings as much as possible. Some areas of the alignment will have temporary (short-term) impacts to these resources because of construction activities associated with building the pipeline, but there will be no long-term significant adverse impacts.

[22] SEWRPC. 2008. *A Regional Water Supply Plan for Southeastern Wisconsin,* Chapter 9, Map IX-8. Planning Report No. 52.

EXHIBIT 5-9
Return Flow Alignment to Root River (river shown only downstream of the return flow)





Impacts to environmental resources were analyzed for the return flow pipeline corridor (Appendix N). The Root River alignment has greater environmental impacts than does the Underwood Creek alignment, primarily because the Root River is a more natural channel than Underwood Creek, which results in more environmental resources are near the Root River. A 75-foot-wide corridor was used along the centerline of the pipeline alignment to assess and compare impacts between alternatives. Exhibit 5-10 summarizes the impacts for the corridor.

EXHIBIT 5-10
Summary of Potential Environmental Impacts for a Root River Return Flow

Resource Type	Potential Temporary Impact of Pipeline Corridor
Stream crossings	24
Water body crossings	9
Water body crossings (acres)	0.34
Wetlands (acres)	12.4

The return flow discharge will not negatively impact the environmental resources along the pipeline corridor. Instead, the discharge was analyzed for its impact on resources within the Root River.

Flow, Geomorphology, and Habitat

The Milwaukee Metropolitan Sewerage District completed a comprehensive study of the Root River in 2007 within MMSDs jurisdiction. The primary purposes of the study were to baseline the existing channel stability in the North Branch of the river and provide hydrologic, hydraulic and sediment transport predictions on the vertical and lateral stability of the river and tributary channels.[23] The study area included the location where return flow is proposed. The results of the study were used, in part, to evaluate the effect of a return flow discharge on the flow, geomorphology, and habitat within the Root River. The flow, geomorphology, and habitat impacts from a Root River return flow were also evaluated in comparison to Underwood Creek. A general comparison can be made because the watersheds border each other and they have similar size, land use, and urbanization at the discharge location.

The Root River has a more natural channel than does Underwood Creek, and it is longer from the discharge location to the confluence with Lake Michigan. With the greater length, there is a greater opportunity for habitat enhancements by augmenting the flow in the Root River with return flow. Similar to Underwood Creek, flow in the Root River sometimes is very low, and the functional habitat in the river is limited by the river flow. Augmentation of the return flow would eliminate the very low flow periods. Because the return flow rate is small compared to the higher flows in the river, return flow is not expected to adversely impact the geomorphic stability of the river. For example, a 20-cfs return flow is about 5 percent of the 2-year river flow in the reach at the discharge location, and about 2.2 percent at the next reach about 1.3 miles downstream of the return flow outfall location.[24] For a 100-year river flow at the two locations, the return flow is about 0.5 and 0.8 percent. These are similar to the Underwood Creek flow, where a detailed evaluation concluded that the return flow would not adversely impact the geomorphic stability of the rehabilitated parts of the creek. In addition, the MMSD sediment transport study of the Root River concluded that the river stability is relatively insensitive to changes in flows because of the erosion resistance of the channel boundary materials, the relatively flat channel gradient, and the presence of a functional floodplain.[25] Consequently, the return flow is not expected to adversely impact the Root River.

23 MMSD. May 4, 2007. *Root River Sediment Transport Planning Study.*

24 MMSD. May 4, 2007. *Root River Sediment Transport Planning Study.* Hydraulics Technical Memorandum 3. HEC-RAS model from enclosed CD.

25 MMSD. May 4, 2007. *Root River Sediment Transport Planning Study.* Hydraulics Technical Memorandum 6. Page 1.

Beneficial habitat effects in the Root River are expected to be similar to those for Underwood Creek and Menomonee River. Because the Root River is longer and has more natural channel (compared to concrete in Underwood Creek) downstream of the return flow location, more habitat benefits are expected. However, because the return flow is a small part of the river flow as the river continues downstream, the habitat benefits are not expected to be significant, similar to Underwood Creek and the Menomonee River.

Fisheries

Fishery data for in the Root River watershed show that 10 new species have been identified, but 10 of 64 recorded species have not been observed since 1986.[26] The most recent fishery surveys, conducted in 2004 and 2007 by the USGS, identified 17 species in the Root River near the proposed return flow location. Some of the new species were observed in reaches of the Root River between the confluence with Lake Michigan and the first dam, suggesting that Lake Michigan's fish community may be influencing the fish community of the lower reaches of the watershed. The Root River is a warmwater habitat, where the balance of fish species indicates a fair quality fishery overall in the watershed that is higher in quality than that of the Menomonee River watershed. Macroinvertebrate data collected within the Root River watershed suggest that the river is dominated by species tolerant of a low quality habitat. Most species within the fish and macroinvertebrate communities generally indicate fair habitat quality.

With the potential presence of one state-listed endangered and three state-listed threatened fish species, there appear to be areas of good quality within parts of the watershed, but there is also impairment because of the agricultural and urban development. The Root River watershed has relatively few streambed and bank modifications, with less than 1 percent of the stream channel observed being in conduit and none lined with concrete. Although habitat conditions in the Root River are fair to good, habitat could be improved by providing more or higher quality habitat. Because return flow would be expected to improvement habitat somewhat, the fish and macroinvertebrate communities could also be expected to improve.

Flooding

Similar to the managed return flow to Underwood Creek, flow would be returned to the Root River in a manner that meets regulatory floodplain management requirements and without causing additional flood damage.

Water Quality

The Root River is classified as a warm water fishery under the WDNR fish and aquatic life standards. The Root River at the potential return flow discharge location is on the 303(d) list for low dissolved oxygen with reported causes from sediment and phosphorus.[27] In addition, the last roughly 6-miles of the Root River upstream of Lake Michigan is on the 303(d) list for PCBs. These listings were all made in 1998.[28] More recently, SEWRPC modeled water quality in the Root River in great detail and found that dissolved oxygen predictions met the standard between 95 and 100 percent of the time for the 11-year period of record analyzed.[29] The water quality findings for

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[26] SEWRPC. 2007. *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds.* Planning Report No. 50. pp. 200–14. Data compilation from MMSD, USGS, and WDNR.

[27] http://dnr.wi.gov/org/water/wm/wqs/303d/303d.html accessed January 19, 2010.

[28] Ibid.

[29] SEWRPC. 2007. *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds,* Appendix N. Planning Report Number 50.

SEWRPC's existing condition scenario are summarized below for three points closest to the proposed return flow location.

Fecal Coliform. The Root River sometimes meets fecal coliform standards during the summer recreational season, where the compliance for the single sample standard is met 58 to 66 percent of the time. The geometric mean fecal coliform concentration for the summer season ranges from 603 to 770 cells/100 mL.[30] The historical performance at the City of Waukesha WWTP for the summer recreation season (May through October) had geometric mean fecal coliform concentration ranges from 2 to 49 cells/100 mL. Because the return flow fecal coliform concentration is much lower than the existing conditions and water quality standards in the Root River, the average fecal coliform concentration with return flow will improve.

Dissolved Oxygen. The SEWRPC study predicted that the Root River would comply with the standards of maintaining 5 mg/L of dissolved oxygen 95 to 100 percent of the time. The City of Waukesha WWTP historical performance for average dissolved oxygen concentration ranges from 7.9 to 10.5 mg/L. Because the return flow concentration is greater and has a very low concentration of biological oxygen demand, the average dissolved oxygen concentration in the Root River could improve compliance with water quality standards.

Total Phosphorus. The Root River meets with the SEWRPC planning level goal of 0.1 mg/L 73 to 84 percent of the time. The City of Waukesha WWTP historical performance for monthly average phosphorus concentration ranges from 0.10 to 0.24 mg/L. Phosphorus concentration in the Root River is expected to increase as a result of return flow. However, the environmental change with an increase in phosphorus could be limited, as described in the Underwood Creek water quality modeling conclusions.

Total Suspended Solids. The average total suspended solids in the Root River ranges from 10.3 to 19.4 mg/L. The historical performance of the City of Waukesha WWTP for total suspended solids concentration ranges from 0.9 to 1.8 mg/L. Because the return flow total suspended solids are much lower than the current concentration, the average total suspended solids concentration is expected to improve in Underwood Creek and the Menomonee River as a result of return flow.

Lake Michigan. Return flow under all alternatives is ultimately to Lake Michigan. The comparison of the return flow water quality loading to that of the greater Milwaukee watersheds is the same as that summarized in the Underwood Creek alternative.

Cost Estimate

Exhibit 5-11 summarizes the screening-level cost estimate for this alternative. The costs were based on return flow to the river through a pump station at the City of Waukesha WWTP, a pipeline, and an outfall to the river. Appendixes E and M contain additional information.

EXHIBIT 5-11
Screening Level Cost Estimate for Return Flow to Root River

Return Flow Alternative	Capital Cost[a]	Annual Operations and Maintenance	20-Year Present Worth	50-Year Present Worth
Root River	$75,963,000	$145,000	$77,627,000	$78,249,000

[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

30 Ibid.

Return Flow Directly to Lake Michigan

A screening-level alignment for return flow directly to Lake Michigan was developed to evaluate the environmental effects and costs (Exhibit 5-12). The conceptual pipeline alignment is the same as that for Underwood Creek and Root River for about the first 9.6 miles. Where the two pipelines diverge, the Lake Michigan alignment continues east about 11.2 miles parallel to a railroad corridor. As the alignment nears Lake Michigan, it continues east about 1.2 miles along a city street where it intersects with the lake. The alignment extends into Lake Michigan about 0.5 mile to provide an offshore outfall.

EXHIBIT 5-12
Return Flow Alignment Direct to Lake Michigan

The alignment is that developed by SEWRPC, except the last segment of is a few city blocks to the north. The city street used for the last segment is larger and the shoreline at Lake Michigan has been previously disturbed and is undeveloped compared to the SEWRPC alignment. This alignment appears to have slightly less constructability challenges and is shorter in distance than the alignment developed by SEWRPC.

Environmental Resources

Similar to the Underwood Creek and Root River alignments, the alignment follows corridors that are previously disturbed and avoids environmental resources such as wetlands, stream crossings, and other similar land uses as much as possible. Some areas of the alignment will have temporary (short-term) impacts to these resources because of construction activities associated with building the pipeline. A minor adverse impact may occur in this alternative where the outfall is constructed within Lake Michigan for an offshore discharge.

The impacts to environmental resources were analyzed (Appendix N) for the return flow pipeline corridor. The alignment has greater environmental impacts than the other two, primarily because it is much longer and includes construction an outfall within Lake Michigan. A 75-foot-wide corridor was used along the centerline of the pipeline alignment to assess and compare impacts between alternatives. Exhibit 5-13 summarizes the environmental impacts along the corridor.

EXHIBIT 5-13
Summary of Potential Environmental Impacts for Return Flow Direct to Lake Michigan

Resource Type	Potential Impact of Pipeline Corridor
Stream crossings	19
Water body crossings	8
Water body crossings (acres)	6.5
Wetlands (acres)	5.4

The return flow discharge will not adversely impact the environmental resources along the pipeline corridor. Instead, a direct discharge was analyzed for the potential impacts on resources in Lake Michigan.

Flow, Geomorphology, and Habitat

The same as the Underwood Creek and Root River alternatives, return flow directly to Lake Michigan does not cause significant adverse impacts to the flow, geomorphology, or habitat in the lake. As discussed under "Return Flow Alternatives," for discharges to Underwood Creek or Root River, the return flow is able to provide a resource benefit by providing additional flow in the creek and river during periods when little or no flow is naturally present. The return flow to a Lake Michigan tributary could provide benefits to habitat with flow augmentation while not adversely affecting geomorphic stability. In contrast, return flow directly to Lake Michigan would have no environmental benefit because the return flow would be conveyed in a pipe, instead of through a surface water where the additional flow could benefit the water dependent natural resources in the Great Lakes Basin. Consequently, return flow directly to Lake Michigan is the least preferred alternative because the return flow is not able to be used as a resource.

Fisheries

Return flow directly to Lake Michigan will not have a significant adverse impact to fisheries in Lake Michigan. The outfall construction would have a minor adverse impact upon Lake Michigan substrate and the return flow water quality loading is small as described above. Consequently, there will be no significant adverse impact on Lake Michigan fisheries.

Water Quality

Under all alternatives, flow ultimately is returned to Lake Michigan. The comparison of water quality loading to that of the greater Milwaukee watersheds is the same as that summarized in the Underwood Creek alternative.

Cost Estimate

Exhibit 5-14 summarizes the screening-level cost estimate for this alternative. Costs were based on return flow to Lake Michigan through a pump station at the City of Waukesha WWTP, a pipeline, and an outfall to the lake. Appendixes E and M contain additional information.

EXHIBIT 5-14
Screening Level Cost Estimate for Return Flow Direct to Lake Michigan

Return Flow Alternative	Capital Cost[a]	Annual Operations and Maintenance	20-Year Present Worth	50-Year Present Worth
Direct to Lake Michigan	$109,848,000	$159,000	$111,672,000	$112,355,000

[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

Return Flow through the Milwaukee Metropolitan Sewerage District

The MMSD operates regional sewage collection and water reclamation systems for most communities within the Lake Michigan Basin in the Milwaukee metropolitan area. Under this return flow alternative, the City of Waukesha sanitary sewer system would collect flow from its sanitary sewer service area and convey return flow to MMSD for treatment and discharge to Lake Michigan. There are two subalternatives for return flow to MMSD:

- Sanitary sewer flow treated at the City of Waukesha WWTP with return flow to MMSD
- Sanitary sewer and return flow conveyed to MMSD without treatment at the Waukesha WWTP

For either option, a new pump station would be located at the WWTP, and a pipeline alignment would be selected to provide return flow while minimizing impacts to environmental resources and other land uses. The City would continue to operate a WWTP, even for the subalternative where the City would return untreated sanitary sewer flow to the MMSD. Continued WWTP operation would occur because there are periods when sanitary sewer flow exceeds the water withdrawal. To prevent returning more than 100 percent of the withdrawn water, discharge to the Fox River for the additional sanitary sewer flow would continue. This intermittent operation of the WWTP would not be possible without significant modification of the existing WWTP processes.

For either subalternative, improvements to the MMSD collection system and treatment plants are likely 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.

As with returning flow directly to Lake Michigan, returning flow to MMSD does not allow the return flow to be used as a resource, because the flow would not be in a Lake Michigan tributary. For the subalternative with treatment of return flow at the City of Waukesha WWTP and MMSD, the return flow would be inefficiently using resources by providing double-treatment with no significant improvement in return flow water quality.

SEWRPC included the MMSD alternative in its evaluation of return flow alternatives, but the MMSD alternative was not recommended because the cost exceeded that of return flow directly to Lake Michigan and to a Lake Michigan tributary.[31] Consequently, this alternative was not evaluated further for these reasons, and for those discussed above.

Preferred Return Flow Alternative

The City of Waukesha is committed to providing return flow for the withdrawn water, with a goal of returning 100 percent of it as discussed under "Return Flow Management Plan." Returning flow through Underwood Creek or Root River, or directly to Lake Michigan, can be achieved, but return flow through Underwood Creek is preferred because it has the least environmental impact, it maximizes use of existing utility corridors and previously disturbed areas, and the discharge can be used as an environmental resource by improving the habitat and fisheries in Underwood Creek and the Menomonee River. Exhibit 5-15 summarizes the environmental impacts for the return flow alternatives for a 75-foot-wide corridor along the pipeline alignments.

EXHIBIT 5-15

Summary of Potential Environmental Impacts for the Pipeline Alignment Alternatives

Return Flow Alternative	Stream Crossings	Water Body Crossings	Water Body Crossings (acres)	Wetlands (acres)
Underwood Creek	17	8	0.15	9.4[a]
Root River	24	9	0.34	12.4
Direct to Lake Michigan	19	8	6.5	5.4

[a]For an outfall near Bluemound Road. The impacts are about 5.0 acres for a discharge 0.9 mile upstream.

31 SEWRPC. 2008. *A Regional Water Supply Plan for Southeastern Wisconsin*, Chapter 9, Page 37. Planning Report No. 52.

Return flow to Underwood Creek also will protect public health by providing return flow with water quality that meets or exceeds the effluent limits proposed by the WDNR (as required by Compact Section 4.9(4)c). The WDNR proposed return flow effluent limits would be a higher standard than that from other Lake Michigan tributary dischargers.

Return flow through Underwood Creek is also significantly less costly than the other alternatives. Because return flow to Underwood Creek and Root River has similar benefits, the additional cost and additional impacts further support Underwood Creek as the preferred alternative. Exhibit 5-16 summarizes the cost estimates for return flow under the three alternatives studied. Flow returned directly to Lake Michigan is least preferred because it does not allow the discharge to provide an environmental resource, and it is the highest cost. A cost estimate for return flow to MMSD was not made, because the alternative is not being considered further.

EXHIBIT 5-16
Cost Comparison for Return Flow Alternatives

Return Flow Alternative	Capital Cost[a]	Annual Operations and Maintenance	20-Year Present Worth	50-Year Present Worth
Underwood Creek	$56,174,000	$119,000	$57,539,000	$58,050,000
Root River	$75,963,000	$145,000	$77,627,000	$78,249,000
Direct to Lake Michigan	$109,848,000	$159,000	$111,672,000	$112,355,000

[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

The proposed return flow to Underwood Creek complies with Sec. 281.346(4)(f)3m of providing the return flow to the source watershed as close as practicable to the withdrawal location. Comparing the Underwood Creek return flow location to a return flow direct to Lake Michigan location, Underwood Creek is more economically feasible, environmentally sound, and protective of human health for the following reasons:

- The location where the return flow is conveyed to Lake Michigan is the same as the withdrawal area . The water withdrawal will be from Lake Michigan in the Milwaukee area (Section 4) and return flow is proposed to be conveyed to Lake Michigan through Underwood Creek and Menomonee River in Milwaukee.
- A return flow directly to Lake Michigan is about double the cost ($53.7 million more) than a return flow to Underwood Creek. A return flow direct to Lake Michigan is not fiscally responsible when providing less of an environmental benefit compared to return flow to a Lake Michigan tributary and is not economically feasible.
- A return flow direct to Lake Michigan provides a water balance in the basin, but it has more environmental impacts compared to discharge to Underwood Creek. The outfall construction in Lake Michigan has a pipeline that is longer than any other alternative and subsequently has more environmental impacts. A return flow to Underwood Creek provides a water balance in the basin and it has more environmental benefits. Because a return flow to Underwood Creek has more environmental benefits, a return flow direct to Lake Michigan is not environmentally sound.
- Underwood Creek and Menomonee River often do not meet water quality standards for fecal coliform bacteria, but return flow will improve the water quality by allowing the creek and river to meet their water quality standards more often. This is accomplished because

the City of Waukesha's WWTP produces a very high quality treated water that will provide high quality return flow. The return flow increases the time that Underwood Creek and Menomonee River meets its water quality standards, which is in the interest of public health. A return flow direct to Lake Michigan does not provide this public health benefit to Underwood Creek or Menomonee River.

The proposed return flow to Underwood Creek complies with the Compact Section 4.9(4)d and Wisconsin Statute Section 281.346(4)(f)5 of providing the return flow with no significant individual or cumulative adverse impact. Return flow will be implemented to ensure that no significant individual or cumulative adverse impacts result to the quantity and quality of the waters and water dependent natural resources of the basin. The Application proposal maintains, and in some cases improves, the chemical, physical, and biological integrity of the Great Lakes Basin as discussed above regarding Underwood Creek under "Return Flow Alternatives."

The return flow management plan has met the Compact and Wisconsin requirements for return flow with no exceptions and it sets a high standard for obtaining a Great Lakes water supply because the Application exceeds the requirements in the following ways:

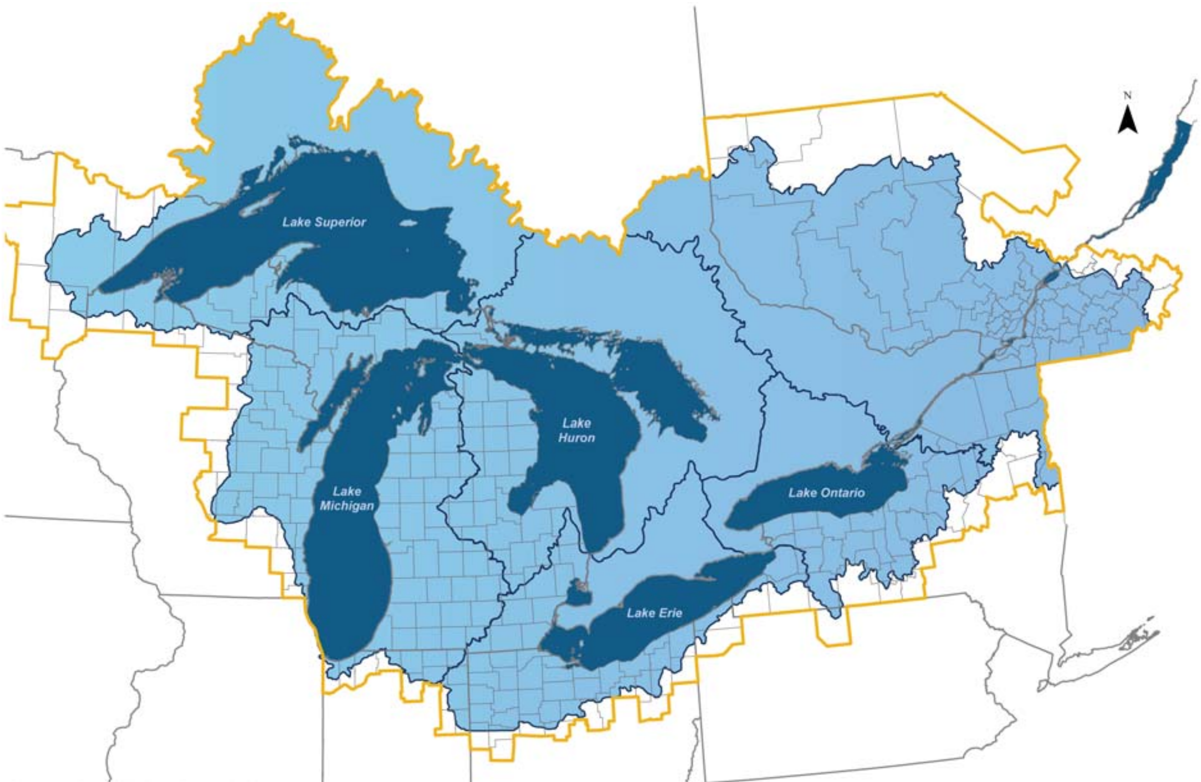
- The City of Waukesha has a return flow goal that is greater than water supply less consumptive use. The return flow goal has been set at 100 percent, which is higher than the Compact requirement.
- Return flow will be used as a resource to benefit habitat, fisheries, and water quality in a Lake Michigan tributary.
- Return flow water quality is more stringent than other Lake Michigan tributary dischargers and will improve the water quality in Underwood Creek by allowing the creek to meet water quality standards more often.

Any future application by others must follow the Compact requirements and will be evaluated at that time on its own merit. The Compact was developed to regulate Great Lakes diversions. Because the return flow management plan meets all the requirements without exception and exceeds some requirements, it would create a high standard if it were to be used as a precedent in the future. By proposing to exceed the Compact and Wisconsin requirements, the City of Waukesha has set a precedent beyond that which is required.

There are few communities with significant populations that are outside the Great Lakes Basin, within a straddling County, and as close to Lake Michigan as the City of Waukesha. Consequently, the Compact diversion exception standard is applicable to few communities of similar size to Waukesha and, communities further away will find a diversion less feasible when a greater distance from the Great Lakes. As required by the Compact, any community within a straddling county will also be evaluated individually for a water diversion based upon their ability to provide no significant individual or cumulative adverse impacts. With the City of Waukesha setting goals that exceed the Compact requirements, and rare similar circumstances of communities in straddling counties as close to the lake as the City of Waukesha is throughout the Great Lakes Basin, there are no significant adverse cumulative impacts possible with any precedents associated with this application.

SECTION 6
Compact Compliance

Compliance with the requirements of the Great Lakes–St. Lawrence River Basin Water Resources Compact and the Wisconsin Compact implementing statute (§281.346, Wis. Stats. and §281.348, Wis. Stats) are addressed in this Section. Each requirement is set out separately followed by either a discussion on how this application meets the applicable requirement or reference to other portions of this application which discuss how the applicable requirements are met.



Source: Great Lakes Commission, www.glc.org

Eligibility to Apply

A proposal by a community within a straddling county to divert Great Lakes water is excepted from the prohibition against diversions, provided that the proposal satisfies all of the requirements of the Compact and Wis. Stat. § 281.346(4). Reference: Compact Article 4, Section 4.9.3; Wis. Stat. § 281.346(4).

A community within a straddling county is defined as "any city, village or town that is not a straddling community and that is located outside the Great Lakes basin but wholly within a county that lies partly within the Great Lakes basin." Wis. Stat. § 281.346(1)(d); See also Compact Article 1.

The City of Waukesha is a community within a straddling county. While the City is located only 18 miles west of Lake Michigan, it is located 1.5 miles west of the Great Lakes watershed surface water divide, and is outside of the Great Lakes Basin. See Exhibit 1.1.

The City, however, is located wholly within Waukesha County, Wisconsin. Waukesha County lies partly within the Great Lakes Basin, and therefore is a straddling county. As a community within a straddling county, the City is eligible to submit this application for Lake Michigan water.

A proposal for a diversion may be made only by an entity operating a public water supply system that would receive water from the diversion. Reference: Wis. Stat. § 281.346(4)(b)2.

The applicant for the diversion is the City of Waukesha. The City operates a public water supply system through its water utility. The Waukesha Water Utility is a public water supplier governed by Chapter 196, Wisconsin Statutes. The water utility is regulated by the WDNR and the Wisconsin Public Service Commission.

Demonstration of Need

A community within a straddling county applying for a diversion must be without adequate supplies of water. Reference: Compact Article 4, Section 4.9.3.a.; Wis. Stat. § 281.346(4)(e)1.a.

"Without adequate supplies of water" is defined by Wisconsin statute to mean "lacking a water supply that is economically and environmentally sustainable in the long term to meet reasonable demands for a water supply in the quantity and quality that complies with applicable drinking water standards, is protective of public health, is available at a reasonable cost, and does not have adverse environmental impacts great than those likely to result from the proposed new or increased diversion." Reference: Wis. Stat. § 281.346(1)(zm).

The City withdraws about 87 percent of its water supply from the deep St. Peter Sandstone aquifer. The deep aquifer is not an adequate source of supply for the long term because the aquifer has been drawn down 500 to 600 feet and continues to decline at a rate of 5 to 9 feet per year.[1] Pumped withdrawals from the deep aquifer continue to exceed the rate at which the aquifer can be renewed. The groundwater mining that is taking place cannot be sustained indefinitely and does not maintain a reliable source of supply for the near future.

Continued use of the deep aquifer is also not environmentally sustainable. As discussed in Section 4, Water Supply Alternatives: Water Supply Alternative 1: Continued Use of Deep and Shallow Aquifers. Continued deep aquifer pumping contributes to the following the cumulative impacts:

- Groundwater level decline
- Reduced baseflows to surface water resources, as water is drawn toward deep wells
- Reversal of the natural flow system as groundwater once flowed east toward Lake Michigan through the deep aquifer in southeastern Wisconsin and now it is drawn to the groundwater pumping centers west of the surface water divide
- Diversion of as much as 30 percent of the water replenishing the deep aquifer from the Waters of the Basin
- Discharge of water from the Great Lakes Basin to the Mississippi River Basin

These impacts illustrate that the waters of the Great Lakes Basin would be better preserved and more effectively managed if regional deep aquifer pumping was reduced. See Section 3, Need for a New Water Supply: Deep St. Peter Sandstone Aquifer.

[1] *Draft Planning Report on Regional Water Supply Plan for Southeastern Wisconsin*, SEWRPC, 2008, p.102–103.

The City also draws about 13 percent of its current water supply from the shallow aquifer As discussed in Section 3, Need for a New Water Supply: Shallow Troy Bedrock Valley Aquifer, that formation is the source of water supply for Village of Mukwonago and the City of Muskego; it is also the home of sensitive environmental resources including the Vernon Marsh Wildlife Area, Pebble Brook (a Class II trout stream), and Pebble Creek.

Continued use of the shallow aquifer to meet the City's needs would not be environmentally sustainable. The estimated cumulative impacts of increased shallow aquifer pumping include groundwater drawdown at the wells of up to 50 to 100 feet and reduction of baseflow to surface waters ranging from 17 to 340 percent.[2] Also, over 400 existing private wells may be impacted if the City increases pumping to as little at 6.4 mgd from the shallow aquifer. See also Section 4, Water Supply Alternatives: Water Supply Alternative 1: Continued Use of Deep and Shallow Aquifers.

Expansion of the Troy Bedrock Valley aquifer supply to meet the City's needs is not a reasonable water source because withdrawing the quantity of water needed by the City would have a devastating impact on extensive, rare water resources that are designated for protection by the state and the regional water quality and land use planning authority.

These facts demonstrate that the City of Waukesha is without an adequate supply of potable water. The City lacks a water supply that is economically and environmentally sustainable in the long term to meet reasonable demands for a water supply in the quantity and quality that complies with applicable drinking water standards, is protective of public health, is available at a reasonable cost, and does not have adverse environmental impacts great than those likely to result from the proposed new or increased diversion.

A community within a straddling county applying for a diversion must have no reasonable water supply alternative within the basin in which the community is located, including conservation of existing water supplies. Reference: Compact Article 4, Section 4.9.3.d.; Wis. Stat. §§ 281.346(4)(e)1.d. and 281.346(4)(e)1.g.

"Reasonable water supply alternative" is defined in Wisconsin statute to mean "a water supply alternative that is similar in cost to, and as environmentally sustainable and protective of public health as, the proposed new or increased diversion and that does not have greater adverse environmental impacts than the proposed new or increased diversion." Reference: Wis. Stat. § 281.246(1)(ps).

This requirement is thoroughly discussed in Section 4, Water Supply Alternatives. Section 4 concludes that the City has no reasonable water supply alternative within the Mississippi River Basin that is as environmentally sustainable, protective of public health, and cost effective as the use of Lake Michigan water.

Conservation of existing water supplies cannot avoid the need for a Lake Michigan supply. In 2006, the City implemented a Water Conservation and Protection Plan that has accomplished significant water savings through water sprinkling restrictions, conservation water rates, plumbing fixture replacement, public education, regional water conservation collaboration, and strategic alliances with national water conservation agencies. Total water use by City customers has dropped 31 percent from 1988 to 2008, despite an 18 percent population increase.[3] Some of the

[2] *Results of Groundwater Modeling Study Shallow Aquifer Source – Fox River & Vernon Marsh Area, Waukesha Water Utility*, RJN Environmental Services, April 2010.

[3] Waukesha Water Utility operating data, 1988 through 2008.

decline in water use is attributed to industry leaving the area and the recent economic recession, but some of the decline can be attributed to the City's water conservation and protection plan. However, while the City's water conservation efforts have been and will continue to be successful, water conservation measures alone cannot offset the projected need for an alternative water supply.[4] See Section 2, Water System Overview: Waukesha Water Conservation and Efficiency.

Allowable Use

Water allowed to be diverted shall be used by a community within a straddling county solely for the public water supply. Reference: Compact Article 4, Section 4.9.3.a.; Wis. Stat. § 281.346(4)(e)1.

"Public water supply" means "water distributed to the public through a physically connected system of treatment, storage, and distribution facilities that serve a group of largely residential customers and that may also serve industrial, commercial and other institutional customers." Reference: Wis. Stat. § 281.346(1)(pm).

The City requests the use of Lake Michigan water solely to serve the City's public water system within the water supply service area determined by the regional water quality planning agency under the provisions of state's water supply plan law, Wis. Stat. § 281.348(2)(cm). See Section 2, Water System Overview: Water Supply Service Area. Currently the City provides water service to the following customer classes: residential (45 percent), commercial (35 percent), industrial (16 percent) and public (4 percent).

Source of Water

If an applicant will not directly withdraw the water proposed to be diverted, the applicant shall identify any entities that may withdraw the water and provide evidence of support from each of those entities in the form of a letter or resolution. Reference: Wis. Stat. § 281.346(4)(b)4m.

The City is discussing the purchase of potable water from Lake Michigan with the City of Milwaukee, the City of Oak Creek, and the City of Racine. Milwaukee, Oak Creek and Racine are all located within the Great Lakes Basin, and they all operate public water utilities that withdraw water from Lake Michigan. All three have submitted letters or resolutions indicating a willingness to negotiate an agreement for the sale of water. See Appendix P.

Amount of Request

An approved diversion shall be limited to quantities that are considered reasonable for the purposes for which it is proposed. Reference: Compact Article 4, Section 4.9.4.b. Wis. Stat. §§ 281.346(4)(f)2. and 281.346(4)(i).

The Wisconsin Department of Natural Resources shall specify a diversion amount equal to the quantity of water that is reasonable for the purposes for which the diversion is proposed when granting an approval for a diversion. Reference: Wis. Stat. § 281.346(4)(i).

Based on extensive water supply planning, the City of Waukesha is submitting a proposal to withdraw up to an average of 10.9 mgd from Lake Michigan. The proposed amount will serve the public water system needs of the City of Waukesha for the ultimate water supply service area population of 97,400, projected to be reached sometime after 2035. See Section 2, Water

[4] AECOM. 2009. *Summary of Water Requirements, Waukesha, Wisconsin, Final Draft Technical Memorandum.*

System Overview. The City of Waukesha is requesting that the WDNR approve this water supply service area plan as part of the Great Lakes application process.

At the end of the 20-year planning period (2010–2030), the City has estimated its water needs to be 9.9 mgd from Lake Michigan with return flow. This proposed amount will serve the public water system needs of the City of Waukesha through 2030. (§ 281.348 (4)(a), Wis. Stat.) This amount is less than the City's application request of 10.9 mgd because the City's request is based upon ultimate build out of the water supply service area which is expected to occur after 2035.

For the purposes of applying the application requirements, the Wisconsin Department of Natural Resources shall use the current or planned service area of the public water supply system applicant. The planned service area is the service area of the system at the end of any planning period authorized by the Wisconsin Department of Natural Resources in the approved water supply service area plan that covers the public water supply system. Reference: Wis. Stat. § 281.346(4)(bg)2.

The amount of the requested diversion is based upon the proposed quantity of water needed to supply the projected City of Waukesha water service area population as delineated by SEWRPC. Under Chapter NR 121, Wis. Admin. Code, SEWRPC is the area-wide water quality planning agency designated by the State to delineate proposed water supply services for all public water supply systems in the southeastern Wisconsin planning area. The delineated water supply service area for the City of Waukesha (See Exhibit 2-2) is consistent with the SEWRPC 2008 regional water supply study.

For the projected buildout of the City of Waukesha water service area (beyond 2035), as delineated by SEWRPC, the annual average day capacity of the proposed supply is 10,900,000 gallons per day; the water supply infrastructure will be sized to supply a proposed maximum day demand of 18,500,000 gallons per day.[5] For the WDNR 20-year planning period (2010–2030) for the City of Waukesha water service area, the maximum day capacity of the proposed supply is 9,900,000 gallons per day and the proposed maximum day demand is 16,600,000 gallons per day. See Section 2: Water Supply Service Area Population Projections and Water Demand Forecasts.[6]

An applicant cannot reasonably avoid through the efficient use and conservation of existing water supplies the need for all or part of the proposed diversion. Reference: Compact Article 4, Section 4.9.4.a.; Wis. Stat. §§ 281.346(4)(f) 1. and 281.346(4)(g).

The City cannot reasonably avoid the need for all or part of the proposed diversion through the efficient use and conservation of existing water supplies. The requested diversion amount assumes the City will continue and expand its water conservation measures. Water savings from conservation is an important element in the City's long-range water supply plan. Based on the effectiveness of current water conservation measures and projected water use across various customer classes over the water supply planning period, and beyond, it is estimated that another 10 percent water savings may be gained through conservation, but that volume—about 1 mgd—is not sufficient to offset the need for a new adequate supply of potable water.

Conservation of Existing Supplies

An applicant shall demonstrate the efficient use and conservation of existing water supplies in accordance with Wisconsin Department of Natural Resources requirements.

5 AECOM. 2009. *Summary of Water Requirements, City of Waukesha, Wisconsin Technical Memorandum.*

6 Ibid.

The City has demonstrated its commitment to the efficient use and conservation of existing water supplies. The City's conservation program is described in Section 2, Water System Overview: Waukesha Water Conservation and Efficiency. The City's water conservation plan (Appendix A) has been referred to by the Wisconsin Public Service Commission as a model for conservation planning in the state. It identifies practical near-term, mid-term, and long-term goals and actions to be evaluated and implemented. The effectiveness of the conservation practices being used is measured so that the City can adapt the plan and target investment to maximize water savings.

Commitment to Conservation of Lake Michigan Water

The proposal will be implemented so as to incorporate environmentally sound and economically feasible water conservation measures to minimize water withdrawals and consumptive use. Reference: Compact Article 4, Section 4.9.4.e.; Wis. Stat. § 281.346(4)(f)6.

"Environmentally sound and economically feasible water conservation measures" is defined by Wisconsin statute to mean "those measures, methods, or technologies for efficient water use and for reducing water loss and waste or for reducing the amount of a withdrawal, consumptive use, or diversion that are, taking into account environmental impact, the age and nature of equipment and facilities involved, the processes employed, the energy impacts, and other appropriate factors, all of the following: 1. Environmentally sound. 2. Reflective of best practices applicable to the water use section. 3. Technically feasible and available. 4. Economically feasible and cost-effective based on an analysis that considers direct and avoided economic and environmental costs." Wis. Stat. § 281.346(1)(i); See also Compact Article 1.

An applicant shall document the water conservation planning and analysis used to identify the water conservation and efficiency measures that the applicant determined were feasible. Reference: Wis. Stat. § 281.346(4)(g).

In 2006, the City implemented a comprehensive water conservation plan to further reduce water use. Water conservation and protection efforts will be continued and monitored to determine which measures are the most effective. Highlights of the City's successful water conservation and efficiency measures are presented below. Additional details are presented in Section 2, Water System Overview: Waukesha Water Conservation and Efficiency and Appendix A.

Customer Metering. The City of Waukesha meters all water customers and monitors water use with accurate automatic flow meters that can be read remotely. Meters are monitored routinely. If a dramatic change in water use is observed, the City contacts a customer to promptly address potential water waste issues.

Limiting Unaccounted-for Water. All water utilities have unavoidable water loss. This water loss, called unaccounted-for water, is used for fighting fires, flushing mains, or is lost through leaks in water pipes. To minimize unaccounted-for water, the City monitors the system for leaks and estimates water used for routine system flushing. Historically, the City averages 4 to 7 percent unaccounted-for water,[7] which is less than the American Water Works Association-recommended benchmark of 10 percent.

Restrict Outdoor Sprinkling. The first conservation initiative implemented in 2006 was adoption of a sprinkling ordinance that affected all customer classes. The ordinance was successful in reducing the average and maximum day water demand. Comparisons show a 15 percent reduction in summer watering season water use from 2005 to 2008.

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[7]Waukesha Water Utility annual operating data submitted to Wisconsin Public Service Commission.

Conservation Water Rates. Waukesha adopted a conservation (inclining) rate structure for residential customers in 2007, becoming the first city in the state to charge customers more per gallon as water use increases.

Toilet Rebate Program. Toilets are the largest user of residential water, accounting for 26.7 percent of the water used in an average home.[8] Toilet replacement is one of the most effective ways to reduce indoor water use. The toilet rebate program was launched in October 2008, with a goal of saving 500,000 gallons per day by replacing old high-flow toilets with new high-efficiency toilets. To help meet this goal, the City is providing rebates for fixture replacement.

Water Conservation Education in Public Schools. Fifth- and ninth-grade students are taught about water conservation by Waukesha Water Utility staff. By visiting water facilities, operating tabletop groundwater models, and collaborating with teachers, the City has introduced water conservation to more than 17,000 students.[9]

No Significant Adverse Impacts from Diversion

An application shall provide information about the potential impacts of the diversion on the waters of the Great Lakes basin and water dependent natural resources. Reference: Wis. Stat. § 281.346(4)(b)4.

An applicant must provide an assessment of the individual impacts of the proposal relative to the requirement that the diversion result in no significant adverse individual impacts in exception standard (f)5. Reference: Wis. Stat. § 281.346(4)(b)5.

A diversion proposal must not endanger the integrity of the Great Lakes basin ecosystem. A diversion proposal will not endanger the integrity of the basin ecosystem if it is determined that the proposal will have no significant adverse impact on the ecosystem. Reference: Compact Article 4, Section 4.3.e.; Wis. Stat. § 281.346(1)(ji).

An application shall provide information about the potential impacts of the diversion on the waters of the Great Lakes basin and water dependent natural resources, and an assessment of the individual impacts of the proposal relative to the requirement that the diversion result in no significant adverse individual impacts. Reference: Wis. Stat. §§ 281.346(4)(b)4. & 5.

The application provides an assessment of the potential impacts of the diversion in Section 4, Water Supply Alternatives: Water Supply Alternative 3: Proposal to Use Lake Michigan Water. The application also provides an assessment of the potential impacts of the return flow in Section 5. These Sections demonstrate there will be no significant adverse impacts to the waters and water dependent resources or the chemical, physical, or biological integrity of the Great Lakes Basin from this proposed diversion.

Waters. There will be no significant adverse impact to the quantity of water of the Great Lakes Basin. As discussed in Section 5, Return Flow, the City will meet the Compact requirement of returning to Lake Michigan the volume of water withdrawn less consumptive use. The City has further set a goal of returning 100 percent of the volume withdrawn from Lake Michigan.

Water Dependent Natural Resources. There will be no significant adverse impact to water dependent natural resources from the Lake Michigan withdrawal, but rather there will be an environmental benefit from converting from deep aquifer pumping to Lake Michigan water.

[8] *Handbook of Water Use and Conservation*. 2001, Amy Vickers.

[9] Waukesha Water Utility. 2009. Annual Educational Program Data.

Section 4, Water Supply Alternatives, discusses the benefits of stopping deep aquifer pumping. Section 5, Return Flow, discusses the City's plan to improve the aquatic habitat and fisheries in the Great Lakes tributary receiving return flow, which will improve water dependent natural resources.

Chemical Integrity. There will be no significant adverse impact to the chemical integrity of the Great Lakes Basin from the Lake Michigan withdrawal. The chemical integrity of the Great Lakes Basin will be protected because the quality of the return flow will meet proposed WDNR water quality requirement. In addition, return flow will either improve in-stream water quality or result in only minor changes as discussed in Section 5.

Physical Integrity. There will be no significant adverse impact to the physical integrity of the Great Lakes Basin from the Lake Michigan withdrawal. The physical integrity of the Great Lakes Basin is protected by meeting the return flow requirement. The physical integrity of potential receiving streams is also protected from increased erosion and sediment scour as described in Section 5.

Biological Integrity. There will be no significant adverse impact to the biological integrity of the Great Lakes Basin from the Lake Michigan withdrawal. The biological integrity of the Great Lakes Basin is protected because there is no opportunity for invasive species to be introduced through the return flow because the flow is confined to a pipe from a wastewater treatment plant. Furthermore, improvements to the biological integrity of the Great Lakes tributary receiving return flow are expected because the return flow will provide more, and higher-quality functional in-stream habitat. The habitat improvements will benefit the fisheries and supporting water dependent natural resources in the Great Lakes tributary as described in Section 5.

A diversion must be implemented so as to ensure that it will result in no significant adverse individual impacts or cumulative impacts to the quantity or quality of the waters and water dependent natural resources of the basin, including cumulative impacts that might result due to any precedent-setting aspects of the proposal, based upon a determination that the proposal will not have any significant adverse impacts on the sustainable management of the waters of the Great Lakes basin. Reference: Compact Article 4, Section 4.9.4.d.; Wis. Stat. §§ 281.346(4)(f)5.

Cumulative impacts is defined in Wisconsin statute to mean "the impacts on the Great Lakes basin ecosystem that result from incremental effects of all aspects of a withdrawal, diversion, or consumptive use in addition to other past, present, and reasonably foreseeable future withdrawals, diversions, and consumptive uses regardless of who undertakes the other withdrawals, diversions, and consumptive uses, including individually minor but collectively significant withdrawals, diversions, and consumptive uses taking place over a period of time. Wis. Stat. § 281.346(1)(g); See also Compact, Article 1.

The proposed diversion as implemented will have no significant adverse individual or cumulative impacts on the quantity or quality of the waters and water dependent natural resources of the Basin. To the contrary, the proposed diversion is anticipated to have a significant positive impact on the quantity and quality of the waters and water dependent natural resources.

The City proposes to use Lake Michigan for its water supply source. After use and treatment, the City would return the water to the basin. As a result of switching to a Lake Michigan source of water, the City would discontinue its use of groundwater from the deep aquifer. Discontinuing the use of groundwater would stop the cumulative adverse impacts identified in Section 4, Water Supply Alternatives.

Switching to a Lake Michigan water supply and discontinuing the withdrawal of groundwater from the deep aquifer would benefit the waters of the basin. Historically, water from the deep aquifer flowed to Lake Michigan. After groundwater pumping of the deep aquifer began, water from the deep aquifer was drawn down and was not available to feed Lake Michigan. As pumping increased, the flow of groundwater was actually reversed and water that would have otherwise fed Lake Michigan was drawn to the groundwater wells. Now with current pumping practices, waters of the Great Lakes Basin are flowing into the deep aquifer rather than recharging Lake Michigan. The USGS estimates that 30 percent of the 33 mgd of water currently pumped by the deep aquifer wells in southeastern Wisconsin originates from inside the Lake Michigan Basin.[10] See Section 3, Need for Water: Deep St. Peter Sandstone Aquifer. Switching from the groundwater supply to a Lake Michigan surface water supply would contribute to aquifer recovery and reduce the diversion of water from the Lake Michigan groundwatershed to the Mississippi River watershed.[11]

Pumping the deep aquifer also pulls down water from the overlaying shallow aquifer to the deep aquifer. It is estimated that 18 percent of shallow aquifer baseflows are diverted toward deep wells and away from surface water resources[12] If pumping of the deep aquifer is stopped, water will no longer be pulled from the shallow aquifer to the deep aquifer, and as a result critical baseflows to surface water resources including wetlands, streams, and lakes, will be restored.

The City's use of Lake Michigan water will also not result in a significant cumulative impact to the water dependent industries of the Great Lakes such as shipping or hydropower generation. The City proposes a goal of providing 100 percent return flow to the basin. On individual days the amount of return flow may be slightly greater than or less than the amount of the withdrawal (the range of flow rates are discussed in Section 5), but over the management period, the City has a goal that the amount of return flow will equal the amount of the withdrawal. By providing 100 percent return flow, there will be no volume change to the Great Lakes Basin and no significant cumulative impact to the water dependent industries of the Great Lakes.

Further discussion regarding the impacts related to return flows can be found later in this Section.

In determining whether to approve a proposal for a community within a straddling county, the DNR shall give substantive consideration to whether the applicant provides sufficient scientifically based evidence that the existing water supply is derived from groundwater that is hydrologically interconnected to waters of the Great Lakes basin, although the DNR may not use a lack of hydrological connection to the waters of the Great Lakes basin as a reason to disapprove a proposal. Reference: Wis. Stat. § 281.346(4)(e)2; See also Compact Article 4, Section 4.3.

Deep aquifer pumping has moved the groundwater divide—the boundary that defines the flow of groundwater toward Lake Michigan or to the Mississippi River—farther to the west. See Exhibit 3-3. Because of deep aquifer pumping, the natural hydrogeology has been altered so that the deep aquifer, which historically fed the waters of the Lake Michigan Basin with groundwater, now draws water from the Basin. Even though the City's wells are located outside the Great Lakes surface water divide, they withdraw water from both the Mississippi River Basin and the Great Lakes Basin. The USGS estimates that 30 percent of the 33 mgd of water currently pumped by the deep aquifer wells in southeastern Wisconsin originates from inside the Lake Michigan Basin. Studies determined that the City's existing groundwater is hydrologically inter-

[10] Ibid.

[11] S. L. Burch. 2002. *A Comparison of Potentiometric Surfaces for the Cambrian-Ordovician Aquifers of Northeastern Illinois, 1995 and 2000.* Illinois State Water Survey Data/Case Study 2002-02.

[12] USGS. Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin

connected to waters of the Great Lakes Basin. See Section 3, Need for New Water Supply: Deep St. Peter Sandstone Aquifer.

Return Flow to the Basin

The applicant is to return the water withdrawn to the Great Lakes basin. If it will not, the applicant shall identify any entities that may return the water and provide evidence of support from each of those entities in the form of a letter or resolution. Reference: Wis. Stat. § 281.346(4)(b)4p.

The City will be responsible for returning the water withdrawn to the Great Lakes Basin.

A diversion proposal must provide that all water withdrawn shall be returned, either naturally or after use, to the source watershed less an allowance for consumptive use. Reference: Compact, Article 4, Section 4.9.4.c.; Wis. Stat. §§ 281.346(4)(f)3. and 281.346(4)(f)4. See also the more general statement of this requirement at Compact Article 4, Section 4.9.3.b.; Wis. Stat. § 281.346(4)(e)1.c.

"Source watershed" is defined in Wisconsin statute to mean "the watershed from which a withdrawal originates." If water is withdrawn directly from a Great Lake, then the source watershed is the watershed of that Great Lake. If water is withdrawn from the watershed of a stream that is a direct tributary to a Great Lake, then the source watershed is the watershed of that Great Lake. Wis. Stat. § 281.346(1)(r); See also Compact Article 1.

Consumptive use is defined by Wisconsin statute to mean "a use of water that results in the loss of or failure to return some or all of the water to the basin from which the water is withdrawn due to evaporation, incorporation into products, or other processes. Wis. Stat. § 281.346(1)(e).

The City will, at a minimum, return the amount of water withdrawn from Lake Michigan, less consumptive use, to the source watershed by managing return flow as described in Section 5. The source watershed is the Lake Michigan watershed because the water is to be withdrawn from Lake Michigan. As the Compact and Wis. Stat. § 281.346(1)(r) provide, "[i]f water is withdrawn directly from a Great Lake, then the source watershed is the watershed of that Great Lake."

The Compact and state law require the City to maximize the amount of water returned to the source watershed to equal the withdrawn water volume less consumptive use. The City's goal is to exceed the Compact requirements by returning 100 percent of the withdrawn water over a management period. See Section 5, Return Flow: Return Flow Management Plan.

No surface water or groundwater from outside the basin may be used to satisfy any portion of the return flow requirement except if it is part of a water supply or wastewater treatment system that combines water from inside and outside the basin, and it is treated to meet applicable water quality discharge standards and to prevent the introduction of invasive species into the basin. In addition, Wisconsin law requires that if the returned water from outside the basin is returned through a structure on the bed of navigable water, the structure meet applicable permitting requirements. Reference: Compact Article 4, Section 4.9.4.c.; Wis. Stat. §§ 281.346(4)(f)3. and 281.346(4)(f)4.

The City discusses how it will minimize out-of-basin water in the return flow in See Section 5, Return Flow, Return Flow Management Plan: Minimizing Out-of Basin Water in Return Flow. Despite the City's best efforts, some out-of-basin water may be returned to the Lake Michigan watershed. Before this out-of-basin water would be discharged to the Lake Michigan watershed it would be collected and treated by the City's wastewater treatment system and to WDNR standards. The return flow will have an approved effluent discharge permit under Wis. Stat. §

283.31. The return flow will prevent the introduction of invasive species by only returning treated wastewater conveyed in a pipe directly from the WWTP to the return flow location. The applicable permits and associated operating requirements for the discharge (Wis. Stat. § 30.12 or § 30.12.4m) will be obtained before the return flow outfall is constructed.

Wisconsin law, but not the Compact, requires that the place at which the water is returned to the source watershed be as close as practicable to the place at which the water is withdrawn, unless the applicant demonstrates that returning the water at that place is one of the following: (a) not cost-effective; (b) not environmentally sound; or (c) not in the interest of public health. Reference: Wis. Stat. § 281.346(4)(f)3m.

The City considered return flow alternatives that discharged directly to Lake Michigan, to Lake Michigan tributaries in the Greater Milwaukee Watersheds, and to the Milwaukee Metropolitan Sewerage District. See Section 5. The preferred return flow location is to Underwood Creek, a lake tributary that will return flow to Lake Michigan through the Menomonee River. Compared to Underwood Creek, return flow to the Root River or directly to Lake Michigan is not cost-effective. Return flow to Lake Michigan also does not provide the aquatic habitat benefits available in Underwood Creek.

Wisconsin law also requires that, if water will be returned to the source watershed through a stream tributary to one of the Great Lakes, the applicant provide documentation of how the physical, chemical, and biological integrity of the receiving water will be protected and sustained, considering the state of the receiving water before the proposal is implemented and considering potential adverse impacts due to changes in temperature and nutrient loadings. If the receiving water is a surface water body that is tributary to one of the Great Lakes, the applicant shall include a description of the flow of the receiving water before the proposal is implemented, considering both low and high flow conditions. Reference: Wis. Stat. § 281.346(4)(b)4s, and § 281.346(4)(f)4m.

The City's preferred return flow location on Underwood Creek is analyzed in Section 5. As demonstrated in Section 5, a discharge of return flow to Underwood Creek protects and sustains the physical, chemical, and biological integrity in accordance with Wis. Stat. §§ 30.12, 281.15, and 283.31. As discussed in Section 5, the physical integrity (geomorphology) of the stream will be protected (Appendix L), the chemical integrity of the stream will be protected (Appendix H), and the biological integrity of the stream will be protected (Appendix L).

In addition, the return flow will prevent the introduction of invasive species by only returning treated wastewater conveyed in a pipe directly from the WWTP to the return flow location. Temperature of the return flow has been considered and is consistent with other municipal wastewater discharges. See Section 5, Return Flow: Return Flow Alternatives: Return Flow to Underwood Creek: Water Quality. Changes in nutrient loadings were evaluated (Appendix H) and found to be less than 1 percent of expected annual loadings to Lake Michigan in the Greater Milwaukee area.

No Significant Adverse Impacts from Return Flow

A diversion must be implemented so as to ensure that it will result in no significant adverse individual impacts or cumulative impacts to the quantity or quality of the waters and water dependent natural resources of the basin, including cumulative impacts that might result due to any precedent-setting aspects of the proposal, based upon a determination that the proposal will not *have any significant adverse impacts on the sustainable management of the waters of the Great Lakes basin. Reference: Compact Article 4, Section 4.9.4.d.; Wis. Stat. §§ 281.346(4)(f)5.*

Cumulative impacts is defined in Wisconsin statute to mean "the impacts on the Great Lakes basin ecosystem that result from incremental effects of all aspects of a withdrawal, diversion, or consumptive use in addition to other past, present, and reasonably foreseeable future withdrawals, diversions, and consumptive uses regardless of who undertakes the other withdrawals, diversions, and consumptive uses, including individually minor but collectively significant withdrawals, diversions, and consumptive uses taking place over a period of time. Reference: Compact Article 1.; Wis. Stat. § 281.346(1)(g).

This requirement was discussed above with regard to the withdrawal from Lake Michigan, and is discussed here with regard to the return flow. Return flow will be implemented to ensure that no significant individual or cumulative adverse impacts result to the quantity and quality of the waters and water dependent natural resources. As discussed in Section 5, the application proposal maintains, and in some cases improves, the chemical, physical, and biological integrity of the Great Lakes Basin as has been previously discussed.

The City's exceeds the return flow requirements and results in a benefit to waters and water dependent natural resources of the basin in the following ways:

- The City of Waukesha has a return flow goal that is greater than water supply less consumptive use. The return flow goal has been set at 100 percent, which is higher than the Compact requirement (see Section 5 of the Application).
- Return flow will be utilized as a resource to benefit habitat, fisheries, and water quality in a Lake Michigan tributary (see Application Section 5 and Appendixes G and L).
- Return flow water quality is more stringent than other Lake Michigan tributary dischargers and will improve the water quality in Underwood Creek by allowing the creek to meet water quality standards more often (see Application Section 5 and Appendix H).

Other Requirements

The proposal is implemented so as 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. Reference: Compact Article 4, Section 4.9.4.f.; Wis. Stat. § 281.346(4)(f)7.

The City will meet all applicable municipal, state, and federal laws as well as regional interstate and international agreements. The requirements of the Boundary Waters Treaty of 1909 are not triggered by this proposal.

The proposal is consistent with an approved water supply service area plan under Wis. Stat. § 281.348 that covers the public water supply system. Reference: Wis. Stat. § 281.346(4)(e)1.em.

The Water Supply Service Area Plan for the City of Waukesha is contained in Appendix D. This plan has been approved by the City of Waukesha's governing body. It is consistent with the findings and recommendations of the SEWPRC Planning Report on Regional Water Supply Plan in Southeastern Wisconsin.

The proposal shall be subject to management and regulation by the Originating Party. Reference: Compact Article 4, Section 4.9.3.c.; Wis. Stat. § 281.346(4)(e).

The WDNR is the Originating Party and it will manage and regulate the diversion.

Review Process

The WDNR conducts a technical review. Reference: Wis. Stat. § 281.346(4)(e)1.f.

The WDNR notifies the regional body; the proposal undergoes regional review; and the WDNR considers the regional declaration of finding in determining whether to approval the proposal. Reference: Wis. Stat. § 281.346(4)(e)1.g., h. and I; Compact Article 4, Sections 4.5 and 4.9.3.f.

The proposal is approved by the Great Lakes Council. Reference: Wis. Stat. § 281.346(4)(e)1.j. Compact Article 4, Sections 4.7 and 5.9.3.g.

The Compact establishes the review process for this application. The City seeks to begin this review process by filing this application with the WDNR.

Conclusion

The City submits this application seeking Lake Michigan water for public water supply. The City has stated a compelling need for Lake Michigan water and its request is supported by detailed alternatives evaluations from numerous experts, including the WDNR, USGS, WGNHS, academia and SEWRPC.

The City has demonstrated that its use of Lake Michigan water will not result in adverse impacts to the Great Lakes. Indeed, this application shows that the Great Lakes Basin will be benefited if the City switches from a groundwater supply to a Lake Michigan supply.

The City also believes it has demonstrated that this application meets all the Compact requirements with no exceptions, and that in numerous ways the City's application exceeds the requirements of the Compact and state law.

The Compact was developed to regulate Great Lakes diversions and protect the water and water dependent natural resources of the basin. Because this application meets all of the requirements of the Compact, and results in increased protection of the water and water dependent natural resources of the basin, the City respectfully requests that its application for Lake Michigan water be approved.