Great Lakes Irrigation Water Resources: *A Brief Overview*

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Water, Water Everywhere

The Great Lakes Basin (Figure 1), the land areas that drain into the Great Lakes and the Great Lakes themselves, contains approximately 85% of North America's and 20% of the world's surface fresh water. Additionally, the volume of groundwater in the Great Lakes Basin is roughly equivalent to that of Lake Michigan, 1,000 cubic miles or over 1 quadrillion gallons. All of Michigan, about one third of New York and Wisconsin, about one quarter of Ontario, one tenth of Minnesota, the northern tip of Ohio and Indiana, the Chicagoland area of Illinois and a small part of Pennsylvania make up the Great Lakes Basin. The surrounding watersheds in the Great Lakes states are also rich in water. With this wealth of fresh water, it seems that there would be no limitation on the amount of water available for irrigation. However, all water is not of the same quality, the source and surrounding conditions of the watershed affect water quality, the characteristics of the source affect the volume of water available, and competition for other uses can affect allocation of water resources. The primary sources of irrigation water are surface water (lakes, rivers, streams), groundwater aquifers, municipal water systems (which may have extracted from surface waters or aquifers), and, increasingly, recycled water. All of these resources have some general water quality characteristics and challenges that set them apart from each other. Understanding water resources is important when selecting a site for a new operation or expanding existing irrigated production.

Who Owns the Water

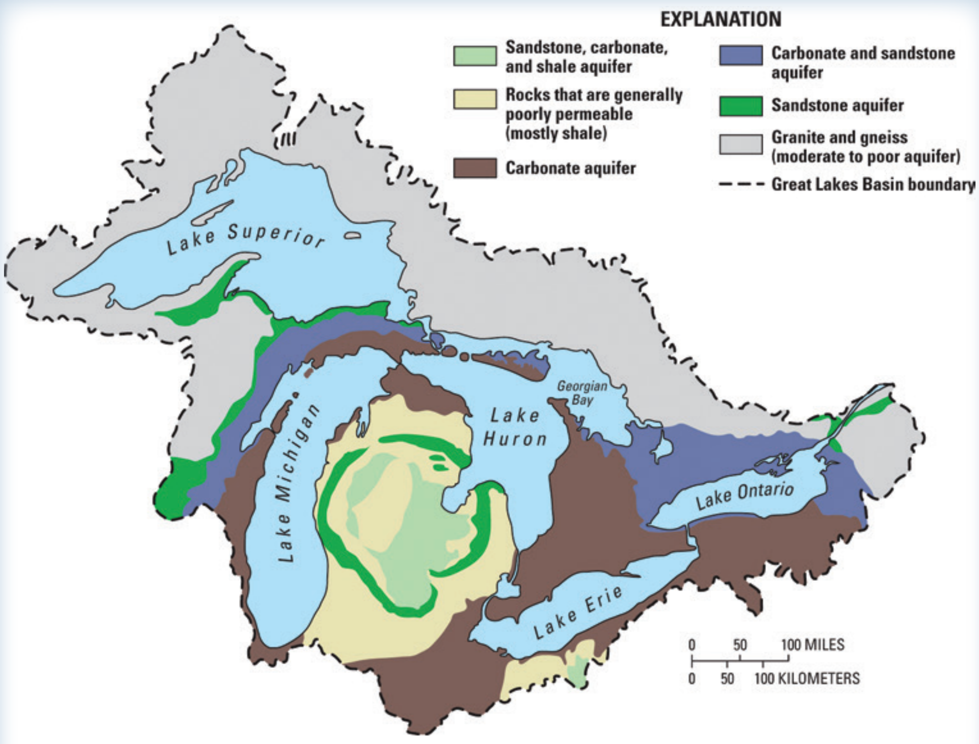

Figure 1. *Impact of installing a high-capacity well on groundwater and surface water resources, A: before installations, B: after installation. Courtesy of the U.S. Geological Survey.*

Before talking about water resources, it is important to know water use rights. Water rights in the Great Lakes Basin are complicated because of federal agreements and treaties between the U.S., Canada, and Native American Tribes and First Nations, as well as different state and province regulations. Water rights for resources in Great Lakes states outside of the Great Lakes Basin follow the same principals but do not have additional issues of international agreements or diversion outside of their watersheds. The following is a very general summary of water rights. Keep in mind there are differences for each state/province and you should check with your state/province for specifics. Also, federal treaties and agreements supersede state laws and there are treaties and agreements for the waters of the Great Lakes Basin. States/provinces own or control surface water and maintain it as a public trust or public good. Water rights to surface waters are granted to users by states/provinces based on a few different methods but, in general, the right to use surface water in the Great Lakes area are based on riparian and reasonable use concepts. A riparian right means that the owner of property bordering a natural watercourse (including lakes) has the right to reasonable use of that water. Reasonable use means use of the water resource without adversely affecting the reasonable use by others with rights to the same resource. Ownership of groundwater varies by state/province in the Great Lakes region, in some the state owns groundwater, in some it is a public trust, and in some it is owned by the property owner. Regardless of ownership, reasonable use also governs groundwater extraction. Figure 2 shows how the installation of a high capacity well can shift the groundwater and affect water flows into surrounding surface water resources, this could negatively impact other users with rights to those water resources. Use of a water resource does not just include extracting the water, other uses include tourism, boating, fishing, wildlife habitat, public and private enjoyment. For example, pumping from a lake that draws down water below dock levels is interfering with the rights of the dock owner to use the lake. Water being returned after use or practices that affect water resources are also included in the reasonable use concept, so pollution of water resources above regulated levels would negatively impact other users and is not a reasonable use. For waters within the Great Lakes Basin, the Great Lakes-St. Lawrence River Basin Water Resources Compact is an international agreement between 8 U.S. states and 2 Canadian provinces, adding Quebec to the ones listed above, that was developed to protect waters from being diverted outside of the Great Lakes-St. Lawrence Basin. Improving water conservation and use efficiency are important goals as well as restricting diversions of water outside (through extraction or drainage) of the Great Lakes-St. Lawrence Basin, adding additional considerations for water use and drainage. Most of the Great Lakes states/province have included permitting processes and regulations to ensure that water extractions and water return flows follow reasonable use principals. High extraction capacity (usually the ability to extract over 100,000 gallons per day) wells are subject to more stringent permitting than low capacity wells that are unlikely to affect other users. There are legal recourses in each state/province for addressing water rights infringements.

Water Sources

Water from municipal water systems is treated to a high quality level and is suitable for growing all crops. However, municipal water is more expensive than most other sources and is not available in all areas, in the volumes needed, or during critical periods (e.g. during drought restrictions). For these reasons, it is rarely used for wholesale production operations. When municipal water is available for a wholesale operation it is often used for high-value specialty production, such as vegetative propagation. Some municipalities add fluoride to water which can be a problem for sensitive plants especially under long production cycles. Douglas fir and several pines are sensitive to fluoride and could be adversely affected by long-term irrigation with water containing fluoride as fluoride will accumulate in plant tissues so be aware of fluoridated water if you use such a source.

Surface water and groundwater are often thought of as isolated sources of water but they are connected and will affect each other. The interaction between surface water and groundwater is typically referred to in relation to the surface water being losing (surface water drains through saturated soil into groundwater), gaining (groundwater feeds the surface water through saturated soil), or disconnected (there is a low permeability restrictive layer separating the stream and groundwater). Gaining surface waters are affected by the aquifer feeding it, losing surface waters affect the aquifer it drains into. There is interaction between disconnected surface water and aquifers but it is fairly inconsequential. Of course, there can be various gradations of these and, especially along the course of rivers and streams, there may be gaining, losing or disconnected segments. Overextraction of either resource can change the relationship in water flow, e.g. change a gaining river into a losing river, and this can result in unreasonable use (Figure 2). Also pollution of one resource will affect the other. While there are interactions between these water resources and they can sometimes greatly affect each other especially in the case of concentrated pollution events, there are some general characteristics that separate surface water and groundwater.

Surface water resources in the Great Lakes region are typically of good to very good quality. Their quality is affected by the bed material (streambed, riverbed, lakebed) to some extent but also by the land surface of the watershed draining into them. They are typically low in soluble salts, have neutral to slightly basic pH, and low alkalinity. However, surface water sources can have suspended particles that need to be filtered out and can be impacted by pollutants introduced from nearby or upstream properties in the local watershed. In addition to herbicides, there are several pesticides that can be phytotoxic to sensitive crops. Plant pathogens from agricultural operations can be transported by water. Industrial and urban pollutants can also be phytotoxic. Runoff from roads can contain soluble salts and heavy metals that can damage crops. All of these pollutants can be transported to and by surface water systems much more quickly and easily than in groundwater. Irrigation return flow (runoff/drainage) quality is considered part of reasonable use and can be regulated to ensure quality standards for certain pollutants are met. Minimum size and flow of rivers and streams and the volume of lakes are often considered when permitting commercial withdrawals.

Groundwater is held in aquifers. Aquifers are water-saturated sediment and porous rock layers. In most areas of the Great Lakes there are more than one aquifer below the surface. The surficial or glacial aquifer, when present, is the uppermost aquifer and is not separated from the overlying soil. It consists of sand and gravel materials deposited by glaciers. The surficial aquifer is one of the most commonly used aquifers due to easy accessibility but there are large areas in the Great Lakes region where it is absent (bedrock is exposed) or too shallow for installing a well. Most states have a minimum depth requirement for a well. This is to minimize extraction of shallow water that may be contaminated by pollutants from the land surface. Successive aquifers can be composed of different material, most commonly limestone, dolomite, sandstone, granite and shale in the Great Lakes region. The different aquifers are separated by a "confining layer" made of low permeable material (dense clay layers, low porosity rock, etc.). The sediment and rock materials that make up an aquifer layer have a large impact on the water quality. The volume of water available for extraction is related to the material composing the aquifer, the denser materials generally providing lower volume. At one time, the Great Lakes region was covered by a prehistoric ocean. Remnants of that ocean are echoed in the salt mines

within the region. Additionally, saltwater is denser than freshwater and has settled to deeper aquifer layers over the eons. Saltwater is composed of many different ions. Thus, there can be quite a bit of difference in water quality in the same region based on the location and depth of the well and the aquifer tapped so it is important to know the characteristics of the water in the aquifer that your irrigation system will tap into.

Soil and their associated microorganisms are an incredible filter for many pollutants. For this reason, groundwater resources are often the least polluted water source. Water moves very slowly in aquifers compared to surface water and slower with deeper aquifers, so pollutants are transferred slowly within groundwater. That does not mean groundwater does not contain natural contaminants or that they cannot be polluted, they are just less likely to be polluted than surface water. The carbonate based (limestone, dolomite) aquifers result in water that is moderate to high in alkalinity. The saline regions in deeper parts of some aquifers are beginning to infiltrate upwards as mentioned in my last article. Despite being good filters for most contaminants, some chemicals (nitrate, some pesticides, PFAS, industrial solvents, fracking chemicals, deicing salts) can move into shallow areas of aquifers or move fairly rapidly in soils or enter at well-heads to contaminate even deep aquifers. Suspended particles are less common in groundwater than surface water but sand and grit can sometimes be transported with the water. This is easier to filter out than most surface water suspended particles.

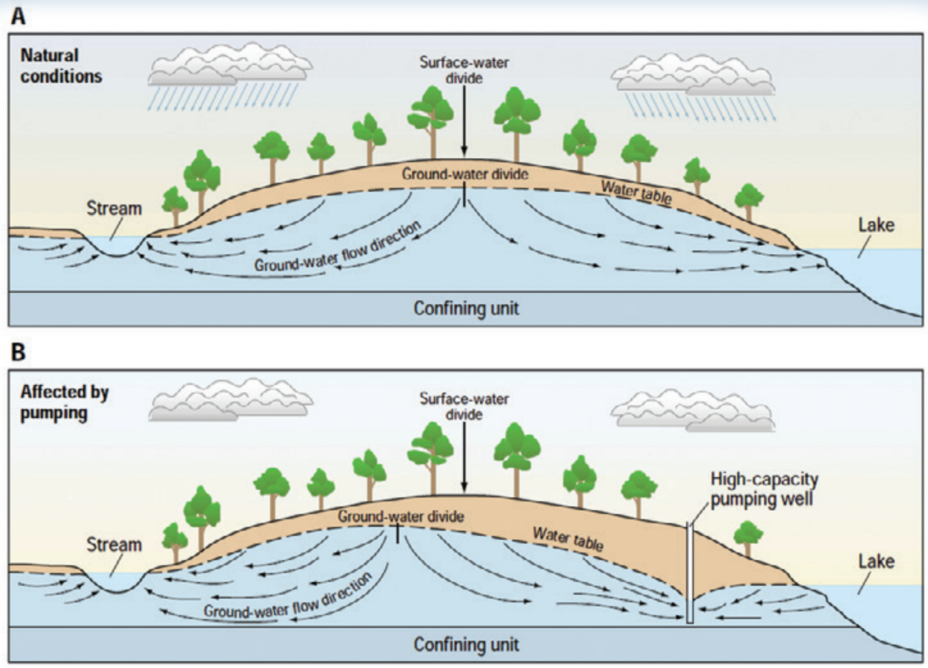

Figure 2. *Recycled water reservoir at a container nursery showing water being returned from production at the far end of the reservoir.*

The same principals of reasonable use regarding drainage water also applies to subsurface infiltration, regulations can be imposed to ensure proper water quality standards are met for irrigation water being returned to groundwater systems. Permitting for extraction is often based on aquifer characteristics such as yield, drawdown, recharge and transmissivity.

Recycled water is more commonly associated with container production than field operations due to the larger volumes of water used (Figure 3). Recycled water may have originally been extracted from any of the above sources but now shares properties more with surface water. Recycling water is more easily accomplished with a new operation since grading and drainage can be planned to deliver water to reservoirs but water flow patterns in existing operations can be redesigned. It may be beneficial to grade to exclude water moving from neighboring lands onto the production site if it is likely to contain undesirable pollutants (road salt, neighboring agrichemicals, industrial pollutants). Recycled water is generally stored in open reservoirs but can be stored in tanks or covered reservoirs. Recycled irrigation will have passed over the production surface and drainage system where it will have been exposed to a range of possible contaminants. Primarily those will be agrichemicals and plant pathogens but may include other contaminants from adjacent areas that drain into the production operation. The introduction of surface contaminants can improve

Figure 3. *The Great Lakes Basin. Courtesy of the U.S. Geological Survey.*

water quality for reuse (recycling nutrients and some pesticides) as well as decrease water quality with the introduction of phytotoxic compounds and plant pathogens. Properly managing recycled water can reduce or eliminate these impairments to water quality. Additionally, rainwater will be intercepted by the production surface, drainage system, non-production areas (roofs, roadways, parking areas, etc.), and the reservoir itself if open. Except in rare circumstances, rainwater is of very high quality and will help improve the quality of recycled water by diluting contaminant concentration. This is especially the case for rainwater falling directly into the reservoir or that which has not contacted production surfaces.

Having access to more than one water source is very beneficial. Deficiencies in water quality can be overcome by blending water sources or using higher quality sources for sensitive crops and propagation and lower quality sources for more tolerant plants and production systems such as field production. Groundwater is less sensitive to short-term droughts and could supplement or replace surface water sources during these periods. Recycled water greatly improves water use efficiency and retains contaminants on-site rather than affecting surrounding ecosystems.

Next Time

With those general characteristics of water resources in mind, there are specific water quality parameters desired for optimum plant production. My next article will discuss specific irrigation water quality characteristics necessary for proper plant production.