Engineering and environmental requirements

Executive Summary

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For each of the four study areas evaluation of the feasibility of aquifer storage and recovery (ASR) on a scale that would provide significant benefit to the nearby communities can be divided into three main stages. The following protocol assumes that injection capacity of the target aquifer is sufficient to store the required amount of water, and that injection and recovery wells will be the main technology for delivering water to and recovering water from the target aquifer. At each stage, if the main requirements cannot be met, then it is unlikely that an ASR project would be viable in the area of interest.

The first stage consists of the identification and evaluation of a source water of ample quantity. The definition of ample quantity is used loosely here, but a good estimation could be an amount equal to the average daily water demand of the municipality interested in pursuing an ASR project, the amount withdrawn for irrigation purposes in a defined area, or a quantity that would be sufficient to impact the target aquifer in an otherwise desirable manner. If no source water can be provided in a quantity that would meet the expected demands of the project for which ASR is being considered as a water security, storage, or remediation technique, then ASR is not a suitable technique for the project.

The second stage consists of evaluating the aquifer geochemistry and native groundwater quality. If the aquifer media is composed of materials that may contaminate stored water despite any pre-injection treatment, or the groundwater is contaminated with pollutants that may render the stored water unsuitable for the ultimate purpose of the project, then ASR is not a suitable technique for the project.

The third and final stage consists of evaluating the feasibility of treating the source water in such a way as to mitigate deleterious water quality changes during storage, and to meet the water quality expectations for the stored water upon withdrawal from the target aquifer. If the necessary treatment is not feasible or it is simply not possible to treat the water to meet these expectations, then ASR is not a suitable technique for the project.

The Buffalo aquifer is located to the east of the city of Moorhead, in Clay County. The City obtains approximately 80% of their drinking water from the Red River, while they draw about 20% from the Buffalo aquifer. Drought conditions can cause the stage of the Red River to drop to the point where sufficient water withdrawals to meet the City's drinking water demand cannot be made from the river. In these cases, the City can rely more heavily upon the Buffalo aquifer. However, the Buffalo aquifer is also used by several smaller outlying municipalities as well as a source of irrigation water for agricultural activity in the county. If the Red River were to experience an extended period of low flow due to drought conditions, it is not clear what sustainable withdrawal from the Buffalo aquifer would entail. In order to provide drought resilience, ASR could be considered as a mechanism to increase the available water volume in the Buffalo aquifer which would provide additional water security to the City.

There are three potential sources of water for injection into the Buffalo aquifer. One is the Red River, which could be drawn at a flow rate exceeding the City's drinking water demand during periods of adequately high flow. Another is the Buffalo River, which is hydraulically connected to the Buffalo aquifer in some of the locations where it is unconfined. However, the average flow of this river is low enough that it would probably not be able to provide sufficient quantities for ASR operations. The final potential source water is the effluent of the City's wastewater treatment plant. Currently, this flow is discharged to the Red River, but it could potentially be redirected for injection into the Buffalo aquifer.

The Buffalo aquifer is composed of sand and gravel from glacial outwash of the Red Lake Falls Formation. This provenance of this Formation iRiding Mountain-Winnipeg, to the northwest, and dated to the late-Wisconsinan period. The source area and rock fragments incorporated in the glacial sediment, make it highly likely that the Buffalo aquifer contains arsenic in iron sulfide minerals such as pyrite. In general, glacial till associated with the northwest provenance late-Wisconsinan age glacial sediment is fine-grained with significant organic entrainment. This has led to the mobilization of arsenic in wells in the Buffalo aquifer. In addition, the aquifer has sulfate, manganese, and is generally hard. Any water that is injected into the Buffalo aquifer should not be expected to maintain a potable condition due to the presence of these natural contaminants. However, if the injected water is not degraded further than the native groundwater, this should not be an issue, as the City already treats Buffalo aquifer water to satisfy 20% of their demand. Therefore, ASR could be a viable technique to provide water security for the City.

The City of Rochester currently derives 100% of their drinking water from groundwater, primarily drawing from the Jordan Aquifer with 33 municipal wells, each equipped with their own treatment system. Rochester has been deemed a destination medical center due to the presence of Mayo Clinic, and is projected to experience substantial growth over the next few decades. This growth will increase the demand on the Jordan Aquifer, which is already utilized at an unsustainable rate. ASR could be implemented in the Jordan Aquifer in the vicinity of the City in order to enhance water supply and reduce net withdrawals to prevent overdrafting.

The only semi-significant source water near the city of Rochester in Olmsted County is the Zumbro River. However, it is unclear if appreciable withdrawals from the Zumbro River near Rochester would be viable. There are other aquifers that could be used as sources of water for injection into the Jordan aquifer, the primary aquifer used for drinking water in Rochester,, however this would result in the depletion of these units, which may be undesirable for a number of reasons. The City does not have centralized drinking water treatment system, which may make treatment of Zumbro River water or water derived from an alternative aquifer more difficult to treat prior to injection. However, the City does operate a centralized wastewater treatment plant. The effluent of this facility could serve as source water for ASR activities if additional treatment processes were installed in order to render the water suitable for injection. The Jordan aquifer in Olmsted County is not known to be significantly contaminated. However, groundwater in Olmsted County in general is known to have a high susceptibility to pollution due to the rather thin layer of unconsolidated material covering the bedrock, leading to high rates of transmission of surface water to the buried aquifers. The pollutant of greatest concern is

nitrate due to the high proportion of agricultural land use in the county. However, injection of treated water is not expected to increase the threat of this pollutant and may serve as a method to ameliorate it in some way. The injection and recovery would likely occur at different wells; the existing well infrastructure of the City's drinking water system would likely be leveraged for recovery, while new wells would be drilled for injection purposes. If it is economical to treat the wastewater from the City to the point where it would be suitable for injection (probably requiring reverse osmosis and advanced oxidation unit processes), ASR could be utilized as a viable method to reduce the overall demand of the City on the Jordan aquifer.

In Washington County all residents rely on groundwater as their primary source of drinking water. Public water systems serve 80% of the population, while the remaining 20% rely on private wells. The Jordan aquifer is the most widely used source of groundwater, but has experienced drawdown due to overdrafting, as well as contamination with PFAS from 3M chemical disposal sites in Oakdale, Woodbury, Cottage Grove, and Lake Elmo. In addition, the population of the county is growing, with the total water demand expected to increase by 27% from 2012 to 2040. ASR could not only be applied as a technique to enhance the water supply and prevent unsustainable groundwater withdrawals, but also as a method for remediation of the contaminated aquifers.

There are ample sources of water that could be injected into the Jordan aquifer in and around Washington County. The county is bordered on its eastern edge by the St. Croix River, its southern edge by the Mississippi River, while the confluence of the two occurs at the county's southeast tip. The county also contains several wastewater treatment plants, including two operated by the Metropolitan Council (Eagles Point and St. Croix Valley). The Metropolitan Wastewater Treatment Plant is also located just to the west of the county. Any of these source waters could provide sufficient quantities to an ASR project. The Jordan aquifer is not composed of media that is associated with natural arsenic, and arsenic is not a major concern in Washington County. Manganese concentrations in the Jordan aquifer are lower than the statewide average, but concentrations of nitrate and chloride are elevated. Radionuclides are not reported as a concern for water withdrawn from the Jordan aquifer. There is known PFAS contamination of the Jordan aquifer near the 3M disposal sites. Considering the reliance of the population on groundwater and its increasing demand, coupled with the relative suitability of the aquifer as a storage target and the availability of source waters, ASR would be beneficial to pursue in Washington County. ASR may be integrated with remediation techniques like pump-and-treat in order to remove PFAS contamination via activated carbon or ion exchange treatment processes.

The unconfined sand aquifers within the Straight River watershed have been designated by the Minnesota Department of Natural Resources (DNR) as an "area of specific concern where groundwater resources are at risk of overuse and degraded quality". The primary land use in this watershedGWMA is irrigated agriculture which is the largest water use in the area. The area surficial aquifer is part of the larger Pineland Sands aquifer, an extensive sandy Quaternary water table aquifer. Water withdrawals from the Pineland Sands aquifer have been steadily increased over the last few decades, and the DNR has suggested that these withdrawals have the potential to become unsustainable. The eponymous Straight River is also a trout stream, which could be

threatened by a declining water table. ASR could be a technique that is applied to portion of the Pineland Sands aquifer in the Straight River watershed in order to protect the cold-water stream while allowing for current appropriations.

However, there are no significant sources of water for ASR. In addition, there is not a water treatment facility that could handle a large additional treatment volume. Park Rapids is located at the southeast end of the watershed and if injection or delivery of recharge water to the Straight River watershed were attempted near the City of Park Rapids, the majority of the watershed would not observe appreciable benefit, due to the southeasterly flow direction. Therefore, ASR is not recommended in this area at this time.