Water Source Development for Irrigation Systems

This guide is designed to help producers determine the feasibility of developing an irrigation system by evaluating water sources and exploring their capital costs.

Missouri water laws

Missouri is a riparian water law state, so landowners have a right to reasonably use water sources that are touching or underneath their land. Under this law, a landowner can withdraw as much water as needed as long as the withdrawals do not adversely impact the water use of other individual water users.

Water users who withdraw or divert 100,000 gallons per day, equivalent to 70 gallons per minute all day, from streams, rivers, lake, wells, springs or other water sources are considered *major water users*. Missouri Water Law (Section 256.400–430 of the Revised Statutes of Missouri) requires that major water users register their water use annually with the Missouri Department of Natural Resources (DNR) (see Major Water Users registration at ***http://dnr.mo.gov/forms***). A producer with several active wells that have a total output of 100,000 gallons would be classified as a major user and should be registered. Users may be designated as *major* even if they only withdraw or divert the 100,000-gallon threshold on one day in a year.

The Army Corps of Engineers has jurisdiction over navigable waters, such as rivers and streams. Someone interested in directly pumping water or diverting water from a stream or river should contact the Army Corps of Engineers district office with jurisdiction for the proposed pumping location. The Corps

- does not regulate temporary structures, such as a floating intake;
- does not require a permit if there is no construction in the channel and as long as no spoil or dredge material goes into the channel;
- does require that if a bank is altered, soil must be brought back and placed on the disturbed area or hauled off; and
- does require that the disturbed area be protected from erosion so that silt does not enter the channel.

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Figure 1. Streams are one possible surface water source. However, during dry weather, a stream water source is already low, so care must be taken not to over pump the stream or allow pumping activities to significantly disturb the stream bank.

Water sources

Three types of water sources exist for irrigation systems: surface water, ground water and public water. You will need to estimate the water quantity available from each source and determine if the given source will have the needed water available through the times when irrigation is needed in the growing season. Additionally, each option may have other issues you need to consider when deciding whether to use it as a water source for irrigation.

Surface water

Surface water includes sources such as streams, rivers, ponds and lakes.

Rivers and streams

If you are considering using rivers and streams, consult the local Army Corps of Engineers district office about the jurisdiction over the area from which the water will be pumped. These are some of the issues, topics or questions you must consider when pumping from a stream or river:

- Ensure that you have ownership of the land connected to the water source where the pumping site would be located.

Estimating pond capacity

1. Establish normal full pond water elevation.
2. Measure or calculate full pond surface area.
3. Estimate volume by multiplying **surface area** by **0.4** by **maximum water depth measured at the dam**.

Source: U.S. Department of Agriculture Natural Resources Conservation Service (1997).

Figure 2. How to estimate pond capacity.

Gallons of water in an acre-foot

	27,200	gallons, approximately, in 1 acre-inch of water
×	12	inches
	326,000	gallons per acre-foot

Figure 3. Acre-foot defined.

- Estimate the volume of water that would be pumped from the river or stream each year.
- Consider pumping to an intermediate water storage impoundment.
- An intermediate water storage impoundment may allow diverting river water when the river flow is such that a floating intake could be used so that no channel modifications would be needed. A floating intake would eliminate the need for a permit from the Army Corps of Engineers for channel modifications.
- Pumping when the flow in the river is above low flow should keep you from having any adverse effect on any other water use (Figure 1).
- Pumping will not adversely impact a downstream owner or fish living downstream from the pumping site.

Ponds and lakes

Ponds and lakes can be good, reliable sources for irrigation. Existing ponds and lakes on privately owned land can be used. Storage capacity for the pond needs to meet the irrigated crop requirements plus any water losses due to evaporation or seepage. Water impoundments should be large enough to store at least a one-year but preferably a two-year water supply. Ensure that the watershed area draining runoff is large enough to refill the impoundment within a normal year. A minimum of 10 acres' drainage for every acre of pond surface is recommended. However, larger watershed areas per acre of water surface area may be required for cases when the pond is used to serve as a significant water supply.

Building a new pond or lake is an option for an irrigation water source. Site considerations include understanding the area adequacy for water drainage, minimum pond depth, drainage area protection, pond capacity estimation

Estimating surface water storage requirements

1. Estimate the daily water usage in gallons per day.
2. Multiply the **daily use** by **days of expected irrigation** to determine an annual estimated water usage.
3. Divide the **annual gallons per year** by **325,828.8** (gallons per acre-foot) to obtain the annual water need into the volumetric measure of acre-feet of water.
4. Multiply the **annual water need in acre-feet** by **4** to obtain the estimated water impoundment storage capacity.

   The constant 4 is derived as follows: A surface water system should be able to supply two years' worth of water need without any significant runoff from the watershed due to dry weather. In Missouri, about half the water stored in a given impoundment is lost due to evaporation and seepage losses.
5. Multiply the **total acre-feet of water storage** by **2.4** to estimate the number of acres needed in the watershed to refill the water impoundments. The size of the watershed to refill the water impoundments should be large enough to refill all the water storage capacity in a normal year. In a normal year, about 5 to 6 inches of runoff can be expected from typical rural watersheds. The 2.4 constant is derived by dividing 12 by 5. The 5 is the depth in inches of runoff from an acre, and the 12 converts inches to feet.

Figure 4. How to estimate surface water storage requirements.

(Figure 2) and landscape evaluation. Select land where the topography achieves the largest volume of water per cubic yard of soil moved to minimize the cost of moving earth.

Soil is important as areas that have a lot of rock or sand make getting a good seal challenging and expensive. Dams should have about 30 percent clay in their structure and hauling in additional clay adds considerably to the construction cost. Generally, the Natural Resources Conservation Service (NRCS) recommendation for minimum pond depth in Missouri is 6 to 8 feet, depending on location. Two recommended reading materials on ponds are the NRCS handbook *Ponds — Planning, Design, Construction* and MU Extension publication G1555, *Reducing Pond Seepage*.

The cost of building ponds and lakes in Missouri averaged $2.84 per cubic yard of soil moved, or $137.96 an hour, in 2016. But note that the costs ranged from $2.00 to $4.25 per cubic yard, or $100 to $200 an hour, which shows that costs vary greatly depending on variables such as location and soils.

Surface water storage requirements are expressed in the volumetric measure of acre-feet of water, with one acre-foot equal to about 326,000 gallons (Figure 3). A method of estimating the total size of surface water storage system required is presented in Figure 4 along with a method of estimating the number of watershed acres that should be available to refill the surface water storage. The estimated

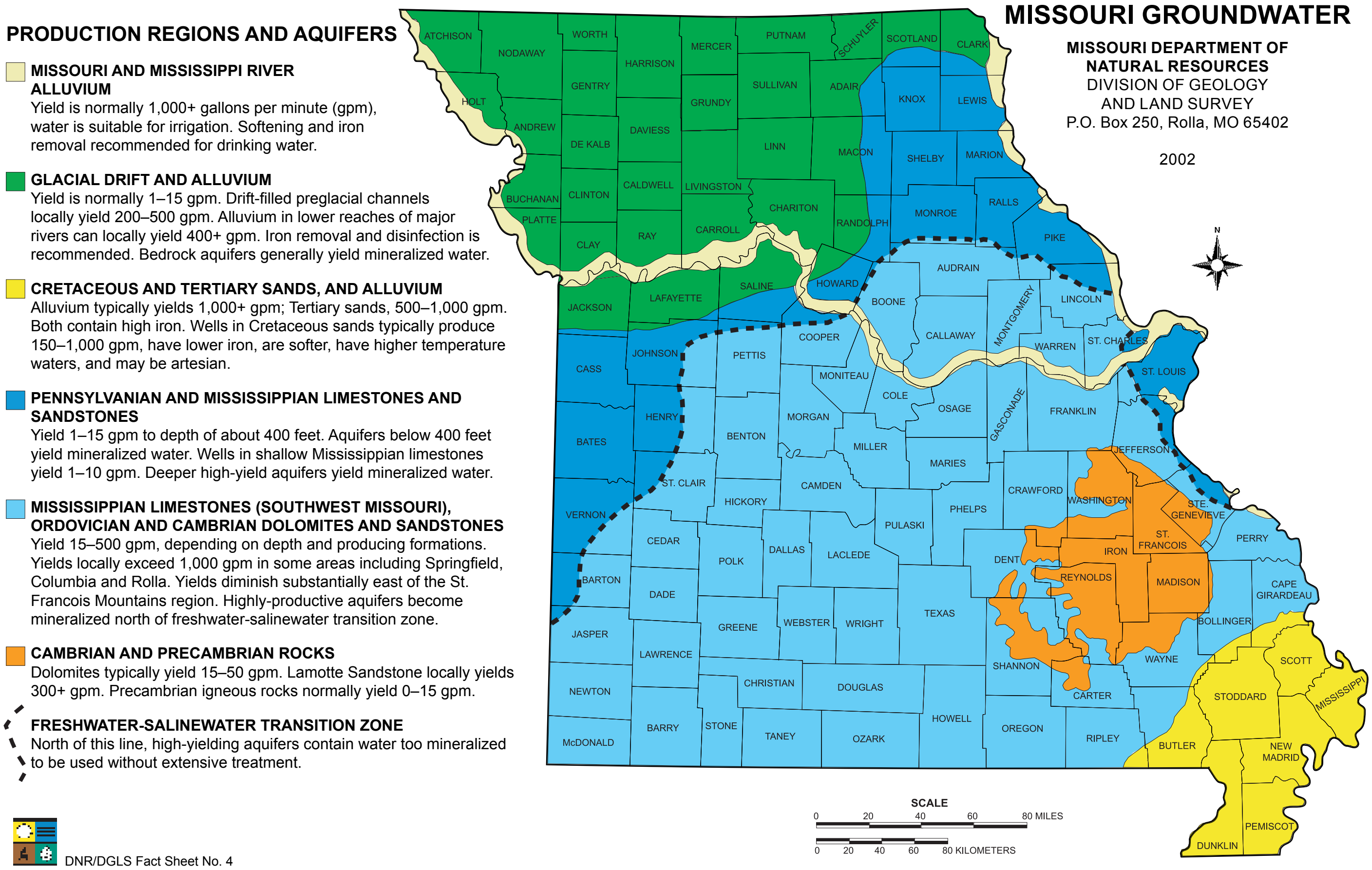

Figure 5. Missouri groundwater production regions and aquifers. (Source: Missouri Department of Natural Resources.)

storage requirement can be provided by one or more water impoundment structures. The watershed acres must be such that all the available runoff from the watershed can be captured and stored in the water impoundment structures.

Ground water

In Missouri, a majority of the water currently used for irrigation comes from groundwater sources. When the U.S. Department of Agriculture's Farm and Ranch Irrigation Survey was taken in 2013, Missouri had a total of 13,621 irrigation wells in operation, serving 1,798 farms. The Missouri Department of Natural Resources (DNR) is the regulatory agency in charge of irrigation wells in Missouri. It is the clearinghouse for all well construction rules. It also maintains a Missouri database of licensed private well drillers and pump installers that should be used when drilling or repairing a well.

The Missouri DNR provides two good tools for making water well decisions. It has established a network of groundwater observation wells located throughout Missouri, available online at ***http://dnr.mo.gov/geology/wrc/wells.html***. Groundwater observation wells are a good way to visualize the real-time depth and availability of water in an area. Additionally, the Well Information Management System (WIMS) has a database of all wells drilled in Missouri after November 1987, online at ***http://dnr.mo.gov/mowells***, which can give you an indication of what to expect when putting in a local well.

Understanding the geology of the state will give you an idea of how much groundwater is available (Figure 5). Further information about Missouri's groundwater and aquifer characteristics is available from DNR at ***http://dnr.mo.gov/geology/wrc/groundwater/education/provinces***. Special areas in Missouri may require that you either case or grout deeper depending on the area and geologic

Table 1. Average Missouri well cost.

Component description	**Cost range**	
Drilling of hole ($6.50–$8.50 per foot × 500 feet)	$3,250	$4,250
6-inch steel casing installed ($17 per foot × 500 feet). [Note: 6-inch PVC casing ($11 per foot) and/or PVC lining ($6 per foot) could be substituted or added as needed.]	$8,500	
Pump package (1.5 hp 10 gpm pump, 40-gallon pressure tank, submersible electrical cable, 50 feet of pipe to hydrant)	$3,500	$4,200
Grout seal required (varies with depth) (15 bags × $50 per bag)	$750	
Boom truck and labor (6.5 hours × $180–$230 per hour)	$1,170	$1,625
Miscellaneous costs (chlorination and Missouri Department of Natural Resources certification)	$150	$250
Total costs	$17,320	$19,575

conditions. Requirements for well construction are based on yield, use of well, and the region where the well is located.

Well system capacity needs to be large enough to supply the daily water need. An intermediate storage system can be used to store water if the well cannot supply the peak demand of water needed through direct pumping. Maximum pump size needs to be slightly smaller than maximum well yield capability.

The average Missouri cost of a 500-foot well, complete with pumping system is shown in Table 1. The final cost of any well installation can be affected by variables such as an increased drilling depth ($6.50– $7.50 per foot), casing needed in steel ($17 per foot) vs. PVC pipe ($11 per foot), and a PVC liner ($6 per foot) needed outside of steel casing due to geological conditions. Contact your local NRCS and Soil and Water Conservation District (SWCD) offices to see what they have on record as average cost for a well in your area, or talk with local well drillers about average depth and cost. For a list of licensed well drillers, contact your county SWCD or the Missouri Geological Survey at 573-368-2165 or online at ***https://dnr.mo.gov/mowells***.

Public water

Public water supplies tend to be an expensive option for irrigation. The Missouri Rural Water Association conducts an annual survey to detail trends in local water rates in Missouri. Based on its 2016 survey, the cost of 5,000 gallons of water for a private system was $31.46, ranging from $13.05 to $58 across Missouri. This cost would be equivalent to $171 per acre-inch of water on average in Missouri, making it prohibitively expensive for irrigation. Many public water supplies may be limited on available water and may put a limit on water use for uses other than domestic use. During times of critical water supply shortages, public water supplies will request and sometimes require reductions for domestic use.

Intermediate water storage

Intermediate water storage structures have been used to extend low yield water supplies [low gallons per minute (gpm) yielding supplies] to provide the required water during periods of high usage (high gpm use periods). For example, if a small irrigation system needs 60 gpm for five hours a day and the well yields only 10 gpm, an intermediate water storage holding at least 15,000 gallons [(60 gpm – 10 gpm) × 5 hours a day × 60 minutes an hour] can allow the 10 gpm well to serve as a water supply for the 60-gpm irrigation system. The well pump would pump water into the intermediate storage, and the irrigation system pump would pump water from the storage. The storage must be full at the start of irrigation, and the well will continue to pump water into the storage after irrigation is complete to refill the storage for the next day's irrigation event.

Another function of the intermediate water storage would be to provide a readily available source of water if flow from the primary water supply is interrupted. This volume of water storage will provide a minimum time frame to correct a water interruption problem or to arrange for the delivery of water by other means. Required intermediate storage volumes may need to equal the anticipated water usage over a 48 to 72 hour period. The availability of service personnel and repair parts required to keep the water system operational will be a major factor in determining the intermediate storage volume requirement.

References

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Contacts

U.S. Army Corps of Engineers district offices, ***http://www.usace.army.mil/Locations.aspx***

Missouri Department of Natural Resources, Missouri Geological Survey, ***http://www.dnr.mo.gov/geology/geosrv/wellhd***

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