Management Plan for the Gallatin Valley Water Exchange

A market-based approach to sustainable water management in Western Montana

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Signature Page

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Abstract

Western Montana’s Gallatin County is growing rapidly, placing increasing pressure on water resources. The surrounding Upper Missouri Basin is legislatively closed to new surface water rights appropriations, so new development depends primarily on groundwater withdrawals. New groundwater users pumping more than 10 acre feet per year (AFY) must develop a mitigation plan to offset any adverse impact of their use on senior rights holders, but this mitigation process is complex and burdensome both for water users and for state agencies. The lack of an effective institution to support groundwater mitigation threatens the continued existence of these mitigation requirements. The Gallatin Valley Water Exchange (GVWE, or Exchange) will facilitate water transactions between existing surface water rights holders and new groundwater users to allow for continued growth while supporting sustainable water use. The Exchange will acquire or contract for surface water rights, change their use to an aquifer recharge or mitigation purpose, and use this water to offset the effects of new pumping on surface water. New developers, municipalities and community water systems can purchase mitigation credits from GVWE to offset the effect their pumping will have on surface water and fulfill their mitigation requirements.

This management plan includes hydrogeological and economic analyses of GVWE. Broadly, this analysis suggests that GVWE may be hydrologically and economically feasible, but implementation will be challenging and dependent on a number of factors. These include the development of a basin-wide hydrologic model, demand for mitigation from the City of Bozeman, the ability to secure sufficient senior surface water rights with appropriate points of diversion, minimization of costs, and collaboration between stakeholders. If these conditions can be met and the Exchange can be implemented successfully, it will serve as a model of successful conjunctive management through strict mitigation requirements and support sustainable water management in the Gallatin Valley.

Executive Summary

Gallatin County, Montana – located within the Upper Missouri Basin – faces substantial new water demand. Gallatin County has the fourth fastest growing population in the state, predominately within the City of Bozeman, but also in neighboring Belgrade and the unincorporated area of Four Corners[1]. In 1993, the basin was legislatively closed to any new surface water appropriations, and new development depends primarily on groundwater extraction.

Water resource stakeholders in the Upper Missouri Basin, including Gallatin County, are faced with balancing increasing water demand with existing senior water rights, environmental quality, and a complex regulatory environment. In 2007, Montana law formally recognized the hydrological connection between surface water and groundwater resources. As a result, new permitted groundwater use must mitigate any adverse effect on surface water rights[2]. The process of developing this mitigation plan is burdensome and costly, requiring water users to find an existing water right, complete a regulatory change of use process, and then prove and sustain appropriate mitigation of the timing, volume, and location of their consumptive water use. To most efficiently offset impacts from new development, a portfolio of mitigation options could be used, combining managed aquifer recharge with instream transfers to provide complete mitigation. The intentional recharge of the aquifer with surface water is often a good mitigation option to offset year-round stream depletion caused by municipal and domestic wells when water is only legally and physically available during the summer irrigation season. However, only one small aquifer recharge site exists in Gallatin County[3].

A recent change in regulations regarding exempt wells has accelerated the challenge of developing and reviewing mitigation plans. Wells that withdraw less than 10 AFY are exempt from the permitting process and mitigation requirements. Prior to 2014, multiple small wells serving the same development were considered exempt unless physically piped together. Between 2007 and 2014, over 35,000 exempt wells were drilled in Montana, augmented by subdivisions exploiting this loophole and drilling individual wells rather than a single water system that would require a permit and mitigation plan[3]. Worried that extensive groundwater use would diminish instream flows, senior surface water right holders pressured the state for change. In October 2014, a district court decision determined that multiple small wells serving the same development and totaling over 10 AFY would require a permit, regardless of physical connectedness. This decision aims to protect surface water rights holders and may support sustainable groundwater use, but it also increases the permitting burden and creates a need for effective mitigation strategies.

In response to this need, local stakeholders are developing the Gallatin Valley Water Exchange (GVWE) to facilitate voluntary water right exchanges between residential and agricultural uses and streamline the mitigation process. GVWE will purchase or contract for senior surface water rights, complete the regulatory change of use process for mitigation, and market mitigation credits. Upon the sale of credits to a new user, the Exchange would provide a portfolio of suitable mitigation, including instream transfers and aquifer recharge. The Exchange will act as a clearinghouse for new water use mitigation, facilitating sustainable residential development within Gallatin County and protecting instream flows and surface water rights.

Should GVWE succeed in offsetting depletions caused by new water use, the potential benefits to river recreation, current surface water users, future development, and the environment are substantial. New groundwater users will avoid the arduous process of finding an existing senior water right and repurposing it as mitigation water, and will instead offset their impact by simply purchasing credits directly from GVWE. Senior water rights holders and environmental agencies will be assured that all new non-exempt water appropriations in the Gallatin Valley are properly mitigated. GVWE will maintain in-stream flows by offsetting stream depletions caused by new groundwater development and provide a cost-effective method for continued development in Gallatin County.

This report outlines suggestions for our clients, project partners, and other collaborators to inform the development and operation of GVWE. These considerations include:

1. An **analysis of appropriate groundwater recharge locations** and methods that ranks appropriate sites based on hydrogeological and land use considerations.

2. An **analysis of the economic viability** of the Exchange, including estimated demand for mitigation, available supply of surface water rights, anticipated costs, and potential pricing.

3. Additional strategies to protect instream flow and increase the **environmental benefits** generated by bank operations.

4. The Exchange's **institutional and operational structure**, including roles and responsibilities, funding sources, and permitting requirements.

Our hydrogeological analysis succeeded in identifying broad areas of the valley that are suitable for the construction of recharge infrastructure, although further groundwater modeling will be required to refine the analysis and select recharge sites.

Based on population projections, per capita water use rates, and estimates of non-exempt well use and net depletion, we find that a moderate estimate would see the Exchange supplying almost 6,000 AFY of mitigation by 2050, mostly for the City of Bozeman. Existing irrigation water rights in the valley are sufficient to meet this demand, but suitable priority dates, points of diversion, and willing sellers limit the supply of water rights available to the Exchange, which will create a potential barrier to implementation.

We also estimate the costs of operating the Exchange through 2048. Water rights acquisition and managed aquifer recharge are the largest expenses, suggesting the Exchange could reduce costs by acting as a broker rather than acquiring rights outright and minimizing recharge requirements by meeting peak summer-season depletions through instream transfers. Cash flow and break-even analysis indicates that the absolute minimum price for mitigation credits will fall in the $2,000-$7,000 per acre foot range, and greatly depend on the chosen operational model. Further, the Exchange will only be financially feasible if the City of Bozeman purchases mitigation credits.

Broadly, these analyses suggest that GVWE may be hydrologically and economically feasible, but will be challenging and dependent on a number of factors, including successful groundwater modeling and recharge site selection, demand for mitigation from the City of Bozeman, the ability to secure sufficient senior surface water rights, and collaboration between stakeholders.

If implemented successfully, the Exchange will serve as a model of successful conjunctive management with strict mitigation requirements and will support sustainable water management in the Gallatin Valley.

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Background, Significance, and Objectives

Study Location

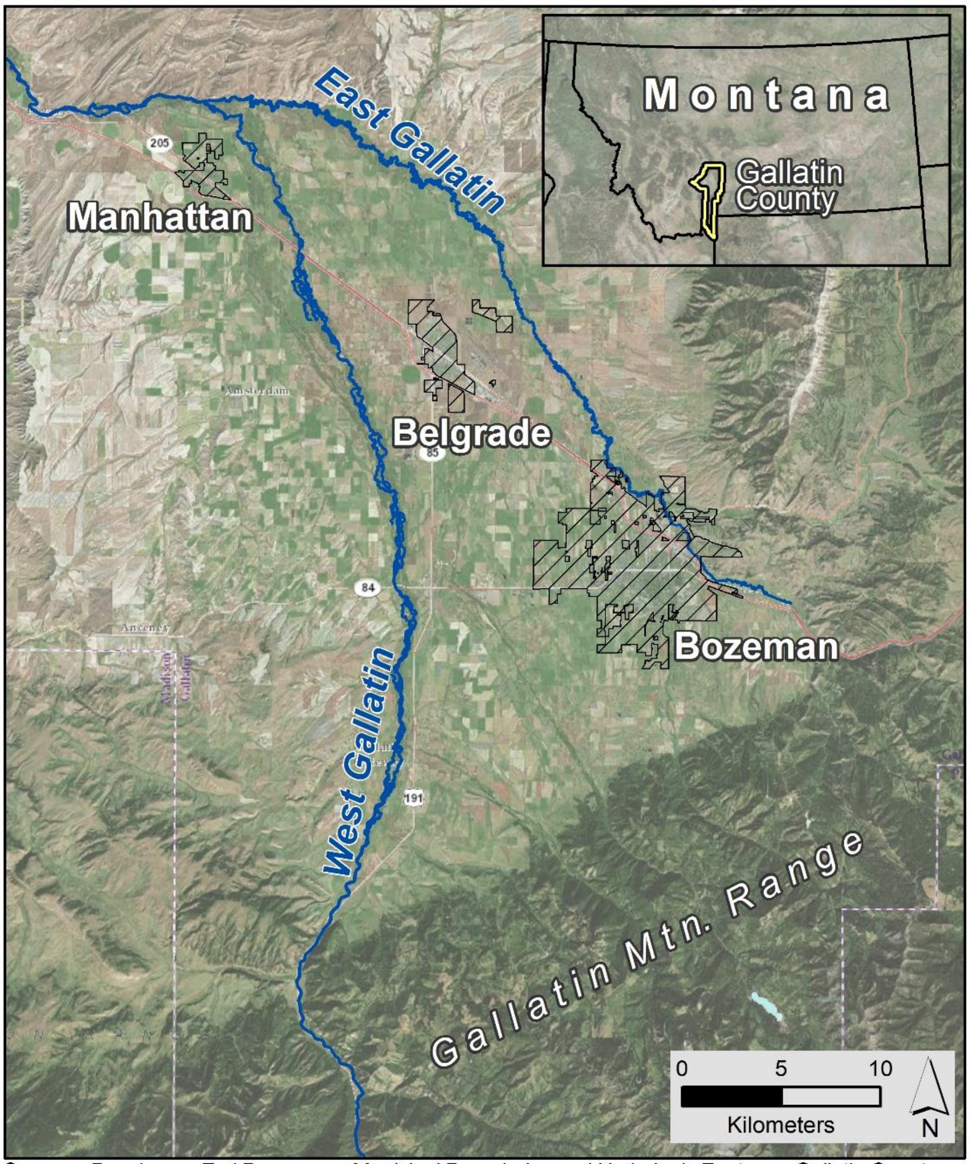
This project focuses on the development of a groundwater mitigation exchange in Gallatin Valley, located in Gallatin County, Montana. Gallatin County is in the southwestern portion of the state; its southern edge borders Wyoming and Idaho (Figure 1). The county encompasses the cities Bozeman and Belgrade, the towns of Manhattan, Three Forks, and West Yellowstone, and the unincorporated resort community of Big Sky. Its economy is primarily supported by Montana State University[4]. About 12% of earnings result from tourism, driven by visits to the Big Sky ski resort, the entrance to Yellowstone National Park in West Yellowstone, and the county's excellent fly fishing for rainbow and brown trout and mountain whitefish. The technology sector is also growing. While agriculture was once a larger economic driver in Gallatin County, it currently accounts for just 5% of economic activity[4].

The intermontane Gallatin Valley is 25 miles long by 20 miles wide, covering roughly 540 square miles (Figure 1). The valley slopes to the north-northwest from roughly 5,400 feet above sea-level to 4,100 feet. The Bridger Range, with an average elevation exceeding 8,500 feet, bounds the valley to the east. At an average altitude of over 9,000 feet, the Gallatin Range forms the south border; the Horseshoe Hills rise 1,000 feet above the valley floor to form the northern border and the Madison Plateau delineates the western watershed boundary[5,6].

The Gallatin River—a tributary of the Missouri River—flows northward for 80 miles through a narrow canyon from its headwaters in the northwest corner of Yellowstone National Park before entering the southern end of the valley south of Gallatin Gateway. Bending gently to the north-northwest, the river flows for 28 miles through the valley. The largest tributary stream, the East Gallatin River, drains the majority of the valley floor, including the entire east side, and joins the main stem shortly before the Gallatin River exits at the only outlet for both surface and groundwater, a narrow gorge near Logan, Montana[5,7].

Gallatin Valley's climate is characterized by long, cold winters and short, cool summers. Most of the valley is semi-arid. Precipitation in the valley falls unevenly; the southern portion of the valley at the base of the mountains receives roughly 20 inches of precipitation per year, while Logan receives on average about 12 inches[7]. At higher elevations in the mountains annual precipitation may exceed 50 inches[7,8]. Groundwater maintains streamflow except during times of high runoff from rainfall and snowmelt[9].

The underlying Gallatin Valley Aquifer is composed of two primary groups of sediment: 1) a shallow, highly permeable Quaternary alluvial aquifer, composed of coarse sediment and only reaching depths of roughly 60 feet, and 2) finer-grained Tertiary sediments which fills the greater basin below the Quaternary alluvium, with a thickness of up to 6,000 feet[10]. These two formations are generally well connected hydraulically, with no known presence of sizable confining layers[9]. Aquifer tests have placed the hydraulic conductivity of the deeper, older sediments in the Tertiary alluvium between 1-40 feet/day, while the conductivity of the Quaternary sediment was found to be between 100-350 feet/day.[10] While these differences are too slight to create separate aquifers or significant discontinuities, this heterogeneity creates variable flow velocities within the aquifer.



Sources: Baselayer - Esri Basemaps; Municipal Boundaries and Hydrologic Features: Gallatin County

Figure 1. Location of Gallatin Valley, municipal boundaries (black dashed lines) and major hydrologic features (blue lines) in Gallatin County, MT.

Existing Water Systems in Gallatin County

Currently, water demand in Gallatin County is met through a combination of surface water appropriations for irrigation, municipal water systems (served by surface diversions, surface storage, and groundwater wells), smaller community water systems (served primarily by groundwater wells), and groundwater wells for individual homes, stockwater, ponds, and some irrigation.

Municipal water systems currently serve Bozeman, Belgrade, Manhattan, Three Forks, West Yellowstone, and Big Sky. Bozeman's water system is by far the largest; as of 2008, it served over 38,000 people and 10,000 service connections[8,11]. Bozeman's system is supplied by surface water from tributaries of the Gallatin River, stored in a set of reservoirs, and conveyed to users through two transmission systems. Wastewater is treated at a single facility and is discharged to the East Gallatin River[8]. Other municipal systems are supplied by a combination of high-capacity groundwater wells and springs[3,8].

Outside the areas served by municipal water systems, some large subdivisions or other communities are served by smaller public water systems, defined as a system that provides water to at least fifteen service connections or 25 people for at least 60 days per year through pipes or other constructed conveyance[12]. In Gallatin County, there are over 50 of these water systems serving a total of over 14,000 people[13]. Residences not served by municipal or community water systems generally draw water from small individual wells. The number of both residential and public wells in the county has increased rapidly since the middle of the 20th century (Figure 2).

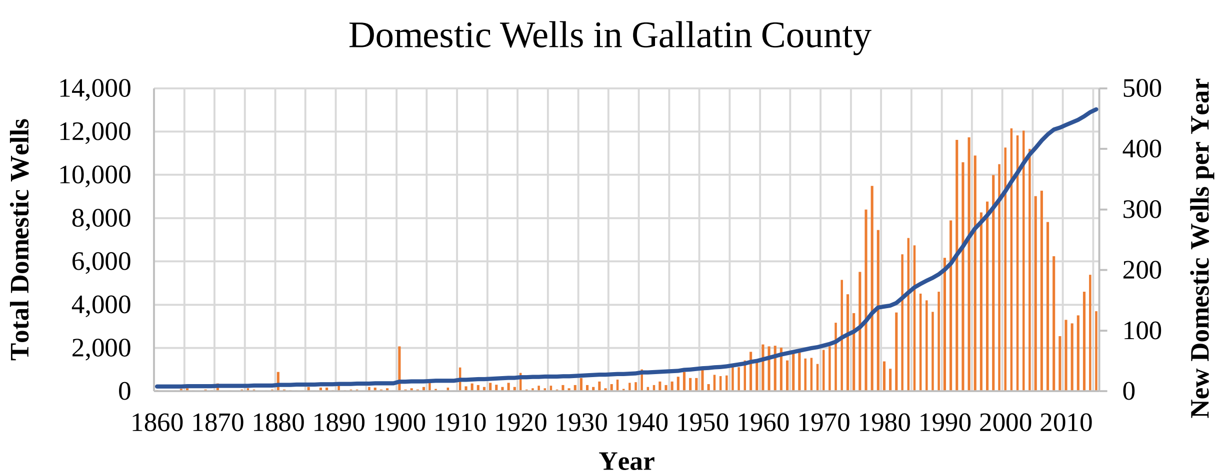


Figure 2. Total, cumulative domestic wells (blue line, left-axis) and new domestic wells per year (orange bars, right-axis) in Gallatin County, MT (1860-2015). Data source: Montana Ground Water Information Center[14].

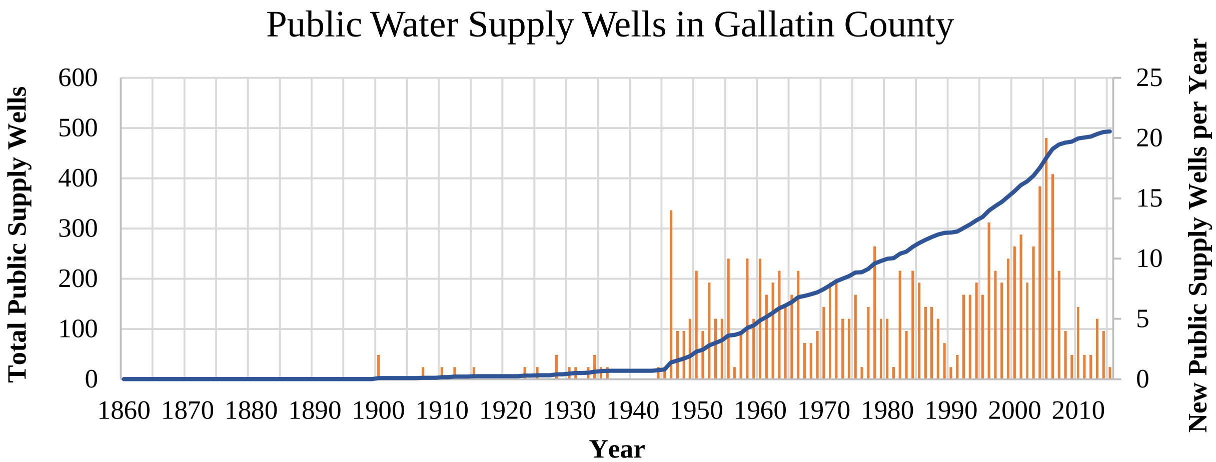


Figure 3. Total, cumulative public water supply wells (blue line, left-axis) and new public water supply wells per year (orange bars, right-axis) in Gallatin County, MT (1860-2015). Data source: Montana Ground Water Information Center[14].

Surface diversions from the West Gallatin River in the southern, upstream portion of the valley provide the majority of irrigation water. An expansive system of infrastructure, including natural streams and canals—which are either privately held or controlled by canal companies and associations—conveys water throughout the valley. Large canal companies in the county include Farmer's Canal, Highline Canal, Lowline Canal, and West Gallatin Canal, which collectively divert more than 40,000 acre feet per year (AFY) from the Gallatin River[8]. To a lesser extent, groundwater wells supply some water for irrigation and stock watering[3].

Rapid Growth and Pressure on Water Resources

Forbes Magazine recently ranked the City of Bozeman the third fastest growing small metropolitan area in the United States[15]; the region's high growth rate has escalated the demand for development and groundwater withdrawals and has created conflict between residential groundwater users and senior agricultural water rights holders[16].

With this increasing pressure on water resources, changes in land use, and changes in irrigation practices, aquifer levels appear to be slowly declining in localized areas, but have yet to become a major cause for concern in Gallatin County. At one USGS well in Belgrade, water levels have dropped roughly 1 foot every 7 years over the past 47 years, potentially due to reduced recharge resulting from conversion of flood-irrigated cropland or from increased groundwater withdrawals. Stress on water resources has also affected surface waters; 152.4 miles of rivers and streams in Gallatin Valley are listed as impaired by the EPA due to low flow alterations[17]. Over 83 miles of streams in the Gallatin River Basin are considered chronically dewatered due to high irrigation demand[18]. This dewatering affects habitat quality for trout and may interfere with junior appropriators' access to water rights.

Climate change will also place increased pressure on water resources. Annual mean temperature statewide in Montana is increasing; since the turn of the century the mean annual temperature has increased by 1 to 2 degrees Fahrenheit from the 20th century average[19]. This warming climate is likely to shift precipitation patterns, with significant implications for water resource management. Compared to 20th century averages, the region may receive a greater percentage of its precipitation in the form of rain, rather than snow. The snowmelt-fed peak flows of the Gallatin River may be reduced or shifted to earlier in the year, reducing low-flow volumes in mid-summer when irrigation demand is highest[20].

Legislative and Regulatory Context

Water law in Montana is generally similar to that in other prior appropriation western states, with an important exception— since 2007, with the legislature's passage of House Bill 831 and associated changes to Montana Code 85-2-360, groundwater and surface water have been managed conjunctively as a single resource. This conjunctive management recognizes the links between groundwater and surface water and the potential adverse effect of groundwater pumping on instream flows.

Gallatin Valley is located within the Upper Missouri Basin, which has been legislatively closed to new surface water rights since 1993 due to high demand[21]. In addition to the limitation on new surface water rights, new groundwater withdrawals in closed basins may only be permitted under strict conjunctive management requirements. Users who wish to drill a new well must demonstrate that there is no adverse effect of their planned pumping on senior water rights holders. If depletion of surface water will occur as a result of the groundwater pumping, then a permit is granted only when "the applicant proves by a preponderance of the evidence that the adverse effect would be offset through an aquifer recharge or mitigation plan[22]." Requirements for mitigation plans are strict, and the plans must fully offset the net depletion, matching the volume, timing, and location of its impacts to surface waters (see *Mitigation Requirements and Options: Regulatory Context for Mitigation* section). The mitigation plans take a variety of forms, but "most often….involve retiring an existing surface water use and changing the water right to mitigate the impacts of the new use[23]."

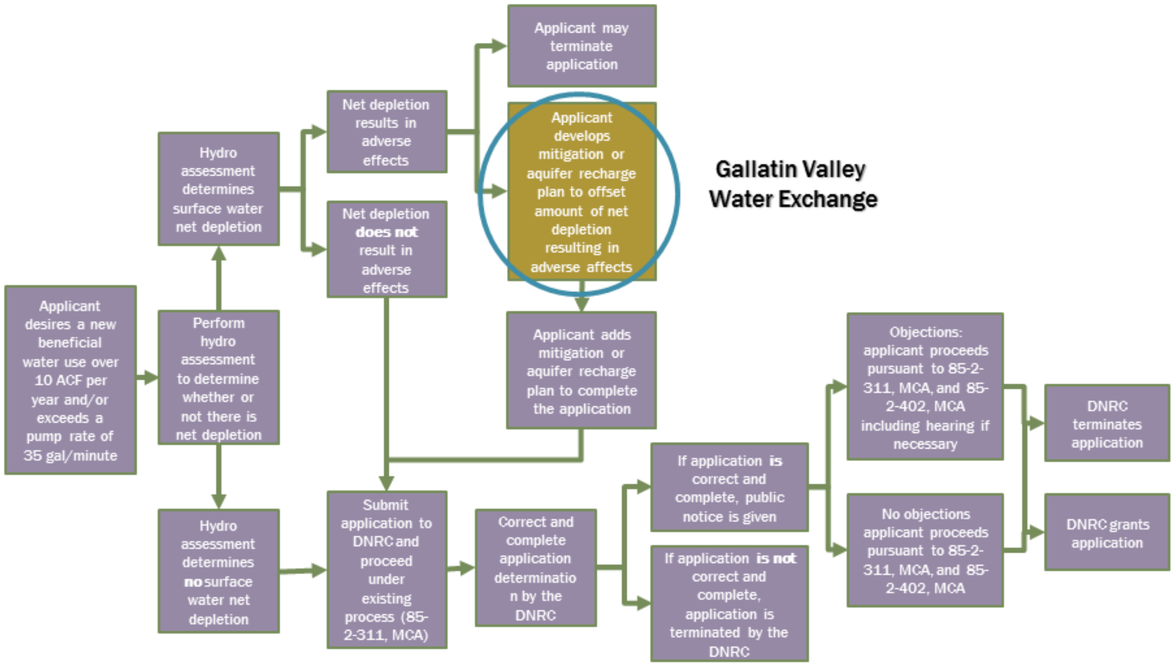


Figure 4. The permitting process for new groundwater appropriations in Montana's closed basins. The role of GVWE in the permitting process is highlighted and circled. GVWE will serve new users, who have already initiated the application process and determined the net depletion of their intended use, by helping to develop a mitigation or aquifer recharge plan to offset the identified net depletion. GVWE's services are therefore not comprehensive to develop the new water appropriation application.

The strict requirements for mitigation plans protect water resources but are challenging in the context of rapid development. Demonstrating that the mitigation plan will offset the volume, timing, and location of a net depletion can require complex groundwater modeling and a portfolio of mitigation methods, from wastewater reuse to instream transfers to aquifer recharge (see *Mitigation Requirements and Options: Approved Mitigation Strategies* section). In addition, it can be challenging for individual water users to acquire surface water rights to use for mitigation, and the change-of-use process to alter the purpose of the water right from its former use to mitigation is complicated, time-consuming, and costly[24].

Furthermore, a recent change in regulations regarding exempt wells has extended this mitigation requirement to additional users. Wells that pump less than 10 AFY or 35 gallons per minute are not required to complete the permitting process, and are therefore not subject to this mitigation requirement. Between 1993 and 2014, this exemption included multiple small wells that were part of the same development but were not physically piped together, creating a loophole that was regularly exploited by developers of subdivisions to avoid the permitting process. Between 2007 and 2014, over 35,000 exempt wells were drilled in the state[25]. In October 2014, however, the Montana First Judicial District Court decided that the exemption did not apply to multiple wells that could be served by a single appropriation, even if they are not physically connected[9].

New multiple-well developments must now undergo the permitting process and obtain mitigation water rights. This change is a positive step towards sustainable water use, but places a significant burden on both new water users and Montana's Department of Natural Resources and Conservation (DNRC) to process an increased permitting and mitigation planning load. In 2006, in response to a petition to address the exempt well issue, DNRC argued that permitting exempt wells would increase their permitting load by 320% and require hiring some 50 additional staff members[18].

The difficulty of developing successful mitigation plans combined with the change in exempt well regulations has laid the groundwork for pushback from developers against stringent mitigation requirements. Without an effective institution to make the mitigation process practicable for water users, the mitigation requirement – and the sustainable groundwater use, surface water availability, and habitat that these regulations protect – may be at risk.

Role of a Water Exchange

This project's clients, The Nature Conservancy and Trout Unlimited, strive to protect instream flows to maintain habitat for native wildlife, and so support complete mitigation requirements. As one strategy to achieve this goal, they and a coalition of partners are interested in developing a groundwater mitigation exchange for Gallatin Valley to encourage the development of mitigation plans that offset the effects of new municipal and residential groundwater withdrawals on these habitats and connected aquifers.

A mitigation exchange has the potential to sustainably balance all water needs, including environmental, agricultural, and municipal uses, and support mitigation requirements by providing simplified mitigation services. The Exchange could manage the mitigation process and sell credits to new groundwater users to serve as their mitigation plans and meet permitting requirements. New groundwater users—such as real estate developers or the City of Bozeman—could avoid the arduous process of finding an existing senior water right and repurposing it as mitigation water, and could instead obtain mitigation water by purchasing credits directly from the Exchange.

By executing this process, a mitigation exchange could reduce transaction costs, ease the permitting burden on DNRC to review change-of-use applications, and greatly reduce challenges to new water users hoping to acquire water for mitigation purposes. Most importantly, the Exchange will demonstrate that mitigating groundwater withdrawals can protect instream flows and senior water right users without impeding future development. Without the Exchange to act as an intermediary in the water permitting process, Montana runs the risk of losing its cap on water withdrawals to development pressure, which would harm instream flows and senior agricultural rights.

Water banks or exchanges implemented in Washington, Oregon and other western states have demonstrated the potential both to improve instream flows and to streamline the water permitting process[26]. While conditions vary between basins and no prototypical water bank structure or function exists, water exchanges in the Pacific Northwest provide models to inform the successful formation of the groundwater mitigation exchange in the Gallatin Valley. Descriptions of existing water banks and results of interviews with bank managers are located in Appendix 12.

Project Objectives

This project has developed an operational plan for GVWE, an institution to support and streamline the groundwater mitigation process in Gallatin County. This management plan meets the following objectives:

1. **Define the institutional structure and operation of GVWE.**
   This project has recommended avenues for operationalizing the mitigation exchange, including mitigation methods, organizational structure, credit sale tracking and monitoring methods, regulatory requirements, opportunities for environmental benefits, and strategies to ensure long-term viability.

2. **Conduct an economic analysis of GVWE.**
   The group has assessed the costs of establishing and operating GVWE, and has recommended appropriate pricing structures for mitigation credit sales. This report also estimates potential demand for mitigation credit purchases and the available supply of senior surface water rights and broadly assesses the economic viability of GVWE.

3. **Assess recharge locations and methods**.
   This project includes a preliminary assessment of potential recharge locations in the Gallatin Valley based on a number of hydrogeological and other criteria. It also recommends methods for conducting managed aquifer recharge.

Gallatin Valley Water Exchange Structure

The high-level function of GVWE is to acquire or contract for senior surface water rights, move the water rights through the change-of-use regulatory process to a mitigation or aquifer recharge purpose, recharge this water into the underlying aquifer or leave it instream, and then sell mitigation credits to new groundwater users to serve as their mitigation plans to offset the adverse effect of new groundwater use (Figure 5).

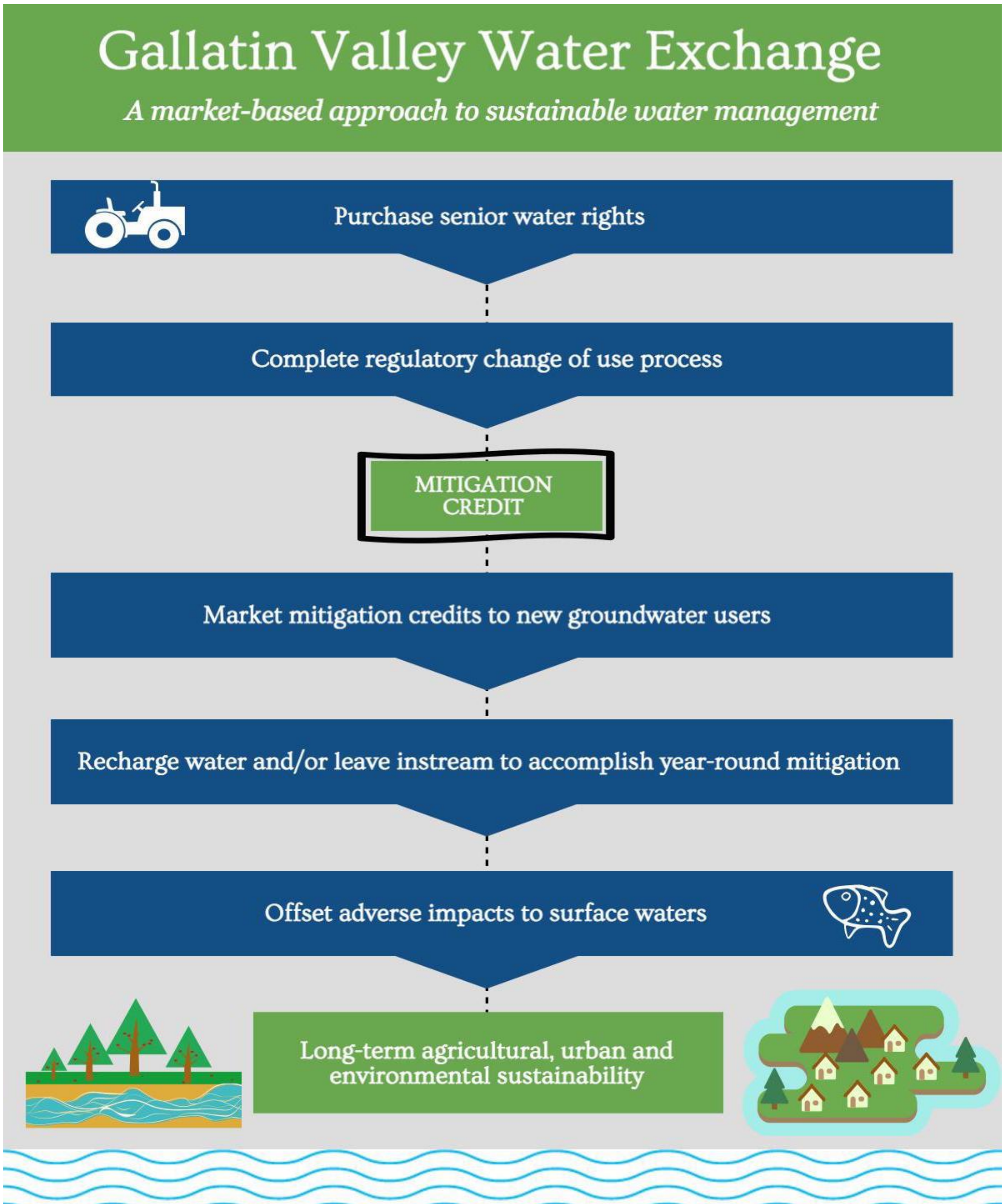


Figure 5. Operation of GVWE to supply mitigation credits to new groundwater users. Figure generated using Piktochart.

Mitigation Requirements and Options

Regulatory Context for Mitigation

Following Montana Trout Unlimited v. DNRC, 2006 MT 72, 331 Mont. 483, 133 P.3d 224, the DNRC legally recognizes the connection between surface water and groundwater and the potential impact of pre-stream capture or use on surface water sources.

GVWE will serve new water users whose intended groundwater use would otherwise cause reductions to stream flow or other surface water sources. The reduction to surface water by a new water use is referred to as “net depletion” and is legally defined as follows:

> **Net depletion:** “for the purposes of 85-2-360, MCA, means the calculated volume, rate, timing, and location of reductions to surface water resulting from a proposed groundwater appropriation that is not offset by the corresponding accretions to surface water by water that is not consumed and subsequently returns to the surface water.” (ARM 36.12.101)

Depending on the pumping schedule and rate of the new groundwater well, stream depletion will manifest as a certain volume, in a certain location of the water body, and at certain times. Thus, when a proposed new groundwater use causes net depletion, the applicant must provide a mitigation plan that offsets the net depletion throughout the period of new use. This can be accomplished through either 1) a mitigation or aquifer recharge plan to adequately offset the net depletion or 2) the analysis of both legal demands, as represented through perfected water rights, and physical availability of water, as determined through hydrological testing, to represent the availability of water in the surface water source if present (see “In the Matter of Beneficial Water Use Permit Nos. 41H 30012025 and 41H 30013629 by Utility Solutions LLC” (DNRC Final Order 2006), “Wesmont Developers v DNRC CDV-2009-823. Montana First Judicial District, Memorandum and Order” (2011), and Change Authorization 76H-30063540, Mountain Water Company. Department of Natural Resources Conservation. Approved May 6, 2014).

By selling mitigation credits, GVWE will meet the needs of applicants seeking a new beneficial use of water that ultimately results in a net depletion to surface water sources. As previously noted, the process of applying for a new beneficial use permit is costly and time consuming. Additionally, GVWE’s services are useful at a crucial but not comprehensive point in the applicant’s process (Figure 5). The applicant, the Exchange, and DNRC will need to coordinate to model the net depletion caused by new use and to determine if the Exchange’s mitigation meets these needs, ideally by using a single basin-wide model for all applications. Further, after an applicant obtains mitigation credits from GVWE, there still remains a formal public reporting process and additional steps for DNRC to grant final permit approval to the applicant.

Approved Mitigation Strategies

A review of historically approved mitigation applications throughout the State of Montana reveals useful insight as to which strategies for offsetting net depletion are accepted by DNRC (examples of each strategy are included in Appendix 3). Aquifer recharge is not detailed here, but is described in the next section (see *Managed Aquifer Recharge* section).

Retiring Irrigation:
Many mitigation strategies involve retiring irrigation rights to offset net depletion. The major benefits of this strategy are that the irrigation rights often hold senior priority dates and the logistics of retiring the right are simple once the necessary volume has been determined. Irrigation rights are seasonal, and thus extra consideration must be given when applying their retirement to offset surface-water depletions outside the irrigation season.

Retiring Groundwater:
Some mitigation strategies include the retiring of groundwater wells. This strategy is beneficial because groundwater, if historically used throughout the year, could be retired to mitigate year-round domestic use. A disadvantage is that these rights are often junior to other uses and can therefore be more prone to water calls in the region; however, this strategy does work well in areas where the risk of calls to junior rights has historically not been an issue.

Retiring Stock Water Rights:
While the retiring of stock water rights is a less common strategy – likely due to the smaller magnitude of these rights compared to irrigation—the benefits of this strategy are that stock rights are historically used year-round and are considered entirely consumptive use. The new user can thus use the full volume of the right for mitigation, and can meet mitigation requirements throughout the year.

Physical Availability:
Rarely, in some areas, there still exists sufficient physical and legal availability of water to preclude additional mitigation requirements, as determined by an initial aquifer drawdown test to establish a zone of influence and the analysis of existing legal demands on the remaining water.

The Role of Managed Aquifer Recharge

As discussed above, retiring irrigation rights and leaving water instream may serve as one component of a successful mitigation plan. However, Montana law requires that mitigation not only match the volume and location of the net depletion, but also the timing of this depletion on a monthly or seasonal basis.

Irrigation water rights are associated with a specific season of use, generally in the summer months, and may only be appropriated during that season. As a result, a retired irrigation right left instream will only manifest during the historic irrigation season, but is unable to mitigate for impacts during the fall, winter and early spring. Municipal pumping occurs year-round, resulting in year-round drawdown of the aquifer and subsequent depletions of hydraulically connected streams (Figure 6).

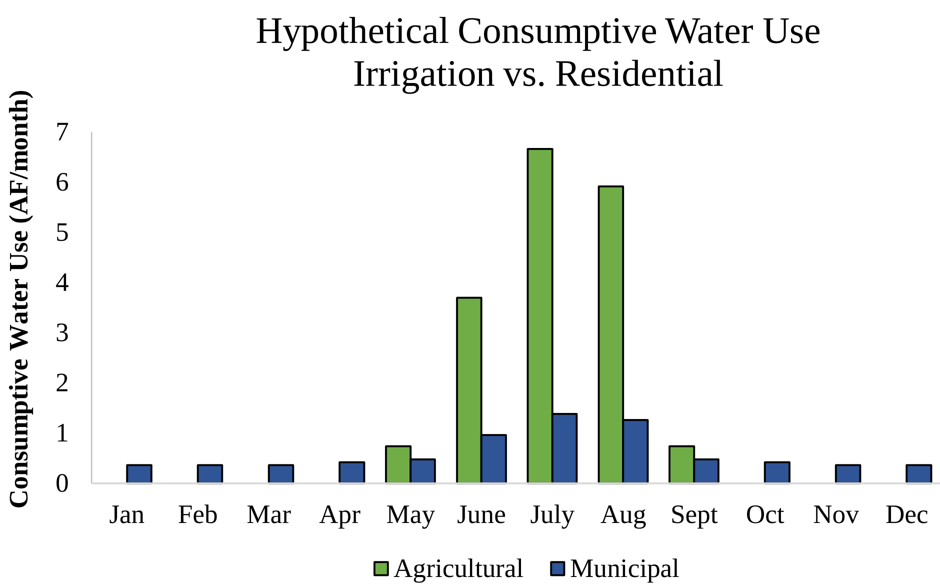


Figure 6. Hypothetical consumptive water use resulting from 24 AFY water application to either irrigated agriculture or municipal use. Agricultural use is assumed to be 100% alfalfa and was estimated from climatic data for the Bozeman Montana State University weather station using the TR-21 Balaney-Criddle Method. Municipal use is assumed to be 60% domestic and 40% lawn and garden and was estimated from DNRC change application averages.

This makes it effectively impossible to offset depletions from new municipal use under the strict volume, location, and timing requirements by simply retiring irrigated agriculture and leaving this water instream. Instead, an additional method is needed to offset net depletion in the non-irrigation season.

Managed aquifer recharge offers a tool to provide year-round return flows to streams, and thus year-round mitigation. In managed aquifer recharge, surface water rights may be diverted during the irrigation season and infiltrated into the aquifer through natural or constructed infrastructure. Provided that the recharge site has suitable geological characteristics and is located sufficiently far from the stream of concern, water infiltrated during the irrigation season may provide year-round baseflow, offsetting the effects of residential groundwater pumping[9].

Managed Aquifer Recharge

Recharge Options

As part of its mitigation program, GVWE will need to recharge surface water into the underlying aquifer to ensure sufficient year-round availability of mitigation. Existing infrastructure—particularly unlined irrigation canals—may potentially meet some of this demand if the Exchange can negotiate agreements with ditch companies and receive approval from DNRC. It is likely, however, that GVWE may need to construct its own recharge infrastructure. Appendix 7 describes a variety of infrastructure types employed in existing aquifer recharge programs, including relative costs and merits.

We recommend infiltration galleries as the best recharge method for the Exchange, due to their lower operational costs, reduced liability, and increased land use potential relative to other available recharge options (Table 1).

Table 1. The costs and limitations associated with various recharge methods including injection wells, vadose wells, infiltration galleries, and surface spreading.

Recharge Method	Construction Costs	Operation & Maintenance Costs	Land Requirements	Evaporation Losses	Limitations
Injection Wells	High	High (energy demand, well cleaning and repair)	Low	Low	Generally used only where an aquifer is confined or geology is unsuitable for passive recharge
Vadose Wells	Moderate	Moderate - High (well cleaning)	Low	Low	Target aquifer must be unconfined; may have limited lifespan
Infiltration Galleries	Low - Moderate	Low-moderate (flushing of sediments from pipes)	Moderate - High, but land over galleries may be used for other purposes	Low	Target aquifer must be unconfined; overlying substrate should be permeable and non-polluted
Surface Spreading	Low – Moderate; Low if existing canals are used	Low - Moderate (dredging of accumulated sediments)	High	High	Target aquifer must be unconfined; overlying substrate should be permeable and non-polluted; potential liability issues.

Case studies indicate that infiltration galleries will require capital costs of roughly $45,000 for each cubic foot per second (cfs) of recharge capacity created[27]. With an anticipated recharge season of 100 days, 1 cfs translates into annual recharge volumes on the order of 200 AFY. The use of infiltration galleries is largely limited to highly permeable, unconfined aquifer systems – a condition that the coarse, unconsolidated alluvium of the Gallatin Valley Basin meets. If properly designed, infiltration galleries may have considerably lower maintenance costs than other methods, often requiring nothing more than an annual flushing of the pipes to remove accumulated sediment.

In addition to the economic advantages, infiltration galleries reduce liability related to flooding and provide more usable land surface, since the land above infiltration galleries can still be used for pasture, shallow-rooted crops, and other purposes. The ability for landowners to continue to cultivate crops such as alfalfa or hay over an infiltration gallery is likely increase the likelihood of securing land use agreements, and potential lease payments may be reduced if landowners are not required to change operations and can maintain existing cultivation.

Limitations of Recharge Duration and Scale

While the annual recharge capacity of managed aquifer recharge sites can be increased by expanding either the size of the sites or the duration of the infiltration period, the response to both of these variables is non-linear, yielding diminishing returns on recharge rates. For example, a sevenfold increase in the infiltration area of managed aquifer recharge sites in the Walla Walla Basin resulted in only a twofold increase in recharge rates[28]. Similarly, studies of the temporal infiltration dynamics of managed aquifer recharge sites have found that they typically begin a marked decline in infiltration rate after about 40 days, dropping down to 10% of the initial rate by roughly 110 days into the recharge season[29].

The primary reason for these limitations is groundwater mounding, which significantly reduces infiltration rates once the mound reaches the bottom of the recharge site[28]. Increases in duration of recharge and site area both yield increases in the height of groundwater mounding beneath the site, creating a tradeoff between the economic efficiencies of scale and the hydrologic risks, complications, and infiltration inefficiencies that also come along with larger recharge sites.

For these reasons, our operations plan predicts annual recharge capacities between 300 and 800 AFY per site; lower capacities were assumed to be economically inefficient, and higher capacities were determined to pose unwanted hydrologic risk and diminishing recharge rates due to groundwater mounding. These values are based on general basin-wide assumptions and provide only rough estimates, since characteristics such as depth to groundwater vary widely throughout the basin and the amount of water that can be safely recharged at any given site may vary by orders of magnitude throughout Gallatin Valley. These estimates should be replaced by more site-specific analyses when choosing recharge sites.

Recharge Suitability Analysis

Hydrogeological properties determine a land parcel's potential to infiltrate water into the Gallatin Valley's shallow, unconfined aquifer. To operate effectively, infiltration galleries require relatively flat, permeable soils and sufficient unsaturated pore space between the land surface and water table to accommodate the volume of recharged water. A valley-wide site suitability analysis was conducted in order to inform the Water Exchange's identification and selection of managed aquifer recharge basins.

The Geographic Information System (GIS) model defines suitable conditions for five surface properties—slope, soil type, surficial geology, land use, parcel ownership—as well as estimated minimum depth to groundwater. Recharge sites should be located on slopes less than or equal to 3%. The Department of Agriculture's soil hydrology groups A and B, characterized by well-drained soils with low runoff potential, are required to maximize infiltration and avoid erosion. Conducive geology includes the Quaternary alluvium and Tertiary sediments that underlie the valley. Recharge sites require undeveloped land, including agriculture, rangeland, or open space. To simplify land use agreements, only land parcels owned by private individuals or the City of Bozeman are classified as suitable; land owned by state agencies or the federal government is excluded. To minimize reduced infiltration capacity from groundwater mounding, the minimum estimated depth to groundwater is 6 meters (19.7 feet). Table 2 displays the criteria and threshold values; Figure 7 displays a map of the final recharge suitability parcels. Appendix 8 precisely defines each criterion, identifies data sources, and explains how each threshold value was determined.

Table 2. Groundwater recharge suitability criteria. Further explanation is in Appendix 8.

Criterion	**Threshold Value**
Surficial Geology	Quaternary Alluvium or Tertiary Sediments
Slope	< 3%
Soil Type	Hydrologic Groups A & B
Land Use	Undeveloped, Agriculture
Land Ownership	Private or City of Bozeman Property
Depth to Groundwater	> 6 m

The model does not rank sites based on potential effectiveness. Instead, the model utilizes Boolean logic, which considers whether each land parcel is suitable or unsuitable for each criterion. The final selected parcels are suitable under all six criteria. The results of the analysis show three general areas of suitable conditions: the southern portion of the valley floor near the base of the mountains, portions of the raised bench west of the West Gallatin River, and parcels north of Bozeman bordering the East Gallatin River and abutting the foot slopes of the Bridger mountain ranges (Figure 7). Due to high water table levels, the majority of the valley floor is considered unsuitable; insufficient distance between the land surface and the aquifer limit the amount of water that may be recharged due to localized mounding impacts.

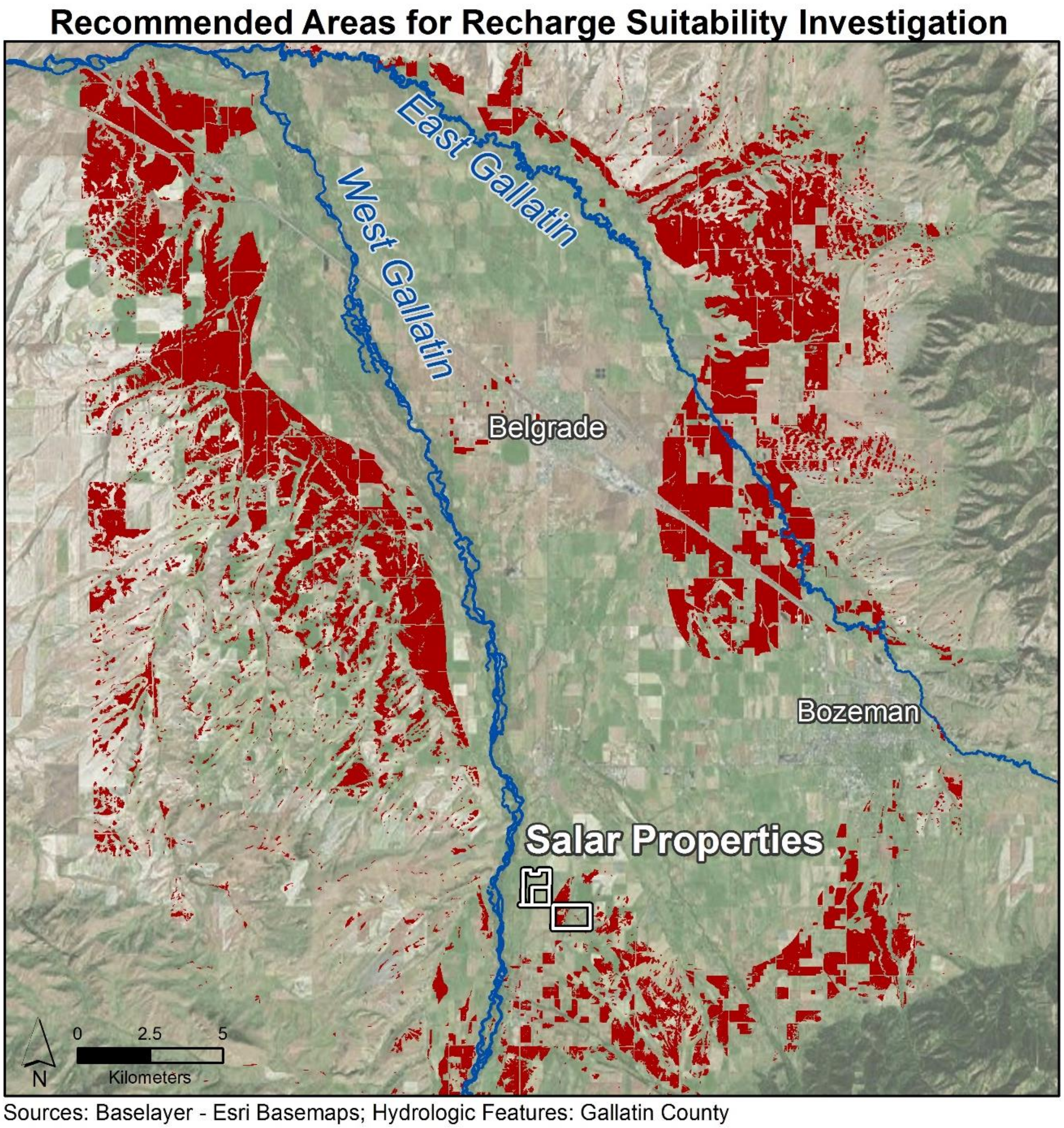


Figure 7. The recommended areas for recharge suitability investigation in Gallatin Valley. Red indicates the areas that satisfy the recharge criterion outlined in Table 2. Salar properties are highlighted as the landowners have expressed a willingness to serve as a recharge site.

This recharge suitability analysis is intended to guide the Water Exchange's initial selection of land parcels. However, further on-site hydrogeological investigation will be required to confirm that the hydrogeological conditions will allow sufficient volumes of water to be infiltrated into the aquifer. Ideally, either DNRC or GVWE would develop a single MODFLOW or other hydrologic model for the entire basin to allow for simplified evaluation of proposed recharge locations.

This analysis does not consider water conveyance potential. While extensive irrigation infrastructure exists throughout the valley, the model does not account for a land parcel's connection or proximity to canals or ditches. The ability to convey water to a recharge site from existing infrastructure is critical and should be addressed during more intensive parcel-specific investigations.

In addition, the model does not include estimates of the timing impacts of recharging at each location. While recharging water during summer irrigation months, GVWE must ensure that the mitigation water returns to the channel of the impacted stream as base flow during the non-irrigation season. Water recharged in close proximity to the channel may reach the stream too quickly and fail to sufficiently offset the impacts of year-round pumping by new groundwater wells during the late winter or early spring. To assist the Water Exchange's selection of recharge locations, the group calculated an idealized, order-of-magnitude estimate of the time delay of recharged water: the stream depletion factor.

Stream Depletion Factor

In conjunction with the recharge suitability analysis, the results of the Stream Depletion Factor (SDF) analysis can help the Water Exchange identify the best potential sites to locate a seasonally-operational recharge facility in order to provide near-constant return flows to the stream.

The recharge suitability analysis identifies hydrogeological properties that will accommodate the surface infiltration of water into the unconfined aquifer, but does not account for timing impacts. Stream depletion factor modeling can provide an order-of-magnitude estimate of the delay between infiltrated water and manifested stream augmentation. By combining the results of both models, the Water Exchange can identify land parcels that both have the appropriate hydrogeological properties and are located far enough away from impacted streams to produce near-constant stream augmentation from managed aquifer recharge, adequately offsetting year-round depletion from residential groundwater use.

The SDF equation (Appendix 9) provides an estimate of how long it will take for impacts from pumping or recharged water to manifest in the nearest stream. Low SDF values indicate impacts from recharge manifest nearly synchronously—water infiltrated during the summer months will return to the river quickly, and may not provide a sufficient delay to offset depletions from pumping during the late fall, winter, or spring months. Conversely, high SDF values represent areas where the augmented baseflow from recharged water manifests to the stream throughout the entire year, even if recharge occurs only seasonally during the summer months—exactly the results required by the Water Exchange to offset year-round but seasonally variable depletion from new wells.[9]

Figure 8 displays a graphic of how the Exchange might utilize stream depletion factor to inform recharge site selection. The calculations, detailed in Appendix 9, provide order-of-magnitude estimates only. The graphic assumes only streams classified as perennial by Gallatin County are connected to the aquifer (and therefore impacted by pumping or recharge). The areas highlighted in green, located closest to perennial streams, may have too low of an SDF value to sufficiently offset return flows. Areas highlighted in yellow and orange, located farther away from target streams and/or located above less transmissive sediments may have sufficiently high SDF values to provide nearly constant year-round baseflow from seasonal recharge.

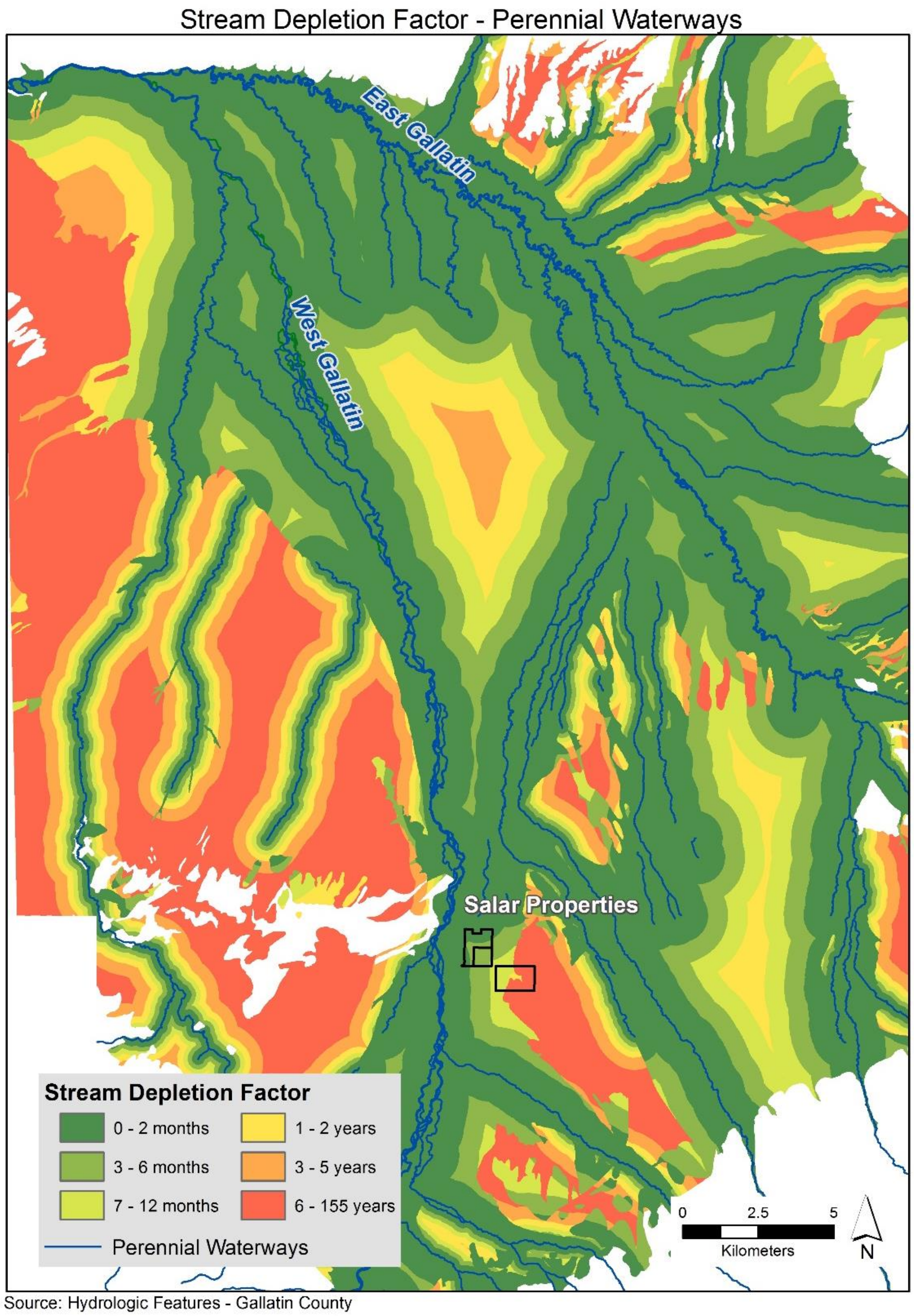


Figure 8. The stream depletion factor for perennial waterways in Gallatin Valley. The Salar properties are highlighted due the landowner's willingness to act as a recharge site.

For further information on stream depletion factor, see Appendix 9.

Salar Property

The Salar property in the Gallatin Valley is poised to serve as a storage site and infiltration gallery for mitigation water in the Gallatin Valley. The 440-acre site was formerly planted with alfalfa and wheat[30]. Previous hydrogeological investigations indicate that the property has many of the necessary characteristics to offset adverse stream level impacts from groundwater pumping along the West Gallatin River[30]. Due to the landowners' interest in participating as a managed aquifer recharge site, the property boundaries are included in some aspects of the recharge site suitability analysis. Additionally, the proximity of the property to the Farmers Canal and West Gallatin Canal as well as the two senior water rights associated with the property (priority dates of 1886 and 1887) make the Salar site an attractive option for recharge.

Our site suitability analysis indicates that a large portion of the Salar site is likely suitable for recharge infrastructure (See Figure 7). Other portions of the site, mainly a gully on the east side of the property, are excluded due to slopes exceeding 3%.

EPA Underground Injection Control Permit

Once recharge sites have been identified and prior to the construction of recharge infrastructure, GVWE will need to acquire federal Underground Injection Control (UIC) approval. Infiltration galleries and spreading basins constitute Class V wells under the Safe Drinking Water Act's UIC program. Montana has not developed its own program to regulate Class V wells, and so approval must be granted by the federal EPA Region 8 office.

Approval of a Class V well can occur either through a rule authorization or a permit. The EPA may grant a rule authorization if the UIC program director believes that the injected or recharged fluids will not adversely affect underground sources of drinking water. If the effect on drinking water is uncertain or potentially negative, however, a permit with additional mitigation and monitoring requirements will be necessary[31].

To determine if a rule authorization will be granted or if a permit will be required, GVWE must submit a Site Information Request Fact Sheet to the Region 8 office. A draft fact sheet that applies specifically to aquifer recharge and aquifer storage and recovery projects is available at http://www.epa.gov/sites/production/files/documents/FSASR.pdf.

The Fact Sheet requires a project description, detailed information about the hydrogeology of the recharge site and underlying aquifer, a description of the maintenance and monitoring program for the site, and water quality information. The necessary hydrogeological information will most likely already have been collected during the site selection and DNRC processes. It includes a description of the underlying aquifer, including its groundwater flow rate, transmissivity, and other characteristics, and an analysis of effects on the aquifer and nearby surface waters. It also requires the location and a description of any public drinking water wells or springs that will be recovering water from this aquifer, and a description of the treatment of any drinking water already being withdrawn from the aquifer.

The Fact Sheet process will require additional water quality information, however, including analysis of both the water to be recharged and, if possible, the underlying aquifer. Water quality analysis must include constituents regulated under the Safe Drinking Water Act, major anions and cations, ambient temperature and pH, and any potential mineralogical constituents in the receiving formation that might be mobilized as a result of injection activities. It must also include a description of any planned treatment of the recharged water and contingency plans to prevent mineral or biological buildup in the recharge infrastructure.

If, on the basis of this information, the UIC program director finds that the recharge project is likely to adversely affect underground drinking water, GVWE will need to apply for a permit with additional treatment and monitoring requirements. Current Class V UIC permit actions in Region 8 are generally related to injection of industrial effluent[32]. As long as the quality of recharged surface water is adequate, it is likely that the recharge program will be authorized by rule rather than requiring a permit—particularly since the project involves recharge of surface water into the same hydrologically connected aquifer.

Montana Ground Water Pollution Control System Permit

This project will not require a state groundwater discharge permit under the Montana Ground Water Pollution Control System. Generally, transfers of unaltered ground water or surface waters do not require state discharge permits. While infiltration of treated sewage or waste water would fall under the discharge program, GVWE's use of surface water diverted from rivers does not constitute an alteration from ambient water quality or a discharge of sewage or industrial waste and so does not require a state permit[33]. We recommend, however, that the project administrators maintain contact with the Montana Department of Environmental Quality – Water Protection Bureau, particularly when the design for any recharge infrastructure is completed, to ensure coordination and compliance.

Demand for Mitigation

Population Projections

To estimate future demand for water in Gallatin County, we projected future population based on past trends in census data. To distinguish between demand from municipal water systems and demand from individual wells or smaller utilities, we projected population in the county as a whole, in areas of the county served by municipal water systems (Bozeman, Belgrade, Manhattan, Three Forks, West Yellowstone, and Big Sky), and in areas not served by municipal water systems. This analysis assumes that the populations served by municipal water systems are equivalent to the population dwelling permanently within that city (Bozeman, Belgrade), town (Manhattan, Three Forks, West Yellowstone), or census-designated place (Big Sky). It also assumes that these municipalities and their water supply systems do not annex new areas over time, which may result in a slight overestimate of exurban water demand. Finally, this analysis includes all of Gallatin County, including Big Sky and West Yellowstone. These areas are most likely not within the initial service area of the Exchange, which will likely be limited to Gallatin Valley, but they are included here for reference; due to their sufficient water supplies, they do not affect overall mitigation demand estimates.

For the county as a whole and for each city and town, population data for July 2000-2014 were taken from Census Bureau intercensal population estimates[34]. The growth rate was calculated for each location in each year, and the annual average growth rate was estimated as the mean of the 2000-2014 growth rates. Generally, these growth rates were highest in 2003-2007, decreased during the recession, and rebounded somewhat beginning in 2011-2014. The average annual growth rate was estimated as the mean over the period 2000-2014; these average growth rates ranged from 0.58% for Three Forks to 2.84% for Bozeman, and were generally quite close to the post-recession growth rates from 2011-2014. Population in the county and for each city or town was projected to 2050, assuming this annual average growth rate will remain constant over time. Planning documents including projected growth rates were available for Belgrade and Bozeman. However, the 8% growth rate projected in the City of Belgrade Water Master Plan 2007 appears unreasonable based on past trends, and Bozeman's Integrated Water Resources Plan presents a range of growth rates from 1-3%, so we chose to use census growth estimates[11,35].

Because Big Sky is a census-designated place and not a city or town, intercensal population estimates are not available, and the only published census population estimates are for April 2010 and 2014. Using these two data points to calculate an annual growth rate results in an estimate of 6.41% growth per year, which is unusually high relative to the rest of the county. However, Big Sky's Water System Source Capacity Plan Update, published in April 2015, recommends an annual population growth rate of 2.5% for water planning purposes; we chose to adopt this lower rate to project Big Sky population to 2050[36].

Projected population in areas not served by a municipal water system was calculated as the total county population minus the population in all municipalities in each year to 2050.

Based on these projections, the population of Gallatin County will exceed 100,000 in 2016, 150,000 in 2032, and 200,000 in 2043 (Figure 9). The proportion of the population not served by municipal water systems will decline very slightly over time, from just over 42% in 2014 to just over 41% in 2050. For a full table of estimated growth rates and population projections, see Excel document "*GVWE Demand Analysis*".

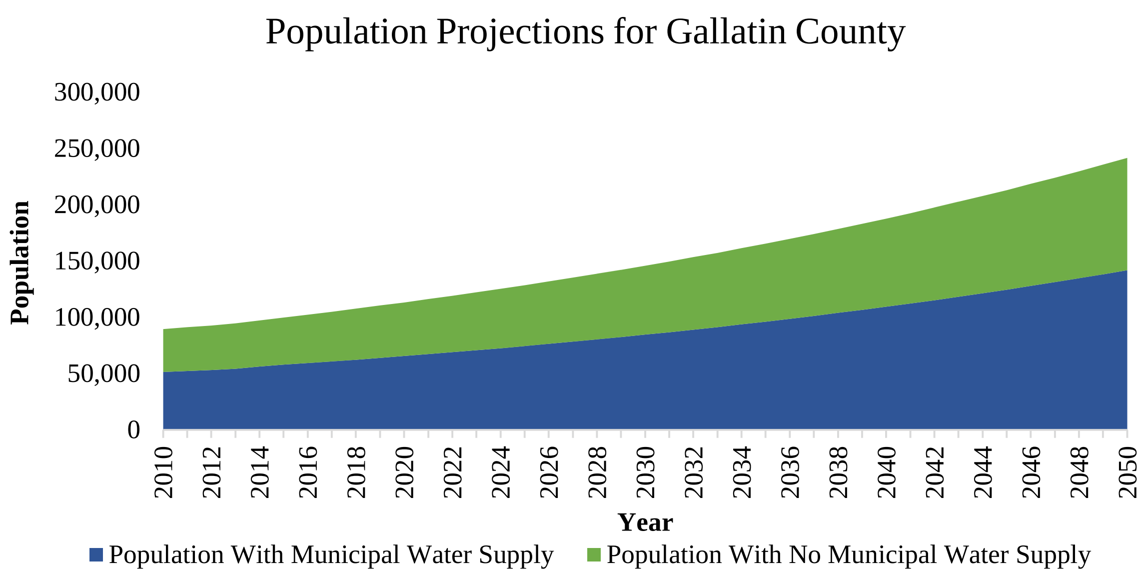


Figure 9. Measured (2010-2015) and projected (2016-2050) total population in Gallatin County, MT for populations with municipal water supply (blue) and with non-municipal water supply (green).

Water Demand and Shortage Projections for Areas Served by Municipal Water Systems

We then used these population projections to estimate future water demand in Gallatin County and investigate the potential for future water supply shortages.

The population projections were first multiplied by per-capita water demand to estimate total water demand. Per-capita water use rates were estimated for each area based on the best available planning information; these rates can vary between towns due to different lawn and house sizes, behavior, and other factors. For Bozeman, personal communication with water conservation officials indicated 156 gallons per capita per day for planning purposes[37] Belgrade's Water Master Plan 2007 indicated design demand of 135 gallons per capita per day[35] For Manhattan and Three Forks, we conservatively assumed 165 gallons per capita per day, the figure used in Bozeman's Integrated Water Resources Plan[38].

Water use estimates for Big Sky and West Yellowstone are complicated by the high transient populations in these areas; Big Sky has a large seasonal flow of visitors to the Big Sky Resort ski area, and West Yellowstone is one point of entry to Yellowstone National Park, and so is also frequented by tourists. As a result, water use per permanent resident reported by the census is much higher than in other areas of the County, since seasonal residents are not counted by the census but still use substantial amounts of water.

For Big Sky, per capita demand was estimated based on Big Sky's Water System Source Capacity Update, published in 2015, which indicated the area had 4,384 Single Family Equivalents (SFE) in 2015, and would have 9,000 in 2044, with total water demand of 2,260 AF per year at that time[36]. This equates to a per-SFE water demand of 0.25 AFY; SFEs and water demand were projected for the years between 2015 and 2044 assuming a 2.5% growth rate. Given census population estimates, this water demand equates to nearly 452 gallons per capita per day, far higher than any other municipality in the County. This high demand may be explained by the large number of transient residents in the County.

Little information on water use in West Yellowstone was available, but given the high number of transient residents and visitors in this area, we estimated per capita water demand to be equivalent to Big Sky's, at 452 gallons per permanent resident per day.

These demand estimates were compared to the current water supply in each municipality to determine if each municipality was likely to experience a deficit in available water that might require new groundwater pumping and associated mitigation (Table 3). Bozeman's current water supply is the firm yield supply listed in its Integrated Water Resources Plan, Big Sky's from its Water System Source Capacity Update, and all others are the sum of all municipal groundwater rights and reservations from the DNRC's water rights query system[3,11,36]. This analysis has not reviewed the water rights of each municipality to assess if any of the water rights are supplemental and thus double counted, so water availability may be overestimated and demand underestimated.

Table 3. Estimated future water demand in 2050 (AFY), current water supply in 2015 (AFY) and water supply deficit in 2050 (AFY) for municipalities in Gallatin County, MT.

Municipality	Estimated Water Demand in 2050 (AFY)	Current Water Supply (AFY)	Deficit in 2050 (AFY)
Bozeman	19,950	10,835	9,115
Belgrade	2,492	3,792	None
Manhattan	361	1,134.11	None
Big Sky	2,613	3,267.35	None
West Yellowstone	918	5417.74	None
Three Forks	433	1171.44	None

These results indicate that, with the exception of Bozeman, all municipalities appear to have sufficient water supply to support continued growth through at least 2050. Bozeman will reach the limits of its current capacity in 2029. This finding aligns closely with the city's Integrated Water Resources Plan, which indicates that Bozeman will experience a shortage of water supply by 2025-2030[11].

Water Demand and Shortage Projections for Areas Not Served by Municipal Water Systems

For unincorporated areas of the county, we estimated future water demand based on population projections and a conservative estimate of 165 gallons per capita per day, the value used in Bozeman's Integrated Water Resources Plan[11]. This analysis assumes that all new groundwater demand beyond 2015 will need to be met by new groundwater pumping. However, it is possible that many of small water systems currently have excess water supply and may not require new pumping to meet all demand.

Based on these estimates, new water demand in areas not served by municipal water systems will exceed 5,000 AFY by 2035 and 10,000 AFY by 2049 (Figure 10).

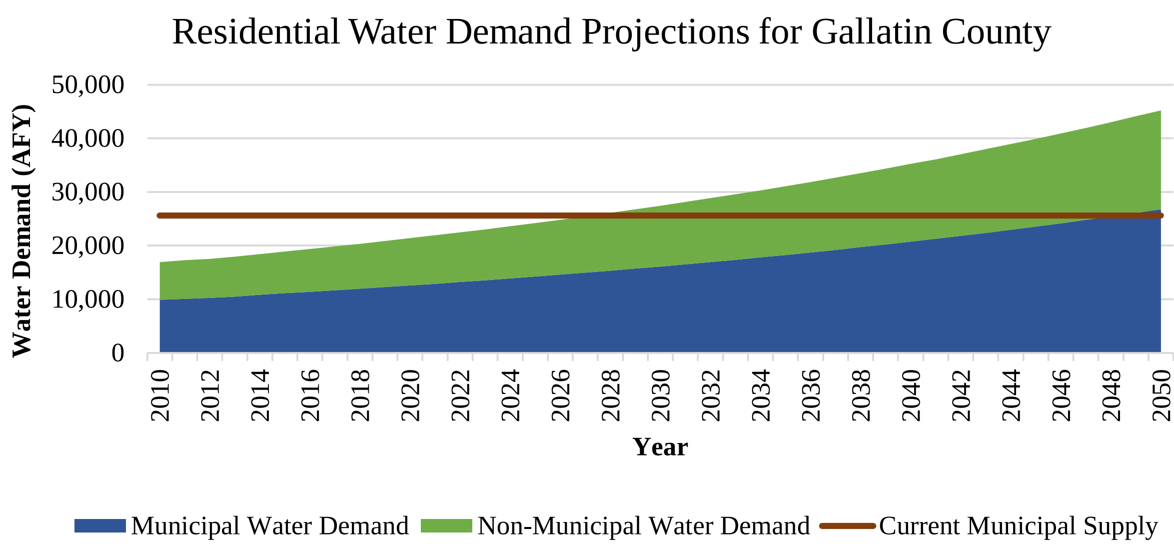


Figure 10. Measured (2010-2015) and projected (2016-2050) municipal water demand (AFY) in Gallatin County, MT for populations with municipal water supply (blue) and with non-municipal water supply (green). Current municipal water supply is represented by red line.

Mitigation Demand

The previous estimates provide a reasonable picture of total future water demand in Gallatin County; however, the actual amount of water demanded for mitigation is only a portion of the total projected water demand. The fraction of future water demand that will require mitigation is determined by two major factors: the percentage of new water demand met through non-exempt wells and the percentage of new water use that results in a net depletion of a stream. These factors were adjusted for municipal and non-municipal areas to develop and model various mitigation demand scenarios to demonstrate the magnitude of mitigation water demanded in Gallatin Valley. Estimating the volume of mitigation demanded by new water users is necessary to assess recharge needs, determine if surface water supply is sufficient, model cash flow, and determine a reasonable price for mitigation credits.

Percentage of New Water Demand Met Through Non-Exempt Wells

Because our demand analysis suggests municipalities other than Bozeman in Gallatin County have sufficient water supply to meet future water demand within the planning horizon (until 2050), these municipalities were omitted from the mitigation demand analysis. Our analysis does suggest that Bozeman will experience a water supply deficit, reaching a total of 9,115 AFY in 2050. The City of Bozeman, however, is actively pursuing new sources of municipal supply, seeking to diversify its portfolio of water supply sources, and implementing water efficiency and conservation measures to meet its growing water needs. Its Integrated Water Resources Plan suggests that a portion—but not all—of its supply deficit will be met through groundwater wells, probably near the west branch of the Gallatin River. These new wells are estimated to supply approximately 5,810 AF of water by 2062, and will be high-capacity, non-exempt wells that require mitigation[11]. Other demand will potentially be met through conservation measures and additional development of existing water rights. For this reason, we capped the amount of mitigation demanded by Bozeman to a conservative estimate of 5,810 AF.

In areas not served by municipal water supplies, all new water demand will be met through groundwater pumping, but a fraction of this pumping may be through wells drawing less than 10 AFY that are exempt from the permitting and thus mitigation requirements. To estimate the percentage of new, unincorporated development that requires a new permit and mitigation, public water supply data obtained from the Montana Department of Environmental Quality were analyzed to approximate how much current non-municipal water demand is met through non-exempt appropriations[13]. Public water supply systems serving populations over approximately 50 people were assumed to be non-exempt (based on an average per capita water use of 165 gpcd). Our analysis suggests that these non-exempt public water systems currently meet approximately 32% of all non-municipal demand. However, the percentage of new development using non-exempt wells or requiring mitigation may increase due to changes in building trends or in response to the more stringent definition of a combined appropriation. Conversely, the number may be overstated, because some existing water systems may currently have excess supply, and so new non-exempt wells may not be required to meet all anticipated future demand.

With these past trends and potential future shifts in mind, for this analysis, we varied the percentage of this demand that might be met through exempt wells from 0% to 100%, with a reasonable moderate estimate of 20%.

Percentage of New Water Use That Results in Net Depletion of a Stream

The fraction of water demand requiring mitigation is dependent on the net depletion the new groundwater pumping causes to surface streams. The net depletion of a stream is extremely variable and is dependent on many factors, including how much of the water use is consumptive and site-specific spatial and hydrogeologic conditions.

Non-consumptive portions of water use will return to the groundwater aquifer via seepage from outdoor irrigation, septic systems, or treated wastewater infiltration basins. This non-consumptive use does not result in net depletion of streams, and so only the consumptive portion of water use needs to be mitigated. The percentage of total water use that is consumptive can vary based on the type and location of discharge of septic or water treatment system and type of outdoor irrigation. For indoor, residential water use, the DNRC approved an average amount of water consumed by indoor residential use of 5%[23]. Residential use also often includes lawn and garden irrigation during the summer months; the consumptive volume of water from lawn and garden irrigation is usually considered 95% to 100%.

The specific location of a well, the pumping rate and schedule, and the hydrogeological conditions of the aquifer will also affect the net depletion of the stream. These factors vary widely and are extremely specific to the characteristics of individual developments.

Bozeman's groundwater pumping is an unusual case, because the city's only wastewater outfall is on the East Gallatin River, while its new high-capacity wells could be sited near either the East or West Gallatin River. In the case of net depletion to the West Gallatin River caused by these new wells, even the non-consumptive portion of water use that returns to the city's wastewater system on the East Gallatin will require mitigation for net depletion to the West Gallatin River. Almost all of the city's groundwater pumping may then have to be mitigated, even if it is not used consumptively and is returned to the East Gallatin further downstream at the treatment plant.

With this variability and complexity in mind, we estimated a range of percentages of new water use that results in net depletion of a stream for both Bozeman and non-municipal areas. For Bozeman, these values ranged from 0% to 100%, with a moderate estimate of 90%.

For non-municipal areas, due to the difficulty of predicting patterns of net depletion, potential net depletion percentages were calculated by analyzing seven existing change-of-use applications approved by DNRC in closed basins (Table 4). In these applications, the percentage of total water use that required mitigation ranged from 10% - 60%, with an average of 39% and median of 36%. Our estimates of this percentage used in the mitigation demand scenarios ranged from 0% to 60%, with a value of 35% determined to represent a moderate estimate of the percentage of water used by non-municipal water systems that requires mitigation.

Table 4. Approved mitigation applications, total new water use and calculated net depletion (consumptive use/required mitigation) to illustrate percent of total new water use mitigated.

Applicant	Total New Water Use (AF)	Consumptive Use/ Required Mitigation (AF)	Percent of Total New Water Use Mitigated
K&J Development	18.8	6.69	36%
Utility Solutions	1,140.68	113.84	10%
Sand Coulee Water District	48	28.7	60%
Kooteni Lodge Estates	89.42	50.19	56%
Wye Area Water Company	622.4	187.62	30%
Missoula County Office of Public Works	16.5	4.52	27%
Mountain Water Company	622.9	346.6	56%

Total Mitigation Demand

The varying percentages of non-exempt well use in non-municipal areas, net depletion resulting from water use in non-municipal areas, and net depletion resulting from water use in Bozeman were combined with our estimates of total water demand to produce several scenarios for potential mitigation demand in Gallatin County through 2050. Four of these scenarios are presented here and are described in the following table: an extreme high scenario for Bozeman and non-municipal areas, a moderate scenario for Bozeman and non-municipal areas, a scenario that assumes no non-municipal demand and moderate demand for Bozeman, and a scenario that assumes no demand from Bozeman and moderate demand for non-municipal areas (Table 5, Figure 11). An extreme low scenario is not presented here, but would result in no demand for mitigation from GVWE. Notably, these scenarios assume that the demand for mitigation is equal to the volume of water that must be recharged into the aquifer to offset net stream depletion. In reality, additional water may be required for managed aquifer recharge due to evaporative losses or non-ideal recharge locations, but this volume is highly dependent on site specific conditions and is not included in this analysis.

Table 5. Mitigation demand scenario descriptions used in demand analysis including projected future cumulative annual mitigation demand (AFY).

Demand Scenario	Description	Cumulative Annual Mitigation Demand (AFY)				
		2020	*2025*	*2030*	*2040*	*2050*
Extreme High	All non-municipal demand is met by non-exempt wells; city has 100% net depletion and non-municipal has 60% net depletion	630	1,339	2,695	8,273	12,224
Moderate	Bozeman has 90% net depletion, non-municipal has 20% non-exempt well use with 35% net depletion	74	156	753	4,289	5,977
Bozeman Only	Bozeman has 90% net depletion; all non-municipal use is exempt	0	0	504	3,818	5,229
Non-Municipal Only	Bozeman needs no mitigation, non-municipal has 20% non-exempt well use with 35% net depletion	74	156	249	470	748

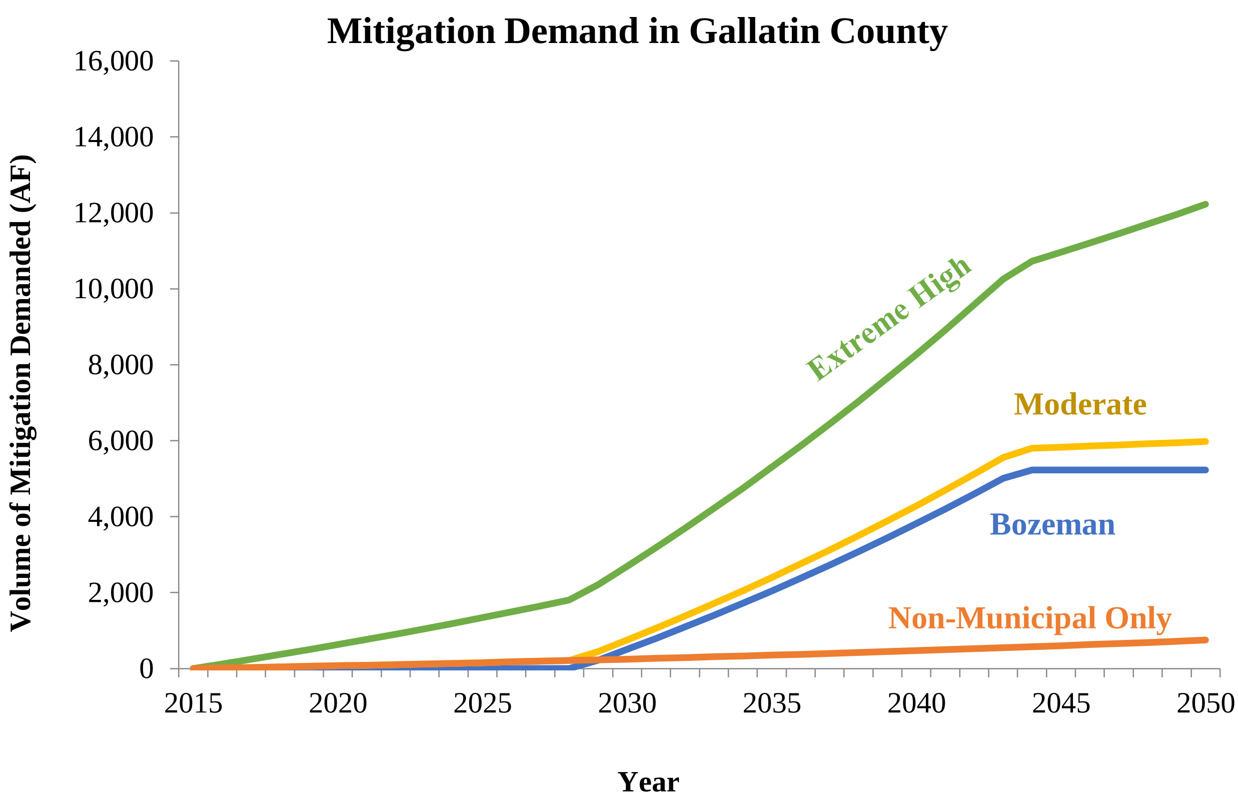


Figure 11. Estimated future demand for mitigation (AF) from GVWE under various demand scenarios including extreme high-demand (green line), moderate demand (yellow line), City of Bozeman only demand (blue line) and non-municipal only demand (orange line) (2015-2050).

While these results are necessarily speculative and uncertain, they are based on the best available information on expected development and the resulting demand for mitigation from GVWE. They indicate that the City of Bozeman will likely be the largest single user of GVWE, and that the volume of mitigation demand anticipated for non-municipal areas is quite small in comparison.

Bozeman will need to acquire substantial volumes of mitigation water to offset adverse impacts on the Gallatin River from its new groundwater pumping. The City is aware of this and is highly invested in and supportive of the development of GVWE. The City has not expressed interest in forming its own mitigation bank or acquiring mitigation water independently, since it does not have the staff resources and understands that public acceptance of a water exchange may be facilitated by a private non-profit administration.

GVWE, in turn, would be highly dependent on Bozeman to create demand for its services. The substantial demand from the City would ideally support the development of the Exchange, offset the relatively higher transaction costs of smaller transactions, and buffer the Exchange against the uncertainty of mitigation demand from unincorporated areas, which will be highly dependent on the number, size, and location of new subdivisions.

An analysis of subdivisions and public water systems provides additional information about potential mitigation demand, and is included in Appendix 10.

Supply of Water Rights

Evaluation Criteria for Supply of Surface Water Rights for Conversion

In addition to estimating demand for mitigation from GVWE (see *Demand for Mitigation* section), it is also important to determine if there are sufficient senior water rights in Gallatin County to supply GVWE with water for mitigation and recharge.

Any existing water right can be put through a change of use process and evaluated for a change authorization as described in MCA 85-2-402. However, the water rights are subject to close scrutiny during this process—only certain water rights may be suitable for conversion to a mitigation or recharge purpose, and only a portion of each water right may be used to offset new use to limit harm to other water users.

The criteria determining the suitability and availability of senior water rights for mitigation and recharge include:

1. **Priority Date:** To mitigate for residential use, it is preferable to use a water right that is unlikely to be subject to a call in even the most water-stressed years. We have not identified a specific statute that explicitly states how priority rights should be addressed in a change authorization to serve the purpose of offsetting net depletions. However, some existing mitigation change authorizations reveal that the seniority of the existing water right was evaluated to demonstrate the likelihood of a call on that right once changed to mitigation.
    a. In the Matter of Beneficial Water User Permit No. 63997-42M by Joseph F. Crisafulli (DNRC Final Order 1990)
        i. "Since there is a relationship between surface flows and the groundwater source proposed for appropriation, and since diversion by applicant's well appears to influence surface flows, the ranking of the proposed appropriation in priority must be as against all rights to surface water as well as against all groundwater rights in the drainage."

    The most senior water right subject to call in Gallatin County had a priority date in 1882 (Table 6)[39]. For this reason, when possible, our supply analysis selects only water rights prior to 1882 as resilient water rights capable of providing mitigation even in times of limited water availability in the county. However, it is still possible that more junior rights could be used if they are diverted early in the season before calls are likely to occur and recharged into the aquifer to provide year-round mitigation.

Table 6. Water calls along West Gallatin River (2005-2015)[39].

Priority Date Cut	Date of call								
	2005	*2006*	*2007*	*2009*	*2010*	*2012*	*2013*	*2014*	*2015*
1891	15-Jul	10-Jul	2-Jul	15-Aug	24-Jul	10-Jul	13-Jul	28-Jul	2-Jul
1/2 of 1890	18-Jul	14-Jul	5-Jul	1-Sep	31-Jul	19-Jul	16-Jul	2-Aug	3-Jul
1/2 of 1890	18-Jul	15-Jul	10-Jul	9-Sep		21-Jul	20-Jul		14-Jul
1889	30-Jul	28-Jul	19-Jul			5-Aug	9-Aug		
1888	30-Jul	28-Jul	19-Jul			5-Aug	9-Aug		
1887	30-Jul	28-Jul	19-Jul			5-Aug	9-Aug		
1886	25-Aug	30-Aug	21-Jul			10-Aug	9-Aug		
1885	27-Aug	30-Aug	21-Jul			10-Aug	13-Aug		
1884	27-Aug	30-Aug	11-Aug			20-Aug	13-Aug		
1/2 of 1883	27-Aug		14-Aug			30-Aug	19-Aug		
1/2 of 1883			29-Aug				19-Aug		
1/3 of 1882			4-Sep						

2. **Historical Use:** An appropriator is entitled to the amount of water that is put to beneficial use as long as it does not exceed the constraints—including point of diversion, place of use, timing, quantity and purpose—outlined in the water right. However, only that amount which has been historically used can be considered when making changes to an existing water right. Any existing right that is put through a change of use process runs the risk of limiting the transferable volume of water based on the actual historic use. In state administrative rulings, the DNRC has held that water rights undergoing a change of use proceeding are defined by the actual historical and beneficial use, not the amount claimed or even decreed.
    a. Town of Manhattan v. DNRC, Cause No. DV-09-872C, Montana Eighteenth Judicial District Court, Montana Eighteenth Judicial District Court, Order Re Petition for Judicial Review (2011) Pgs. 11-12. "Proof of historic use is required even when the right has been decreed because the decreed flow rate or volume establishes the maximum appropriation that may be diverted, and may exceed the historical pattern of use, amount diverted or amount consumed through actual use." (Page 58-59)[40]
    b. The Montana Supreme Court additionally describes: "An appropriator historically has been entitled to the greatest quantity of water he can put to use. The requirement that the use be both beneficial and reasonable, however, proscribes this tenet."(Page 59)[40]

The Water Resources Survey is frequently the first point of reference to determine historic irrigation of a parcel of land. The report, published by the State Engineers Office, surveyed and ground-truthed irrigation throughout Gallatin County in the early 1960s[41]. Additional aerial photographs, signed interviews, surveys, historical documents, and other documents can all be used to lend additional evidence to historic use.[41] This resource is not definitive, as some previous change applications have successfully proved historical irrigation that was not reported in the Water Resource Survey by providing supporting testament, photographs, and other historical documents[42]. Since another countywide irrigation survey has not been completed, this source is represented in the supply analysis to corroborate the amount of water historically put to beneficial irrigation use and thus potentially eligible for a change of purpose by GVWE.

3. **Consumptive Use:** Applicants to change a water right may not increase the consumptive use of the water right under its new purpose. Increasing the consumptive portion of an existing water right would constitute a new appropriation and would harm other users (Page 60)[40]. Therefore, GVWE must assess the supply of water rights in the region based on the consumptive use portion:

> "The amount of water being changed for each water right cannot exceed or increase the flow rate historically diverted under the historic use, nor exceed or increase the historic volume consumptively used under the existing use." (ARM *36.12.1902)*[43]

The DNRC has a formal methodology to calculate consumptive use of agricultural irrigation rights[44] also suggested by ARM 36.12.1902. This methodology uses the United States Department of Agriculture (USDA) Natural Resource Conservation Services (NRCS) Irrigation Water Requirements (IWR) program. When determining the historic consumptive use that will be utilized in a change application, an applicant has the option to deviate from this methodology and describe why that particular water right has a higher or lower consumptive use (ARM 36.12.1902.7.n.ii). However, for the purposes of this analysis, the DNRC's approved methodology was used.

The volume of consumptive use is based on the number of irrigated acres, a management factor specific to the county and the evapotranspiration (ET) of alfalfa by either flood/sprinkler or pivot irrigation (Equation 1). The ET values vary for different weather stations and are dependent on the climatic zone.

*Consumptive use (AF)=irrigated area (acres)*management factor*ET (feet)*

Equation 1. Consumptive water use calculation. Source: ARM 36.12.1902[43].

Alfalfa is not the only crop irrigated in Gallatin Valley; however, the IWR method—which uses ET values for alfalfa—was still used to determine consumptive use. Alfalfa is a predominant hay crop in Montana with the highest seasonal water demand of any other hay crop in Montana[44]. In this analysis of Gallatin County, the consumptive use value for alfalfa was determined using the appropriate management factor (73.5%) as determined by the Bozeman Montana State Weather Station[44].

The consumptive use was calculated for both flood and pivot irrigation, with pivot irrigation representing higher values of consumptive use than that of flood (Table 7). Since our data sources did not differentiate between pivot or flood irrigation, the more conservative flood estimate was applied to all acres so as to not overestimate the consumptive use available to supply mitigation.

4. **Adverse Effect:** MCA 85-2-401 recognizes an appropriator's right to stream conditions as they existed at the time of appropriation, so a new water user must prove all prior appropriators can continue to reasonably exercise their water rights under any potential changes caused by the new proposed use. 85-2-311(1)(b), MCA requires that applicants to a new beneficial water use prove, by preponderance of evidence, that the water rights of a prior appropriator under an existing water right, certificate, permit, or state water reservation will not be adversely affected. Analysis of adverse effect must consider the impact of the intended new use and demonstrate that this new use of water will be controlled such that the water rights of prior appropriators will be satisfied. Additionally, section 85-2-311 (1) (b) MCA does not contemplate a *de minimis* level of adverse effect on prior appropriators. Montana Power Co. 1984, 211 Mont. 91, 685 P.2d 336 (the purpose of the Water Use Act is to protect senior appropriators from encroachment by junior users). Notably, this adverse effect applies to all other appropriators, including those benefiting from return flow from a previous use or even co-ditch users. For this reason, recharge sites located close to a right's historic point of use would be preferable to avoid changes in infiltration and return flow patterns that might result in adverse effect.[45]

   Given the difficulty in predicting the spatial distribution of new water use, which water rights may be negotiable for sale, and how their change of use could impact existing users, this factor is not included in this analysis but should be considered during the process of seeking existing water rights.

5. **Spatial Distribution of Existing Water Rights**: While not legally required, the spatial distribution of the water rights was also evaluated. The water right's point of diversion can influence how appropriate the water right may be for supplying mitigation water. For example, when supplying instream mitigation by retiring irrigation water rights and leaving the previously diverted and irrigated water instream, it is necessary for the point of diversion to be upstream of the depleted reach. While the point of diversion can be changed in a change application, it is often difficult to avoid adverse effect on nearby appropriators. Reducing the complexity of the change application by avoiding point of

diversion changes is ideal and can help reduce the time it takes for the application to be approved.

The existing water rights of greatest value to GVWE would be those upstream of the Gallatin Valley, as they would be most suitable for mitigating any potential depletions occurring downstream. Water rights conveyed by the large irrigation districts in the region, Farmers Canal and West Gallatin Canal, represent ideal water rights to mitigate depletion to the West Gallatin since they are upstream in the valley and have access to extensive irrigation infrastructure to be able to move water to a given recharge location.

Quantitative Supply Analysis

Given the previous criteria, our analysis of existing water rights in Gallatin County utilized various sources to indirectly assess the consumptive portion of historically used irrigation water rights in Gallatin County (Table 7). Specifically, the number of irrigated acres from each source was converted to consumptive use in AFY using the DNRC Consumptive Use methodology[44]. In addition, the percentage of this water that GVWE may require by the year 2050 was assessed. Under the moderate mitigation demand scenario, GVWE may need to acquire between 5 and 10% of the consumptively used water in the County.

Table 7. Consumptive water use (AFY) in Gallatin County, MT. Consumptive water use was calculated using the DNRC Consumptive Use methodology for several different sources of irrigated acreage. The percentage of the consumptive use that GVWE may need was calculated using the moderate and extreme demand scenarios in 2050. Because the Water Resource Survey distinguishes the East Gallatin from the West Gallatin but our demand scenarios do not, percentages are not calculated for consumptive water use estimates from the Water Resource Survey.

Source	Acreage Irrigated	Flood Total Consumptive Use (AFY)	Pivot Total Consumptive Use (AFY)	% GVWE Need Under Moderate Demand	% GVWE Need Under Extreme Demand
USDA Census 2012[46]	79,100	89,243	103,632	10%	17%
USDA Census 2007[47]	81,651	92,121	106,974	10%	17%
Water Resource Survey East and West Combined - Present Irrigated Acres[41]	108,611	122,538	142,295	7%	13%
Water Resource Survey (East Gallatin)[41]	24,073	27,160	31,539	N/A	N/A
Water Resource Survey (West Gallatin)[41]	84,538	95,378	110,756	N/A	N/A

Spatial Supply Analysis

To further refine the spatial aspect of water rights availability, we mapped points of diversion along with the maximum flow rate of each right. Irrigation water rights including priority dates of 1882 and prior with a diversion point on the West or East Gallatin were mapped (Figure 12). GVWE may seek to acquire senior water rights on the West Gallatin at the West Gallatin Canal or at and above the Farmers Canal as these canals can be used for conveyance to recharge sites. There are 74 irrigation water rights with a priority date of 1882 and earlier with a point of diversion at or between these canals, totaling 61,778 AFY of maximum flow rate (Figure 13). The DNRC Water Resources Division has compiled point of diversion, place of use, acreage, and maximum flow rate into their Montana Water Rights geographic information dataset[48]. Acreage is provided for each place of use associated with a water right, but cannot be used to estimate the consumptive use of that right as irrigation and fallowing patterns are unknown.

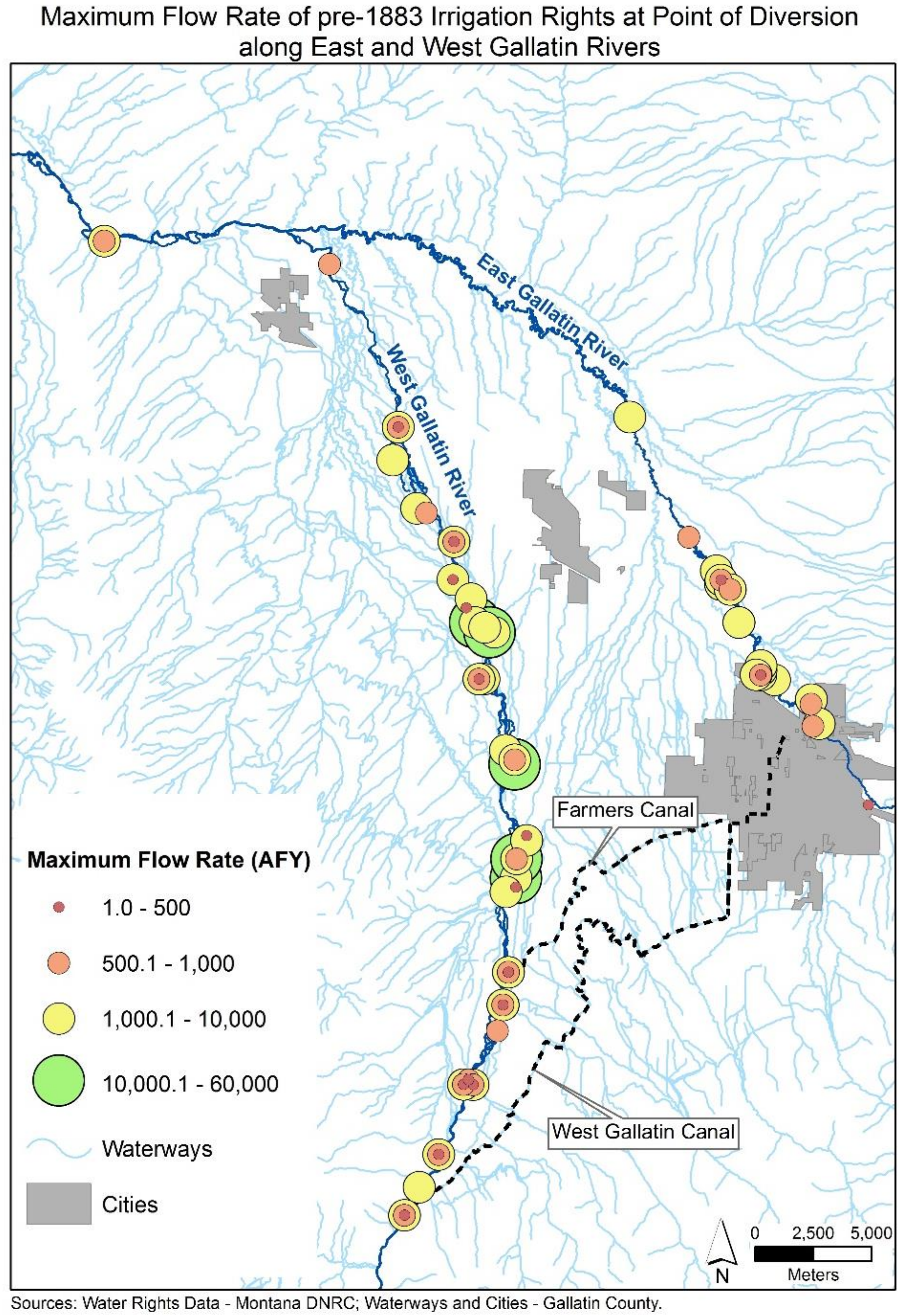


Figure 12. Maximum flow rate (AFY) of irrigation water rights with a priority date of 1882 and earlier along the East and West Gallatin Rivers. Colored circles indicate the maximum flow rate for each water right and are placed at the point of diversion associated with that water right. Note that the number of circles does not indicate the number of rights associated with that point of diversion, but represents that there is at least one right with the indicated amount of maximum flow rate. Additionally, this figure does not include points of diversion located on tributaries to the East and West Gallatin Rivers.

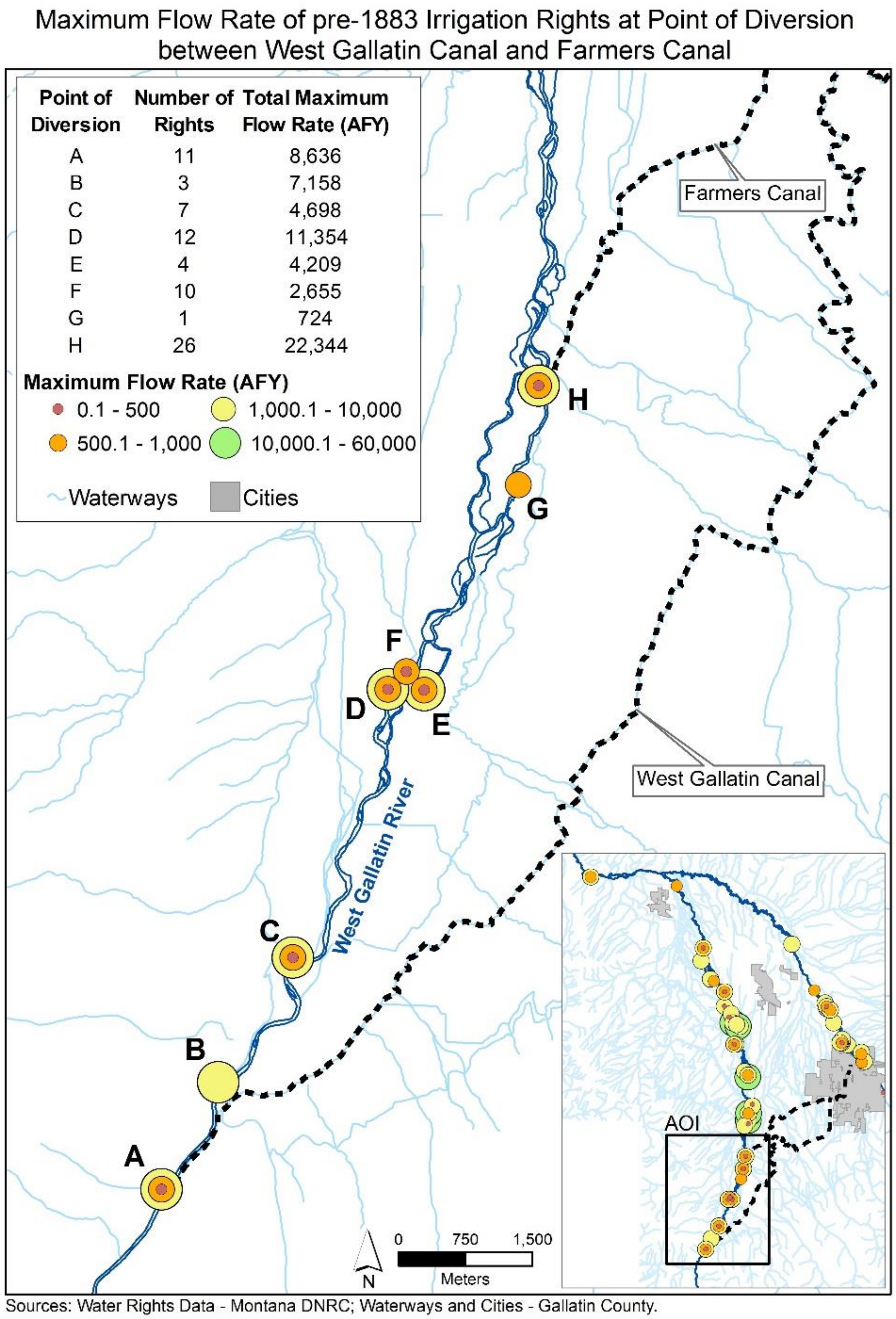


Figure 13. Maximum flow rate (AFY) of irrigation rights appropriated 1882 and prior between the West Gallatin Canal and Farmers Canal on the West Gallatin River. The colored circles indicate the maximum flow rate for each right and are placed at the point of diversion associated with that water right. Note that the number of circles does not indicate the number of rights associated with that point of diversion, but represents that there is at least one right with the indicated amount of maximum flow rate.

Table 8. Consumptive water use based on location. Consumptive water use (AFY) was calculated from the irrigated acreage using the DNRC Consumptive Use methodology for flood irrigated alfalfa and pivot irrigated alfalfa and 1882 and prior water rights with various points of diversion.

Source	Acreage Irrigated	Flood Total Consumptive Use (AFY)	Pivot Total Consumptive Use (AFY)
Pre-1880 Irrigation Diversions: West Gallatin Downstream of Farmer's Canal	5,840	6,589	7,651
Pre-1880 Irrigation Diversions: West Gallatin Upstream of Farmer's Canal	4,517	5,096	5,918
Pre-1880 Irrigation Diversions: East Gallatin	8,691	9,805	11,386
Entire County Irrigation	159,537	179,993	209,015
Pre-1880 Irrigation: Area of Interest	39,924	45,044	52,306

The priority date, historic consumptive use, and spatial distribution all influence the supply of water available for GVWE. However, every water right is unique and must be analyzed on a case-by-case basis, and a willing seller is required for a transaction to take place. Potential sellers include individuals looking to retire or decrease their acres irrigated, as well as those who sell their land to development and want to capitalize on their water rights.

The consumptive use calculations (Table 8) provide a rough estimate of supply, but the actual volume of senior surface water rights may be lower due to these additional constraints. While 5-10% is likely a manageable percentage of available supply needed through 2050 by GVWE, this percentage increases to 17% under a high-demand scenario. When spatial constraints and priority dates are taken into account, the supply of water rights declines even more, and could be a constraint on GVWE's implementation under a high-demand scenario. The Exchange could pursue short-term agreements or the use of more junior rights for aquifer recharge as part of a portfolio of mitigation to broaden the range of water rights suitable for providing mitigation water through GVWE. Notably, junior rights may be considered for mitigation only if new applicants are able to temper their water use during water calls, for example through conservation measures such as decreased lawn and garden watering or behavioral changes in domestic water consumption.

The agricultural sector in Gallatin Valley will need to be willing to take a leadership role in responding to the population growth rates of the valley. With leadership from the agricultural sector, the Exchange is one avenue of supplying water for new population growth, while protecting senior water right claims and allowing irrigators to capitalize on the demand for water coming from the new population growth. Without some vehicle like the GVWE, it is likely that the pressure of population growth will roll back the integration of ground and surface water management, and allow unmitigated new groundwater pumping to supply water for new population growth, regardless of the impact of pumping to senior surface water rights.

Financial Analysis

Pricing and Credit Structure

Mitigation exchanges in other regions have often used a fixed pricing structure and mitigation credit size and are described in detail in Appendix 12. The Dungeness Water Exchange, for example, has a three-tiered pricing structure for indoor use ($1,000 one-time fee, 150 gallons/day), indoor and basic outdoor use ($2,000 one-time fee, 239 gallons/day), and indoor and extended outdoor use ($3,000 one-time fee, 350 gallons/day) that assumes relatively consistent patterns of water use and associated depletion. Water banks in the Kittitas and Yakima basins in Washington generally assume indoor domestic use of 350 gallons/day plus 500 square feet of outdoor irrigation, but can include additional fees based on location, adding an additional layer of spatial complexity to pricing. A complete table of pricing structures from the interview process is included in Appendix 12. The pricing structure of other exchanges can be influenced by several factors, such as potential state, federal, or even organizational subsidies to encourage initial market participation, additional environmental fees to new water users, or the regional pace of approval. It is therefore important to consider these prices in context in order to understand how the operation has adapted to local opportunities and challenges.

Due to the spatial, volumetric, and circumstantial variability of mitigation demanded by potential GVWE clients, we recommend that GVWE should implement a sliding mitigation credit size. The per-AF price of mitigation purchased from the exchange would be fixed, but each individual project must be evaluated by DNRC during the permitting process to determine its effect on stream depletion and resulting mitigation requirements (see *Mitigation Requirements and Options* section). This determination will be based on a combination of the size and characteristics of the project, its expected water demand, its seasonal patterns of use, and its relative location to the stream. For example, two 50-home developments may have quite different mitigation requirements if one has larger lot sizes (and so more irrigation needs) or is located closer to a stream or river. Ideally, either DNRC or GVWE would develop a single MODFLOW or other hydrologic model for the entire basin to allow mitigation requirements for individual projects to be rapidly determined at a low additional per-project cost. Appendix 5 describes the hydrological suitability mapping developed by Ecology to determine mitigation credit requirements as an example.

Unlike most mitigation exchanges, GVWE is assuming the additional responsibility and liability of ensuring continual recharge for as long as the mitigated water use continues. The costs necessary to operate the recharge program on a continual basis represent an additional challenge to an upfront service fee. An annual fee might be most appropriate for ensuring long-term financial viability. However, collection of an annual fee might be logistically challenging for many users of the exchange, given that the purchasers of mitigation credits (e.g., developers) might not be the same as the end water users (homeowners). Annual fee collections would also incur additional costs for billing and enforcement. For these reasons, it is recommended that GVWE not charge an annual fee for individuals or developers purchasing mitigation from the exchange, but rather charge new mitigation users a one-time fee that is sufficiently high to fund recharge costs in the long term. There is potential, however, for municipalities and utility-scale community water systems to be charged an annual fee. These types of users have consistent rate-paying clientele that can absorb the ongoing costs. They are also likely to require larger volumes of water than individual users and to remain the end users of water for as long as mitigation is required. These factors make an annual fee a more feasible and efficient mechanism for municipalities and utility-scale community water systems. Finally, an annual fee could reduce financial risk to the Exchange in the event that costs are higher than projected in the future. This is because the annual fee could be scaled in the future appropriately, whereas one-time fees are locked in based on cost projections that may be inaccurate. Since annual fees are only feasible with the largest clients predicted to use GVWE, these risk-reduction effects could be significant.

Financial Analysis and Operational Scenarios

An initial model (See excel document, "*GVWE Financial Analysis_Initial Scenario*") was developed to demonstrate the financial performance of purchasing water rights and servicing all mitigation credits via managed aquifer recharge. This model was then modified to represent two subsequent scenarios to illustrate the reduction of costs associated with alternate operation models: a broker scenario and a lean scenario:

- Broker Scenario (See excel document, "*GVWE Financial Analysis_Broker Scenario*")
  - GVWE could avoid water rights acquisition costs by acting as a broker rather than purchasing rights outright. However, it is important to recognize that these costs would be borne by potential customers seeking mitigation. Therefore when considering the cost to potential clients, GVWE must consider the additional costs to the users to purchase existing water rights. The costs in this model thus reflect only the administrative and recharge costs for the management of mitigation after a purchase of existing water rights.
- Lean Scenario (See excel document, "*GVWE Financial Analysis_Lean Scenario*")
  - GVWE may also minimize aquifer recharge costs by acting as a broker as well as using instream transfers as mitigation whenever timing requirements allow. The City of Bozeman uses approximately 45% of water during peak summer demand (CITE Integrated Water Resource Plan). Therefore, this model was run to conservatively reflect a profile of 40% of mitigation demand met through instream transfers and 60% of mitigation demand met through aquifer recharge. This reduces the cost of managed aquifer recharge.

The nascent state of the mitigation credit market, lack of comparable sales in the region, and unique nature of Montana's regulatory infrastructure pose a challenge to price determination through comparative market strategies. Thus, we analyze the impact of various hypothetical prices on the complete operation to determine at which prices the costs of operating the GVWE will be returned. While market conditions will ultimately determine the price that GVWE can charge, these prices serve to advise GVWE the range of prices that could sustain the operations and thus should be considered a base estimate with which to approach future negotiations. It is important to note that as prices for mitigation rise, new water users may be encouraged to find alternative options, limit themselves to exempt wells if possible, or otherwise avoid compliance with permit mitigation which will effectively put an upper limit on the price GVWE is able to charge.

The GVWE will face high uncertainty and risk in its development as the exchange relies on recent regulatory developments, the unpredictable pace of bureaucratic permitting processes, and even the possibility that necessary permitting components may be denied. This risk is included in our analysis as the discount rate. By varying the discount rate, we can model how the exchange would fair under different risk assumptions. GVWE should seek opportunities to reduce risk wherever possible, such as securing grant capital to reduce financial leveraging or guaranteeing future clients through contracts wherever possible.

Cost Estimates and Cash Flow Model

Estimates of costs associated with the development and operation of GVWE were collected through online research, personal interviews, and comparisons to similar operations. The complete list of costs is included in the "Cost Descriptions" tab of each financial analysis workbook. This tab describes each itemized cost and includes the sources consulted to determine the assumption used in the model. The "Cash Flow and Model Analysis" tab models these costs through 32 years from 2016-2048 to include business development and three aggregated approval phases to convert existing water rights for use as inventory to the operation.

To determine the annual cash flows required incorporating sales predictions and establishing the capacity of GVWE to service mitigation. Our analysis is founded on the Moderate demand scenario (See *Demand for Mitigation* section). These values are incorporated into our model in three ways: 1) to advise the capacity of recharge sites, and thus the construction costs of developing new sites, needed to service this mitigation demand, 2) to calculate the variable costs per mitigation credit sold to model the financial performance of the operation, and 3) to determine the future sales base that will provide revenue and thus advise the financial viability of the operation.

The incorporation of per capita mitigation demand (as determined by the Moderate demand scenario) to project our future mitigation sales is likely unrealistic. Instead, mitigation credit sales would occur in larger aggregations, as public water systems, community subdivisions, or municipalities purchase them prior to anticipated demand. However, given the unpredictable nature of these transactions, we chose to disperse demand over time in our costs model rather than aggregating it into lumped transactions.

Our model was developed under the following parameters and categories:

- **Operational/Administrative:** includes the overall administration of the bank including employee salaries, office expenses, marketing and communication, and office operations such as accounting and legal fees.
    - These expenses are all modeled as annual fixed costs, except for one variable cost per transaction completed to represent the additional bureaucratic burden of making a sale.
- **Business Development:** includes the initial expenses for business development, including legal counsel to help develop initial contracts (i.e. sales and purchasing, City of Bozeman MOUs, conveyance, etc.), further guide the long term operational structure, and assess liability, technical water right consulting, financial consulting to better narrow down on the pricing structure; and other initial administrative needs.
    - These expenses are all modeled as initial development and start-up costs required to initiate the launch of the bank and establish an effective strategy and operation.
- **Water Acquisition:** includes the costs associated with obtaining existing water rights (when applicable) and putting them through the DNRC process.
    - This section is modeled to purchase water rights every 10 years in a quantity sufficient to meet the future decade of predicted demand. This allows for the expensive and time consuming process to be optimized by converting multiple existing water rights collectively.
    - There is an additional cost premium and time delay (4 years) on the initial conversion to reflect DNRC's hesitance to approve new change authorizations without established precedent, as well as the potential need for additional development of hydrologic evidence to support the change authorization. The second change authorization takes 3 years, while subsequent change authorization proceedings take 2 years.
- **Groundwater Recharge:** includes the costs associated with the construction of recharge sites, planning and design, and monitoring of the various sites required to service mitigation credits that require managed aquifer recharge.
    - The model was developed to begin with the development of a smaller pilot recharge site with a capacity of 300AF. Subsequent recharge sites will be built to a capacity of 800AF (see *Managed Aquifer Recharge* section). The model is linked to update the construction of new recharge sites upon changes to the "Demand for Mitigation (AF)" row.

For the complete methodology used to calculate the free cash flow from this model, including equations and variables, see Appendix 11.

Total Costs of Various Operational Scenarios

Figure 14 illustrates the total cost, discounted at 10%, of each operational category from 2016-2048 for each scenario. This analysis reveals which category constitutes the predominant expense for the GVWE. The initial scenario is most expensive ($6,475,607), followed by broker scenario ($2,980,473), then lean scenario ($2,755,473). Water rights acquisition (dark blue) and aquifer recharge (light blue) are the two dominant cost categories in the initial scenario, and therefore lend credibility to the exploration of alternative operational scenarios. The broker and lean scenarios both are attempts to reduce these substantial costs and the reduction in costs is demonstrated with the scenario titles.

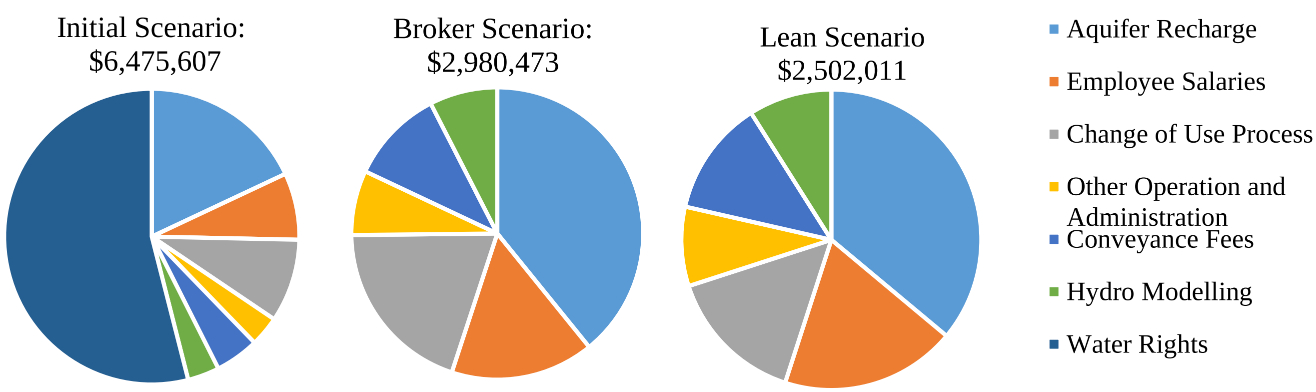


Figure 14. Total costs from 2016-2048, discounted at a rate of 10%. The lean scenario closely resembles the broker scenario but aquifer recharge costs have been reduced by $264,953.14. Source: Excel document: GVWE Financial Analysis_Initial Scenario, Excel document: GVWE Financial Analysis_Broker Scenario, Excel document: GVWE Financial Analysis_Lean Scenario.

Annual Cash Flow Profiles of Various Operational Scenarios

Annual cash flow is important to understanding the financial viability of the GVWE as it establishes GVWE's capacity to manage endowments, afford loan payments, or expand programing. Figure 15 illustrates the free cash flow, or gross margin prior to taxes or other considerations, of the three operational models from 2016-2048 assuming all mitigation credits are sold at a price of $6,000/AF in terms of 2016 dollars. Notably, only the broker and lean scenarios are able to generate positive cash flow without the participation of the City of Bozeman, but it should be remembered that these models would require the mitigation buyer to purchase or otherwise obtain existing water rights for use in the mitigation process, so $6,000 is excessive for these models as the product sold is not fully comparable.

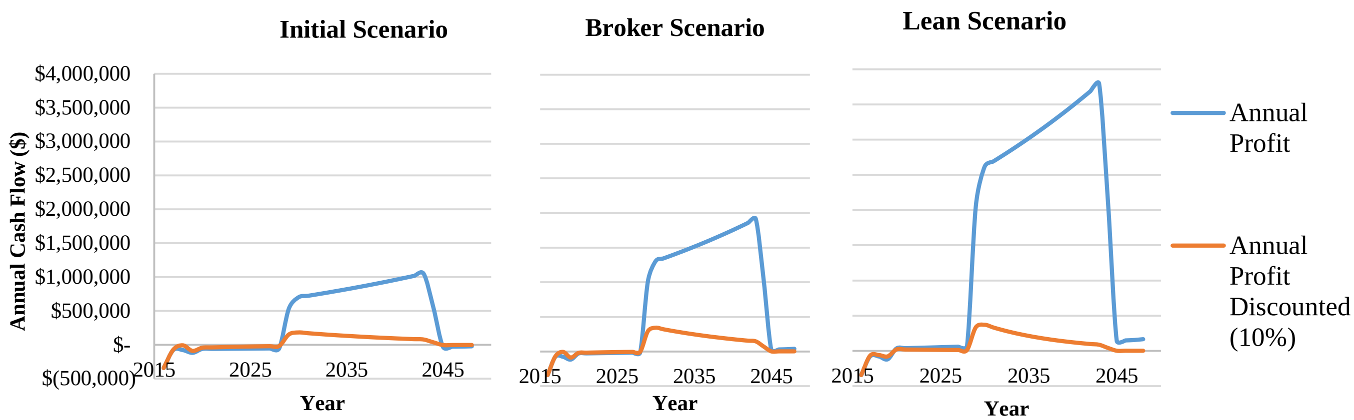


Figure 15. Free cash flow (total annual margin – total annual fixed costs) from 2016-2048 for each operational scenario at a sale price of $6,000 per acre foot. Blue lines represent the undiscounted cash flows and orange lines represent the same cash flow discounted at a rate of 10%. Source: Excel document: GVWE Financial Analysis_Initial Scenario, Excel document: GVWE Financial Analysis_Broker Scenario, Excel document: GVWE Financial Analysis_Lean Scenario.

Total Value Analysis of Various Operational Scenarios

Once GVWE takes on the obligation to service a mitigation credit it must fulfil that obligation into perpetuity. GVWE's responsibility to continue recharging and mitigating in perpetuity raises concerns. Because collecting an annual fee from non-municipal customers is not practicable, the upfront price will have to be sufficiently high to account for long-term costs. Our analysis measured the financial viability of GVWE at various prices to identify the range in which prices may be feasible to operate GVWE (Figure 16). First, we calculated the net present value from 2016-2048. Then we calculated the terminal value using the average of the final four years of cash flow to project the value of that stream of cash into perpetuity. The 2044-2048 values are significant as they represent years without the exceptional demand created by the City of Bozeman. The discounted terminal value was added to the net present value to result in total value, or the complete value of the operation as expressed in 2016 dollars. Additional information on the calculation of the terminal value can be found in Appendix 11. The point where the return on the investment equals zero, or breaks even, is where the total value equals zero.

The return break-even prices for the initial scenario range from $4,300 to $6,500. Those for the broker scenario range from $2,500 to $4,500, and those for the lean scenario from $2,000 to $4,000. These results can be used to advise what price ranges may allow GVWE to break even on its operation costs, however exceeding these prices in order to generate additional revenue for contingency planning and uncertainty is paramount to the financial success of GVWE and should be considered in the ultimate determination of price. While not included in our model, the ability to charge some users an annual fee would reduce these costs, as the overall financial risk would be less.

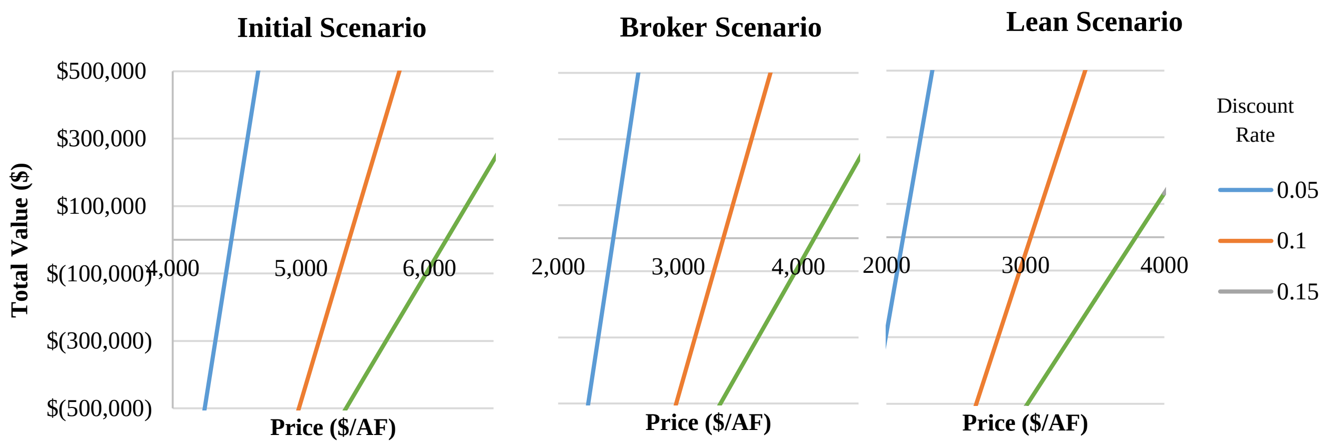


Figure 16. Total value as represented by the net present value for cash flows from 2016 to 2048 plus the terminal value for each price at each discount rate. The terminal value was calculated with a final cash flow growth rate of 2% to conservatively account for incremental growth into the future. Blue lines represents total values calculated with a discount rate of 5%, orange lines are 10%, and green lines are 15%. Source: Excel document: *GVWE Financial Analysis_Initial Scenario*, Excel document: *GVWE Financial Analysis_Broker Scenario*, Excel document: *GVWE Financial Analysis_Lean Scenario.*

Conclusion and Economic Viability

The lean version of the operational model with no outright purchase of water rights and with a portfolio of mitigation including 60% managed aquifer recharge and 40% instream transfers creates the least expensive price range ($3,200-$4,200 in addition to expenses for existing water rights) that allows for a return of value on investing in the GVWE. This model may require more positioning within the community to earn the trust of existing water rights holders to put their water through the change of use process and utilize the bank's services to match their water right with willing sellers. While our model is based on a price charged per unit at the point of sale, additional development of how pricing and sales would work in this type of arrangement would be necessary. Since the GVWE would serve the needs of both the seller with the existing water right and the buyer with the demand for mitigation there may be an opportunity to collect a service fee from both of these parties. For example, GVWE may choose to encourage existing water rights holders to participate as sellers by initially subsidizing their change of use process but then collect a commission based fee upon sale of the transformed mitigation credit to a new buyer. This would result in additional changes to the projected cash flows of the operation and need to be accurately modeled. Additionally, GVWE may charge prospective buyers an application fee to announce and confirm their intent to seek mitigation and a follow-up service fee upon successful completion of a sale. Once a pricing structure is chosen, additional analysis should be done to specifically determine price ranges with that price structure.

There are additional benefits to not purchasing water rights upfront that lend strength to the broker and lean models of operation. These models represent a significant reduction in costs which would relieve GVWE from needing to attract substantial upfront capital and paying large interest payments over the course of operation. This in turn reduces long-term expenses of the bank and thus allows the bank more flexibility in determining price and a better chance of remaining competitive with alternative options. Finally, these scenarios are also more flexible for meeting the needs of various clientele who may have personal access to existing water rights that can serve to supply their mitigation need. The price of water rights is a major component of uncertainty – across all scenarios and across time – so removing it from the GVWE's balance sheets reduces risk and preserves the flexibility of the Exchange in meeting unique client needs.

All models demonstrate that the City of Bozeman represents a substantial customer to the GVWE. Without their participation as a client, the GVWE is not financially feasible given the current conditions in the region. Additional unincorporated demand would need to exist to sustain the bank, which is unlikely given that the groundwater well exemption of 10AF is still sufficiently large to meet the needs of certain developments or even encourage development patterns designed to specifically utilize the exemption and avoid mitigation.

This financial model relies solely on mitigation credit sales as a source of revenue for GVWE. Alternate income may also come from managing an endowment with the additional cash flow not utilized to cover annual expenses. Returns generated from a sufficiently large and well managed endowment could also be used as operating income for the bank, and may be feasible under the high-demand scenarios created when the City of Bozeman services their mitigation demand through GVWE.

Broadly, these results suggest that GVWE may be economically viable with an upfront price model, however an annual fee should be seriously considered as a way to reduce financial risk and improve feasibility. The supply of surface water rights is sufficient to meet new mitigation demand, although the supply of pre-1880 water rights in ideal locations will very likely be limiting.

Funding and Development

GVWE will incur substantial up-front costs to cover construction of a recharge facility, water rights acquisition and change-of-use, and employee compensation. Opportunities to cover these upfront costs include loans, investor funding, and grants. A table of possible funding sources is included in Appendix 11. By using an integrated capital strategy which supplements loans with

grants, GVWE can effectively reduce its cost of capital and thus lower its net discount rate. Grant funding can also help capitalize the development of GVWE through the most risky initial development process when investor capital is less likely.
One promising source of grant funding is the Bureau of Reclamation's WaterSMART grant program. WaterSMART Water and Energy Efficiency grants can be used for projects that conserve and use water more efficiently, increase the use of renewable energy, improve energy efficiency, benefit endangered and threatened species, facilitate water markets, carry out activities to address climate-related impacts on water or prevent any water-related crisis or conflict (BOR WaterSMART Water and Energy Efficiency Grants). Grants are awarded yearly and range in size from $300,000 to $1,000,000, depending on the project scope. Applicants must be able to match funds and complete the project within 2-3 years of receiving the funding. The applications are due in mid-January and awards are announced in June. Applicants must be water users with water delivery authority, such as municipal water districts or irrigation districts.

WaterSMART grants are very competitive and project proposals are ranked based on meeting the following criteria: quantifiable water savings, water-energy nexus, endangered species benefit, water marketing, water supply sustainability, implementation and results, additional non-federal funding (>50%), and connection to reclamation projects. GVWE could apply for a WaterSMART Water and Energy Efficiency Grant in cooperation with a local canal company or the City of Bozeman.

The Dungeness Water Exchange, located in Washington State, received a WaterSMART Water and Energy Efficiency Grant to fund an irrigation efficiency project and water acquisition to seed the water exchange. The proposal, "Dungeness Basin Water Conservation: Irrigation Efficiencies and Water Banking in, Clallam County WA" was proposed by Agnew Irrigation District with assistance from Clallam Conservation District and Washington Water Trust in May, 2010. The proposal was awarded $299,857 and was matched by non-federal funds from Agnew Irrigation District and the Washington State Department of Ecology (Ecology).

Environmental Benefits

Inherent Environmental Benefits

GVWE provides an inherent environmental benefit for the Gallatin Valley by creating a mechanism to support sustainable groundwater management in the face of development pressure. Montana's mitigation requirements—which mandate that mitigation offsets the adverse effect of new groundwater pumping in accordance with its volume, timing, and location—are unusually complete and strict relative to other western states. The state, however, lacks an institution to allow developers to readily meet these requirements and the DNRC to effectively enforce them. The change to the definition of an exempt well in October 2014 created an additional regulatory burden and raised questions about the agency's ability to enforce the rules[49]. As a result, Montana's strict mitigation requirements may be at risk from legal or political challenges, and weakening of the law may threaten the continued sustainability of groundwater use.

By facilitating water transactions and providing a simplified mechanism to comply with regulations, GVWE will serve as a model institution to demonstrate the practicability of Montana's stringent mitigation requirements and support their continued existence and enforcement. Ultimately, protecting these regulations and providing a simpler mechanism to comply with them will support sustainable groundwater use and protect stream levels and the habitat of native flora and fauna.

Additional Opportunities

Beyond these inherent benefits, there are additional ways in which GVWE could provide environmental benefits through the mitigation credit purchase process.

GVWE could incorporate an environmental fee into the pricing structure for its mitigation credits. This additional fee could be used to retire a portion of acquired water rights to support instream flows, particularly along dewatered stretches of stream in the Gallatin Valley. The fee could also be used for restoration work along the Gallatin River, such as the projects outlined in the 2010 Gallatin Watershed Restoration Prioritization Planning report prepared for the Gallatin Conservation District and the Greater Gallatin Watershed Council[50].

GVWE could also incorporate contingency purchases into the sale of its mitigation credits, requiring that developers purchase slightly more mitigation than their anticipated need. This contingency would account for uncertainty in groundwater modeling and could support additional instream flows.

Finally, GVWE could offer mitigation credits for purchase by non-profits or other entities with an interest in sustainable water management in Gallatin Valley. These entities could then choose to retire mitigation credits to support instream flows. This option, however, might create legal challenges, since the water rights used by GVWE will have been changed to a mitigation purpose, not instream flow, and so cannot legally be left instream. If GVWE chooses to pursue this option for environmental benefits, it may have to structure its change of use applications so that a portion of an acquired water right is changed to an instream flow purpose rather than mitigation.

Recommendations and Conclusions

Insights from Other Water Banks

To learn from other water banks, nearly 20 water bank operators and experts were interviewed to lend insight on how to form and manage a successful groundwater mitigation exchange. Notably, every water bank is unique. The optimal operational strategy for each one differs based on physical location, local and state laws, hydrologic characteristics, managing entity, and other factors. Furthermore, many operations are still adapting to local conditions and changes and the optimal strategy has yet to be confirmed. However, several themes and lessons learned have emerged that can be applied to the development and management of GVWE. Appendix 12 has a full summary of various water banking entities explained, and the top five takeaways applicable to the development and operation of GVWE are:

1. **Engage with a diverse group of stakeholders.** Diverse stakeholder involvement is key to the implementation of a successful program. Specifically, leadership from the agricultural community will be needed for the development of GVWE from concept to implementation. A broad group of stakeholders involved and supportive of a GVWE is likely to bring together the needed agricultural leadership, water rights expertise, and early private and public funding needed to capitalize the GVWE, successfully engage with DNRC, and work with willing buyers to purchase GVWE's mitigation water. In addition, when communicating with different stakeholders, it is important for GVWE to be aware of and communicate in terms with which they are familiar (acre-foot, gallon, share, cubic feet per second, etc.) and be sensitive to historical biases.

2. **Operation and administrative costs are often underestimated.** GVWE must strive to keep costs as low as possible, but remain aware of potential unexpected costs. This is important when applying for grant funding and when setting the price for mitigation credits. Notably, many other banks had alternative revenue streams (e.g., an irrigation company, private landowner, or resort) that helped sustain operations.

3. **Simplify whenever possible.** Water marketing is already a complex regulatory, legal, physical, environmental and social topic. GVWE should avoid adding complexity and attempt to streamline the mitigation process whenever possible. Mitigation solutions should be parsimonious, and the Exchange may benefit most from the implementation of good solutions rather than waiting for perfect solutions.

4. **Identify incentives and motivation of potential users.** There are many ways in which a potential user may be incentivized to mitigate, including legal requirements, saving

money, or saving time. Most successful banks emphasize all of these parameters. Effective and competitive mitigation must be preferable to the status quo – often by being less expensive and less time consuming than obtaining the credits as an individual. In addition, mitigation must be mandated by the state to some degree; stronger regulation improves market participation as many water users will find a way to avoid purchasing mitigation credits under loopholes if possible.

5. **Managing in perpetuity raises concerns.** It is essential for GVWE to develop a program and pricing scheme that allows the aquifer recharge aspect of mitigation to be managed in perpetuity. GVWE will be liable for monitoring and reporting and maintaining the recharge galleries into the future. This responsibility may benefit from institutionalization (i.e. incorporation by the state or county) in the future.

Recommendations and Lessons Learned

Our hydrogeological and economic analysis of GVWE suggests several lessons and recommendations to guide its development and ensure its long-term viability:

- There are several areas throughout the valley suitable for recharge, but options may be limited due to spatial constraints. Many sites along the West Gallatin River are further downstream in the valley, and there are limited recharge options upstream of Bozeman along the East Gallatin. Additional hydrologic investigations, including a basin-wide model, will provide a greater understanding of groundwater flow patterns and further refine the recharge suitability analysis, and this modeling must be completed prior to operationalization. This model can also be used to determine zones of stream depletion and the number of mitigation credits required for a new user.

- Demand for mitigation is difficult to predict, but assuming the City of Bozeman chooses to purchase mitigation credits from GVWE, a moderate estimate would see the Exchange supplying almost 6,000 AFY of mitigation by 2050. To meet this demand, GVWE will want to obtain the most secure, upstream rights to avoid any calls, simplify the change of use process, and have the option to leave water instream. The estimated consumptive use of water rights meeting these criteria indicates that as the bank continues to grow, the opportunity to access sufficient rights will be limited.

- Generally, our analysis suggests that GVWE is economically viable, and that prices for mitigation credits might fall in the $4,000-$10,000 per AF range. Mitigation credit prices must be sufficiently high to account for costs into perpetuity, and additional opportunities for environmental benefits may be incorporated in the pricing structure for mitigation credits.

- It is recommended that the administrator of GVWE explore opportunities to reduce the high initial upfront costs associated with running a water bank, such as water rights acquisition and recharge site construction. To reduce these costs, GVWE could create mitigation portfolios that deemphasize aquifer recharge. Additionally, GVWE could act as a broker between buyers and sellers to avoid the costs of purchasing water outright.

- The City of Bozeman accounts for the vast majority of projected demand and is a critical component to the success of GVWE. GVWE is unlikely to be profitable without the City of Bozeman as a customer.

- Water mitigation banks are most effective when all new users are required to mitigate. Closing the 10AF exemption for new groundwater users would create a much larger customer base for GVWE and help to ensure its success.

Conclusions

Montana's strict requirements for mitigating new groundwater use in closed basins help protect senior appropriators and the environmental quality of surface waters. Offsetting the exact volume, location, and timing of new use, however, can present a significant challenge, particularly in areas like Gallatin County that are experiencing rapid growth. GVWE would address these challenges by creating an institution to facilitate transactions between senior water rights holders and new groundwater users and help new users meet mitigation requirements.

Development of GVWE will be challenging and dependent on a number of factors, including successful groundwater modeling and recharge site selection, demand from the city of Bozeman, the ability to secure sufficient senior surface water rights with appropriate points of diversion, minimization of costs, and collaboration between stakeholders.

These challenges to the development of GVWE are exacerbated by the undeveloped nature of the market and lack of comparative models that successfully accommodate the unique regulatory conditions for mitigation in the Gallatin Valley region. These same characteristics emphasize the need for such an institution as the GVWE. Our analysis has confirmed the demand, albeit potentially delayed into the future, for an institution that can effectively connect existing water users to new water use applicants and simplify the mitigation process for both users and regulators. The development of such an institution will require both time and trial and error to realize opportunities for increased efficiency and improvements to how such an institution should best operate within these conditions. However, as an initial market participant, the Exchange will be well positioned and best experienced to meet the mitigation needs of the region once realized.

If the Exchange can be successfully implemented, it will offer an example of successful conjunctive management in a closed basin that is able to meet strict mitigation requirements, support those strict mitigation requirements and the closure of the exempt well loophole, and help protect rivers and streams in Gallatin Valley from depletions caused by new groundwater use.

Appendix 1: Exempt Wells

Exempt Well History

Montana first began requiring permits for most water use in 1973[51]. Certain types of wells have been exempt from the permitting process ever since. The exemption rules have changed over time, but since 1987, wells drawing less than 35 gallons per minute and less than 10 acre-feet per year have not been required to complete the permitting process. This exemption was intended to reduce the permitting burden on water users and Montana's Department of Natural Resources and Conservation (DNRC) for rural residential and agricultural use that would not have a substantial impact on groundwater resources[52].

While exempting small single wells, the law requires that combined appropriations—wells that individually would be exempt, but when taken together exceed the limitation—do require permits. Over the past several decades, stakeholders, legislators, and the courts have debated what constitutes a "combined appropriation." In 1987, DNRC's original rule regarding the matter suggested that two or more wells that could have been accomplished by a single appropriation are a combined appropriation, regardless of their physical connection[52]. In 1993, however, a revised DNRC rule indicated that multiple wells from the same source for the same development are only a combined appropriation requiring a permit if they are physically piped together[18].

In response to the rapid proliferation of subdivisions pumping water from multiple exempt wells and the resulting potential for large cumulative impacts on groundwater, stakeholders challenged this interpretation of the exemption[16]. A group of ranchers with senior water rights and the Clark Fork Coalition led this effort, and were joined by other parties, including Trout Unlimited. In 2010, the First Judicial District Court oversaw a settlement between these parties and DNRC, through which DNRC agreed to rewrite its regulations regarding multiple exempt wells within 15 months[53].

In January 2014, DNRC abandoned its efforts to change the exemption after a number of failed and controversial attempts, calling "any further attempt at rulemaking…futile at this time[11]." In response, the Clark Fork Coalition and a group of ranchers holding senior water rights filed a petition for judicial review. On October 17, 2014, Judge Jeffrey Sherlock of the Montana First Judicial District Court ruled that the multiple well exemption violated the intent of the Water Use Act and reinstated the 1987 definition of combined appropriation[52]. The parties and DNRC attempted a number of bills to craft a statutory compromise to the reinstated 1987 regulatory definition during the Montana Legislative Session that started two months after Judge Sherlock's ruling. Despite significant time and effort to find common ground, no bill had full support of all parties, and no legislation passed. The Montana Realtors Association is appealing Judge Sherlock's ruling to the Montana Supreme Court. While this appeal is pending, the 1987 rule requires mitigation water for any new project or development exceeding 10 AFY, whether on one large well or multiple, small wells. This requirement will drive non-municipal demand for mitigation water to the mitigation bank.

Debate Regarding Effects of Exempt Wells

Numerous articles published in recent years have attempted to evaluate the effects of exempt wells in western states, with a range of opinions regarding the severity of impacts. Ziemer et al. (2012) noted that between 1991 and 2010, DNRC issued over 56,000 permits for exempt wells in Montana, nearly half of which were in closed basins[18]. Ziemer et al. (2006) point to clear links between groundwater withdrawals and reduced instream flows in Montana[2]. Richardson (2012) argues that spatial and volume restrictions on exempt wells limit their impact in most of the West, but unlike most of these states, Montana does not limit the use of exempt wells for irrigation purposes[54]. Generally, Brozović et al. (2014) show that groundwater pumping can negatively impact neighboring wells, adjacent stream flow, aquatic species and ecosystems, and water security for growing populations[55].

In 2008, DNRC issued its own report regarding the potential effects of exempt wells on senior surface water rights[23]. The report predicted an additional 70,000 new exempt wells drawing 47,000 acre-feet per year could be constructed in the next 50 years in Montana; given the rapid recent growth in Western Montana, this may be an underestimate. DNRC notes that previous authors suggested some of this largely non-consumptive residential demand would be offset by reduced consumptive agricultural use. They acknowledge, however, that this transition will not be enough to limit potential impacts, and that in some cases "historic consumption by agricultural irrigation may be less than summer-long lawn and garden irrigation." Furthermore, there is no practical way for senior water rights users to place a call on exempt wells, limiting the ability to protect senior users in periods of surface water shortages.

In 2011, the Montana Legislature passed House Bill 602, which stated that the law did not provide DNRC adequate guidance on exempt wells and commissioned a report from its Water Policy Interim Committee on their effects. That report, released in October 2012, argues that on a statewide scale, withdrawals from exempt wells are negligible, but that local and regional effects may be significant[51]. It recommends more restrictions on exempt wells—in particular, the administrative creation of "stream depletion zones" where exempt wells are likely to have more severe impacts on surface water. The Committee, however, recommended maintaining the then-current definition of a combined appropriation as only those wells that are physically piped together.

Appendix 2: Change of Use Process

GVWE would meet the needs of new beneficial users that have net depletion in areas where there is no physically and legally available water to directly meet their need. In order to offset this net depletion within the legislatively closed Upper Missouri Watershed, GVWE must obtain existing water rights or identify existing water rights holders willing to undergo a change authorization. This change of use process would change the purpose of the existing right to a legally recognized purpose able to offset the net depletion of new beneficial uses. There are five legally defined water uses capable of offsetting net depletion from new water use:

1. **Mitigation**: "the reallocation of surface water or ground water through a change in appropriation right or other means that does not result in surface water being introduced into an aquifer through aquifer recharge to offset adverse effects resulting from net depletion of surface water." (MCA 85-2-102)[56]
2. **Aquifer recharge**: "either the controlled subsurface addition of water directly to the aquifer or controlled application of water to the ground surface for the purpose of replenishing the aquifer to offset adverse effects resulting from net depletion of surface water." (MCA 85-2-102)[56]
3. **Aquifer storage and recovery project:** "a project involving the use of an aquifer to temporarily store water through various means, including but not limited to injection, surface spreading and infiltration, drain fields, or another department-approved method. The stored water may be either pumped from the injection well or other wells for beneficial use or allowed to naturally drain away for a beneficial use." (MCA 85-2-102)[56]
4. **Augmentation**: "Augmentation plan" means a plan to provide water to a source of supply and its tributaries to mitigate the depletion effects of a permit or change authorization. The augmentation water right priority date is important to the success of any augmentation plan since a call can be made on that water right. Examples of augmentation include, but are not limited to, augmenting the source of supply with water from a non-tributary source, or retiring all or a portion of senior water rights in the same source of supply in amounts equal to or greater than the depletion effects of the permit or change application." (Mont. Admin. R. 36.12.101)[57]
5. **Marketing for Mitigation/Aquifer Recharge:** "During the completion period authorized by the department for a change pursuant to this section, the appropriator may continue to use the appropriation right for any authorized beneficial use provided that proportionate amounts of the appropriation right are retired as the mitigation or aquifer recharge beneficial use is perfected." (MCA 85-2-420)[58]

The Marketing for Mitigation/Aquifer Recharge represents the most likely designation for the purposes of GVWE, but the other designations can be utilized if a buyer is identified at the time of the change authorization. Marketing for Mitigation/Aquifer Recharge, made legal by HB24 in

2011, allows for an appropriator to continue their original beneficial use of the water while going through the change-of-use process and marketing their water rights for a mitigation purpose without prior identification of mitigation buyers. Upon sale of mitigation water to a buyer seeking to mitigate their application for beneficial water use, the original use is then repurposed exclusively for mitigation or aquifer recharge as required by the buyer's terms and conditions set by their assessment of net depletion. Agents marketing water rights for sale for mitigation/aquifer recharge have 20 years from the approval date of their change application to market and sell water[59].

Should GVWE choose to purchase water rights outright, they must submit a request for a change of ownership through the DNRC upon the discovery, negotiation, and purchase of an existing water right or portion thereof and prior to initiating the change process. The DNRC categorizes ownership into three designations: land sales that include the sale of the accompanying water right (Water Right Ownership Update Fee Log Sheet; $50 for first right + $10 per additional right); water rights sales separated or decoupled from the sale of the accompanying land (Form 642; $50); or for either condition if a water right and/or land is being divided into portions (Form 641; $50). GVWE would likely use a combination of the portion and the reserved/decoupled ownership changes to collect a portfolio of existing water rights that then can then put through the change of use process. Alternatively, this step could be avoided should GVWE instead choose to partner with existing water rights holders who maintain ownership and use of the existing water right until a sale.

These existing water rights would then be put through the change of use process to the optimal purpose as listed above. The change of use process initiates with a pre-application review meeting with the DNRC to facilitate the process and reduce permitting costs by $200. The DNRC distinguishes changing irrigation water rights (Form 606 Irrigation; $900) from changing non-irrigation water rights (Form 606: Non-Irrigation; $1,100). Applicants looking to change a water right have the burden to prove, by a preponderance of evidence, the following criteria as stated by Section 85-2-402(2), MCA:

1. *"The proposed use will not adversely affect the use of other water rights or other planned developments for which a permit or certificate has been issued or water has been reserved.*
2. *The proposed means of diversion, construction, and operation of the appropriation works are adequate.*
3. *The proposed use of the water is a beneficial use.*
4. *The applicant owns or has permission from the person who owns the property where the water is to be used.*

If a valid objection pertaining to WATER QUALITY is received, the applicant must also prove one of the following.

1. *The water quality of an appropriator will not be adversely affected.*
2. *The ability of a discharge permit holder to satisfy effluent limitations of a permit issued in accordance with Title 75, chapter 5, part 4, MCA."*

GVWE will also require a Water Marketing Purpose Addendum (§ 85-2-310(9)(A)(V) MCA) included with the Application for Change of Appropriation as the purpose of the change application will be to market or sell water.

Once submitted, the application must be evaluated and reviewed by both the DNRC and a process for notice and hearing by the public. Upon approval, GVWE must file a Notice of Completion for Change of a Water Right (Form 618; $0)[60] to notify the DNRC when the approved change of use is complete.

The entire change of use process can take a substantial amount of time to complete. The time spent to develop the application is highly variable and requires first the development of an argument with a preponderance of evidence, and second, the processing of the application by the DNRC after they receive the application. The first stage requires the development of a comprehensive argument to substantiate the offset and requires at least professional hydrogeological review. The Grass Valley French Ditch Co. took a few years for this process, and Chris Corbin reflected that DNRC is likely to be more cautious with approvals under new permitting processes to be conservative with what sets precedent for future users[61]. The DNRC records also demonstrate this phenomenon; for example, "Mitigation" change authorizations have been converted for over a decade and thus are reviewed faster, while only one "Marketing for Mitigation/Aquifer Recharge" change authorization has been completed and took substantially longer. Factors affecting the pace of approval may include, among other things, public hearings and announcements, editing and revision, and court cases when objectors exist[59]. A sample of existing state wide change authorizations that were granted for purposes of offsetting net depletion are demonstrated in Table A-1, and additional are included in the Appendix 3. These reflect that even when the application is complete and comprehensive, GVWE will be legally and bureaucratically delayed by 2 years at minimum in the approval and success of their change authorization, but much more likely 3-4 years. Chris Corbin recommends frequent updates and contact with the DNRC to maintain a good relationship and appropriate progress on the application.

Table A-1. Sample change authorizations to demonstrate rate of approval for various mitigation options. Source: DNRC Water Rights Record Query System, See Additional Source Information in Citations under Change Authorization Column.

Change Authorization	Owner	Converted Purpose	Date Submitted	Date Approved	Total Time
76M-30052086[45]	Grass Valley French Ditch Co.	Marketing for Mitigation/Aquifer Recharge	Oct 25, 2011	Dec 17, 2014	3.15 years
76H-30043132[62]	Missoula Federal Credit Union	Aquifer Recharge	Aug 25, 2008	June 21, 2011	2.82 years
41H-30046243[3]	Utility Solutions LLC.	Augmentation	Jun 29, 2009	Sept 30, 2011	2.25 years
76H-30063540[63]	Mountain Water Company	Mitigation	Jun 28, 2012	May 6, 2014	1.85 years

Appendix 3: Examples of Approved Mitigation Strategies

Retiring Irrigation

- MOL LLP: Needed to mitigate the net depletion to the Bitterroot River caused by the development of groundwater wells to serve a subdivision. Successfully proposed excessive mitigation in the irrigation months to augment the insufficient mitigation in non-irrigation months. The mitigation would occur at 100% for several years prior to full buildout of the subdivision and many decades before the full net depletion is realized in the Bitterroot River. The timing of excessive mitigation provides more flow to the depleted stretch during the months of peak demand. (Pg. 10-11).[64]
- K&J Development: Proposed mitigation diversions through Willow Creek during the irrigation season in excess of mitigation requirements in those months. This additional amount was calculated by determining the seepage rate from this creek and demonstrating that this seepage would offset net depletion to Bitterroot River in the non-irrigation season. The proposed seepage does not meet the full depletion requirement, but the mitigation would begin immediately, and would occur at 150% for several years prior to full build out and at least 5 decades before full depletion is realized in the Bitterroot River.[65]
- Wye Area Water Company: Did not need to address all of adverse effect or retiring acres given that Grant Creek already goes dry in most years shortly after snowmelt, and thus downstream users were not affected. Mitigation instead offsets that initial, early-season streamflow. Additionally, the mitigation plan claims that changes in water use due to development and incomplete use of entire water rights demonstrate that water is available downstream, even though a large portion of that water is legally claimed by existing water rights. [42]

Retiring Groundwater

- Sand Coulee Water District: Retires municipal use from the hydraulically connected Kootenai aquifer to allow new pumping from the Madison Aquifer. The proposed groundwater rights for retirement have never been subject to a call.[66]
- Kootenai Lodge Estates, LLC: Proposed retiring groundwater and surface water for mitigation. The applicant made special note that their plan for use of the permitted water demonstrates that the water use can be controlled so that the rights of a prior appropriator will be satisfied. Applicant proposed to implement the following steps to respond to a call in the area should one arise: initially reduce irrigation application 50%; cease irrigation application; initiate domestic water rationing to 50% during extreme shortage; and finally turn the well pumps off (Pg. 35).[40]

Retiring Stock Water Rights

- Rocking J. Ranch LLC: 100% of the diverted stock water proposed for conversion to mitigation was historically consumed by stock, so no analysis related to return flows is necessary.[67]

Physical Availability

- Mountain Water Company: Met the total net depletion caused by the proposed drilling of two new wells through a combination of retired irrigation rights and proving the physical and legal availability of the water without causing adverse effect to any existing water rights holders. In the event of a call from either senior groundwater appropriator or downgradient senior surface water user, the community water system can institute a water rationing program to reduce diversion rates and volumes to make more water available to senior water users (Pg. 48).[63]

Table A-2. Summary Table of Change Authorizations to be used for Mitigation throughout State of Montana. This table illustrates the variety of uses and strategies that have utilized mitigation change authorizations in Montana. Each entry represents application for a closed water basin. Source: DNRC Water Rights Record Query System, See Additional Source Information in Citations under Applicant Column.

Applicant	Dates Submitted; Approved	Proposed Use	Required Mitigation	Water Right Changed	Notes
Treeline Springs LLC.[68]	2/13/2008; 4/8/2011	Three subdivision groundwater wells with total net depletion of 65.87 AF.	Retires 56.3 irrigated acres to provide 65.87 AF of mitigation. Water left instream on source of net depletion, Jack Creek.	Surface water irrigation	Not subject to HB831 or HB40 (Pg. 14). Annual mitigation component not addressed in application. Mitigation considers and addresses historic return flows.
Centennial Livestock Inc.[69]	6/3/2009; 12/12/2011	Two public water supply groundwater wells. Domestic only, no lawn and garden. Net depletion of 1.1AF.	Retires 2.11 irrigated acres to leave water instream in Prickly Pear.	Surface water irrigation	Applicant determines additional benefit to stream, exceeding mitigation requirement, since the previous consumptive use now retired is left instream (Pg. 20). Net depletion calculated in monthly increments to determine time of required mitigation.
MOL LLP[64]	8/23/2007; 3/14/2008	Two public water supply groundwater wells to serve max total use of 83.09 AF. Net depletion of 38.87 AF.	Retires irrigation and closes a groundwater well to mitigate a total of 41.71 AF (exceeding their net depletion). Calculated monthly depletion and return mitigation to justify timing.	Surface water irrigation Groundwater domestic well	Excessive mitigation in the irrigation months (5.4 AF monthly depletion, 6.6 AF monthly mitigation) augments the insufficient mitigation in non-irrigation months (0.2AF monthly depletion, 0.012 AF monthly mitigation). **Additionally, mitigation would occur at 100% for several years prior to full build out of Daly Estates and many decades before the full net depletion is realized in the Bitterroot River. Last, the timing of mitigation provides more flow to the depleted stretch during the months of peak demand. (Pg. 10-11).**
Mountain Water Company[63]	6/28/2012; 5/6/2014	Three public water supply groundwater wells with combined flow rate of 2000GPM and total use of 778.4 AF. Total net depletion is to the Bitterroot River at a total depletion of 572.9 AF.	Changes 10 water rights to retire a total of 233 acres of irrigation from Miller Creek, 50.06 Acres of lawn and garden irrigation, and 114.5 Domestic connections supplied by a groundwater well.	Surface water irrigation Groundwater domestic well	**Not all months are fully mitigated, but proved physical availability and no adverse effect for the depletions.** Mitigation will replace 390.69 AF of the total 572.9 AF calculated depletion to Bitterroot River. Depletion will not be fully mitigated in the months of March, April, July, August, September, and November. The applicant proved that water is legally available in the Bitterroot River for the proposed unmitigated depletions in these months and that they will not adversely affect any existing surface water users (Pg. 49). **In the event of a call** from either senior groundwater appropriator or down gradient senior surface water user, **the community water system can institute a water rationing program to reduce diversion rates** and volumes to make more water available to senior water users (Pg. 48).
Sand Coulee Water District[66]	5/16/2013; 7/9/2014	Groundwater public water supply well to divert a max of 121 GPM up to a total of 48AF for municipal use. Total net depletion is 28.7 AF to affect Missouri River, Giant Springs, Sound Coulee Creek and Spring Coulee Creek.	Stream depletions are calculated to be uniform year round at 2.39AF per month. Retires municipal use from the hydraulically connected Kootenai aquifer to allow their	Groundwater Certificate Groundwater Provisional	The proposed groundwater rights have never been out of priority nor have they been subject to any call. **DEQ permit is not necessary since it is not aquifer recharge, but rather a cessation of use.**

			new pumping from the Madison Aquifer. The rights retired represent a total of 62.21 total AF diverted, with 30.17 of CU. So the retiring of these rights slightly exceeds the new proposed use.		
Rocking J. Ranch LLC.[67]	11/5/2008; 10/6/2009	New groundwater well to divert 110 GPM or 4.5 AF for commercial use. 10% of the 4.5 AF, or 0.45 AF, would result in depletion to Rock Creek.	Applicant is requesting to change the purpose and place of use of an existing water right from stock use (groundwater for stock watering) to mitigation. Previous water right served 300 head of cattle.	Groundwater well	100% of the diverted amount is consumed by stock, therefore no analysis related to return flows is necessary.
Missoula County Office of Public Works[62]	4/20/2011; 10/3/2012	Two public water supply groundwater wells diverting combined max use of 16.5 AF.	Retiring 5.55 acres and 44.5 animal units to supply 6 AF of mitigation water which will be left in the groundwater aquifer to offset the groundwater pumping	Groundwater well for stock use Surface water irrigation (sprinkler)	The community was operating as a public water supply system without a water right since 1976. This change app will mitigate future impacts.
Wye Area Water Company[42]	7/31/2008; 11/13/2009	Two groundwater wells that pump no more than 681 GPM up to a maximum volume of 622.4 AF for municipal purposes.	Total annual depletion volume is 187.62 AF of which 3.3 AF is depletion to the Bitterroot River and 184.32 AF is to the Clark Fork River. Retires 32.4 acres of irrigation, retires 101.5 acres, and abandons the groundwater wells for Waldo Williams Subdivision.	Surface Water Irrigation Groundwater Well, Domestic	**Return flow of the retired acres considered - other water users on Grant Creek were not adversely affected because Grant Creek already goes dry in most years shortly after snowmelt. So historically there were no return flows available to downstream users during the irrigation season when water was in short supply (Pg. 20-21).** Claims that change of use to development and incomplete use of entire water rights to show that water is available to downstream. **Uses other water right negligence to their benefit in showing no adverse effect.** Can counter the Water Resource Survey (1961) statement of what has been historically irrigated with interviews, aerial photos, and other proof.
K&J Development Inc.[65]	12/24/2007; 6/25/2008	For additional pumping at existing public water supply well to increase by 20 GPM and a total volume of 18.8 AF/yr. Total net depletion is to the Bitter Creek will occur along a 2.5 mile reach and equals 6.69 AF. Hydro analysis determined depletion to be 0.54-0.57 AF per month.	Retires 6.7 acres (10 AF CU) and channels water through natural carrier Willow Creek to mitigate net depletion to Bitter Creek. Drainage from this carriage satisfies the annual component by exceeding the amount (required 6.69 AF for CU, mitigating 10AF) in Willow Creek seepage returns to Bitter Creek after irrigation season ends.	Surface Water Irrigation	Amount moved through natural carrier exceeds required mitigation amount by 3.31AF and it was calculated that the seepage would return at the correct times. Mitigation waters are diverted through Willow Creek during irrigation season in excess, and they calculated that 2.1 AF will be lost to seepage and help mitigate flows during the remainder of the year. **Seepage is calculated to return to the river at a uniform rate of 0.175 AF per month throughout the year. (Note, does not cover monthly depletion exactly)** Additionally, mitigation would begin immediately, occur at 150% for several years prior to full build out, and at least 5 decades before full depletion is realized in the Bitterroot River. Together this is sufficient.

Utility Solutions LLC.[70]	6/29/2009; 9/30/2011	High capacity public water supply groundwater well to divert a max flow rate of 3420 GPM and 1140.68 AF for municipal use. Total net depletion to the West Gallatin River and nearby tributaries is 91.82 AF. Hydro modelling shows an additional 22.02 AF will be consumed by recharge due to aquifer properties and the location of aquifer recharge relative to the surface water sources. Total depletion is 113.84 AF	One (of two) change apps to cover 17.46AF of required mitigation retires 37 irrigated acres from their existing water right. 1.31 AF CU were also changed to provide for carriage water to deliver the full consumptive use portion to the aquifer recharge basin. Aquifer recharge will occur from May 15 to July 10. Applicant is required to measure water diverted into aquifer recharge basin for aquifer recharge purposes. Ditch loss was 7%, so carriage water was added to mitigation total. Overall mitigation strategy discharges treated wastewater effluent to the Rapid Infiltration Basin and discharge of existing surface water rights to recharge basins located in the Northstar Subdivision.	Retires and Recharges Surface Irrigation	Despite consumptive use not happening immediately (predicted in twenty years) the full amount would be recharged upon approval of the mitigation.
Kootenai Lodge Estates LLC[40]	11/7/2014; 10/14/2015	Two public water supply groundwater wells from Flathead Valley's deep alluvial aquifer for total use of 89.42 AF. Total CU is 50.19AF.	Retires irrigation and aquifer recharge to meet mitigation requirements.	Surface Water Irrigation Aquifer Recharge	The applicant's plan for the exercise of the permit demonstrates that the applicant's use of water can be controlled so that the rights of a prior appropriator will be satisfied contains measures of reduced use and finally total cessation. Applicant proposes to implement the following steps: Initially reduce irrigation application 50%, cease irrigation application; initiate domestic water rationing to 50% during extreme shortage and finally turning the well pumps off. (Page 35)
Mountain West Bank[71]	10/11/2012; 8/18/2014	Two public water supply groundwater wells for total diversion of 46.13 AFY at 60 GPM. Net depletion is 14.78 AF occurring to Tenmile Creek.	Retires the irrigation of 27.57 acres which had received water from Tenmile Creek Depletion calculated at a monthly rate. Able to mitigate from Apr 1 - Jul 7 because the right they are converting is senior to everything else along affected reach, and since there is already no water in the stream after July 7, they determined there was 'insufficient streamflow for other existing water rights to historically have diverted from Tenmile Creek after early July.	Surface Water Irrigation	**Depleted stream historically goes dry in July so mitigation is not required after this time since only adverse effect is mitigated.**

Eastgate Water and Sewer Association[72]	12/16/2010; 6/5/2014	Existing groundwater well for Eastgate Water and Sewer Assn. Original mitigation water was thought to be sufficient, later study revealed need for 50.5 AF of additional water to offset net depletions.	Original mitigation volume was overestimated by 50.5 AF. Therefore, applicant had to acquire additional mitigation water. Bought water from Helena Valley Canal Water Users Association through Bureau of Reclamation contract. Delivered water 2.9 miles downstream of historical irrigation diversion	Surface Water Irrigation	No comments on timing of additional 50.5 AF of water from Helena Valley Canal, presumably during irrigation season?
Rock Creek Cattle Co.[73]	12/22/2005; 5/12/2006	Irrigation water for golf course for 245 AF per year.	Intent to stop irrigating hay in order to use water rights on golf course which does not have any. Means of diversion remains original headgate, piped to a new on-site reservoir. Original place of use in different drainage, no finding of adverse effect -- see notes. No change of timing related to original rights.	Surface Water Irrigation	"Although downstream water users in the Willow Creek drainage may have used seepage water in the past, they do not have a legal right to its continuance."

Appendix 4: Organizational Structure

GVWE could be successfully administered by several types of entities, including a non-profit organization, private business, or a government branch. Considerations when choosing an entity to act as the administrator include the ability to generate funds to cover initial start-up costs and to operate the Exchange in perpetuity, as well as the capacity to retain part- or full-time employees for day-to-day GVWE operations.

Roles and Responsibilities

Project Manager: The Project Manager will be the day-to-day operator of GVWE. It is anticipated that the workload will vary between part- and full-time. The Project Manager's main responsibilities include:

- Coordination and communication with customers (subdivision developers and the City of Bozeman)
- Marketing GVWE to potential customers
- Stakeholder outreach and communication
- Using the groundwater model decision making tool (Excel tool, map) to see if subdivision is in mitigation zone
- Using the tool to determine how many credits a new subdivision requires
- Tracking credit sales in Excel document
- Filing any monitoring and reporting requirements
- Fielding questions from interested parties, including the public, press, academics, etc.
- Participating in conferences and other opportunities to collaborate with other water bank operators
- Writing grant applications
- Other tasks as appropriate

Water Rights Consultant: The water rights consultant is a vital partner to GVWE and will be the primary contact with water rights holders. The Water Rights Consultant's main responsibilities include:

- Locating and negotiating water rights to purchase
- Conducting due diligence on potential water rights to purchase
- Preparing and filing water rights change applications
- Coordinating with DNRC on all permitting applications

Legal Consultant/Consultants: A legal consultant is necessary to assist with issues pertaining to contracting, tax implications, liability and other legal issues that arise.

Hydrologic Consultant: A hydrologic consultant will be required to develop a hydrologic model that can be used to determine the impact that groundwater development and aquifer recharge has on surface streamflow. This information will then be used to determine the number of mitigation credits required for each customer.

Science for Nature and People (SNAP) Working Group: The SNAP Working Group, in progress through April 2017, has identified GVWE as a pilot program to assess and compare to other multi-objective water agreements. The group is developing indicators for GVWE to measure its progress and is populating them with baseline data, and hopes to better inform water resource management in other watersheds throughout the western United States. The SNAP Working Group members also act as an advisory board dedicated to assisting the development of GVWE at no cost to the Exchange.

Appendix 5: Tools for Determining Mitigation Credit Requirements

GVWE—likely in collaboration with DNRC—will need to develop a tool to determine each customer's mitigation requirements, depending on their adverse effect on surface waters. In Washington State, mitigation banks use similar hydrologic tools to assist in determining mitigation requirements and suitability. The Yakima River Basin Water Exchanges each have a mitigation availability map that depicts their service areas (Figure A-12). The maps are color-coded and show the bank's availability to provide mitigation through three suitability zones: green, yellow and red. Green is likely suitable, yellow requires more information and red is unsuitable. New groundwater appropriators can purchase mitigation credits from any water bank that serves their area. Notably, the suitability maps do not guarantee mitigation approval for applicants located in the green or yellow zones. Rather, they represent Ecology's best professional judgment and are used for initial planning; an application can still be rejected upon further review. However, this method allows mitigation banks to easily determine which new groundwater users are likely unsuitable based on a map.

In the Dungeness Basin, a "Mitigation Calculator" was developed by Ecology in 2010. This user-friendly Excel tool uses the basin's MODFLOW groundwater model to calculate total mitigation obligation in gallons per day based on the parcel, aquifer and daily consumptive water use. (For additional descriptions, see Appendix 12).

Appendix 6: Tracking Credit Sales

The most appropriate way to track GVWE's transactions is to utilize a relatively simple accounting spreadsheet (see Figure A-1 for example from Suncadia Water Bank). The accounting spreadsheet will be a clear way to indicate the transaction number, parties involved and quantity of water mitigated, along with other pertinent information. In addition, it is recommended that a separate table be included in the accounting spreadsheet that indicates the total and remaining volume of water that GVWE owns. This will highlight how much water is available for future transactions and indicate when GVWE needs to purchase additional water rights. The transactions spreadsheet should be publically published on GVWE's website as a means to increase transparency and build trust among the Gallatin Valley community and others interested in this type of water management strategy.

GVWE must also comply with DNRC reporting requirements. The information recorded by GVWE at the time of sale should reflect the information required by the DNRC for both annual reporting and tracking the submission of appropriate post-sale forms:

Information to record as per Form 600: Water Marketing Purpose Addendum (§ 85-2-310(9)(A)(V) MCA) requires verbatim:

The firm contracts to purchase must include the following information

1. *The name of the entity who will use the water*
2. *The amount of water (acre-feet) each entity will use*
3. *Where the entity will use the water*
4. *The nature of relationship between the applicant and each entity using the water (The Applicant may not contract with itself to buy water)*
5. *Terms sufficient to demonstrate the bona fide intent to the water to use under § 85-2- 310(9)(c)(v), MCA.*

The WM-09 Mitigation and Marketing for Mitigation Reporting Form must be filled out and submitted to the DNRC within 30 days each time a portion of a water right that has been transferred to mitigation purposes is sold or leased.

In addition to the DNRC formal requirements, GVWE must report any additional DNRC stipulations as outlined in its individual change of use applications. Often times this includes validation and reporting that conditions of mitigation as outlined by the change of use permit are being met[3].

Lastly, purchase and sales agreements should be tracked for financial accounting purposes as required by both non-profit reporting and tax filing.

Bank Name: New Suncadia

Trust Water Rights (Mitigating Rights):

Water Right Number	Name of Record	Starting Qa	Re-allocated Qa	Remaining Qa
CS4-00176sb2	New Suncadia LLC	0.877	0.137	0.740
CS4-00626CTCL@2sb7	Suncadia LLC	125.570		125.570
CS4-00908CTCL@3sb7	Suncadia LLC	228.190		228.190
S4-05259CTCL@2sb7	Suncadia LLC	64.570	63.138	1.432
	Totals:	419.207	63.275	355.932

Mitigated Water Use Authorizations (Mitigated Rights):

File Number	Name of Record	CU Qa	Parker IF Qa	Storage Contract Qa	TWR Qa Debit	Area Irrigated	ERUs Served	Map Region	Mitigating Right
G4-35279	West Seattle Eye Clinic Retirement Tru	0.138	0.024	0.072	0.162	500	1	Green	S4-05259CTCL@2sb7
G4-35280	Ray Stanfield et ux	0.215	0.029	0.087	0.244	2,500	1	Green	S4-05259CTCL@2sb7
G4-35283	Gordon Gaub	0.137	0.024	0.072	0.161	500	1	Green	S4-05259CTCL@2sb7
G4-35284	Roger Connolly	0.137	0.024	0.072	0.161	500	1	Green	S4-05259CTCL@2sb7
G4-35285	Michael Glain	0.254	0.031	0.094	0.285	3,500	1	Yellow	S4-05259CTCL@2sb7

Figure A-1. Example of tracking credit sales from Suncadia Water Bank in Kittitas County, Washington. Qa = Annual quantity in acre feet per year; ERU = Equivalent residential unit (i.e., number of connections); CU = Consumptive unit; IF=Instream flow; TWR = Trust Water Right. Source: State of Washington Department of Ecology[74].

Appendix 7: Managed Aquifer Recharge Methods

Conjunctive management of surface and groundwater creates opportunities to achieve multiple benefits for both sustainable groundwater development and instream flows. Increasingly, in response to water shortages, the over-allocation of water resources, and/or water quality concerns, water managers are implementing managed aquifer recharge projects to intentionally store and sometimes treat water in aquifers[75,76].

Groundwater and surface water are hydraulically connected in Gallatin Valley, an alluvial-valley stream-aquifer system. Under natural conditions, surface water enters the shallow unconfined aquifer through the soil during precipitation and flood events, but the primary source of natural recharge is through streambed seepage[5,77]. To supply future use or enhance instream flows for environmental benefits, managed aquifer recharge projects capture and/or convey surface water to store in the groundwater aquifer. The Gallatin Valley Water Exchange will augment the aquifer with surface water and mitigate new groundwater pumping.

While managed aquifer recharge projects share similar goals, they often employ quite different recharge methods as a response to unique hydrogeological or regulatory constraints. This mini-report highlights the tradeoffs associated with the most common infiltration strategies: injection wells, surface spreading techniques, and subsurface infiltration galleries.

Both infiltration galleries and surface spreading are potentially suitable for GVWE's aquifer recharge project(s), but due to lower operational costs, reduced liability, and the ability to use the land for multiple purposes, infiltration galleries are the recommended best option. Injection wells are unlikely to be appropriate for GVWE. The high construction and maintenance costs of this managed aquifer recharge method mean that it is typically only used where geology or other local conditions are unsuitable for passive recharge methods. Since the Gallatin Valley's aquifer is unconfined and shallow and the overlying substrate is typically uncontaminated, the valley is well-suited to less expensive recharge systems.

Injection and Vadose Wells

Injection wells actively force surface water directly into aquifers. They are used as part of two managed aquifer recharge systems – aquifer recharge (AR) and aquifer storage and recovery (ASR). AR wells are used for the sole purpose of replenishing groundwater in an aquifer, while ASR wells pair injection wells with recovery wells in the same wellfield. Injection wells are widely used in aquifer recharge projects in some regions, particularly the Western and Southeastern United States. However, only 51 AR or ASR wells are in use in the EPA region that includes Colorado, Utah, Wyoming, North Dakota, South Dakota and Montana.[78]

Injection wells are expensive to construct, and operation costs are higher than other types of managed aquifer recharge due to energy demand. Maintenance costs can also be significant due to the tendency of the wells to clog and biofoul without regular cleaning. Due to these high costs, injection wells are generally used to recharge aquifers in areas where the surface substrate is unsuitable for recharge through other methods, where the aquifer is very deep or confined, or where land availability is limited[79].

An additional option for well recharge is the passive use of wells in the vadose zone. This method may employ new wells or existing wells that have gone dry due to excessive groundwater extraction. Vadose well recharge requires the absence of any confining layers overlaying the aquifer. Construction and operation costs are lower for vadose wells than for injection wells, but they suffer from the same clogging and biofouling issues. If the wells lack an easy mechanism for cleaning, these issues may limit the useful lifespan of the wells to several years[80].

Surface Spreading

Surface spreading – one of the simplest and most common managed aquifer recharge methods – involves intentionally spreading water over the land surface and allowing it to percolate into the underlying aquifer. Known interchangeably as infiltration ponds/basins, percolation ponds, and spreading basins, surface spreading techniques have found widespread use, due primarily to their low costs. The annual costs of operating, maintaining, and managing spreading basins have been found to be less than half those of injection wells per volume of water[81]. This is because spreading basins do not require pumping or significant pre-treatment of recharge water, two of the major costs borne by injection wells[81]. Still, basins do incur maintenance costs, mainly for the removal of sediment from the basin bottom to prevent a deterioration in recharge efficiency, which must be done about every 2-5 years[27,78].

Despite their affordability, surface spreading techniques are not appropriate for all circumstances. Most notably, recharge by surface spreading is only possible if the target aquifer is unconfined at the point of recharge. Secondly, the substrate beneath a surface recharge site must have adequate soil quality to prevent mobilization of pollutants down to the aquifer, and have sufficient permeability to allow percolation and recharge within a practical time scale. Finally, while spreading basins may require less money than other methods, they require considerable land area. There may be cases in which recharge is needed in areas of high urbanization and development, for which sufficient land is unavailable or overly expensive. In these cases, methods such as injection wells may prove more practical.

Canals

GVWE may also have an opportunity to recharge water through existing irrigation canals. Most canals in Gallatin County are unlined, and water naturally infiltrates from them into the aquifer. GVWE could thus use the canals—especially dry portions of them—essentially as a surface spreading mechanism. This strategy is an option if GVWE can prove additional seepage from canals, as historical seepage is already counted toward return flow. Should this option be available to GVWE, it would reduce construction costs associated with building recharge infrastructure and conveyance to this infrastructure, although there may be additional costs associated with contracting with canal companies.

Infiltration Galleries

Infiltration galleries convey water to the aquifer through covered percolation trenches buried one to several meters below the surface and filled with a coarse substrate (i.e. gravel) and a supporting structure with internal void spaces, such as perforated pipes or synthetic leach drains[82]. Similar to requirements for recharge basins, infiltration galleries require permeable geology to achieve sufficiently high recharge rates, and must overlie an unconfined aquifer to function effectively. Commonly, infiltration galleries are used in managed aquifer recharge projects utilizing source water of poor quality, such as stormwater or recycled water from wastewater treatment plants[82].

The project team interviewed Steven Patten, Senior Environmental Scientist at the Walla Walla Basin Watershed Council (WWBWC). Steven manages the WWBWC's aquifer recharge projects, using both surface spreading and infiltration galleries. The WWBWC's experience suggests that infiltration galleries, while bearing comparable construction costs to spreading basins, tended to require less maintenance. One spreading basin site with a recharge capacity of 1.5-2 cfs (200 af/year) cost roughly $50,000-$55,000 to construct and a 3-4 cfs infiltration gallery cost roughly $70,000 to construct. While the basins must be cleared of sediment by a bulldozer every other year, the galleries maintained high infiltration rates with annual flushing of the pipes[27].

Recharge basins also create additional liability concerns related to flooding or trespassing into the basins. In addition, infiltration galleries require comparable or less land area for similar recharge volumes. Importantly, the land over the sub-surface galleries may be planted with shallow-rooted crops like alfalfa and pasture grasses. As a result of these considerations, the WWBWC generally uses spreading basins only due to landowner preference or to support a secondary use, such as storage for irrigation.

Patten further indicated that the Watershed Council has tested a number of materials for use in infiltration galleries, and has found that pipe typically used in septic systems (4 inch pipe with ½ inch holes) has been the most cost-effective choice. The pipe is placed 4-6 feet underground with the holes facing the land surface to allow sediment to settle in the bottom of the pipe without causing clogs; the system is flushed through an outlet valve at the end of each recharge season. Although further engineering and design work will need to be conducted for GVWE's projects, this system may serve as a good model.

Appendix 8: Recharge Site Selection

Surface Criteria

Surficial geology: The classification of loose, non-consolidated sediments that overlie bedrock on the Earth's surface based on age, mineral composition, and physical characteristics.

The floor of the Gallatin Valley is predominately covered by Quaternary alluvium deposits characterized by coarse gravels and cobbles. Finer-grained Tertiary sediments also occur in the valley. The aforementioned classifications provide the most suitable areas for recharge, particularly the coarse alluvium. Together, these sediments form a single, generally unconfined aquifer unit with varying characteristics[83].

Data Source: Vuke, Susan M., Jeffrey D. Lonn, Richard B. Berg, and Karl S. Kellogg. 2002. "Geologic Map of the Bozeman 30' X 60' Quadrangle Southwestern Montana (1:100,000)." Montana Bureau of Mines and Geology.

Slope (%): The change in vertical elevation per horizontal distance multiplied by 100.

Infiltration galleries require relatively flat ground to limit or prevent surface runoff. Suitable infiltration sites should have slopes less than or equal to 3% [84]. Slopes up to 5% have been considered suitable in other[85,86]. Additional on-site grading to create a level infiltration bed to maximize efficiency is likely to be performed prior to conducting groundwater recharge.

Data Source: USGS 1/3 arc-second (10-meter) digital elevation models (DEM) downloaded from the National Elevation Dataset.

Soil type: The classification of water-retaining material consisting of weathered rock, mineral particles, and decaying organic matter based on physical properties.

Suitable soil types require moderate to high levels of permeability to effectively infiltrate water. A soil classification map based on Natural Resources Conservation Service (NRCS) data (Custer et al. 2000) will be used as a proxy for soil infiltration capacities. Generalized soil types may be sufficient to identify areas for more detailed analysis by MBMG.

The US Department of Agriculture classifies soils into four hydrology groups, A – D[87]. Groups A and B, characterized by low saturated runoff potential and high infiltration rates, should be considered suitable for recharge sites[86].

Soil Hydrology Group A:
<10% clay, >90% sand/gravel (some exceptions)
Saturated hydraulic conductivity >5.67 inches/hour
Depth to water-impermeable layer > 20 inches

Soil Hydrology Group B:
10-20% clay, 50-90% sand; loamy sand or sandy loam textures
Saturated hydraulic conductivity = 1.42 - 5.67 inches/hour
Depth to water-impermeable layer > 20 inches

Data Source: Custer, Steve, William Christner, Stewart Dixon, Gretchen Burton, Robert Snyder, Richard Aspinall, Gretchen Rupp, Tim Roark, and Wright Andrea. 2000. "Spatial Data for Septic Assessment, Local Water Quality District, Gallatin County, MT." Bozeman, MT: Montana State University. http://www.montana.edu/uessc/SepticAssessment/010lwqdsepindx2010.html.

Land use: The land parcel's primary function (i.e. cropland).

Suitable land requires little vegetative cover; dense urban areas are inappropriate for recharge galleries[88]. Therefore, infiltration parcels must not be developed, forested, or covered by surface water. Crop and/or rangeland, light residential, open space, gravel-mining pits, or undeveloped parcels are considered suitable land uses for managed aquifer recharge projects.

Data Source: Montana Natural Heritage Program (MTNHP). 2013. Montana Land Cover/Land Use Theme. Helena, Montana.
http://ftp.geoinfo.msl.mt.gov/Data/Spatial/MSDI/LandUse_LandCover/

Land ownership: The individual or entity that owns the title to the land parcel.

Suitable land parcels must be owned by a private individual or company or City of Bozeman property in order to expedite land-use agreements and the construction of an infiltration gallery.

Data Source: "Parcels_20150227." 2015. ESRI Shapefile. Gallatin County, Montana: Gallatin County.
http://gallatincomt.virtualtownhall.net/Public_Documents/gallatincomt_gis/Data Download Page.

Subsurface Criteria

Vadose zone thickness (depth to groundwater): The vertical distance between the land surface and the top of the water table.

Managed aquifer recharge sites require sufficient unsaturated space between the bottom of the recharge site and the top of the underlying water table to allow for natural attenuation of recharge water, and to prevent the complications imposed by excessive groundwater mounding. Locally elevated water tables caused by recharge, or groundwater mounds, can cause flooding of nearby basements, waterlogging and increased salinity of the root zone, and significant reductions in the recharge rates of the managed aquifer recharge site itself if the water table reaches the surface[89–91]. The greater capacity for water quality improvement by natural attenuation of sites with thicker vadose zones is another reason that high depths to groundwater are often sought after for during recharge siting[88].

A minimum depth to groundwater threshold of 6 meters was chosen for the recharge suitability analysis, based on a combination of analytical and experimental results of previous aquifer recharge studies[29,88,92], personal correspondence with operators of existing managed aquifer recharge programs[27], and model results obtained from the Hantush (1967) mounding equation[93] using specific characteristics of the Gallatin Valley (Attached GW Mounding Calculator from USGS 2010)[90]. A threshold of 6 meters was determined to be a reasonable and conservative estimate, given that all results and recommendations were in the 3 to 6 meter range (Table A-3).

<u>Data Source</u>: Static water level – daily averages (Gallatin County). 2/13/2015. Ground Water Information Center (GWIC), Montana Bureau of Mines and Geology and Montana Tech of the University of Montana.

Table A-3. Summary of recharge site minimum depth to groundwater recommendations based existing literature of analytical and experimental results, personal correspondence with recharge site operators, and model results for estimated Gallatin Valley-specific properties.

Source	Depth (m)
Hantush (1967)[90] Model Results for Gallatin Valley	4 - 6
Rahman (2012)[88]	> 5
Racz (2012)[29]	3 - 6
Asano (2004)[92]	3 - 6
Walla Walla Basin Watershed Council Suggestion[27]	> 6
Average *(Range)*	**5 *(3-6)***

The kriging method has been found to be the most accurate interpolation method for modeling groundwater levels[94–96]. Therefore, the kriging method was used to interpolate a map of groundwater depths within the Gallatin Valley using 365 groundwater wells. The minimum depth to groundwater on record for each well was used as the input for the groundwater depth interpolation map to provide a conservative estimate of vadose zone thickness. Figure A-2 displays the interpolated minimum depth to groundwater.

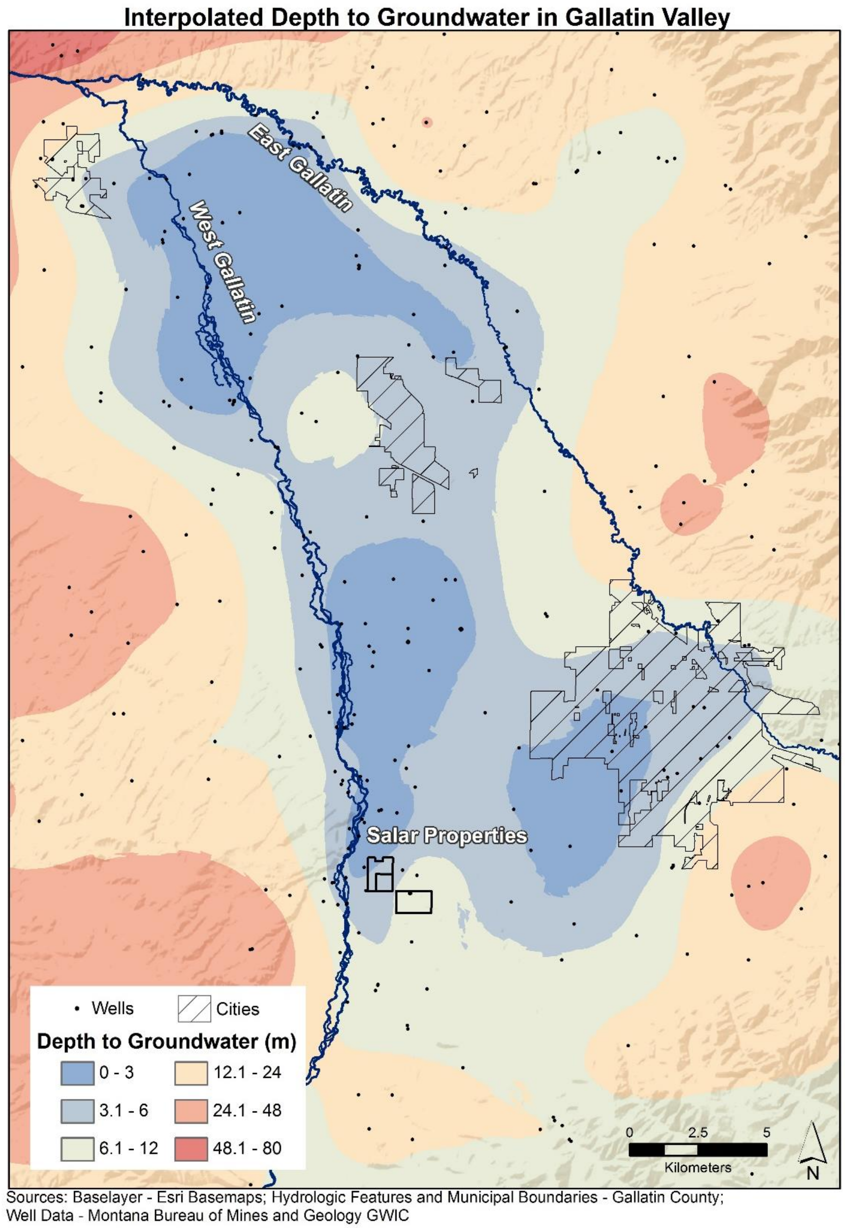


Figure A-2. The interpolated depth to groundwater (m) in Gallatin Valley using the kriging method in ArcGIS. Depth to groundwater measurements were acquired from static water level well data distributed by the Montana Bureau of Mines and Geology, Ground Water Information Center. Cool colors indicate shallower depths to groundwater, or a higher water table elevation. Warm colors indicate deeper depths to groundwater, or a lower water table elevation.

Appendix 9: Stream Depletion Factor

In hydrologically connected basins, water extracted from wells located near surface streams also abstracts water from the stream because in the absence of pumping the groundwater would have discharged into the stream[77,97]. Stream depletion is defined as the volume of water that no longer enters the stream as a result of groundwater extraction. Notably, stream depletion factor (SDF) modeling is already utilized throughout the West to analyze depletions and accretions resulting from groundwater pumping and infiltrated water. For over 30 years, SDF modeling has been used to compute groundwater pumping and recharge effects in Colorado on the South Platte River[98] and the SDF has also been utilized in the Republican River Basin in Kansas[99]. While it relies on idealized assumptions about aquifer and streambed properties, stream depletion factor modeling approximates relative impacts to streams and can provide order-of-magnitude estimates to inform initial selections of suitable recharge sites.

The following text summarizes the empirical basis on which the equation is based, explains the implications of different SDF values, and discusses how the equation can be used in conjunction with the groundwater recharge suitability analysis to inform the Water Exchange's selection of infiltration basins or spreading ponds.

Attempts to quantify the impacts of groundwater pumping on stream depletion date back to at least 1941, when Theis first developed a mathematical method to model stream drawdown under the assumption of a uniform and infinite aquifer[100]. Glover and Balmer (1954)[101] adapted Theis' work into a more user-friendly equation (Equation A-1) which produces a stream depletion rate as a complementary error function of given constant pumping rates and aquifer properties[98]. The "Glover Equation" solution is calculated by the following expression:

$$\frac{\Delta Q}{Q} = \operatorname{erfc}\left(\sqrt{\frac{\sigma L^2}{4Tt}}\right)$$

Equation A-1. The "Glover" Equation

Where:

ΔQ = stream depletion flow rate;
Q = constant flow abstraction from the well;
erfc = complementary error function;
σ = specific yield for an unconfined aquifer or storativity for a confined aquifer;
L = shortest distance between the well and stream edge;
T = aquifer transmissivity; and
t = time.

A USGS hydrologist, Jenkins, attempted to find a way to compare stream impacts from multiple different wells. Although the previous work assumed idealized aquifer conditions, Jenkins found that for many wells the non-ideal response curve, which included impacts of aquifer heterogeneity and finite-width aquifers, was functionally similar to the idealized curve[98,100]. Jenkins' work suggests the mathematically-ideal Glover equation stream can reasonably represent response curves in complex stream-aquifer systems[98].

The SDF is the time when the volume of stream depletion reaches 28% of the volume pumped from the given well. At this point, $tT/(a^2S)$, a dimensionless measure of time, equals one[102]. As such, SDF can be calculated by the following equation (Equation A-2):

$$SDF = \frac{a^2S}{T}$$

Equation A-2. Stream Depletion Factor (SDF) equation.

Where:

a = distance to nearest stream (m)
S = Storage coefficient
T = Transmissivity (m^2/day)

The Stream Depletion Factor relies on 10 simplifying assumptions[103]. The discrepancies imposed by these assumptions have since been modeled against experimental tests and MODFLOW results in order to assess both the predictive accuracy of the SDF model in whole and to rank each assumption by relative accuracy and significance. Key findings of this work indicate that the SDF model consistently overestimates stream depletion (and, conversely, recharged baseflow), and that the three most significant complications resulting in this inaccuracy are: aquifer heterogeneity, degree of stream partial penetration, and streambed clogging[99]. In other words, the Jenkins model assumes that aquifer transmissivity is constant in space and time, that all streams fully penetrate the aquifer, and that the aquifer and streambed are perfectly connected with identical hydraulic conductivities. These assumptions represent idealized conditions and are unlikely to directly reflect actual aquifer properties. The primary benefit of SDF is that the complex numerical modeling only needs to be performed once, allowing the creation of a map tool which can then be used to assess multiple pumping management strategies[98].

Stream Depletion Factor Modeling Utility

The results of the SDF map(s) can help the Water Exchange identify the best potential sites to locate a seasonally-operational recharge facility in order to provide near constant return flows to the stream.

Managed aquifer recharge is the intentional infiltration of water into aquifers through either enhancing natural gravitational infiltration or directly injecting water into the aquifer. Just as groundwater pumping can cause stream depletion, managed aquifer recharge can offset the effects of groundwater pumping by increasing net streamflow. The Stream Depletion Factor Model provides a tool to quantify this balance. Essentially, for managed aquifer recharge to offset the streamflow depletion generated by groundwater pumping, all that is needed is for both recharge and pumping to have high SDF values and for the total annual volume of pumping and recharge to be equal[100].

A high SDF value means that the effects of either pumping or recharge will be relatively constant throughout the year, even if the activity occurs seasonally, whereas wells with small SDF values cause stream depletion to occur nearly synchronously with seasonal pumping, and can result in large seasonal fluctuations in streamflow (Figure A-3). Importantly, groundwater recharge that is sufficiently far from the stream would have a large SDF value, producing constant annual discharge to the stream to offset year-round depletion from municipal and domestic wells.

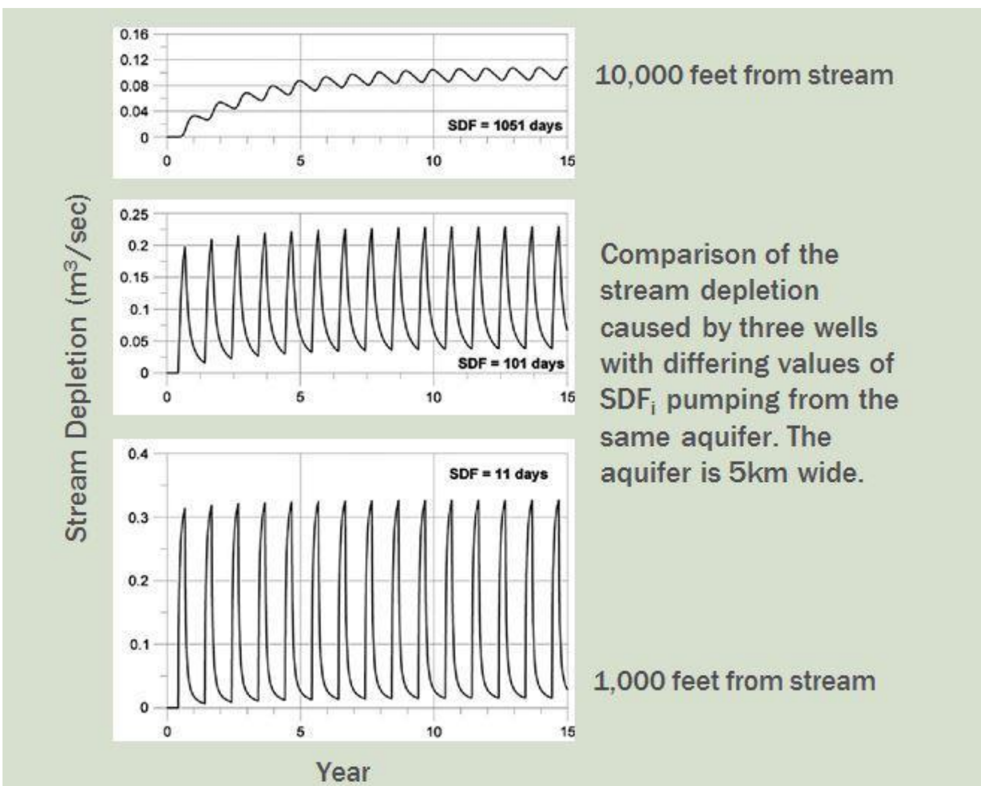


Figure A-3. Comparison of the stream depletion caused by differing values of SDF. Adapted from Bredehoeft and Kendy 2008[100].

Importantly, SDF modeling should only include streams that are connected to the groundwater aquifer. Disconnected streams, by definition, would not be impacted by groundwater pumping. The team was unable to determine with confidence which streams are hydrologically connected to the alluvial aquifer. Three SDF maps were created to represent different results. Figure A-4 is the most conservative estimate, and it assumes all natural waterways are connected to the aquifer, even though intermittent waterways exist in the valley. Figure A-5 includes only streams classified as perennial indicating groundwater contributes baseflow to the stream. Figure A-6, the least conservative estimate, treats only the main channels of the West and East Gallatin Rivers as connected to the aquifer. Ultimately, more complete hydrologic modeling will be required to identify connected reaches and develop a final SDF analysis.

Preliminary Gallatin Valley SDF Models

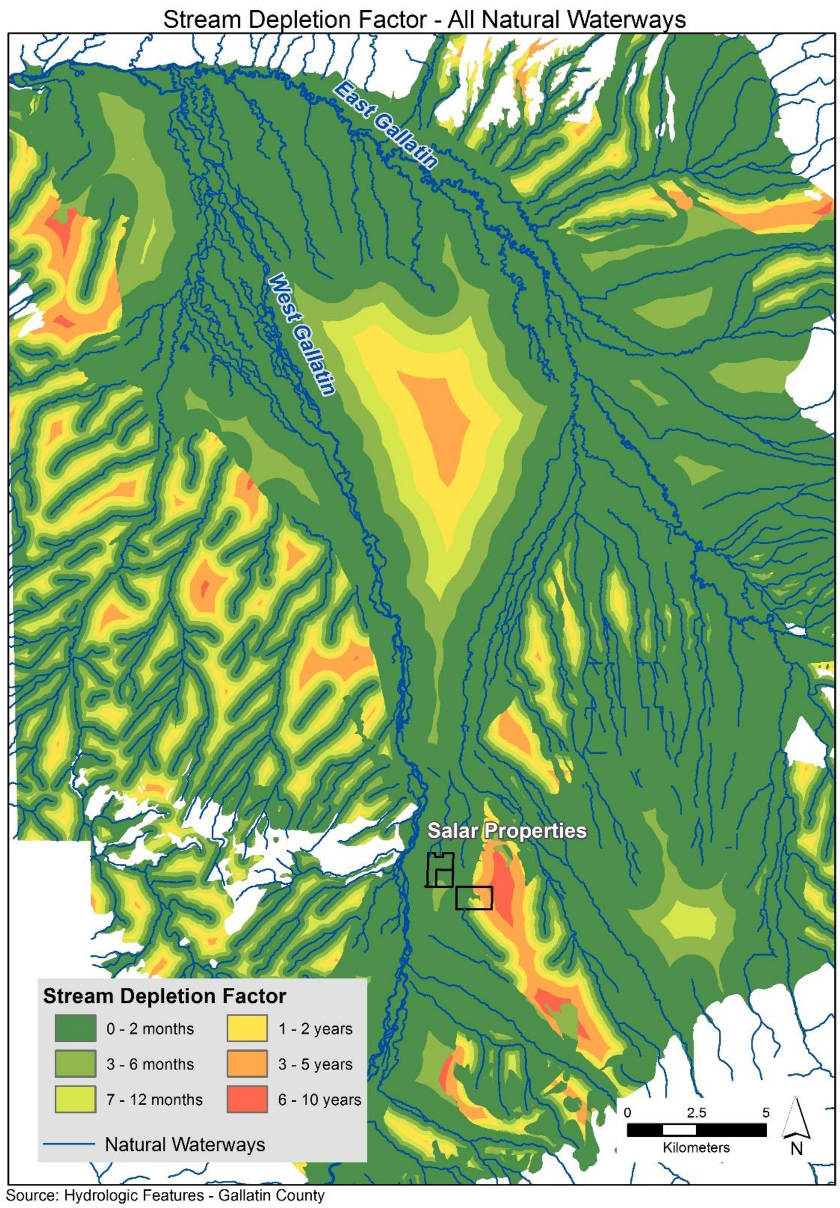


Figure A-4. The stream depletion factor for all natural waterways in the Gallatin Valley. The Salar properties are highlighted due the landowner's willingness to act as a recharge site.

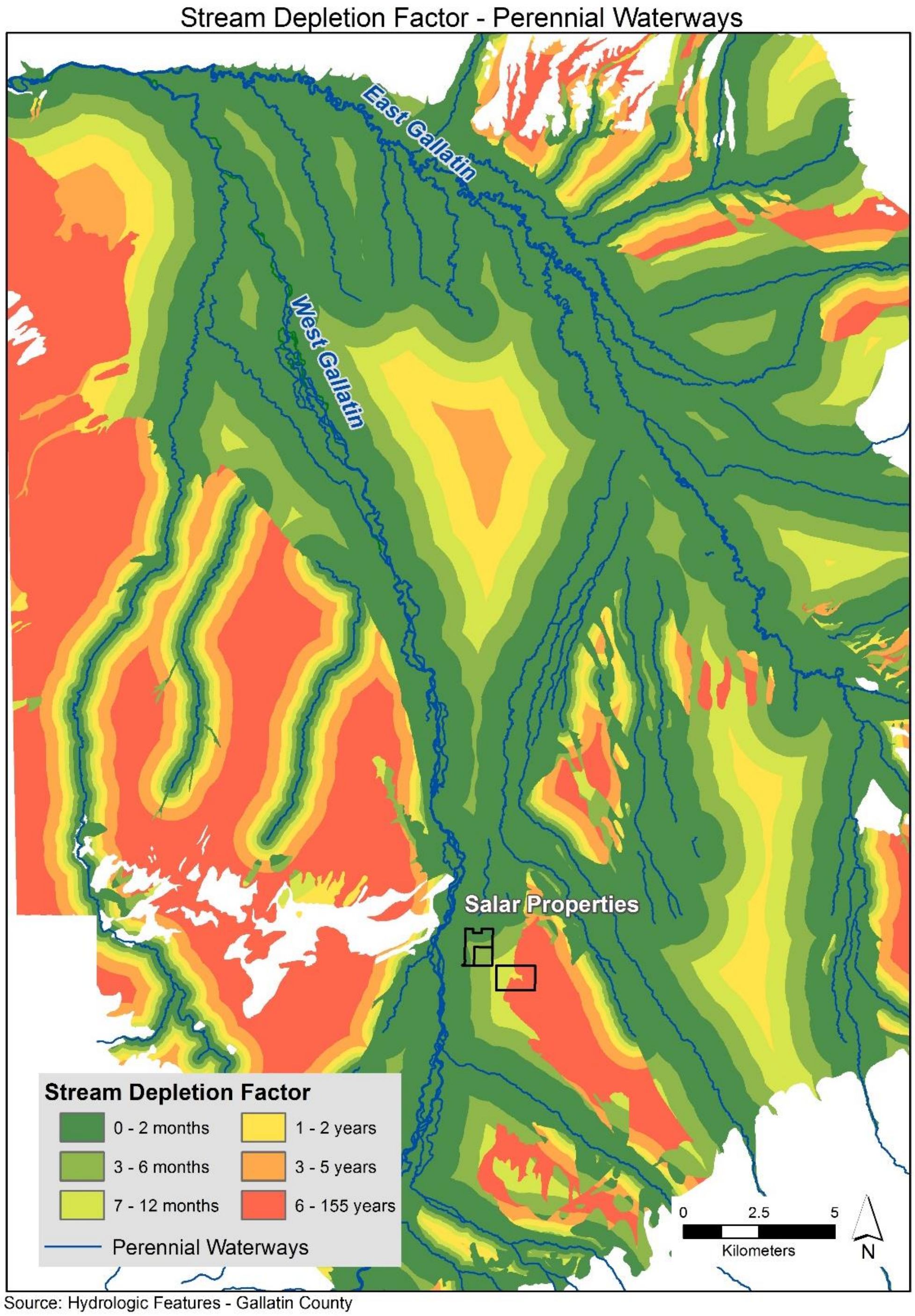
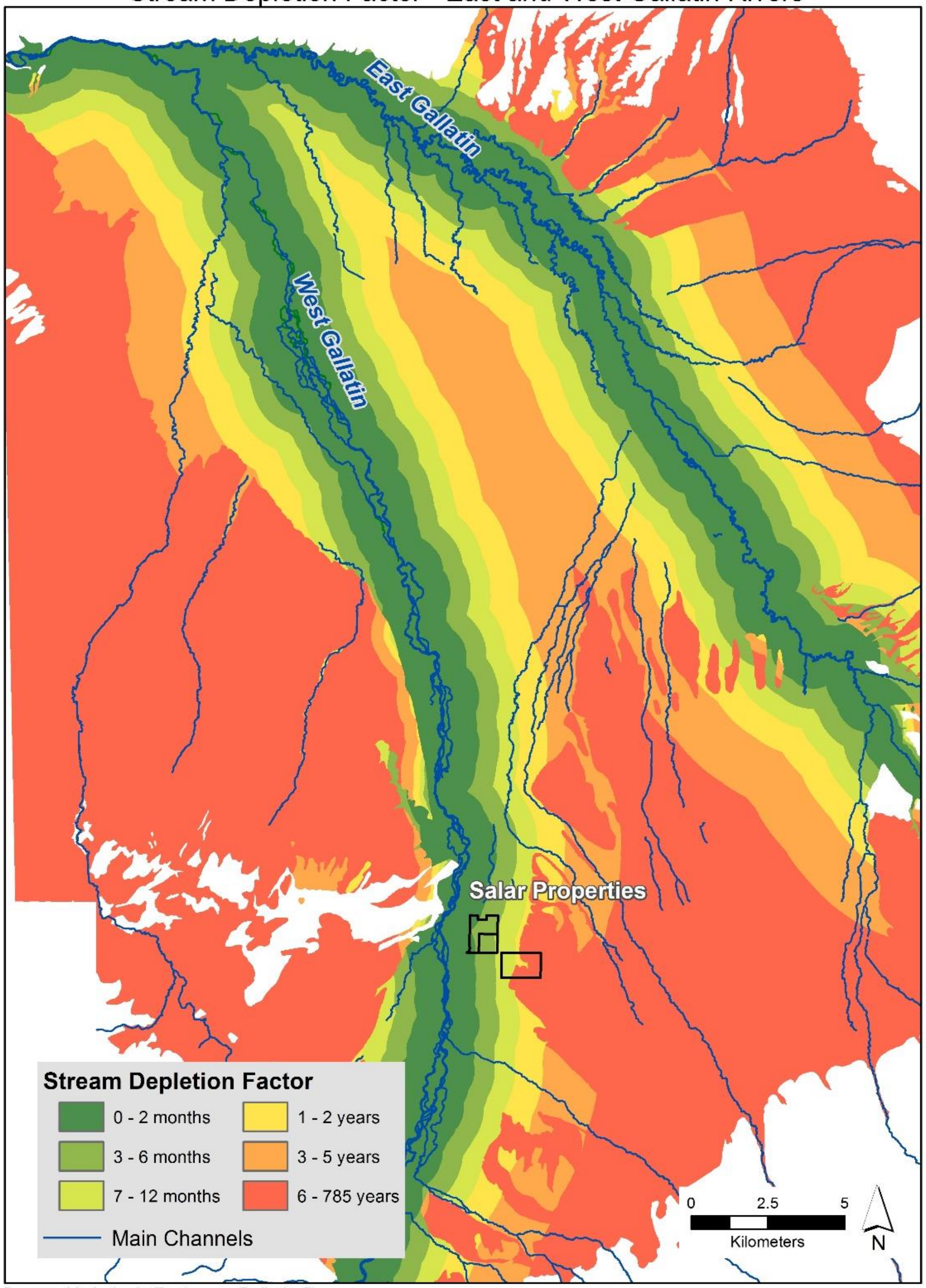


Figure A-5. The stream depletion factor for perennial waterways in the Gallatin Valley. The Salar properties are highlighted due the landowner's willingness to act as a recharge site.

Stream Depletion Factor - East and West Gallatin Rivers



Source: Hydrologic Features - Gallatin County

Figure A-6. The stream depletion factor for the East and West Gallatin Rivers in the Gallatin Valley. The Salar properties are highlighted due the landowner’s willingness to act as a recharge site.

Appendix 10: Subdivision and Public Water System Analysis

Subdivisions

The new development of large subdivisions in the Gallatin County represents an additional opportunity for analysis of future mitigation demand, since the October 17, 2014 ruling requires that these projects' water use be considered collectively, eliminating the loophole allowing them to meet their water needs through multiple exempt wells[52]. Here, we analyze the historic trends in the new development of large subdivisions from 2009 to 2015 as a supplement to the per capita total water demand analysis.

All new subdivisions in the State of Montana must go through an initial review and approval process prior to development, including approval from the Montana Department of Environmental Quality (DEQ). DEQ subdivision approval data thus lends insight into trends of subdivision growth throughout the state. However, it should be noted that while DEQ approval represents a final step in the subdivision approval process, it is not a definitive indication that the subdivision was actually built.

This report uses these approved subdivision applications to assess recent subdivision growth trends from FY2009-2015[104]. Major events that might affect subdivision growth during this time include the start of the recession in 2008 and the October 2014 exempt well ruling.

The complete dataset was highly skewed toward small developments of five lots or fewer. To continue the analysis with only large subdivisions, the data was subset into subdivision approvals for 20 or more lots. Applying the DNRC estimate of 165 gallons per person per day and assuming an average of three inhabitants per house, subdivisions larger than 20 lots are likely to require more than 10AF of groundwater to be developed and thus requiring DNRC permitting approval.

Statewide, there were 165 large subdivisions approved from FY2009-2015 from 29 different counties (Figure A-7). The five counties with the largest total number of subdivision approvals were Yellowstone and Flathead (20 each), Gallatin (15), Lincoln (13), and Richland and Lewis and Clark counties (12 each).

Some developers and commenters have speculated that the burdensome nature of the permitting process would stymie subdivision growth and development after the Montana District Court ruling on October 17, 2014. An ANOVA was run on the dataset to determine if there was a significant difference in subdivision lot approval before and after the ruling.

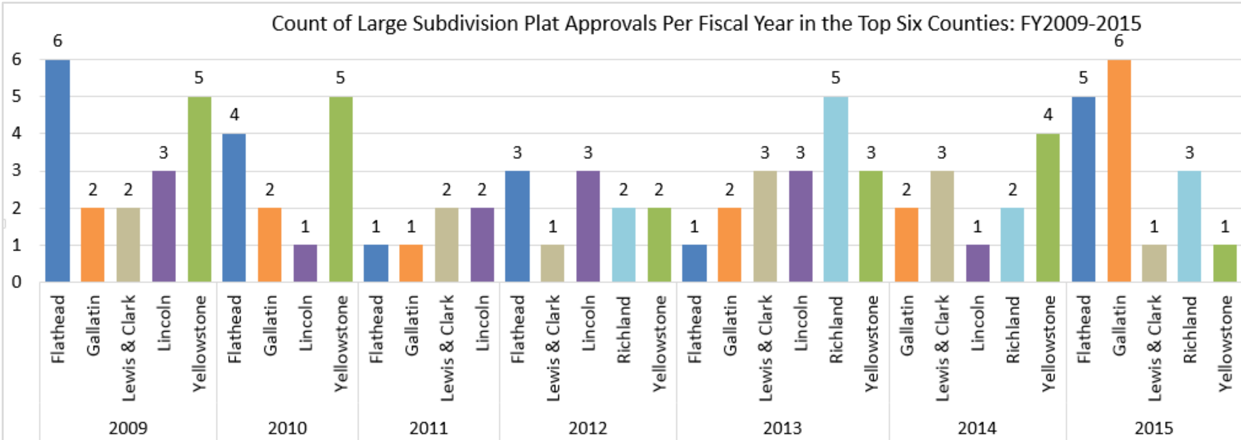


Figure A-7. Count of Large Subdivision Plat Approvals Per Fiscal Year in the Top Six Counties for Subdivision Development, FY2009-2015. Represents the number of subdivision plat applications approved by the MDEQ for the appropriate fiscal year. Source: MDEQ Data.[104]

Since the ruling happened in the midst of the fiscal year, for this analysis each fiscal year was broken into pre and post October 17th for comparison between years. The number of approvals in the post October 17th period did not significantly vary between each fiscal year (α=0.05; one-way ANOVA, $F(1, 5) = 1.88$; p=0.23), nor did the sum of lots approved in each fiscal year (α=0.05; one-way ANOVA, $F(1, 5) = 1.88$; p=0.23). Lot numbers were only found to be significantly different between the ruling periods of fiscal years 2009 and 2011 (p=0.02) and 2009 and 2014 (p=0.01) (α=0.05; one-way ANOVA, $F(6, 109)$=3.1)) (Figure A-8), but the ruling in October 2014 did not significantly change number of lots, frequency of approvals, or total sum of lots in the subsequent period. Given the short period of time with which to determine the effects of the ruling, however, detecting a trend is unlikely, and so these findings are inconclusive.

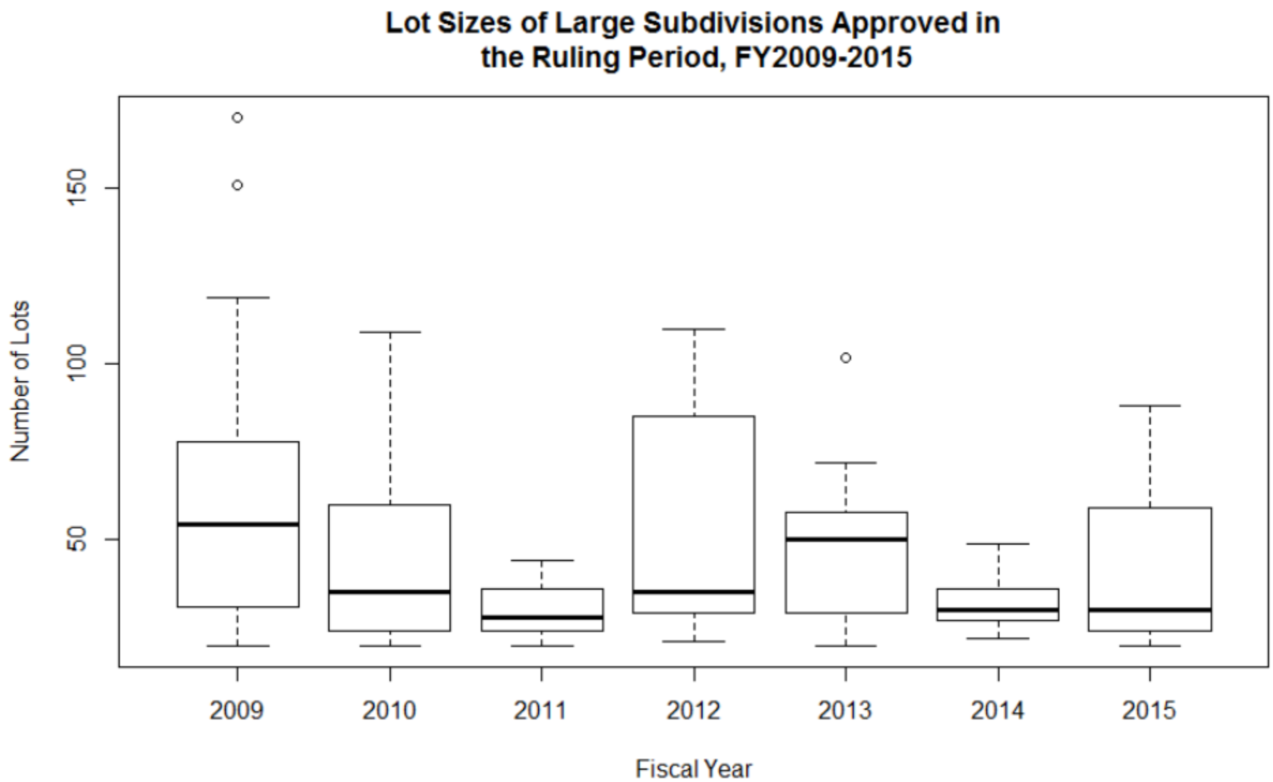


Figure A-8. Lot Sizes of Large Subdivisions Approved from Oct 17 to June 30 per fiscal year (2009-2015). Boxes indicate values from the 1st to the 3rd quartile; dots indicate outliers that are beyond 1.5 times the interquartile range; black lines in boxes indicate sample medians. Figure represents the lot sizes of any approved subdivision plat application that builds more than 20 lots, thus showing variability in large applications based on the number of lots. Source: MDEQ Data.[104]

There were 15 total large subdivisions approved specifically in the Gallatin County from FY2009-FY2015 that show no substantial linear trend in lot numbers (Figure A-9).

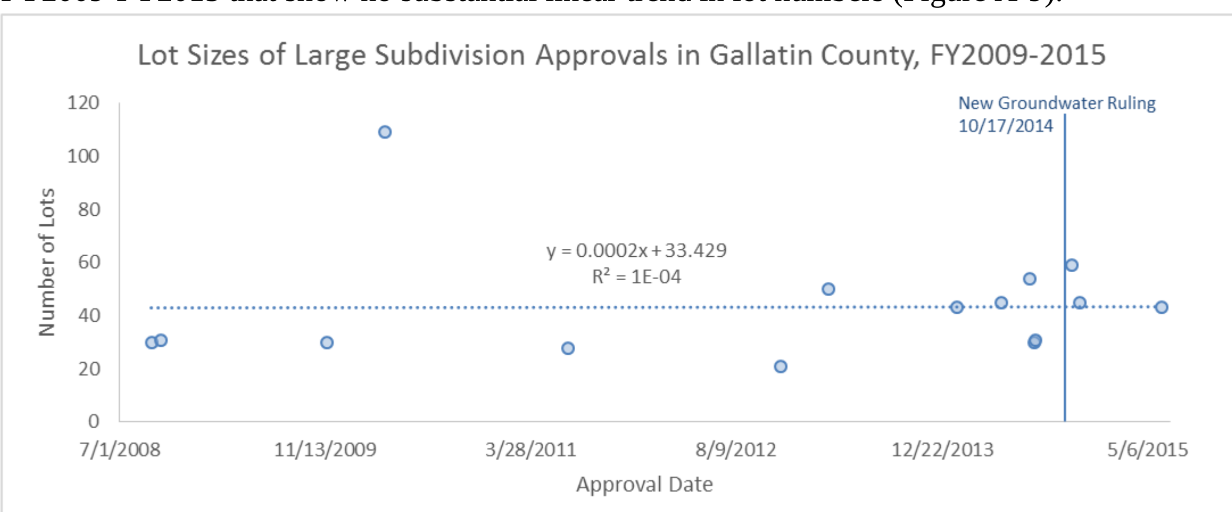


Figure A-9. Trend in the number of lots for large subdivision approvals in Gallatin County, MT (2009-2015). Large subdivisions include applications that serve over 20 individual lots. Source: MDEQ Data.[104]

These results indicate that the October 2014 change in exempt well regulations has had no perceptible effect on subdivision approvals in Gallatin County to date, and that future demand for water from subdivisions is likely to be comparable to past trends.

Public Water Systems

The location of new water use in Gallatin County affects which streams may experience net depletion and dictates how either mitigation or aquifer recharge sites must be obtained and provided by GVWE. However, accurate estimates of where new demand may be located in the valley is complicated by flexible residential zoning for subdivisions and the opportunistic nature of real estate development.

While the spatial nature of new demand is difficult to predict, the burdensome nature of groundwater permitting process may push many new developments to seek connections to existing public water supplies. Personal communication with the Montana Department of Environmental Quality indicates that all recent approved subdivision applications utilized existing public water systems as their source of water[104]. This may initially aggregate new water demand around the larger existing public water systems and create a need for these systems to increase capacity and acquire additional water rights. There are 52 community water systems listed as active in the Montana Safe Drinking Water Information System (SDWIS) in Gallatin County, defined as those that "provide piped water for human consumption and have at least 15 service connections or regularly serve an average of at least 25 individuals daily at least 60 days per year[105]." These systems range from serving mobile home parks to entire municipalities, and report serving populations that range from five to 32,000 people.

An estimated total water use was calculated for each community water system by multiplying the total population served by the DNRC per capita estimate of 165 gallons per person per day and converting this to AF. A complete list of community water systems that require over 10AF is found in the following table. The spatial distribution of these systems throughout the county demonstrates a high density within the Gallatin Valley between the West and East Gallatin Rivers (Figure A-10).

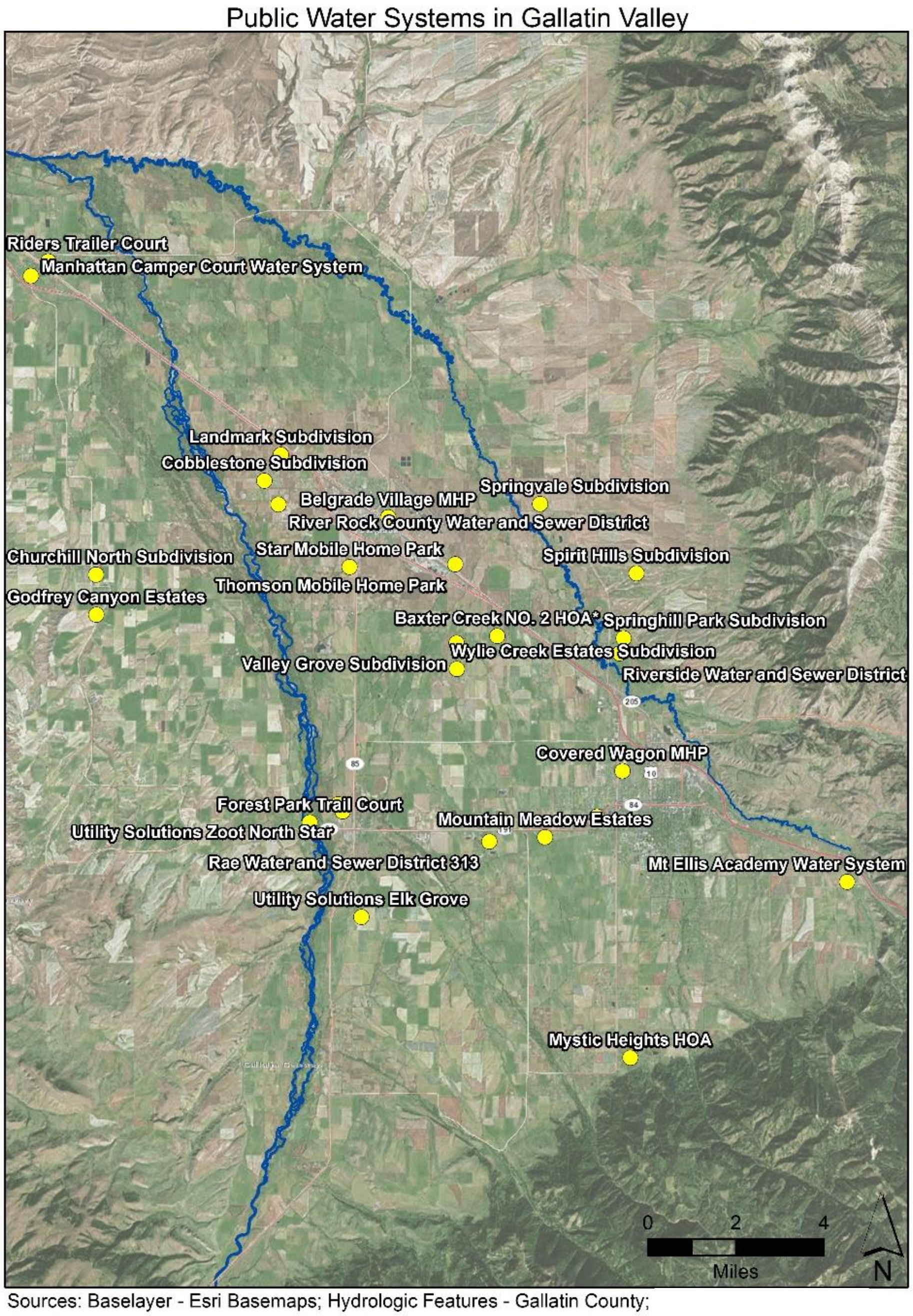


Figure A-10. Large Community Water Systems demonstrate the highest density around the Bozeman and Gallatin Valley area, indicating a likely region for new groundwater use. Source: EPA: Safe Drinking Water Information System (SDWIS).[105]

This analysis demonstrates that new demand will likely aggregate within the valley, indicating the most likely service region for GVWE to focus on to maximize their ability to serve this demand.

Table A-4. Active Large Community Water Systems in Gallatin County, MT that serve a population that is estimated to exceed the 10AF exemption based on DNRC per capita consumption of 165GPD. Source: EPA: Safe Drinking Water Information System (SDWIS).[105]

Active Large Community Water Systems in the Gallatin County

Water System #	Water System Name	Primary Source Water Type	Service Period (Annual/ Other)	Population Type	Population Served	Estimated Total Water Demand (AF/Year)	Service Area
MT000 0548	PONDEROSA MB HOME SUBD	Groundwater	Annual	Residential	60	11.09	Mobile Home Park
MT000 1262	MT ELLIS ACADEMY	Groundwater	Other	Residential	60	11.09	School
MT000 1326	YELLOWSTONE HOLIDAY WTR AND SEW DISTRICT	Groundwater	Annual	Residential	60	11.09	Residential Area
MT000 0037	THOMSON MOBILE HOME PARK	Groundwater	Annual	Residential	65	12.01	Mobile Home Park
MT000 2398	GODFREY CANYON ESTATES	Groundwater	Annual	Residential	87	16.08	Subdivision
MT000 0796	SPRINGHILL PARK SUBDIVISION	Groundwater	Annual	Residential	90	16.63	Homeowners Association
MT000 0795	MYSTIC HEIGHTS HOA BOZEMAN	Groundwater	Annual	Residential	96	17.74	Homeowners Association
MT000 1376	RIDERS TRAILER COURT	Groundwater	Annual	Residential	100	18.48	Mobile Home Park
MT000 4363	SETTLEMENT THE	Groundwater	Annual	Residential	100	18.48	Homeowners Association
MT000 4899	BELGRADE VILLAGE MHP	Purchased Groundwater	Annual	Residential	100	18.48	Mobile Home Park
MT000 4431	CHURCHILL NORTH SUBDIVISION	Groundwater	Annual	Residential	108	19.96	Subdivision
MT000 1823	SPRINGVALE SUBDIVISION	Groundwater	Annual	Residential	142	26.24	Residential Area
MT000 4035	RAMSHORN VIEW ESTATES	Groundwater	Annual	Residential	150	27.72	Subdivision
MT000 4572	COBBLESTONE SUBDIVISION	Purchased Groundwater	Annual	Residential	150	27.72	Subdivision
MT000 1983	HEBGEN LAKE ESTATES CO W AND S DIST	Groundwater	Annual	Residential	163	30.13	Residential Area
MT000 4208	SPIRIT HILLS SUBDIVISION	Groundwater	Annual	Residential	170	31.42	Subdivision
MT000 0034	STAR MOBILE HOME PARK	Groundwater	Annual	Residential	190	35.12	Mobile Home Park
MT000 1983	HEBGEN LAKE ESTATES CO W AND S DIST	Groundwater	Annual	Residential	200	36.96	Subdivision
MT000 4262	LANDMARK SUBDIVISION	Purchased Groundwater	Annual	Residential	250	46.21	Subdivision
MT000 1366	FOREST PARK TR CT NO 1 BOZEMAN	Groundwater	Annual	Residential	260	48.05	Mobile Home Park
MT000 1791	MOUNTAIN MEADOWS ESTATES LLP	Groundwater	Annual	Residential	300	55.45	Mobile Home Park
MT000 2173	RIVERSIDE WATER AND SEWER DIST	Groundwater	Annual	Residential	344	63.58	Residential Area
MT000 4236	FIRELIGHT MEADOWS LLC	Groundwater	Annual	Residential	350	64.69	Subdivision
MT000 3961	WYLIE CREEK ESTATES SUBDIVISION	Groundwater	Annual	Residential	400	73.93	Subdivision
MT000 3323	BAXTER CREEK NO 2 HOA	Groundwater	Annual	Residential	450	83.17	Homeowners Association
MT000 3810	COVERED WAGON MHP	Purchased Surface Water	Annual	Residential	500	92.41	Mobile Home Park
MT000 4248	UTILITY SOLUTIONS ELK GROVE	Groundwater	Annual	Residential	658	121.61	Subdivision
MT000 4262	LANDMARK SUBDIVISION	Purchased Groundwater	Annual	Residential	750	138.62	Residential Area
MT000 3780	VALLEY GROVE SUBDIVISION	Groundwater	Annual	Residential	825	152.48	Subdivision

MT000 0628	RAE WATER AND SEWER DIST 313	Groundwater	Annual	Residential	1110	205.15	Mobile Home Park
MT000 3136	WEST YELLOWSTONE TOWN OF	Groundwater	Annual	Residential	1435	265.22	Residential Area
MT000 0285	MANHATTAN TOWN OF	Groundwater	Annual	Residential	1520	280.93	Residential Area
MT000 4284	UTILITY SOLUTIONS ZOOT NORTH STAR	Groundwater	Annual	Residential	1675	309.58	Industrial Agricultural
MT000 4082	RIVER ROCK COUNTY WATER AND SEWER DIST	Groundwater	Annual	Residential	3500	646.88	School
MT000 0136	BELGRADE CITY OF	Groundwater	Annual	Residential	7000	1293.77	Municipality
MT000 0161	BOZEMAN CITY OF	Surface Water	Annual	Residential	32000	5914.36	Hotel/Motel
MT000 0343	THREE FORKS CITY OF	Groundwater	Annual	Residential	N/A	N/A	Municipality
MT000 1821	MANHATTAN CAMPER COURT	Groundwater	Annual	Resident	55	10.17	Mobile Home Park
MT000 3136	WEST YELLOWSTONE TOWN OF	Groundwater	Other	Transient	7100	1312.25	Subdivision
MT000 4284	UTILITY SOLUTIONS ZOOT NORTH STAR	Groundwater	Other	Transient	75	13.86	Other Non Transient Area

Appendix 11: Financial Analysis

Cash Flow Modeling

To project annual free cash flow required splitting costs into fixed and variable costs. Table A-5 includes the costs that constitute variable costs – all other costs were summed into fixed costs:

Table A-5. Variable costs per AF of mitigation serviced by the GVWE under the initial operational scenario. The broker scenario excludes the cost of water acquisition. The lean scenario excludes the cost of water acquisition and reduced the variable cost of recharge site development and operation to $809.91. Source: GVWE Financial Analysis_Initial Scenario, GVWE Financial Analysis_Broker Scenario, GVWE Financial Analysis_Lean Scenario.

Variable Costs Per AF of Mitigation Serviced			
Item	**Description**	**Methodology**	**Cost**
Change Authorizations	Estimate of a per unit change authorization increment	Estimate	$333.33
Water Acquisition	Price to purchase original AF	Estimate	$2,000.00
Recharge site development and operation	Total costs of recharge site developments divided by capacity	Sum of all recharge required for 2016-2048 divided by total mitigation serviced.	$822.79
Other	Charge per AF to represent additional transactions fees	Estimate	$200.00
		Total Variable Costs Per AF	**$3,356.12**

The total margin was then calculated for each year using Equation A-3:

$$\mathit{Annual\ Total\ Margin} = \mathit{Annual\ Demand} * (\mathit{Price\ Estimate\ Per\ AF} - \mathit{Variable\ Cost\ Per\ AF})$$

Equation A-3: Total margin per year.

Finally, the annual free cash flow was calculated by subtracting the annual fixed costs from the total margin per year (Equation A-4).

$$\mathit{Annual\ Free\ Cash\ Flow} = \mathit{Annual\ Total\ Margin} - \mathit{Total\ Fixed\ Costs\ Per\ Year}$$

Equation A-4: Free cash flow equation.

Net Present Value

The net present value of the resulting cash flows for 2016-2048 were assessed for three discount rates, 5%, 10% and 15% for each operational model. Net present value was calculated using Equation A-5:

$$NPV = \sum_{t=0}^{T} \frac{Cash\ Flow_t}{(1+r)^t} - Initial\ Cash\ Investment$$

Equation A-5: Net Present Value (NPV), where T is the total time period, t is the cash flow period, and r is the discount rate.

Table A-6. Net present value for 2016-2048 at $6K/AF and various discount rates for each scenario. Additional price values can be found in the excel workbooks. Source: GVWE Financial Analysis_Initial Scenario, GVWE Financial Analysis_Broker Scenario, GVWE Financial Analysis_Lean Scenario

Net present values for the various operating models and discount rates at $6,000/AF from 2016-2048			
Discount rate	0.05	0.1	0.15
Initial Scenario	$3,882,122	$1,130,394	$120,630
Broker Scenario	$8,266,122	$2,952,560	$954,634
Lean Scenario	$9,001,455	$3,258,194	$1,094,523

Terminal Value

The NPV only calculates the value for a fixed period of years. However, GVWE will assume responsibility for ensuring groundwater use is mitigated each year into perpetuity, and so it is necessary to estimate the costs of operations into perpetuity when considering the pricing structure necessary to sustain operations.

A terminal value can be added to the net present value to represent the future cash flow streams into perpetuity. The terminal value equation (Equation A-6) is:

$$Terminal\ Value = \frac{Final\ Projected\ Year\ Cash\ Flow * (1 + Long\ Term\ Cash\ Flow\ Growth\ Rate)}{Discount\ Rate - Long\ Term\ Cash\ Flow\ Growth\ Rate}$$

Equation A-6: Terminal value equation

The terminal value was determined for various prices by setting the final year projected cash flow equal to the average free cash flow from years 2045 to 2048. The City of Bozeman's demand will have been fully met in 2044, so these years are a good indication of ongoing future demand and cash flow. An estimated 2% growth rate on cash flows was used as our demand projections continue to increase with population growth. The terminal value was calculated at various price values for three discount rates: 0.05, 0.1, and 0.15. The resulting calculation was then discounted back to present day value to appropriately sum with the NPV.

Table A-7. Terminal value results for when the price of a mitigation credit is $6K/AF for the various operating scenarios for various discount rates. The calculation includes a 2% growth rate. This represents the additional value of operating the GVWE into perpetuity by taking an average cash flow projection once cash flows are reasonably stable, in our case after the City of Bozeman, and determining the present value of continuing that cash stream into perpetuity. Additional price values can be found in the excel workbooks. Source: GVWE Financial Analysis_Initial Scenario, GVWE Financial Analysis_Broker Scenario, GVWE Financial Analysis_Lean Scenario

Terminal values for the various operating models and discount rates at $6,000/AF			
Discount rate	0.05	0.1	0.15
Initial Scenario	$ -(186,169)	$ -(332,657)	$ -(204,712)
Broker Scenario	$221,310	$395,449	$243,353
Lean Scenario	$289,657	$517,575	$318,507

Funding Sources

Table A-8. Grant opportunities potentially available to GVWE.

Type	Organization	Description	URL
WaterSMART Water and Energy Efficiency Grant	United States Bureau of Reclamation	WaterSMART Water and Energy Efficiency Grants contribute to the WaterSMART strategy by providing cost-shared assistance on a competitive basis for projects that seek to conserve and use water more efficiently, increase the use of renewable energy and improve energy efficiency, benefit endangered and threatened species, facilitate water markets, or carry out other activities to address climate-related impacts on water or prevent any water-related crisis or conflict. Applicants must provide at least 50% of the total project costs from non-federal sources, either in cash or as in-kind contributions.	http://www.usbr.gov/WaterSMART/weeg/faq.html

Program Related Investment or Grants	The David and Lucille Packard Foundation	PRIs, which are typically loans or loan guarantees or other similar loan/ bond-type vehicles, are designed to generate both social and financial returns. Like grants, PRIs are vehicles for making inexpensive capital available to organizations that are addressing social, cultural, or environmental concerns. Worked previously with the Freshwater Trust (as one of their "exemplary PRIs") so a strategy similar to our might have a good chance. Some are much larger loans but they might be interested in our project.	http://www.packard.org/what-we-fund/program-related-investments/
Grant	National Fish and Wildlife Foundation: Columbia Basin Water Transactions Program	To enhance stream flow, the CBWTP works through locally based entities to acquire water rights voluntarily from willing landowners. Using temporary and permanent water rights acquisitions and other incentive-based approaches, the CBWTP supports program partners in Oregon, Washington, Idaho, and Montana to assist landowners who wish to voluntarily restore flows to key fish habitat.	http://www.nfwf.org/cbwtp/Pages/home.aspx#.VbXQQvlViko

Appendix 12: Case Studies and Lessons Learned

Introduction

This section summarizes the interviews of 17 water bank operators and experts, representing over 11 entities, to lend insight on how to form and manage a successful groundwater mitigation exchange. Following are the major points from the various interviews, key lessons learned, operational structures, pricing information, and other insights.

Notably, every water bank is unique. The optimal operational strategy for each one differs based on physical location, local and state laws, hydrologic characteristics, managing entity, and other factors. Furthermore, many operations are still adapting to local conditions and changes, so the optimal strategy has yet to be confirmed. Because of this, the information presented is not all directly applicable to Gallatin County. However, many themes and lessons learned have emerged that can be applied to the development and management of GVWE, which are listed in the Management Plan conclusions. Additional detail on each water bank is provided here.

Table A-9. List of water bank operators and experts interviewed for water bank case studies.

Contact	Organization
Bob Barwin	Department of Ecology, involved in the development of the Dungeness Water Exchange
Bruce Aylward	Ecosystem Economics, involved in the development of mitigation banks in both Washington and Oregon state
Chris Corbin	Corbin Brands, Grass Valley French Ditch Company Water Bank
Travis Greenwald	Highland Economics, Grass Valley French Ditch Company Water Bank
Amanda Cronin	Washington Water Trust, Dungeness Water Exchange
Joe Holtrop	Clallam Conservation District
Dave Nazy	Department of Ecology
Steven Patten	Walla Walla Basin Watershed Council (WWBWC)
Kathi Masterson	Water right holder, Masterson Ranch Water Bank
Jessica Kuchan	Mentor Law Group, Suncadia Water Bank (Upper Kittitas, WA)
Mitch Williams	Developer, water rights holder, Williams and Amerivest Water Bank (now acquired and assigned to Kittitas County)
Kelsey Collins	Department of Ecology, Yakima Camps and Cabin Owners' mitigation program
Brett Golden	Deschutes River Conservancy
Kyle Gorman	State of Oregon Department of Water Resources, Deschutes Groundwater Mitigation Program
Tom Iseman	Department of the Interior, The Nature Conservancy (prior), involved in the development of the Colorado Water Bank
Taylor Hawes	The Nature Conservancy, the Colorado Water Bank
Orrin Feril	Central Kansas Water Banking Association
Terri Rossi	Arizona Water Banking Authority
Rachael Young	Mammoth Trading

Grass Valley French Ditch Company Water Bank

Grass Valley French Ditch Company (GVFDC) is one of the oldest and largest irrigation systems around Grass Valley and Frenchtown, Montana, holding senior water rights with a priority date of 1901. In response to growing urban and industrial development and decreasing demand for irrigation, in December 2014 the GVFDC successfully changed 3,733.5 AF of irrigation water rights for the legal purpose of Marketing and Mitigation/Aquifer Recharge and established the first private water bank in Montana: Grass Valley French Ditch Company Water Bank[106]. This designation allows the ditch company to continue business as usual, while also offering the mitigation water for sale[56] to interested parties, including housing developers, industrial water users, or even other agricultural projects in need of new water use[107]. The service area for mitigation is located in Missoula County within an open basin, yet it is effectively closed. It includes a reach along the Clark Fork River spanning from Missoula to a reservoir in Sanders County (Page 23)[45]. Once a transaction is completed, GVFDC will retire a sufficient amount of acres from seasonal irrigation to offset the required mitigation by leaving the water instream[45]. The reservoir at the end of the reach then receives the water and has storage capacity to offset annual groundwater use from this seasonal water availability.

The regulatory framework in the region creates both opportunity and challenges for GVFDC's water bank. In 2007, Montana formally recognized the connectivity between groundwater and surface water and required all new water uses to obtain approval, often by mitigation, from the DNRC. In 2011, HB 24 allowed water rights owners to apply for a Marketing for Mitigation/Aquifer Recharge designation, allowing them to maintain previous water uses until a mitigation sale is confirmed. While both of these laws create demand and opportunity for mitigation credits, the exemption for groundwater wells under 10 AFY positions the bank to serve only the needs of large water users such as large subdivisions with public water systems or industrial use.

Since its inception in 2014, mitigation sale negotiations have begun with two interested parties, but a sale has yet to occur. The permitting process for new water use requires that applicants conduct a hydrological review and quantify their net depletion of the water basin to accurately determine their need for mitigation prior to the purchase of any mitigation. Therefore, all clients to the GVFDC Water Bank are in the initial stages of a substantial permitting process and represent committed large water users. The scalability and future success of the water bank going forward rely on sufficient transfers of this nature[61].

A major strength of the GVFDC Water Bank's operation and development is its symbiosis with the ditch company. GVFDC is a senior water rights holder with an expansive water canal infrastructure that already sustains its operations with the annual acre-based payments of its shareholders. The water bank is thus seen as a side operation, with the bulk of costs coming up front, helping the company respond to changing conditions in the area. Since mitigation is accomplished by changing the diversion and leaving additional water instream, the operation of the bank can be sustained with only minor changes to business as usual operations. A small increase in shareholder annual fees, a loan, and two DNRC grants were able to cover the up-front costs of developing the bank. Furthermore, the irrigation district had strong and supportive agricultural board members prominent in the community that played a major role in onboarding local cooperation and support, as well as meeting the permitting process requirements required by the change of use authorization. Additional partners that contribute to the bank's success include the Clark Fork Coalition, which performs the monitoring requirements set by the DNRC, and Highland Economics, which helps to set case-by-case mitigation prices – both for a greatly reduced cost. Having a third party to set the bank's prices has helped with perceived fairness by clients[61].

In determining the prices, Highland Economics utilized both comparable sales and income capitalization methods. For comparable sales, they used proprietary information of recorded water transactions in Western states as well as the Salish Kootenai Water Compact to help advise the range of prices they proposed. Additionally, they assess income capitalization to consider the value of the water to the new water users when applied to the intended use. With these numbers, they create a range of suitable prices and engage in negotiations with the buyer under these terms. This allows flexibility to changing conditions in the area[108].

GVFDC began its change of use process in 2008, and the application was approved in 2014. Its experience revealed that the DNRC is highly regulatory and acts as a reviewer rather than offering help or consultation. As one of the first to use the Marketing for Mitigation/Aquifer Recharge, the DNRC used additional scrutiny in reviewing GVFRC's application, as it was hesitant to set a precedent.

Applying this experience to GVWE highlights the following considerations:

1. Private investment for water banks may be stymied by regulatory risk, including delays or denial of the change authorization process required for bank implementation.
2. Onboard the support of the community early on – especially agricultural.
3. Transaction costs are predominately up front. Pass consulting plans by DNRC first.
4. Market transactions for comparative pricing are limited and not helpful. However, using income capitalization and comparative sales from the Salish Kootenai Water Rights Compact helped to utilize a third party for perceived equity to clients.
5. No one inherently wants to buy water; the New Beneficial Use permitting process is the front end of all transactions as it mandates applicants to seek mitigation and is required for new use.

Dungeness Water Exchange

In the rain shadow of the Olympic Mountains, the Dungeness Basin on the Olympic Peninsula faces competing water demands for agricultural withdrawals, domestic consumption, and instream flows. The Dungeness Water Exchange (DWE or Exchange) launched in 2013 in response to the Washington State Department of Ecology's (Ecology) 2013 Water Resources Management Program Rule for the Dungeness Watershed. The Dungeness Rule regulated new groundwater development, requiring that all new groundwater users (including permit-exempt well users) offset the impact of their consumptive use on surface water[109].

The DWE is currently administered by the Washington Water Trust (WWT), a 501(c)(3) nonprofit organization that uses market-based incentives and cooperative partnerships to protect and enhance Washington State's water resources[110]. Ecology and Clallam County selected WWT and the consulting firm Ecosystem Economics, to design a strategy for the mitigation bank[111]. Together, the organizations conducted several analyses including feasibility, cost benefit, and multi-criteria for the design and operation of the bank[111]. Ultimately, the Department of Ecology authorized WWT to operate the mitigation program through the Exchange.

The DWE has two major functions: mitigation and restoration. The mitigation program aims to offset impact of new wells to surface flows of the Dungeness River and other streams. To meet regulatory requirements, new groundwater users, such as homeowners, must obtain a mitigation certificate to certify their impacts have been offset. The restoration program uses state and federal funds to improve the local watershed by replenishing groundwater and restoring streamflows[112].

Clallam County requires that mitigation must be in place in order to acquire a building or subdivision permit. The mitigation is based on consumptive use and is focused on late season streamflow in order to protect the instream needs of salmon. Generally, 10% of indoor water use and 90% of outdoor water use is considered consumptive under the rule[113]. The consumptive use impact to streamflow is calculated using the Dungeness groundwater MODFLOW model and is largely based on well's proximity to the nearest stream and the depth of the well[109]. The basin-wide hydrologic model was jointly developed by the USGS and Ecology and has undergone several iterations since the 1980s. The model is estimated to have cost approximately $1 million[114]. The model calculates the impact to surface streams in the watershed from groundwater pumping and aquifer recharge. In 2010, Dave Nazy, a hydrogeologist with Ecology, developed a user-friendly "mitigation calculator" that uses the MODFLOW model to calculate total mitigation obligation based on parcel, aquifer and consumptive water use.

The Excel tool has a series of drop down selection boxes (blue boxes, Figure A-11) in which the specific parcel number, aquifer pumped from, and consumptive water use (in gallons per day) are selected and the corresponding impact on surface waters (%; gallons per day) and total mitigation obligations (gallons per day) are displayed.

		Mitigation Requirement (percent of consumptive use)			
1	Select Parcel Number Below	Shallow Aquifer	Middle Aquifer	Deep Aquifer	Bedrock Aquifer
Parcel Number:	009-043025310275	95.902%	89.510%	0.000%	89.510%

		Distribution of Surface Water Impacts and Mitigation Requirements								
2	Select Aquifer Below	Bagley Creek	Bell Creek	Cassalery Creek	Dungeness River	Gierin Creek	Matriotti Creek	McDonald Creek	Meadowbrook Creek	Siebert Creek
Aquifer:	Shallow Aquifer	0.002%	1.952%	8.411%	76.694%	12.748%	0.104%	0.015%	0.075%	0.000%
	Gallons per Day:	0.00	4.68	20.16	183.88	30.56	0.25	0.04	0.18	0.00

3	Enter Consumptive Quantity	Total Mitigation Obligation
Gallons per Day:	200	239.75

Figure A-11. Screenshot of the Dungeness MODFLOW Mitigation Excel Calculator developed by Dave Nazy, Washington Department of Ecology. The total mitigation obligation for the given parcel number, aquifer and consumptive quantity selections, is 239.75 gallons per day. Source: Washington State Department of Ecology[115].

New water users are required to either present their own mitigation plan, or participate in the DWE. If participating in the Exchange, a new water user is required to obtain one credit per household. The Exchange offers three mitigation packages (Table A-10). These packages are relatively inexpensive and the cost is typically incorporated into the building cost of the home[111]. The most popular package is the Indoor Only Package, which costs $1,000.

Table A-10. Dungeness Water Exchange mitigation packages. Source: Washington Water Trust[112].

Mitigation Package Descriptions				
Package Description	Average Amount of Indoor Use (Gallons/Day)	Average Amount of Outdoor Use (Gallons/Day)	Amount of Irrigated Lawn Area (Square Feet)	Amount of Irrigated Lawn Area (Acres)
Indoor Only Package (minimal incidental outdoor use only) $1,000	150* (average)	0	0	0
Indoor with Basic Outdoor Package $2,000	150* (average)	89	2,500 sq. ft. (approx. 50 x 50 ft.)	.06 acres
Indoor with Extended Outdoor Package $3,000	150* (average)	200	5,625 sq. ft. (approx. 75 x 75 ft.)	.13 acres

*Note: The Exchange accounts for domestic mitigation using a standard average daily amount of 150 gallons (WAC 173-518-080 (b). This is the annual amount of water that the Exchange and the mitigation certificate purchaser agree upon as the basis for their transaction.

The money generated from the sale of mitigation certificates funds the purchase and retirement of senior water rights historically used for irrigation. Once retired, these water rights are left instream to offset the new groundwater well's impacts on the Dungeness River.

Aquifer recharge is required for impacts on smaller streams in which there exist insufficient water rights to purchase and leave instream for mitigation. WWT partnered with the Clallam Conservation District and local irrigation districts and companies to build and operate managed aquifer recharge sites. These projects are estimated to be complete in 2016.

Ecology provided the primary funding to start the DWE with the notion that over time it would become self-sustaining. Ecology subsidized the first 100 mitigation certificate applicants[111]. The program received federal funds from a WaterSMART Water and Energy Efficiency Grant. The WaterSMART Grant proposal, "Dungeness Basin Water Conservation: Irrigation Efficiencies and Water Banking in, Clallam County WA" was proposed by Agnew Irrigation District with assistance from Clallam Conservation District and Washington Water Trust in May 2010. Amanda Cronin from Washington Water Trust was the grant project manager and main contact for the proposal. The grant awarded approximately $250,000 to fund an irrigation efficiency project and $50,000 for the startup of the DWE. The federal grant was matched by non-federal funds as well.

Approximately $350,000 was spent to purchase 175 AF of irrigation water rights at a price of $2,000/AF and about $130,000 went towards the development of aquifer recharge[111]. A significant amount of time and expenses were also dedicated to stakeholder outreach, including public workshops, public meetings, media outreach and the development of outreach materials[111]. Fortunately the agricultural community, primarily the Dungeness Water Users Association, demonstrated cooperation and support for the program.

While there has been opposition to the Water Rule by property rights advocates, public perception of the DWE has been relatively positive. Still, development of the DWE was largely subsidized by the state and was an expensive and lengthy process. The time spent on stakeholder outreach could have been reduced if the program launched once it got key stakeholders on board, rather than waiting and attempting to achieve universal approval (as this is an unreasonable expectation).

The DWE is an example of a successful, multi-stakeholder driven program that meets the state's instream flow rules and requirements. The program is largely aimed towards permit-exempt well users and subdivision developers that require mitigation for individual households. Currently, two WWT staff members work ¼ - ½ Full Time Equivalent on the program. Staff members field questions on mitigation, conduct outreach and prepare mitigation certificates. WWT distributes approximately 40-50 mitigation certificates a year.

Applying this experience to the Gallatin County highlights the following considerations:

1. While significant investment must be made in stakeholder outreach, it is important to launch the program once the key stakeholders are on board.
2. The mitigation packages utilized by DWE may not be replicable in the Gallatin Valley. Some potential clients, such as the City of Bozeman, will require a specific volume of water measured by pumping rather than household count.
3. Enforcement of mitigation will be improved by requiring proof of mitigation in other official processes specific to new water users (i.e. county planning, zoning, or building permitting).
4. The mitigation strategy utilized by DWE is approved by Ecology and carries weight, however, it is still susceptible to being challenged in court. This is important when considering which entity— the Exchange or the mitigation credit buyer—is legally held liable.

Yakima River Basin Water Exchanges

In the early 2000's, Kittitas County experienced high rates of growth due to a housing boom. Thousands of lots were built in subdivisions on former railroad and forest land that historically did not hold water rights[117]. This development was largely dependent on permit-exempt wells and led to a drawdown of surface waters in the Yakima River and tributaries, threatening native anadromous fish, aquatic habitat and downstream senior water right users. In 2007, Aqua Permanente, a private company, petitioned Kittitas County and Ecology to place a moratorium on the development of any new exempt wells until more was known about the effect of the wells on senior water rights holders and stream flows[118]. The moratorium led to the establishment of a permanent rule requiring any new groundwater appropriations in Upper Kittitas County to be water budget neutral. Under the rule, all water withdrawals for new development must be mitigated and granted approval by Ecology in the form of a water budget neutral certificate[117]. This led to the establishment the Yakima River Basin Water Exchange, where new groundwater users such as developers and individuals can purchase mitigation water from basin specific mitigation banks to offset their consumptive water use and obtain water budget neutrality[119]. In addition, the rule requires that all new development in the Upper Kittitas basin must have water meters for each residential connection or source well that serves multiple residential connections and water users must report their metering data[120].

The Yakima River Basin is composed of the Upper Kittitas, Lower Kittitas, Central Yakima and Lower Yakima groundwater basins. Senior water rights holders can establish mitigation banks, of which there are currently nine. Due to the need to precisely mitigate impacts to surface flows and the presence of separate hydrologic sub-basins, each water bank may only supply mitigation water within a defined area. Each water bank has a mitigation availability map that depicts the area they can serve (Figure A-12 is an example for the Suncadia Water Bank). The maps are color-coded and show the bank's availability to provide mitigation through three suitability zones: green, yellow and red. Green is likely suitable, yellow requires more information and red is unsuitable. New groundwater appropriators can purchase mitigation credits from any water bank that serves their area. Notably, the suitability maps do not guarantee mitigation approval for applicants located in the green or yellow zones. Rather, they represent Ecology's best professional judgment and are used for initial planning; an application can still be rejected upon further review.

Mitigation approval is required prior to receiving a building permit and this prolonged process (lasting between 4-6 months) is out of tune with the real estate market conditions[121]. A more streamlined process that included pre-approval would be preferred in the area.
Washington State's Trust Water Rights Program allows a water rights holder to hold their water rights in trust for future use without relinquishment while retaining the water right's original priority date[122]. Water marketers in the Yakima River Basin use the Trust Water program to protect their water rights instream while marketing them for mitigation.

While mitigation is only required by rule in the Upper Kittitas, water banks are available to provide security for new groundwater appropriators in the other basins as well. Unmitigated water users are subject to curtailment in the event of water shortages and conflicts with senior water users. By obtaining mitigation through senior trust water rights, water users can avoid curtailment[123]. However, the ultimate responsibility still lies with the water user and in the unlikely event that senior trust water rights are curtailed, the state cannot be held responsible[124]. As of December 2015, 371 transactions have occurred, representing 829 Equivalent residential units[125]. The program is characterized by high costs, with permits ranging in price from $500-$14,000 per home depending on availability within the region as defined in the mitigation suitability map[126]. The bank suffers from a lack of local support, as critics characterize the state-mandated rules to be a moratorium on new wells, and more generally as a growth control measure. Further, the lack of public input has led to the private sector determining mitigation credit prices. The average cost per mitigation credit, representing .17 AF of consumption use, is $5,700. Calculated in terms of a full AF of consumption use, the price translates to roughly $30,000, which greatly exceeds the cost of purchasing an individual water right which ranges between $2,000-$3,500 per AF of consumptive use[119].

The Bren Team interviewed representatives from four water exchanges in the Yakima River Basin: Suncadia Water Bank, Masterson Ranch Water Bank, Williams and Amerivest Water Bank and the Yakima Camps and Cabin Owners.

Suncadia Water Bank

Suncadia Water Bank is one of the oldest and most successful water banks in the Yakima River Basin. It was established in 2010 when Suncadia, a resort community located approximately 80 miles east of Seattle, transferred three water rights into the state's Trust Water Rights Program. As of December 2015, Suncadia completed 222 transactions, representing mitigation needs for 368 residential units[127]. It charges applicants a fee based on the cost of securing Ecology's approval for the new use ($1,000-$1,250 for green zone, and $2,500-$2,700 for the yellow zone) in addition to the cost of water[74]. Most development occurs in the yellow zone in regions that require additional analysis to see if there will be impacts on small tributaries that may have steelhead runs (Figure 2). On average, the total cost of mitigation is relatively high and ranges from approximately $5,800-$10,000 per equivalent residential unit[74].

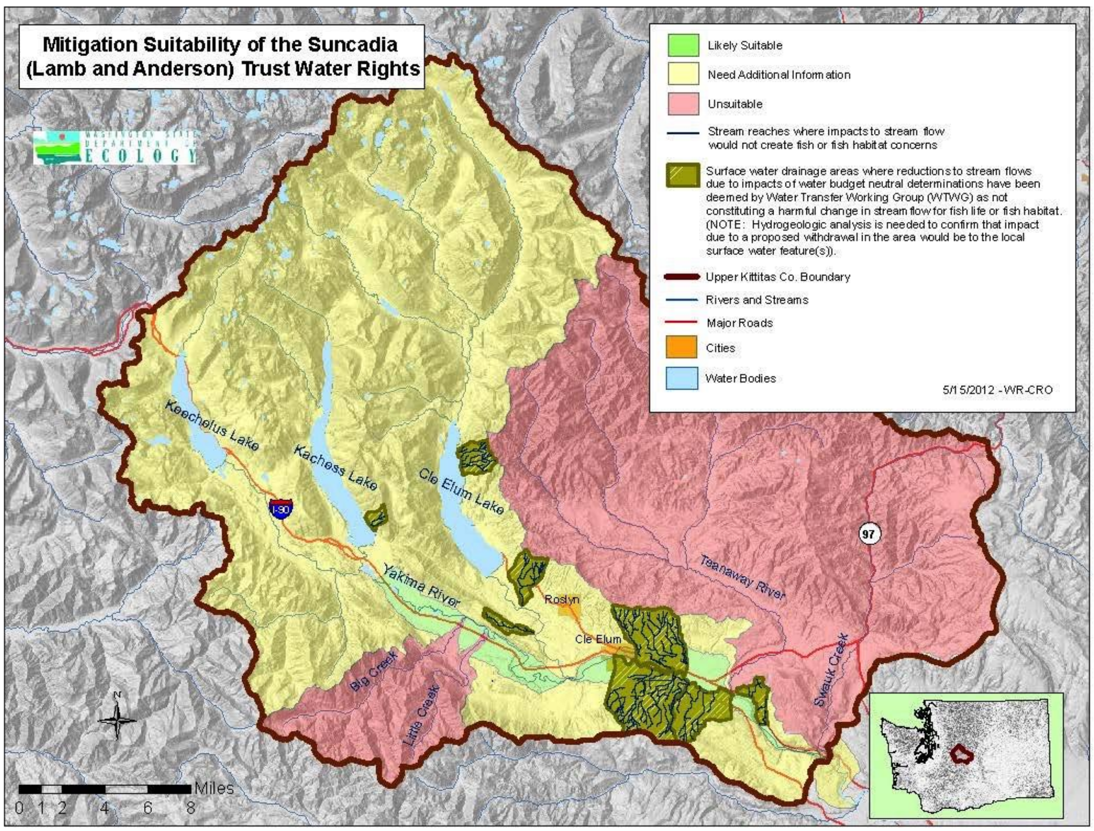


Figure A-12. Mitigation suitability map for the Suncadia Water Bank. Source: State of Washington Department of Ecology[128].

Suncadia was well poised to be successful in this market, as at the time of the new regulation they already had water rights in their possession. Suncadia was required to purchase a certain volume of water rights under state and federal environmental protection laws to meet the needs of its community, and ended up with water rights available to sell.

Mentor Law Group administers Suncadia's groundwater mitigation bank by fielding questions from interested parties (as much as 50% of applicants are "window shoppers" who do not end up purchasing credits), screening incoming applications and moving appropriate applicants through the mitigation process. The process for applicants consists of several steps. First, the applicant submits a water use questionnaire that helps Mentor Law Group determine if the bank can mitigate the proposed water use. If the prospective user is in the green (suitable) or yellow (may be suitable pending additional information) zones, Mentor Law Group drafts a Letter of Intent that includes the price for mitigation and conditions the transfer[129]. Once the Letter of Intent is signed, Mentor Law Group prepares a Groundwater Mitigation Agreement. This is a purchase and sales agreement to transfer a portion of Suncadia's trust water rights interest onto the prospective water user. The agreement is subject to several conditions, including the payment of a percentage of the purchase price into escrow and approval from Ecology[129]. Mentor Law Group then works with the applicant to submit an application for a Water Budget Neutral Determination. If the application is approved, the prospective user receives a "Groundwater Mitigation Certificate" from escrow that is recorded by the Kittitas County Auditor and is attached to the property for which it was purchased[129].

As a private entity, Suncadia was able to set its own price for mitigation, which, along with their location in the mitigation suitability map and relative scarcity of sellers, led to high prices compared to state subsidized mitigation banks elsewhere in Washington (e.g. Dungeness Water Exchange). Furthermore, the bank's use of an escrow company to handle all fees provides an added level of certainty to prospective water users[74].

Masterson Ranch Water Bank

The Masterson Ranch Water Bank is a private water bank owned and operated by Kathleen (Kathi) Masterson. Kathi Masterson entered into Ecology's Trust Water Rights Program in 2012 as a means to bring in additional income. She manages Masterson Ranch, a 2,000-acre ranch that consists of 230 acres of hay and 1,770 acres of timber. The 230 acres of hay was converted to dry-land (i.e. no irrigation) so the conserved irrigation water could be leased for instream flow to supply mitigation credits. In addition, the Masterson Ranch Water Bank acquired additional water rights from the Teanaway River to expand the bank's service area to serve more customers. Unfortunately, the market for Teanaway River mitigation credits has not been as active as anticipated, and only one entity has purchased a mitigation right from that source[130].

The Masterson Ranch Water Bank enrolled approximately 40 AF into the Trust Water Rights Program. It has entered into 33 transactions, reallocating about 5.5 AF of water to provide mitigation for 40 residential units[130]. Kathi Masterson interviews prospective mitigation buyers to see if the Masterson Ranch Water Bank may be suitable to provide mitigation and files the appropriate paperwork with Ecology. Notably, Kathi Masterson is wary of Ecology's suitability maps and runs every prospective parcel by Ecology to ensure suitability prior to filing paperwork to initiate the Ecology approval process. She experienced a case when a parcel was located in a green (or suitable) zone, yet upon further review was rejected by Ecology.

Masterson Ranch Water Bank priced its mitigation certificates at $4,500 per certificate. $1,500 goes towards the cost of water and $3,000 is for administrative fees including time, excise tax, fees to Ecology, title company charges, recording fees with Kittitas County[131]. The mitigation certificate covers an indoor water use of 350 gallons per day and outdoor use of 500 gallons per day. In addition, there is an additional $500 fee if the new water use negatively impacts the Teanaway Basin. This fee goes towards restoration in the basin and is managed by the Kittitas Conservation Trust.

Williams and Amerivest Water Bank

Williams and Amerivest Water Bank is operated by Mitch Williams, a builder in Kittitas County. Mitch Williams entered the mitigation banking industry for several reasons. First, he realized that the residential developments he built were not secure in water rights, and that he would be the one liable if they were curtailed. Second, he owned more water rights than he needed and realized the opportunity to market his water for mitigation. Mitch Williams entered his irrigation water rights into the Trust Water Rights Program, which required him to fallow fields and leave the water rights instream while marketing his water for mitigation. Notably, the Trust Water Rights Program had an opt-out option in which he would be able to put his water back into irrigation if he did not sell it all to mitigation. This option to exit was a major motivational driver for Mitch Williams to enter the water banking market[121].

The Williams and Amerivest Water Bank initially priced its water based on the cost of securing a water meter with a city's water department, which costs about $6,000-$10,000. However, the sale price of mitigation credits varied with circumstance. For example, Kittitas County was able to negotiate a lower rate of $2,500 per unit by buying a large wholesale order of approximately enough to supply approximately 1,000 residential units[121].

Yakima Camps and Cabin Owners

The Yakima Camps and Cabin Owners Mitigation program is an Ecology run and subsidized mitigation bank designed to provide mitigation water for camps and cabins in the Upper Yakima Basin. The mitigation bank serves two kinds of water users: those with existing junior water rights and those with no water rights. Both types of water users tend to only use the water seasonally, as most camps and cabins are for recreation or vacation. The cost of mitigation for those with existing junior water rights is $395-$617 per unit, depending on how much water is actually used, and the cost of mitigation for those with no water rights is an additional $550 plus the cost of publishing a public notice in a newspaper[132]. The full breakdown of the fees is available in Table A-11.

Mandatory mitigation created sufficient frustration among cabin owners as some were using water for over 50 years.[133] However, all existing and new cabins are required to obtain mitigation water in order to avoid curtailment when senior water users do not get their full supply. Notably, obtaining mitigation credits protects camp and cabin owners from curtailment by large water users, however, Ecology does not guarantee that a water user won't be curtailed based on local curtailment.[133]

Applying the experiences in the Yakima River Basin to the Gallatin County highlights the following considerations:

1. The mitigation program in the Yakima River Basin does not require mitigation banks to offset the timing of impacts, but rather utilizes the State's Trust Water Rights program in which senior water rights are retired and left instream to provide mitigation. The program does account for spatial impacts and water banks have zones of suitability to provide mitigation. This zonal-based suitability led to some mitigation banks almost acting as monopolies if no other banks are suitable in a certain area. Because of the private mitigation bank model, this led to high prices of mitigation credits in some regions.
2. Many water banks in the Yakima River Basin were developed as a way to bring in extra revenue to an already existing company or establishment. This reduced costs of operation as the water rights were already owned prior to marketing as mitigation credits.
3. It is very important to garner enough supply. To do this, GVWE must be able to motivate senior water rights holders to participate. In Washington State, the Trust Water Rights program has an option to back out and return the water to irrigation if not all the water is sold for mitigation. This provides water rights holders security in participating in the mitigation program.
4. It is important to make the mitigation program as clear as possible and stakeholder outreach is key. Senior water rights holders must be educated about what they market as mitigation, as only the consumptive portion of a water right can be changed for mitigation purposes.
5. Hydrogeological and spatial variability of market participants throughout the basin greatly influence the ability to connect sellers and buyers within the correct region to offset the location of impact, thus leading to additional variability in prices and speed of transaction throughout the basin.
6. Approval processes to confirm the suitability of mitigation is valuable but time-consuming to process through the state bureaucracy. Look for opportunities to streamline this process, such as bundling transactions to reduce the burden.

Walla Walla Water Exchange

In Washington, state-wide regulations allows permit-exempt groundwater wells to pump up to 5,000 gallons per day (gpd). In 2007, the Washington State Department of Ecology (Ecology) restricted permit-exempt groundwater extraction rates in the Walla Walla basin to a maximum of 1,250 gpd, and required outdoor water use to be mitigated[26]. Recognizing the potential difficulty for individual homeowners to find mitigation water on their own, Ecology hired a local non-profit, the Washington Water Trust (WWT), to set up a mitigation bank—the Walla Walla Water Exchange— and provide "banked" water through the initial purchase of seven acre-feet of groundwater, from which credits could be issued[26]. Due to the basin's shallow gravel aquifer, it was determined that one set mitigation fee would be sufficient to offset pumping impacts. Homeowners have two options to mitigate their residential use: either find their own mitigation water (by using an existing water right), or pay a one-time fee of $2,000 to offset their use, calculated to be .55 AFY based on an assumption of 1,000 gpd outdoor use during the 108-day irrigation season[26]. In 2011, the Walla Walla Watershed Partnership took over management of the Walla Walla Water Exchange. While legislatively authorized in 2009 as a pilot program to improve water management, the organization functions as a non-governmental nonprofit.

Despite the simple operation of the bank, general public support for the endeavor, and relatively inexpensive mitigation credits, only three transactions have occurred. This lack of transactions is likely due to poor enforcement of mitigation by the state, although the economic recession which reduced the number of new building permits may have played a role[119,126].

Applying this experience to the Gallatin County highlights need for proper regulatory enforcement to ensure demand for mitigation.

Deschutes Groundwater Mitigation Program

The Deschutes Groundwater Mitigation Program was developed by the State of Oregon to meet new groundwater uses while maintaining scenic waterways and instream flows in the Deschutes Basin[134]. The Mitigation Program requires mitigation for all new groundwater permits in the Deschutes Ground Water Study Area, identifies tools for obtaining mitigation through mitigation projects or by obtaining mitigation credits, and allows for the formation of mitigation banks[135]. It also set a cumulative allocation cap at 200 cfs and requirements for annual and five-year reviews[134].

Under Oregon law, several types of groundwater uses are exempt from the permitting process. These include stock watering, lawn and noncommercial garden watering of no more than 0.5 acres, domestic use of less than 10,000 gallons per day (or approximately 16.8 AFY), industrial use under 5,000 gallons per day, down-hole heat exchange use and watering school grounds of less than 10 acres[136]. All other groundwater users must obtain a groundwater permit and mitigate for their use.

To establish a new groundwater right, an applicant must first submit a groundwater application to the State of Oregon Water Resources Department (OWRD). OWRD then reviews the application and determines the applicant's mitigation obligation— the consumptive portion of the proposed use that must be mitigated—and the zone of impact—where the proposed use will impact surface waters. The applicant must then propose a mitigation strategy that meets both the volume (mitigation obligation) and location (zone of impact) requirements. The mitigation strategy can include purchasing mitigation credits from a mitigation bank or proposing an individual mitigation project. The OWRD will issue a proposed and then final order that lists the mitigation requirement in number of credits and zone of impact[137]. Once the final order is issued, the applicant has five years to provide the mitigation; once the mitigation is provided, the groundwater permit will be issued. On average, the entire permitting process takes three years[138]. However, the final order can take as little as six months to issue in some cases[137].

Seven zones of impact were determined using a hydrologic model developed by the USGS and the OWRD. These include six localized and one general zone (Figure A-13). The general zone was developed to address impacts to both regional and local surface waters. The majority of new groundwater users were found to have an impact on the general zone[135]. The zone of impact is influenced by parameters including depth of well, losing and gaining reaches of streams, proximity to springs, and known horizontal and vertical groundwater movement and geology[137]. Mitigation projects must be established in the zone(s) of impact for the proposed use. If mitigation credits are purchased, they are no longer usable in any other zone in which they were available.

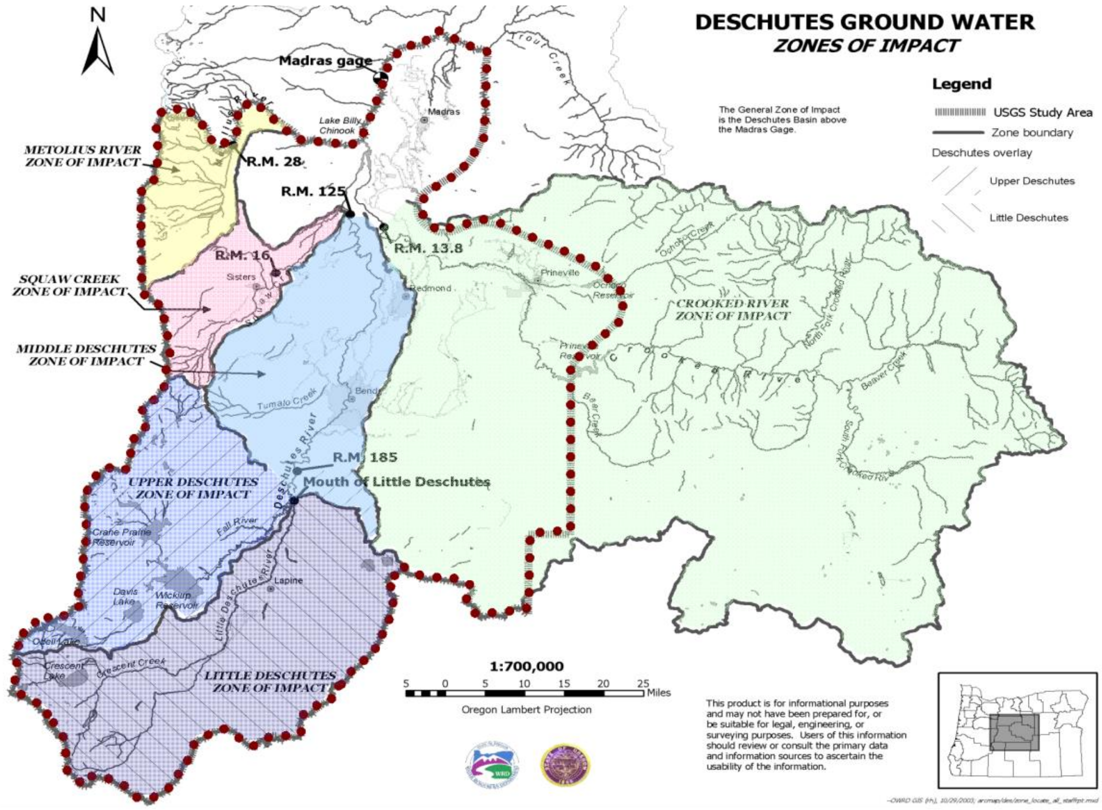


Figure A-13. Deschutes Ground Water Zones of Impact. Source: State of Oregon Department of Water Resources.

Several types of projects can be used to establish mitigation water. These include instream leases (only allowable for mitigation banks generating mitigation credits), permanent instream transfers, allocation of conserved water, release of stored water, aquifer recharge and well-to-well transfers. The type of mitigation strategy used varies by groundwater use. The majority of participants in the Deschutes Groundwater Mitigation Program are individual “hobby farmers” who use small, but non-exempt, volumes of groundwater for non-commercial grazing and pasture[138]. Other major participants are municipalities, including the City of Bend and Redmond, which require larger volumes of permanent mitigation.

Under the Deschutes Groundwater Mitigation Program, individuals and organizations can apply to be a state chartered mitigation bank and sell mitigation credits. A mitigation credit is defined as one AF of consumptive use with a specified zone of impact[137].

Currently, there are two chartered mitigation banks, the Deschutes River Conservancy (DRC) Groundwater Mitigation Bank, and John Short’s mitigation bank. The DRC Groundwater Mitigation bank began in 2003 and is operated by the DRC, an Oregon-based nonprofit corporation that uses market-based mechanisms to restore streamflow and improve water quality in the Deschutes Basin. The DRC mitigation bank offers temporary or annual mitigation credits from instream leases. The second mitigation bank is operated by a local water rights consultant and offers permanent mitigation credits. A chartered mitigation bank is not required for an entity to sell permanent credits. Furthermore, water rights that an entity already owns can be transferred instream and become mitigation. For example, the City of Redmond transferred irrigation rights it owned instream, generating mitigation credits it could use for its own purposes[139].

Instream leases can provide mitigation credits on an annual basis. Because they are temporary in nature, the OWRD requires the ratio of water protected instream to groundwater used is 2:1[137].This requirement generates substantial flow restoration to the basin and is the type of credit DRC offers. Temporary credits must be purchased each year. Permanent transfers, on the other hand, only require a mitigation credit to groundwater ratio of 1:1. Permanent credits are generated through the permanent retirement of water rights. Permanent credits are more expensive to obtain; however, they offer more security. Municipalities exclusively obtain permanent mitigation credits to avoid the complexities of managing a portfolio of temporary mitigation credits[139].

The amount of credits generated from a surface water right is based on the right's current consumptive use. Irrigation water transferred instream generates approximately 1.8 credits per acre[137]. Over 200 landowners participate in DRC water leasing each year[137]. Other surface water rights, such as municipal and industrial, can also be transferred and the credits generated are based on the consumptive use (typically 40-50% for municipalities and resorts).

DRC works to match mitigation credit customers with an appropriate mitigation project. DRC tracks its projects, credits generated by projects and the zone of impact associated with each credit. This information is submitted to the state in an annual report[137].

The price for mitigation credits offered by DRC has increased over time as subsidies have expired. Credits from 2003-2007 were partially subsidized and cost $70 per credit. In 2008, the credits were no longer subsidized and cost $105 per credit from 2008-2015, and are currently $120 per credit[137]. For context, an individual with a 1 acre irrigated pasture would require 1.8 mitigation credits, at a price of $216 per year. 52% of the credit price goes towards leasing water instream, 38% towards administration and operation, and 10% goes towards restoration[137].
A 2011 analysis of the Deschutes Groundwater Mitigation Program indicated that overall, the program is preferable to either a complete moratorium on new groundwater use or no regulation at all[138]. However, general acceptance of the program was low. The analysis reported that many participants felt as if they were being punished for following the law, as obtaining mitigation is expensive and enforcement is low[138]. The analysis recommended that the state improve its mitigation program by simplifying the process and increasing public awareness primarily

through the creation of more accessible documents, time-lines to set expectations and updates on the program's progress and why it is required[138].

Applying this experience to Gallatin County highlights the following considerations:

1. Development of a comprehensive hydrological model is a worthwhile investment (by the Exchange or the state). A sound hydrological model, even one that is relatively conceptual, can reduce hydrologic consultant fees down the road.
2. Solicit stakeholder feedback and incorporate it into the Exchange's design. Make sure to cite the stakeholder by name to show that Exchange development is truly a multi-stakeholder process.
3. Invest in supplying the public with clear, understandable information about the mitigation program, how to obtain mitigation and why it is required.
4. Deschutes Groundwater Mitigation Bank subsidized initial transactions to launch the entity and encourage market participation.

Colorado River Water Bank

Drought coupled with rapid population growth in the Colorado River Basin has led to water demands exceeding current supplies[140]. Furthermore, in the event of a Colorado River shortage declaration and subsequent curtailment, the state of Colorado may need to reduce its overall use to ensure Lake Powell remains above minimum power pool and that the Upper Basin does not end up in a Colorado River Compact compliance situation. The Colorado River Water Bank was proposed as a mechanism to increase water security for all Colorado water users that rely on the Colorado River[140]. The idea was proposed by The Colorado River District[1] over 7 years ago, and the program is still in development. A coalition of stakeholders—led by The Colorado River District with assistance from The Nature Conservancy—are working to develop a program that works within the current legal, political and social constraints but there may need to be additional policy changes down the road. Currently, a series of studies and technical meetings are taking place, where important questions, such as how temporary fallowing and split season leasing might impact farmers and the agricultural community, are bring addressed. West slope irrigators see the potential monetary benefits in leasing their water rights to ensure system resiliency, yet are cautious of any potential negative impacts that long term banking will have on the agricultural economy.

The administrative structure of the water bank has not been decided yet, but will likely be led by a steering board with representatives from various interests, including farmers[141]. Importantly, The Nature Conservancy is not face of the bank, but rather acting as a catalyst to help its

[1] The Colorado River District is a public water policy agency representing 15 West Slope counties. It is governed by a Board of Directors and provides legal, technical and political representation regarding Colorado River Issues for its constituents. More information: http://www.coloradoriverdistrict.org/

development. The developmental process of the Colorado River Water Bank highlights the extensive time and energy that can be dedicated to stakeholder outreach and obtaining acceptance of the agricultural community prior to launching the program. GVWE must balance the time it takes to get stakeholders on board and the time-sensitive requirement to get a mitigation program up and running to meet demand for mitigation water.

Applying this experience to the Gallatin County highlights the following considerations:

1. Engagement and leadership among major agricultural stakeholders is an invaluable and enduring process. In addition to agricultural leadership, education and involvement of the public regarding the impact and opportunities created for local communities, is important to creating a broad base of support.
2. Utilizing temporary leases for dry years is a way to provide water for short-term demand.

Central Kansas Water Banking Association

In 1993-1998 the State of Kansas closed its boundaries to new water rights appropriations for all uses over 15 AF per year. Later, in an effort to reduce water use, the Kansas state legislature passed the Water Banking Act in 2001 to allow regions to develop water banks by submitting information about their intended administrative model, proposed economic viability, and proposed capacity of the organization for approval. This act evolved over time to become a chartered non-profit, the Central Kansas Water Bank Association (CKWBA), that upholds the rules and regulations for banks. Only one bank has been established under this system within the jurisdiction of Big Bend Groundwater District 5 which helps to operate CKWBA simultaneously with their own administration of groundwater banking to serve the needs of their district[142].

Under the rules and regulations, the banks are distinct entities that must operate under a fee based system sufficient to reimburse the State and affiliated groundwater districts. There are two major functions provided by the bank: 1) provide a safe deposit account for water rights to keep them from use it or lose it laws, and 2) leases of water from water rights that have been deposited in the CKWBA. The charter also requires a minimum of 10% water savings in consumptive use on all deposit and lease transactions to promote water conservation[142].

Safe deposits are based on the historic consumptive use, and only consumptive use can be made available for leasing to others. Leasing of water rights is based on a state wide hydrological map that establishes mitigation suitability throughout the region. The cost to establish a hydrological model for half of the state cost around $750,000 with additional costs to improve it.

The bank was initially set up as a part of the management strategy for Big Bend Groundwater District 5 (GMD5), and became its own entity after approval. The GMD5 funded the bank with a no interest loan and loose terms and conditions to repay the loan that could keep pace with the bank's capacity to generate income. Initially the bank set the prices of a water deposit to recover expenses and maintain a high quality of monitoring, with all expenses paid up front. Deposits initially lasted for seven years and monitoring was charged at $100 a year with a $100 sign-up fee – making the total cost of depositing water $800. After a fee restructuring, which dropped the annual monitoring fees leaving only $100 to sign up, the bank began receiving nearly 300 accounts per year and generates sufficient revenue to cover the bank's expenses. This switch from quality to quantity was further justified as the groundwater districts already had monitoring aspects built into their regional management plans.

Despite the success in changing the fee structure for water rights safe deposits, the fees for deposits for leasing remain high at $600 for initial paperwork and $100 per year for monitoring for up to 5 years. Leasees pay $350 up front and $100 per year for monitoring. So far the bank has only had about 5 leases. Furthermore, these leases have all been within the same ownership – an owner of a water right will deposit and then lease his or her right as this method is one of the very few ways that purpose and place of use can be legally changed.

The bank is still undergoing growing pains and learning how to sustain operations. Revenue streams come predominately from the volume of safe deposit accounts but also from unsuccessful applications, as the fee is non-refundable. The bank is looking to improve fair distribution of water rights purchases for farmers who wish to retire their right and sell to new individuals, which, while rare, was met with incredible demand from the community. They plan on the development of auctions and using community outreach methods like opt in texting of new water right availability to notify all potential buyers at the same time[143].

Applying this experience to Gallatin County highlights the following considerations:

1. Price determination is paramount to the success of this bank: too high - no users, too low - insufficient revenue.
2. Affordable initial capital costs are extremely important.
3. Great benefits come to regional users from statewide hydrological models.
4. Consider the role of use it or lose it regulation – can it be used as leverage to get a desired outcome or participation?

Arizona Water Banking Authority

The Arizona Water Banking Authority (AWBA) was established in 1996 to store the unused portion of Arizona's 2.8 million AF Colorado River water entitlement for future use[144]. It functions as a system of storage facilities that bank unused water to be used in times of shortage to secure water for municipal, industrial, and other users in Arizona.[145] AWBA operates in a very different fashion and at a drastically larger scale than that possible in the Gallatin Valley, including interstate compacts and statewide tax funding[144]. Despite these extreme differences in operation and the details excluded from this analysis, the AWBA provides valuable insight to groundwater management.

Applying the AWBA expertise to the Gallatin County highlights the following considerations:

1. Operations never work out as expected or modeled. There is great benefit in creating small incremental steps and piloting smaller projects allow for adaptive management as the program grows.
2. The easiest, simplest, and most cost-effective form of groundwater mitigation is to not remove the groundwater at all. Some of AWABs best mitigation is their retirement of previous groundwater use.
3. Injection wells did not work out as well as AWAB had predicted. Infiltration basins are their preferred method of aquifer recharge, but they require a lot of land.
    a. AWBA maintains a 5% ‘cut to the aquifer’ as a conservation method that is not intended for removal.
4. AWAB’s greatest strength is its legislative and tax base support. They contribute many successes to regulations that make mitigation more affordable or increase AWAB revenue.

Mammoth Trading

Mammoth Trading is a company that specializes in the design and operation of water markets. Currently, it operates groundwater trading in Nebraska and surface water trading in Washington State. The company uses an algorithm tailored to each market that pools together interested parties and pairs them according to local rules for trading and their comparative prices[146]. The algorithm finds the best matches based on price and regulatory rules for transfers, including hydrologic constraints and adjustments (e.g. flow zone boundaries and stream depletion factors). Once a match is made and approved by the region’s regulatory agency, Mammoth Trading finalizes the financial transaction.

Mammoth Trading mostly deals with agriculture-to-agriculture water transfers that can be either permanent or temporary. Permanent transfers are easier to regulate due to lower monitoring and enforcement costs; however, leases offer more flexibility. Agricultural water right holders are much more likely to lease their water right rather than sell it permanently. Leases also allow flexibility in the price of water and can adjust to its current value, which can vary based on regulatory, economic and climatic conditions.

Mammoth Trading found that markets are successful in offering customers a way to meet multiple goals. First, they help water to move to its most efficient and profitable uses.[146] Second, if designed correctly, they help to sustain the longevity of water resources in the community, thereby conserving resources for future generations of farmers[146].

Mammoth Trading is a unique type of water bank administrator. The company was founded after extensive research that indicated that farmers and ranchers trust private companies over government or nonprofits as administrators of a water market[147]. In addition, it is important to have an impartial party operate the water market. There is a conflict of interest if an organization is operating a market and also purchasing water in that same market. This is consistent with the mentality in Gallatin County, where the City of Bozeman chose not to operate its own groundwater mitigation bank to avoid appearing to control too much water in the County.

Applying Mammoth Trading's expertise to Gallatin County highlights the following considerations:

1. Technology may be used to help streamline matching mitigation water with new groundwater development, reducing transaction costs.
2. Understanding stakeholder needs is important in designing a water bank. Acknowledging and meeting the secondary goals of the region, while supplying mitigation water, can help GVWE be successful.
3. Demand may be reduced if transaction costs are high or if there is too large a cut to the environment.

Table A-11. Summary of pricing structures for various water banks analyzed.

Water Bank	Pricing Structure
Grass Valley French Ditch Company Water Bank	Cost is $40-80/AF for annual leases and $800-$1,600/AF for permanent sales. In addition, there is a canal shareholder charge of $12/year per AF.
Dungeness Water Exchange	Per unit prices vary based on mitigation packages: Three different mitigation packages: 1. Indoor only: $1,000. This includes 150 gal/day. 2. Indoor, basic outdoor: $2,000. This includes an additional 89 gal/day to irrigate up to 0.06 acres. 3. Indoor, extended outdoor: $3,000. This includes an additional 200 gal/day to irrigate 0.13 acres.
Suncadia Water Bank	In addition to the cost of water, a per unit charge is based on suitability zone: 1. Green: $1,000 - $1,250 2. Yellow: $2,500-$2,700 The total cost of mitigation ranges between $7,500-$10,000 and includes 350 gal/day for domestic use and 500 square feet of outdoor irrigation.
Masterson Ranch Water Bank	The cost of one mitigation certificate that supplies 350 gal/day of indoor use and 500 gal/day of outdoor use is $4,500. This includes $1,500 for the water and $3,000 for administrative fees (including Kathi Masterson's fee, excise tax, fee to ecology, tile company charges for services, recording fees with county, etc.). In addition to the mitigation certificate, water users impacting the Teanaway River have an added $500 conservation fee.
Williams and Amerivest Water Bank	Water rights were acquired and are not assigned to Kittitas County. The County purchased the water at a discounted bulk rate of $2,500 per equivalent residential unit (1,000 units were sold).
Yakima Camps and Cabin Owners	Mitigation credits are highly subsidized by Ecology and range in price from $395-$617. The cost for those with existing junior water rights consists of three fees: 1. $37 - $220 per cabin depending on how much water is used (based on $3,643 /AF); 2. $8 - $47 for assignment of mitigation to the USBR/Ecology Storage Contract; (based on $22 /AF for 35 years); and 3. $350 contract development fee Those with no water rights must pay the above fee as well as the following: • $50 application filing fee • Public Notice (price set by newspaper) • $500 for a Report of Examination (authorizing the new use; this cost may be shared by multiple cabins in a group).
Deschutes River Conservancy Groundwater Mitigation Bank	A mitigation credit is 1 AF consumptive use. Temporary mitigation credits cost $120 credit (including the required reserve credit) and permanent credits range from $2,000-$5,000.

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