Village of Volo
Lake County, Illinois

Groundwater Supply Planning White Paper

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1. LAKE COUNTY WATER SUPPLY

1.1 Overview

The existing and anticipated regional water demands and the groundwater supply limitations found in Lake County have sparked concerns regarding the long-term sustainability of groundwater as the source of municipal water supplies. And indeed, several aspects of groundwater supply are of concern. First, increased groundwater pumping in the future may exceed the capacity of the available aquifers. Second, increased human activity in the County adds to the potential for groundwater contamination. Finally, a less evident but no less critical impact of excessive groundwater use is the potential loss of water supply to the County's natural wetlands, fens, streams and lakes.

As more people move to Lake County, greater demands will be placed on the limited water resources. However, under current Federal and Illinois State laws, neither Lake County nor the municipalities have the authority to regulate groundwater withdrawals. Furthermore, there are no statutory provisions to address well interference issues between multiple users of groundwater aquifers.

Due to these issues, communities in the northwest Lake County region began investigating alternative sources of water supply and came to the conclusion that conversion to Lake Michigan water would be the best means to assure their future water supply. Through these efforts, the communities of Antioch, Fox Lake, Fox Lake Hills, Grandwood Park, Lake Villa, Lindenhurst, Volo and Wauconda have secured Lake Michigan water supply allocations from the Illinois Department of Natural Resources (IDNR). These communities are referred to as the North-West Lake County Water Planning Group (abbreviated as WPG throughout this report).

The purposes of this White Paper are to: provide a brief outline of the water supply issues; evaluate the existing groundwater supplies; and assist the communities in determining whether to move forward with their Lake Michigan water allocations or to remain on groundwater supplies.

A study has been prepared for each of the public water supplies so that the specific and unique characteristics of their water supplies can be considered. Each report is divided into four sections. Section 1 is a general introduction to the basics of groundwater and is intended to provide readers with the information they need to understand their community's water supply. Section 2 outlines the existing water supply situation for each community in greater detail. Section 3 evaluates future groundwater supply considerations. Finally, Section 4 summarizes our opinions as to the long-term viability of groundwater as the public water supply for each community.

1.2 <u>Basics of Groundwater</u>

Groundwater is water that saturates tiny underground voids (interstitial spaces) between sand, gravel, silt, or clay particles, or crevices in underground rocks. Underground formations that are sufficiently permeable to readily yield economically useful quantities of groundwater to wells, springs or streams are called aquifers. Aquifers may consist of "consolidated" bedrock, such as limestone or sandstone, or "unconsolidated" deposits made up of sand and gravel. The size and interconnections of interstitial spaces control how well water flows in these subsurface formations.

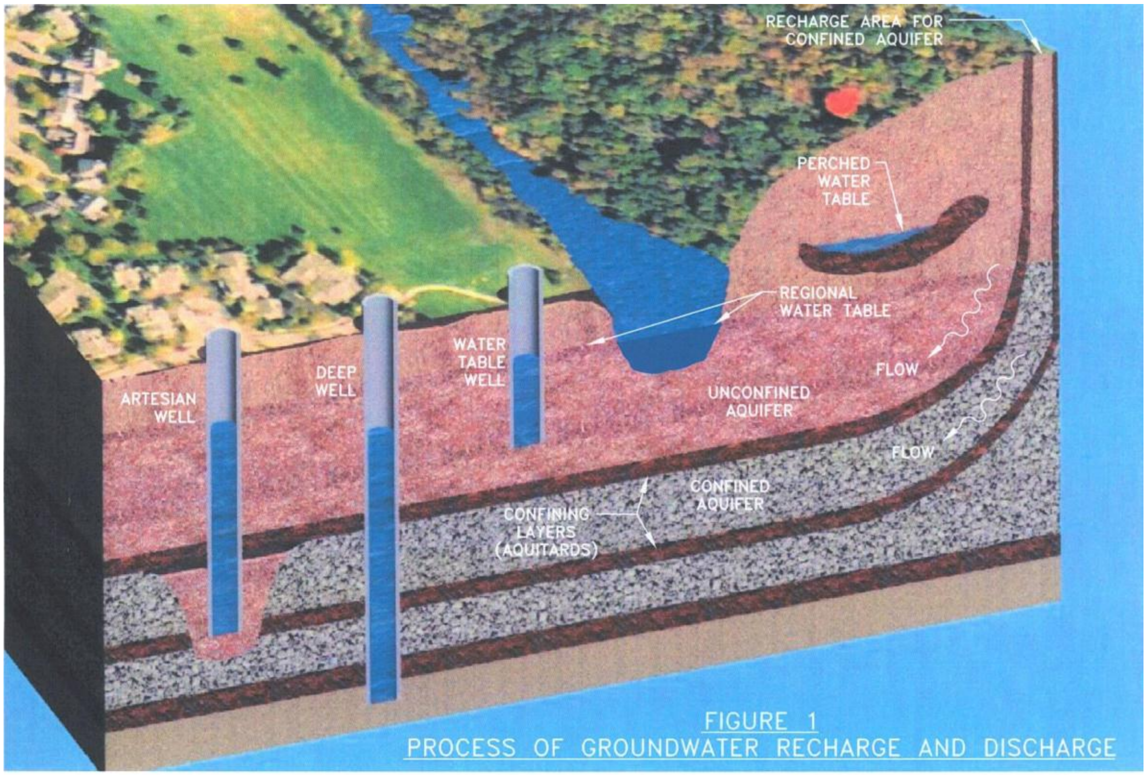
In the vicinity of Lake County, unconsolidated sand and gravel aquifers generally can extend from just below the ground surface to depths of up to 300 feet. Residences, farms and municipal water utilities tap the sand and gravel aquifers because the water is relatively close to the surface making it fairly easy and inexpensive to drill wells and pump water. However, the amounts of water these aquifers can yield varies a great deal from location to location. Some aquifers may barely supply one well on a small farm, while others may supply entire communities.

Below the unconsolidated deposits are various sedimentary bedrock formations comprised of limestones or sandstones that can function as aquifers. Factories, businesses, homes, farms and municipal water utilities tap these aquifers.

Groundwater originates from rainfall and surface water that percolates through the soils until it reaches the saturated zone in the subsurface: a process known as recharge. In some areas, streams, wetlands or lakes recharge aquifers through bed infiltration. In some locations, the rainfall simply moves downward through the soils. The areas that contribute water to aquifers are called recharge zones. In other cases, water flows from the aquifers to the surface in the form of springs or seeps into streams, lakes or wetlands. These are called discharge zones. The water surface in the stream, lake or wetland may or may not be a reflection of the aquifer water table depending on the local hydrogeological conditions. These and other groundwater terms are shown visually in Figure 1.

FIGURE 1

Process of Groundwater Recharge and Discharge



Source: Introduction to Environmental Engineering and Science

The amount of groundwater available to the aquifers is a function of the recharge zone's climate. In the case of the relatively wet and mild climate of northern Illinois, approximately 25 percent of the precipitation infiltrates into the subsurface where it is available to recharge the groundwater. Estimates from various sources indicate that approximately half of the water that makes it to the subsurface is then available for use from aquifers.

The sustainable yield of an aquifer is the amount of water that can be pumped from the aquifer over a long period of time without causing overall, continuing declines in water levels and without doing undue damage to wetlands and streams. The sustainable yield is mainly controlled by the amount of recharge the aquifer receives. If total discharge (i.e., natural discharge plus water withdrawn for human activities) exceeds the recharge rate, water levels within the aquifer will drop. This decline will continue until a new balance is reached, or until the groundwater in an aquifer is depleted to the point where further withdrawals are no longer feasible.

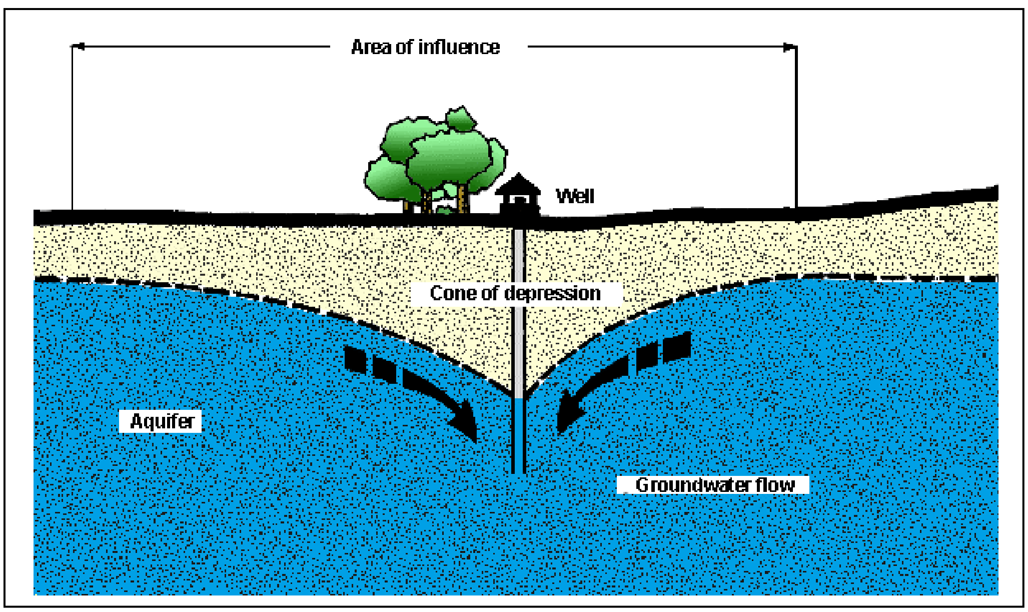
1.3 Potential Issues Associated with Groundwater Resources

Several issues with existing water supply wells and aquifers, including decreased water production and contamination incidents, led the WPG communities to pursue Lake Michigan allocations. These issues impact both the quality and quantity of water available from aquifers, and are anticipated to have increased consequences in the future as development further strains the aquifers. Some of the factors to be considered are outlined below.

Well Zone of Influence and Well Interference - When a well begins operation, water from the surrounding aquifer flows toward the well to replace water that is withdrawn. As shown in Figure 2, a cone-shaped region, called the cone of depression, forms beneath the well. The area over which this lowered water level may be measured is called a well's zone of influence. As pumping continues and the zone of influence broadens, it may affect wells of neighboring users, forcing them to deepen or move their wells to avoid losing their supply. This condition is referred to as well interference.

FIGURE 2

Well Zone of Influence and Cone of Depression



Source: Cornell Cooperative Extension, Cornell University, July 1988

Groundwater Mining - Perhaps the most significant effect of excess groundwater consumption is depletion. If rates of withdrawal exceed rates of recharge, a condition known as "mining" exists. By definition, groundwater mining is not sustainable. There are limits on the amount of water that can be withdrawn from a given aquifer over a certain time period. If groundwater pumping begins to stress an aquifer, yields may decline and wells may eventually "go dry" as the water level drops below the top of the aquifer.

To replace lost capacity, new wells may have to be constructed, pumps may need to be lowered or existing wells may need to be extended to greater depths; any of which increases capital and electrical power costs. Additionally, while water from greater depths is generally better protected from surface contamination, the deeper water will have a naturally different quality (either better or worse), and there is a risk that treatment costs may increase. Eventually, continued withdrawals in excess of the sustainable yield will no longer be feasible, and water usage must be reduced or different sources must be identified.

Another less obvious impact of groundwater mining is the effect on river and stream base flows, and the loss or reduction of water supplies available to wetlands and springs. Reduced base flows may result in a decline in water quality, reduced habitats and recreational opportunities. The loss of water to wetlands may result in the disappearance of these unique habitats.

Degradation of Groundwater Quality - Groundwater quality may become a major concern as the water in an aquifer is either depleted or because of human activities. If potentially hazardous materials are placed on land surfaces or buried underground, they may seep downward through the soils and contaminate the groundwater. In some cases, chemicals may follow more direct routes such as unsealed or abandoned wells. Contaminants that reach an aquifer move through it and form a plume of contaminated water. When this plume reaches a well, it may threaten human, animal and environmental health. Following are several potential sources of groundwater contamination:

- ***Agriculture*:** Chemicals such as fertilizers and pesticides may seep through the soils into groundwater. Intensive livestock production (i.e., confined animal feeding operations) also poses a risk to groundwater quality because farmers normally apply large quantities of animal manure to the land as a means of nutrient recycling. Excessive levels of nutrients (nitrates and phosphorous) and/or pathogens from the manure may contaminate the groundwater, particularly if the manure is applied near wellheads.

- ***Industrial and Commercial Activities*:** Raw material extraction (e.g. gravel pits), manufacturing plants and some retailing and service industries handle a wide range of chemicals. The three categories of most concern are volatile organic compounds (VOCs), nonvolatile organic chemicals and inorganic compounds. Leaking underground storage tanks (LUSTs) containing these chemicals are of special concern at commercial and industrial facilities. Released petroleum products contain many potentially hazardous and toxic chemicals that may pose serious threats to human and environmental health.

- ***Residential Sources***: Homeowners may contaminate groundwater via the improper use and disposal of garden chemicals, paint products, motor oil and other auto products.

- ***Superfund Sites***: Superfund is the name given to the environmental program established by the United States Environmental Protection Agency (USEPA) to address abandoned hazardous waste sites. Superfund sites contain hazardous materials, typically in large quantities or widely dispersed areas. These sites have serious potential to contaminate shallow aquifers because, in most cases, the contamination existed for several months or even years before anyone was aware of it. This provided opportunity for contaminants to spread unchecked through the subsurface, which makes long-term control and containment of the contaminant plumes difficult.

- ***Municipal Landfills:*** Municipal landfills have been, and will continue to be, the most common way to dispose of solid wastes. The concern with landfills is that, given enough time, they will leak regardless of how well they are designed. Liquids called leachate percolate through layers of wastes and eventually migrate through the constructed barriers. During this process, leachate dissolves chemicals and collects microorganisms. If the leachate reaches groundwater, contamination may result. Older landfills pose the greatest risk because they have fewer means of protection and are not subject to long-term monitoring. Most newer landfills have systems to collect leachate and are equipped with monitoring mechanisms to verify the quality of adjacent groundwater. This monitoring is required to be continued indefinitely after the landfill is closed.

- ***Abandoned Water Supply Wells and Stormwater Injection (Dry) Wells***: Improperly abandoned (i.e. unsealed) water supply wells may pose a threat to groundwater quality regardless of depth. Stormwater injection wells, commonly referred to as dry wells, have also been identified as routes through which contaminants may pass directly to the groundwater. The use of dry wells for the disposal of stormwater that may contain pollutants such as chlorides and petroleum compounds increases the chances of contamination.

- ***Road Salt Use***: Cities, villages, townships, counties and private land owners that spread and store deicing salts are causing increased chloride levels in shallow aquifers. When salts are spread excessively or stored improperly, they may leach into the subsurface at an accelerated rate. Neighboring McHenry County has tracked chloride levels in shallow aquifers and found a slow but steady increase over the years. Studies conducted by the Illinois State Water Survey have confirmed the increases in groundwater chlorides throughout the Chicagoland area (Kelly, 2004). Other possible routes of salt contamination found in municipalities are abandoned dump sites, septic tanks and stormwater infiltration basins.

- ***Naturally Occurring Contaminants***: Many groundwater contaminants are naturally occurring substances such as barium, calcium, fluoride, hydrogen sulfide, iron, manganese, magnesium and radium. As many as 50 naturally occurring minerals may be present in water; but generally do not cause health problems since they usually occur in small amounts or are inert. More often, minerals cause aesthetic problems such as taste, odor and staining. However, in some regions of the nation, including Lake County, naturally occurring elements such as barium and radium have been found in the groundwater in levels exceeding primary drinking water standards.

Impacts of Urbanization on Recharge - High rates of urbanization are generally believed by the public to have negative impacts on groundwater recharge areas. This belief is understandable because during development and construction, many natural landscape features are significantly altered. Soils are compacted by construction equipment and grading. Trees and other vegetation are replaced by extensive stretches of impervious surfaces such as roofs and pavement. The expected result is that less water soaks into the ground, and the volume of recharge to shallow aquifers below the developed property may decline. But this has been proven not to be the case on the basis of research in urban areas around the world. The supposition of the researchers is that the leakage from buried pipes such as water mains and storm sewers more than off-sets the effects of reduced infiltration (Wehrmann, 2010, p.10). The real concern from urbanization is the increased potential for groundwater contamination resulting from spills, leaking underground tanks and the application of road salt to deice roads and parking lots.

Cost of Groundwater Impairment - As development continues, the probability of groundwater contamination increases and the amount of groundwater available for use declines. These factors can result in significant direct costs to the affected community, including hazardous waste collection and disposal, groundwater remediation, additional water treatment facilities, or abandonment of the contaminated wells and replacement with new wells. Costs to individuals, such as lost wages, medical costs, reduced property values and higher water bills are additional factors that are more difficult to quantify, but are nevertheless significant.

2. EXISTING GROUNDWATER RESOURCES AND DEMAND

2.1 General

The eight communities participating in the WPG currently pump an average of 5.9 million gallons per day (mgd) from a combination of shallow and deep aquifers[1]. Maximum day demands in the various communities range from 1.7 to 2.0 times higher than average day demands, causing strain on the aquifers during these high pumpage periods.

This section provides an overview of the local hydrogeology and water availability, with specific focus on the aquifers in which the Village's wells are finished. This information is then compared to current water demands to set the stage for discussion of future water supply needs.

2.2 Regional Groundwater Resources

Four major aquifer systems are present in Lake County. Those aquifers include the unconsolidated sand and gravels, the shallow Silurian dolomite (a form of limestone) bedrock, the deep Cambrian-Ordovician sandstone bedrock and the very deep Elmhurst-Mount Simon sandstone bedrock. All but the extremely deep and saline Elmhurst-Mount Simon aquifer are utilized for public and private water supply in Lake County. The characteristics and geographic extent of these aquifers vary widely.

The hydrogeology of groundwater resources in western Lake County, as discussed below, was provided by the Illinois State Geological Survey (ISGS) three-dimensional model of the subsurface formations in Lake County and the Illinois State Water Survey (ISWS) projections of water production capacity and demand on each aquifer system.

2.2.1 Shallow Sand and Gravel Aquifers - Sand and gravel deposited by glaciers supply a portion of the water used in most Lake County groundwater municipalities and many homes and businesses with private wells. The largest and oldest shallow aquifer in western Lake County is a formation composed mostly of fine sand mixed with some silt (finer grained materials). This material was deposited as interbedded layers across the entire western half of the County while that area was covered by a shallow lake at the face of a glacier beginning approximately 16,000 years ago. The top of this formation is generally approximately 100 to 150 feet below the ground surface and extends down another 50 to 100 feet to the top of bedrock. This aquifer can supply high capacity municipal wells, though the fine-grained nature of the sand and silt deposits typically limits production to less than 500 gpm per well.

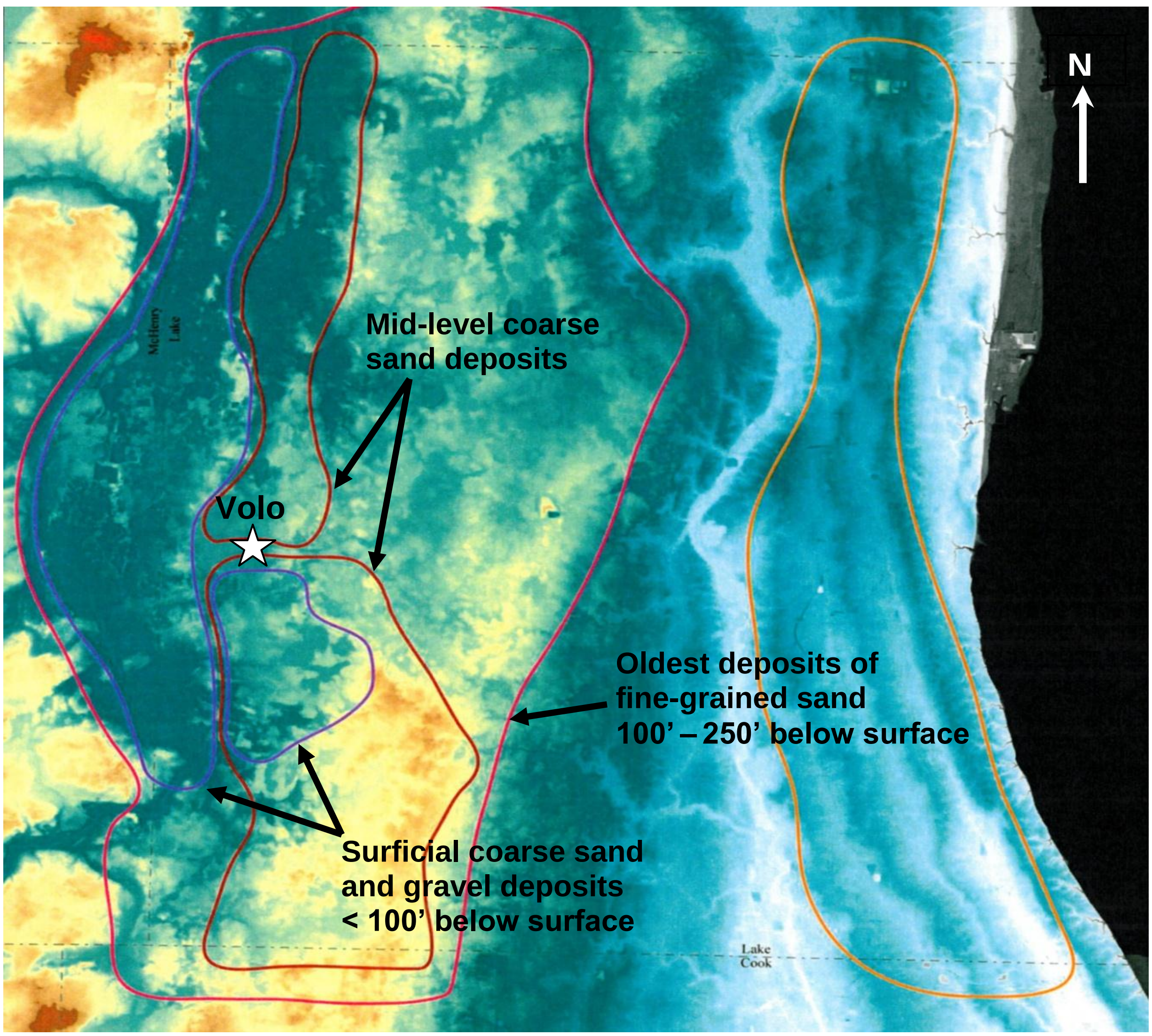
1 Current demand is estimated as the average of actual well pumpage in 2009 and 2010.

Two additional aquifers consisting of somewhat coarser sands and gravels are scattered throughout the western half of the County. These aquifers are found on top of the older formation described above and are typically less than 100 feet below the ground surface, though some isolated deposits extend 200 to 300 feet below the surface. These aquifers typically have higher production rates than the deeper fine-grained sand aquifer, though they are much more scattered and isolated.

Figure 3 is excerpted from the ISGS subsurface model of Lake County. It identifies the largest deposits of water-bearing subsurface materials present in Lake County, as described above (ISGS, 2011). The location of Volo is shown in the figure relative to these formations.

FIGURE 3

<u>Shallow Subsurface Geology of Lake County</u>



Source: Illinois State Geological Survey

The closeness of the two upper sand and gravel aquifers to the ground surface is both a blessing and a curse. Their presence near the surface makes it very easy for rain water to recharge these aquifers with large quantities of water. In fact, these aquifers also serve as the main means of recharge for the deeper sand formation which is cut off from the surface in other areas to the east by the fine grain near-surface materials.

This ease of recharge, however, also makes these aquifers especially at risk of contamination because there are no layers of impermeable materials such as clays and silts above the formation to block the movement of contaminants from the surface. There have been cases of heavy metal and chemical contamination of the shallow aquifers from businesses and landfills at several locations in the County. There is also solid evidence of contamination of these aquifers from the salt used to deice roadways (Meyer, 2004, p.6). In northeastern Illinois, background levels of chlorides in shallow groundwater were 10 mg/L historically. Currently, it is not uncommon to see chloride concentrations of 60 to 100 mg/L with annual measurable increases. Natural water quality in terms of iron, manganese, hardness and sulfate concentrations can vary greatly among the shallow aquifers, but generally treatment is needed to make the water aesthetically pleasing.

Currently, the shallow aquifers are being used to provide a total of 18.4 mgd for public and private uses throughout the County. The total water that may be available for all uses (artificial and natural) is thought to be approximately 61 mgd (Lake County, 2008).

In McHenry County to the west, the shallow sand and gravel aquifers are used extensively for water supply but because of the deposition and extent of these shallow aquifers, water pumpage from the shallow aquifers in McHenry County generally does not have an impact on shallow groundwater water availability in Lake County. Immediately to the north in southeastern Wisconsin there is a relatively small amount of pumpage from the shallow aquifers at this time.

2.2.2 Silurian Dolomite Aquifer - The Silurian dolomite shallow bedrock aquifer is primarily overlain by the fine-grained sand aquifer described above. Dolomite aquifers are generally most productive along fracture lines, where water from overlying sand and gravel aquifers can collect at sufficient rates to sustain a well. Private wells finished in the Silurian dolomite aquifer are prevalent in the southwest quadrant of the County, where there is increased prevalence of coarse sand and gravel directly overlying the dolomite. In northern and western Lake County this aquifer is typically not productive enough to supply high capacity municipal wells.

The Silurian dolomite is susceptible to man-made contamination primarily where it is connected directly to the surface by sand and gravel formations or from abandoned wells. Once contamination is within the formation, it can move very rapidly through the solution channels in the rock.

Natural water quality in the limestone aquifers is generally poor in terms of iron, manganese, hardness and sulfate concentrations. Generally, treatment is needed to make the water aesthetically pleasing.

2.2.3 Cambrian-Ordovician Aquifers - The deep bedrock Cambrian-Ordovician sandstone aquifers are important sources of groundwater to communities in Lake County and the surrounding counties in Illinois and Wisconsin. The common names for these aquifers are the St. Peter sandstone and the Ironton-Galesville sandstone. Wells reaching this extensive aquifer system are typically 800 to 1,300 feet deep. Since the mid-20th century, withdrawal rates from the Cambrian-Ordovician aquifers have exceeded their estimated sustained yield. In 1979, withdrawals from the aquifers in the eight-county area in Northeastern Illinois reached an all-time high of approximately 182 mgd. In contrast, the ISWS estimates that the practical sustained yield of the aquifer in a six-county area is only in the range of 46 to 80 mgd. At the peak of the heavy pumping in 1980, water levels in portions of the deep bedrock aquifers had declined by more than 850 feet from their original, predevelopment levels.

In the 1980s, Lake Michigan water became more accessible to suburban communities in Lake, Cook, Will and DuPage counties, and withdrawals from the St. Peter and Galesville sandstone aquifers dropped to 67 mgd. ISWS reported that water levels in these aquifers rebounded by an average of approximately 15 feet per year between 1991 and 1995. By the 2007 reporting of water levels, however, water pumpage had increased to more than 85 mgd and measurements showed that groundwater level declines in the Chicagoland area had resumed with large portions of the area again having water level decreases of 25 to 50 feet (Burch, 2008, p.25). Looking specifically at the data gathered in Lake County, water pumpage from the aquifer is approximately 4.4 mgd (Lake County, 2008, p.18) and water levels were dropping at the rate of approximately five feet per year countywide between 2000 and 2007 (Burch, 2008).

In confirmation of those findings, the ISWS has identified that the townships of Grant, Avon, Warren, and Wauconda already exceed a use-to-yield ratio of 0.9, leaving little room, if any, for increased pumpage in the future (Winstanley, 2006 p.50). In his report, Winstanley states "Deep sandstone aquifers have been overused in this region, and increased use of this resource may not be sustainable."

One major limitation on the capacities of the sandstone aquifers in Lake County is the distance to the aquifers' recharge area. The major recharge areas for the sandstone aquifers serving Lake County lie primarily in Boone County in Illinois, and western Walworth and Rock Counties in Wisconsin. These are areas where the rock is closer to the land surface and it is not overlain by confining shale formations.

Currently, there is a substantial amount of pumping from these aquifers in McHenry County, with the primary pumping centers being found in Crystal Lake, Huntley and Algonquin. Several other McHenry County communities also have deep sandstone wells in use. The pumping of water from the sandstones in McHenry County is pulling down the water levels in southeastern McHenry County and preventing a portion of the water from moving east to Lake County. In Wisconsin, there currently is very little municipal pumping of groundwater immediately north of Lake County. (SEWRPC, 2002, p.77). Thus, pumpage in Wisconsin is having a minimal impact on Lake County water supplies at this time.

The potential for contamination by migration of chemicals into the sandstone aquifers from the land surface above is very low. However, other contaminant pathways such as abandoned wells can pose a threat to the groundwater quality in the deep bedrock. Natural water quality in the deep sandstones is generally good in terms of iron, manganese, hardness and sulfate concentrations. From an aesthetic standpoint, the water can be used without treatment. However, the deep well waters frequently contain barium and radium in excess of drinking water standards. These elements must be reduced to prevent potential health consequences. Excessive amounts of barium over long periods have been tied to high blood pressure. Long-term exposure to radium increases the risk of developing several diseases such as lymphoma, bone cancer, and diseases that affect the formation of blood, such as leukemia and aplastic anemia.

2.2.4 Aquifers Serving Volo - Volo's residents and businesses historically were served by private wells, the most productive of which were finished in the shallow bedrock (dolomite) aquifer. The sand and gravel deposits in and around Volo are not highly productive due to the presence of thick clay deposits, which inhibit water movement in the subsurface. Therefore, in 2001, the Village constructed a public water supply system consisting of three wells finished in the far more productive deep sandstone aquifer, which served the northern portion of the community. A separate system, consisting of two deep sandstone wells, was constructed in 2007 to serve the remainder of the community.

2.3 Local Water Supply and Demand

The Village has two separate water systems, called the North System and the South System. Table 1and Table 2 provide details on the wells, including a comparison of total capacity and firm capacity (total pumping capacity with the largest well out of service).

TABLE 1

Village of Volo North System – Existing Water Supply Wells

Well No.	Aquifer Type	Capacity (gpm)	24-hour Capacity (mgd)	18-hour Capacity (mgd)
1	Sandstone	500	0.72	0.54
2	Sandstone	250	0.36	0.27
3	Sandstone	700	1.01	0.76
Total Capacity		**1,450**	**2.09**	**1.57**
Firm Capacity		**750**	**1.08**	**0.81**

TABLE 2

Village of Volo South System – Existing Water Supply Wells

Well No.	Aquifer Type	Capacity (gpm)	24-hour Capacity (mgd)	18-hour Capacity (mgd)
4	Sandstone	750	1.08	0.81
5	Sandstone	700	1.01	0.76
Total Capacity		**1,450**	**2.09**	**1.57**
Firm Capacity		**700**	**1.01**	**0.76**

The realistic approach is to evaluate firm capacity assuming the wells are operated a maximum of 18 hours per day (0.81 mgd and 0.76 mgd). Eighteen hours per day is typically considered to be the maximum time frame for pumping to maintain good well management practices in the long-term.

Total pumpage from the Village's two water systems in 2009 and 2010 is summarized in Table 3. This includes maximum day pumpage for each year, though it is noted that 2009 and 2010 were relatively wet years and do not reflect historical maximum demand. The population from each year is utilized to estimate average per capita demand, which is listed in terms of gallons per capita per day (gpcd).

TABLE 3

Village of Volo – Current Water Demands

	2009	**2010**
Average Day Demand (mgd)	0.20	0.25
Maximum Day Demand (mgd)	0.39	0.50
Population*	2,654	2,929
Avg. Per Capita Demand (gpcd)	74	85

* 2009 population was interpolated from 2000 and 2010 Census records.

Firm well capacities (18 hours/day pumping) in the North System (0.81 mgd) and the South System (0.76 mgd) exceed the average day demand (ADD) and maximum day demand (MDD) for the Village as a whole. Therefore, the Village has sufficient water supply redundancy at present.

3. FUTURE GROUNDWATER RESOURCES AND DEMAND

3.1 General

This section summarizes projected water supply demands as outlined in the Village's approved Lake Michigan allocation. The future demands are then compared to existing groundwater resources in the immediate vicinity and the anticipated regional demand for these resources in the future.

3.2 Projected Water Demands

The Village's anticipated water demands (Systems 1 and 2 combined) and demands for the WPG as a whole are outlined in Table 4. Current ADD is estimated as the average of actual well pumpage in 2009 and 2010. Future ADD values are as stipulated by IDNR in the approved Lake Michigan allocations, and are based on population projections by the Chicago Metropolitan Agency for Planning (CMAP). Current and future MDD is estimated by applying peaking factors observed in 2009 and 2010.

TABLE 4

Projected Water Demands*

	Village of Volo		WPG Total	
	ADD (mgd)	MDD (mgd)	ADD (mgd)	MDD (mgd)
Current	0.22	0.44	5.86	11.09
2020	0.68	1.19	8.13	14.23
2030	1.41	2.47	10.83	18.96

* Based on quantities in final allocation ruling.

The Village's overall ADD is projected to increase by over 530 percent by 2030. In comparison, the regional ADD for the WPG as a whole is anticipated to increase by almost 80 percent (over 6 mgd) in the same period. This has the potential to cause significant additional strain on both shallow and deep aquifer resources.

3.3 Availability of Existing Groundwater Resources

3.3.1 Shallow Sand and Gravel Aquifers - As-yet untapped shallow aquifers exist in northern and western Lake County, which have the potential to be used as additional water sources in the future. However, the development of these aquifers as new, substantial water sources to the Village is problematic. The lower sand formation that is present throughout the western half of the County is fine grained and is interspersed with silts and clays. These conditions limit the flow of water and limit the production of wells to 500 gpm or less. The younger, coarser grained sand and gravel formations are more sporadic and limited in size. This characteristic will likely necessitate a lengthy and costly process of hydrogeological exploration and test well drilling to determine if there are any productive shallow aquifers within the Village's corporate limits.

The development potential of the shallow sands and gravels is further limited to the practical sustainable yield of the formation which, in turn, is controlled by a number of factors. First, and particularly important in the Fox River watershed areas: "a significant concern in developing shallow groundwater is potential effects on water levels in nearby streams and wetlands" (Winstanley, 2006). The reason is that, under natural conditions, aquifers are in a state of approximate equilibrium with amount of recharge equal to the amount of discharge to rivers, streams, wetlands and springs. When a new well is added to an aquifer system, the new discharge must be balanced by an increase in recharge of the aquifer, or by a decrease in the natural discharges, or by a loss of storage in the aquifer, or by a combination of these (ISWPTF, 1989, p.144). The overreliance on the shallow aquifer system under the assumption that the system is sustainable so long as the pumping rate is kept at less than or equal to the rate of discharge will likely greatly reduce the available water to the streams and wetlands that make up the County's landscape (Wehrmann, 2010).

The practicality of placing new wells in the Village is also impacted by the proximity of other wells. Each operating well creates a cone of depression. If wells are drilled too closely together the wells will interfere with one another and limit the available flow of water to the wells. Generally, in the shallow sands and gravels, wells need to be at least half a mile apart to avoid most interference effects.

There have not been any detailed studies completed by the ISWS attempting to quantify the water available for use in the shallow sand and gravel aquifers in Lake County. Just to the north in Kenosha County, Wisconsin, an attempt was made to quantify the availability of water in the shallow aquifers. Based on their modeling work, the Southeast Wisconsin Regional Planning Commission (SEWRPC) concluded that in the areas with fine grained near-surface materials, if residential development is served with sewers and the lot size is less than five acres, the domestic water use (36 gallons per day per acre) will exceed the recharge potential of the area and hence cause a reduction in water levels and stream flows. In areas with coarser near-surface materials, lot sizes of one acre (180 gallons per day per acre) could be supported without exceeding the natural recharge of the area (Bradbury, 2009 p.20). These values are considerably lower than the 1,000 gallons per day per acre used as a rule of thumb for urban water supply planning.

The chloride levels in the shallow aquifers are anticipated to continue to increase from the current levels of 60 to 100 mg/L to the range of the Secondary Maximum Contaminant Level (SMCL) of 250 mg/L within 20 years. At that point, it will become necessary to treat a portion of the pumped water with reverse osmosis to keep the chloride levels below the SMCL.

The nature of the shallow subsurface deposits causes additional water quality issues that are mostly of an aesthetic nature rather than a health threat. These include elevated hardness, iron, manganese and sulfides. Treatment will be needed for these constituents using filtration or ion exchange softening, to prevent scaling of plumbing fixtures, staining of laundry and plumbing fixtures, and water taste complaints.

3.3.2 Shallow Dolomite Aquifer - The shallow Silurian dolomite aquifer has the potential to supply a small portion of the water needed by Volo in the future, but it is unlikely that this supply would be economically feasible to pursue given the water treatment requirements and the low pumping rates.

3.3.3 Deep Sandstone Aquifer - The St. Peter sandstone formation and the underlying Galesville sandstone are continuous under northern and western Lake County. It is, therefore, much easier to locate a productive well in this aquifer as compared to the shallow aquifers. Further, these aquifers are not as susceptible to contamination from the surface or shallow subsurface, due to the presence of overlying shale deposits that prevent the movement of water and contaminants from the shallow aquifers downward into the deep sandstone aquifers.

While the deep aquifers present a solution to the water supply limitations of the shallow aquifers, they have their own set of equally serious issues. Foremost is the fact that regional demand on this aquifer is greater than the safe yield as determined by ISWS through modeling and water level measurements (Wehrmann, 2010) (Burch, 2008).

While estimates of the deep bedrock aquifer's practical sustained yield have not been updated in a number of years, and there remains debate as to the appropriate value, it nonetheless appears that the deep bedrock aquifer should not be relied upon as a sustainable source of additional water to accommodate Lake County's future water demands. The reasons for this are twofold. First, the declining water levels demonstrate that current groundwater withdrawals exceed the sustainable yield of the sandstone aquifers as a whole.

Second, water in these aquifers flows generally from northwest to southeast (this is called the flow gradient of the aquifer). This means that Lake County is last to draw from the aquifers, after communities in Boone and McHenry Counties in Illinois and Kenosha, Walworth and Rock Counties in southeast Wisconsin. Communities in Boone and McHenry Counties have no serious intentions at this time of pursuing alternative water supplies due to the distance from Lake Michigan and the costs of attempting to use nearby surface water sources such as the Fox River and Rock River. Most communities in southeast Wisconsin, while close in proximity to Lake Michigan, do not have the legal right to draw water from Lake Michigan due to the Lake Michigan

Compact, which makes them just as dependent on groundwater as land-locked Boone and McHenry Counties. Further, the shallow groundwater resources in southeast Wisconsin are limited in many locations, making the deep aquifers the only alternative for large volumes of water.

It is clear that communities in these areas will not only continue utilizing the deep sandstone aquifers, but that their dependence on this water source will increase over the next 20 years. Groundwater pumping in southeastern Wisconsin adjacent to Lake County is relatively minor at this time. This will not remain the case. SEWRPC adopted a regional water supply plan in late 2010, which anticipates significant population growth over the next 25 years. The study estimates that average day groundwater pumpage by municipal water utilities in SEWRPC's six-county planning area will nearly double from 44.8 mgd in 2000 to 89.5 mgd in 2035, causing water supply shortages in many of the communities (SEWRPC, 2010).

The McHenry County Groundwater Resources Management Plan, completed in 2006, forecasts a similar trend: average day pumpage of 34.6 mgd in 2000 increasing to 67.5 mgd in 2030. High growth areas in the southeast quadrant of McHenry County are anticipated to experience water supply shortages by 2030 (Baxter & Woodman, 2006).

The presence of so many demands on the sandstone aquifers up-gradient of Lake County means that the WPG communities will likely suffer significant declines in deep aquifer water levels due to regional groundwater mining. The results of the ISWS modeling do not indicate water levels in Lake County dropping to the top of the aquifer by 2050, but they do expect that the water levels will continue downward with declines in production being unavoidable in the foreseeable future (Wehrmann, 2010). Water use law in Illinois provides Lake County communities with little recourse to stop this from happening. The only alternatives in this situation are to deepen the wells into the Mt. Simon formation and/or lower the well pumps, or to find an alternate source of supply.

In addition to the water quantity concerns over the deep sandstone aquifers, water quality is also an issue. As stated in the last section, deep sandstone aquifers in Lake County contain radium and barium at concentrations exceeding the Maximum Contaminant Levels (MCLs) established by the USEPA to protect public health. The presence of these contaminants nearly always necessitates treatment for any deep well that cannot be blended with a shallow well supply to dilute the radium and barium. Further, waste disposal costs are increased due to the requirements associated with disposing of radioactive wastes.

4. GROUNDWATER SUPPLY PROGNOSIS

4.1 General

This section summarizes the potential of the aquifers under the Village of Volo to supply the future water needs of the community.

4.2 Projected Water Demands

Volo is anticipated to need a reliable, sustainable water supply capable of providing at least 2,820,000 gallons per day. If the community is to remain with groundwater, this will require the construction of at least three new deep wells and accompanying water treatment facilities. This assumes the community will not lose the use of at least one of the existing wells during that period due to declining water levels or well maintenance issues.

4.3 Availability of Groundwater Resources for Future Use

Volo's best option for continued groundwater supply is to use the deep sandstone aquifer. This is in spite of the fact that the long-term use of this aquifer is not sustainable.

Shallow sand and gravel formations appear to be largely absent below the community and the production capacity of the Silurian dolomite has proven to be limited. The deep sandstone aquifer is the proven source of additional water supply in the short term. However, the ISWS aquifer water level projections demonstrate that the deep aquifer is not a sustainable resource in the long-term at the current and projected rates of regional pumping. Due to historical and projected over-pumping, water levels are expected to continue to decline. Further, use of the deep sandstone aquifer water will require treatment to remove radium and barium before the water is supplied to customers.

4.4 Summation and Conclusion

The following concerns have been identified with the continued use of groundwater as the Volo water supply:

- The shallow sand and gravel aquifers appear to be absent in the Volo area.
- The Silurian dolomite in this area is not sufficiently productive to support municipal wells and is vulnerable to contamination from the deposits above it.

- The water levels in the deep sandstone aquifers are dropping. Population growth to the west and north will accelerate the rates of decline. Pumpage from the deep sandstone aquifers at ever higher rates is not sustainable over the long-term.

- The radium and barium found in the deep well water will cause operational and compliance issues with both water treatment and waste disposal.

We conclude that the future groundwater supply available to Volo is not sustainable over the long-term and expensive to maintain in the meantime.

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