Big Sky County Water and Sewer District No. 363

Source Capacity Plan 2022 Update
Volume 1 - Report

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Western Groundwater Services, LLC
6595 Bear Claw Lane
Bozeman, MT 59715
(406) 585-5947
www.westerngroundwaterservices.com

WESTERN GROUNDWATER SERVICES

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1. INTRODUCTION

Big Sky County Water and Sewer District No. 363 (District) owns and operates Public Water System (PWS) MT0002385, serving most of Meadow Village and Mountain Village in the Big Sky Resort community (**Figure 1**). This Source Capacity Plan 2022 Update (Plan) is the third such plan prepared with the purpose of evaluating water demand, supply capacity, and source capacity improvements.[1] The goal of the plan is to identify necessary improvements that enable the District to maintain a reliable, high-quality, potable water supply within the service area.

This Plan is limited to source capacity for the public water system. It does not include an evaluation of horizontal infrastructure (pipes, booster pumps, tanks, etc.) and does not evaluate the adequacy or reliability of the system to achieve fire flows.

This Plan is also limited to the data on which it is based. Continued monitoring of supply adequacy and growth of the public water system is necessary into the future. Given the rapid growth of the Big Sky area, updates of this Plan should be prepared at five year intervals. A demand projection spreadsheet has been prepared as part of the work and can be used to assess how changes will impact supply capacity at intervals of 1-year.

1.1 SUMMARY OF FINDINGS

1.1.1 Growth Rates

- At the end of 2021, the District had permitted water supply services to 5,381.54 SFE (Single Family Equivalent). There were 3,303.54 SFE permits in Meadow Village and 2,078.00 SFE permits in Mountain Village. Using data for 2015 through 2021, there was a total SFE growth rate of 3.9%. Meadow Village was growing at a rate of 4.7% and Mountain Village at a rate of 2.6%.

1.1.2 Source Capacity

- The existing source capacity for Meadow Village includes five wells, designated MV-1 thru MV-5. The total capacity available from these wells is 975 gallons per minute (gpm). The existing source capacity for Mountain Village is supplied from seven wells, MTN-1 thru MTN-7. The effective capacity of these wells is 990 gpm.

- The DEQ source capacity standard requires groundwater supply systems to achieve the maximum day demand with the largest well out of service. Because Mountain Village can supply Meadow Village, the largest well is determined to be MTN-6 with installed capacity of 450 gpm. Consequently, the available capacity compliant with the DEQ standard for Meadow Village remains 975 gpm. For Mountain Village the available capacity is 540 gpm.

1.1.3 Water Demand

- Meadow Village in 2021 had an average daily use of 362,000 gallons per day (gpd). The maximum day use was 850,000 gpd and the peaking factor was 2.35. The unit water use rate for the average day was 114 gpd/SFE. The maximum day unit water use rate was 267 gpd/SFE.

1 Western Groundwater Services, LLC (2009) Water System Source Capacity Plan, Report to District, 6/9/2009; Western Groundwater Services, LLC (2015) Water System Source Capacity Plan Update, Report to District, 8/11/2015.

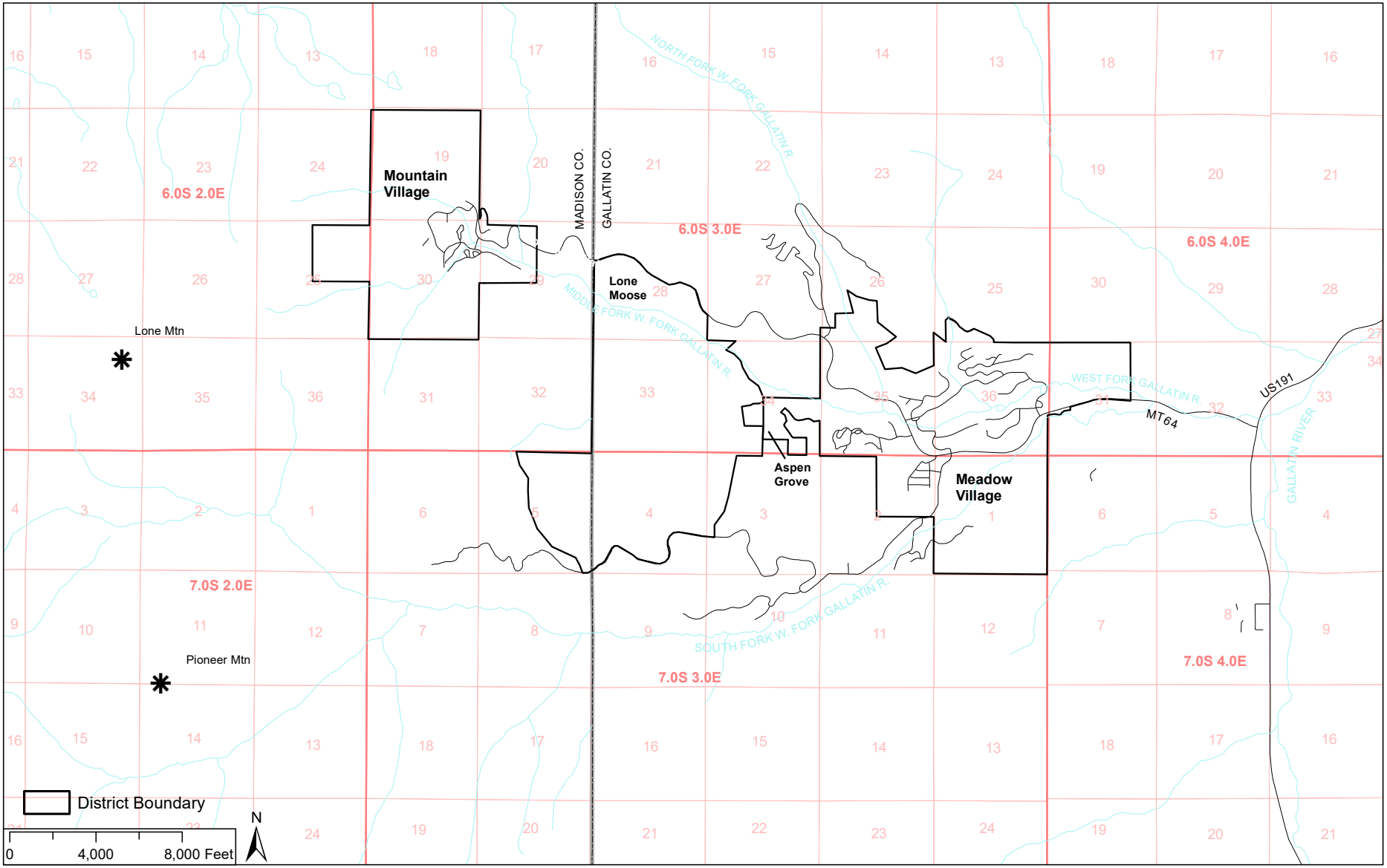

Figure 1. Service Area Map

- Mountain Village (excluding water sold to Yellowstone Club) in 2021 had an average day use of 246,000 gpd, and a maximum day use of 469,000 gpd. The peaking factor was 1.91. Mountain Village usage has declined substantially due to effective leak repairs and conservation measures. The unit water use rates were 127 gpd/SFE for average day and 241 gpd/SFE for maximum day.

1.1.4 Source Capacity Limits

- Meadow Village source capacity will become insufficient by about year 2030. The existing supply is estimated to accommodate 1,858 SFEs resulting in 5,162 SFEs for Meadow Village . There are 930 additional SFEs already committed for Meadow Village. 928 additional SFEs could be added to fully utilize the existing source capacity.

- Mountain Village (including Lone Moose and Aspen Grove) source capacity will become insufficient by about year 2038. The existing supply is estimated to accommodate 1,132 SFEs resulting in 3,210 SFEs for Mountain Village. These SFEs are already committed for service.

- Additional supply for Mountain Village can be obtained by treating wells MTN-3, MTN-5, and MTN-6, resulting in available capacity of 660 gpm. This treatment will accommodate about 740 additional SFEs, of which 413 SFEs are already committed.

1.1.5 Water Rights

- Existing water rights owned by the District can be used to permit additional source capacity beyond the present supply. Meadow Village water rights for alluvial aquifer wells have additional volume of about 366 acre-feet that can be used to permit new source capacity. Mountain Village water rights for bedrock aquifer wells have additional volume of about 561 acre-feet that can be used to permit additional capacity. It may be necessary to file for new beneficial use to increase the maximum rate of withdrawal, however, these filings would not add new volume, and therefore would not create new depletion of surface water.

1.1.6 Water Conservation

- The District can realize significant water use reductions, mostly in Meadow Village, by restricting irrigation use of potable water to no more than 500 square-feet. This restricition should be phased in over a few years for existing properties, but shoud be immediately implemented for new property development. It should apply to all land use types. Non-mandatory conservation measures may be included, however, these have been shown to have minimal participation in many conservation programs across the country and would not result in useful water savings for the District.

1.1.7 Groundwater Development

- There is limited opportunity for new groundwater development in Meadow Village. The Meadow Village aquifer in the vicinity of the District's existing wells may have additional capacity for one or two new vertical wells with combined total capacity of 200- to 400-gpm.

- There is limited opportunity for new groundwater development in Mountain Village as determined from 10 test wells that were constructed from 2019 to 2021. There appears to be additional groundwater capacity that could be developed in the vicinity of the Thunder Wolf chairlift. However, iron and manganese treatment of the water is likely to be necessary and water right permitting may

be difficult due to proximity of the well sites to the Middle Fork channel.

1.1.8 Other Source Capacity Development Options

- Development of surface water from the Gallatin River mainstem is a source of supply that is accessible to the District. Surface water could be developed with offset of depletions by discharge of treated effluent. Permitting of this source for either water rights or discharge is considered difficult and may not be feasible.

- Direct potable reuse of treated effluent as a source of supply to the public water system may be a viable source of supply. This water use also provides discharge of treated effluent. There are governmental and societal difficulties anticipated for this source development.

1.1.9 Preferred Alternatives and Costs

- The preferred alternatives for improvements to the public water system include: 1) conservation by restriction of irrigation ($0); 2) test well drilling in the Meadow Village aquifer ($110,000); 3) Direct Potable Reuse Engineering Study ($50,000); 4) well water level sensor installations ($270,000); 5) water right filings for changes to Place of Use (District Service Area) and Type of Use (Municipal) ($30,000); and 6) Mountain Village Hydraulic Improvements Engineering Study ($30,000). The total budget estimate for these alternatives is approximately $490,000.

1.1.10 Meadow Village Capacity Improvements and Timelines

- The District should implement conservation measures to reduce irrigation use in 2022. Reduced irrigation could save about 400 gpm by 2042 and enables the District to defer the need for new capacity development by about 5-years. Meadow Village test wells are not required until about 2030, with new production wells being constructed and put into service by 2035, assuming 250 gpm of new capacity (125 gpm per well). Direct potable reuse of 150 gpm is required by 2040. These timelines and estimated capacities would enable Meadow Village to meet demand through 2042.

2. GROWTH RATE PROJECTION

The District defines a Single Family Equivalent (SFE) as the unit of measure for services. Each connection is assigned an SFE quantity based on living space and associated water uses. On average over all account types, there are 2.00 SFE per account.[2] Considering only residential accounts, the average is 1.8 SFE per account. SFE data were used to establish unit water use rates (quantity of water per SFE) and also to estimate growth rate within the service area. The data used for these analyses were limited to the period from 2015 to 2021, as these years are expected to provide the most relevance to current conditions.

The District provides wastewater-only services to the Spanish Peaks subdivision. These SFEs were excluded from the data used for growth rate analysis. The Spanish Peaks subdivision is within the Meadow Village service area.

The District data include a tabulation of net SFE added for each permit, and are recorded by account and date. These data were summed over all accounts annually to obtain total SFE values (excluding Spanish

2 Calculated from the District "Sewer Users Billing Master" data file.

Peaks subdivision).[3] SFEs were tabulated according to subdivisions and each subdivision was assigned to either Mountain- or Meadow-Village. Growth rate estimates were made based on the annual totals (**Figure 2**).

Growth rates were calculated by fitting an exponential function (steady growth model) to the SFE data. Total annual growth rate was estimated at 3.9%. A slightly higher growth rate was estimated for Meadow Village, at 4.7%, and a slightly lower growth rate was estimated for Mountain Village, at 2.6%.

At the end of 2021, there were a total of 5,381.54 SFE permitted, with 3,303.54 (61%) in Meadow Village, and 2,078.00 (39%) in Mountain Village. The distribution of SFEs by use was approximately 79% residential and 21% commercial.

There is about an 18-month lag time for the construction to occur before the new SFE is actually using water. With consideration of lag time, at the end of 2021 there were an estimated 3,183 SFE in Meadow Village, 1,983 SFE in Mountain Village, and a total for the service area of 5,166. This lag time is factored into determining the unit water use rates.

For the purpose of source capacity planning, this version of the Plan is using a 20-year growth period ending in 2042. SFE forecasts were based on the steady-growth models fit to the SFE data for the period 2015 through 2021 (**Figure 3**). In year 2042, Meadow Village is estimated at 9,065 SFE and Mountain Village at 3,561 SFE.[4]

As shown, the 75% confidence limits expand beyond the data used to fit the model, which ended in 2021. The low end of the confidence limit, if it were to occur, would reflect a reduction in growth rate. The high end is controlled by the District and therefore is not unavoidable. It would only occur if the District was able to determine adequate service capacity was available to accommodate the SFEs. SFE forecasts are also provided at five year intervals in **Table 1**.

Table 1. SFE Forecasts

Year	Meadow Village	Mountain Village	District Total
2025	4,083	2,291	6,374
2030	5,162	2,608	7,770
2035	6,527	2,969	9,497
2040	8,253	3,381	11,634
2042	9,065	3,561	12,626

2.1 Undeveloped SFEs with Committed Service

Undeveloped SFEs with committed service are summarized in **Table 2**. A discussion of these SFE allocations is provided below.

Based on county parcel data within the District service area there are 161 vacant lots in Madison County (Mountain Village) and 180 vacant lots in Gallatin County (Meadow Village). These lots occur in platted subdivisions and have committed service from the District. On average, there are about 2.0 SFE per lot,

3 Calculated from the District "Permits" data file.

4 These projections are based on the data and model used. Use of other data and models can result in different projections.

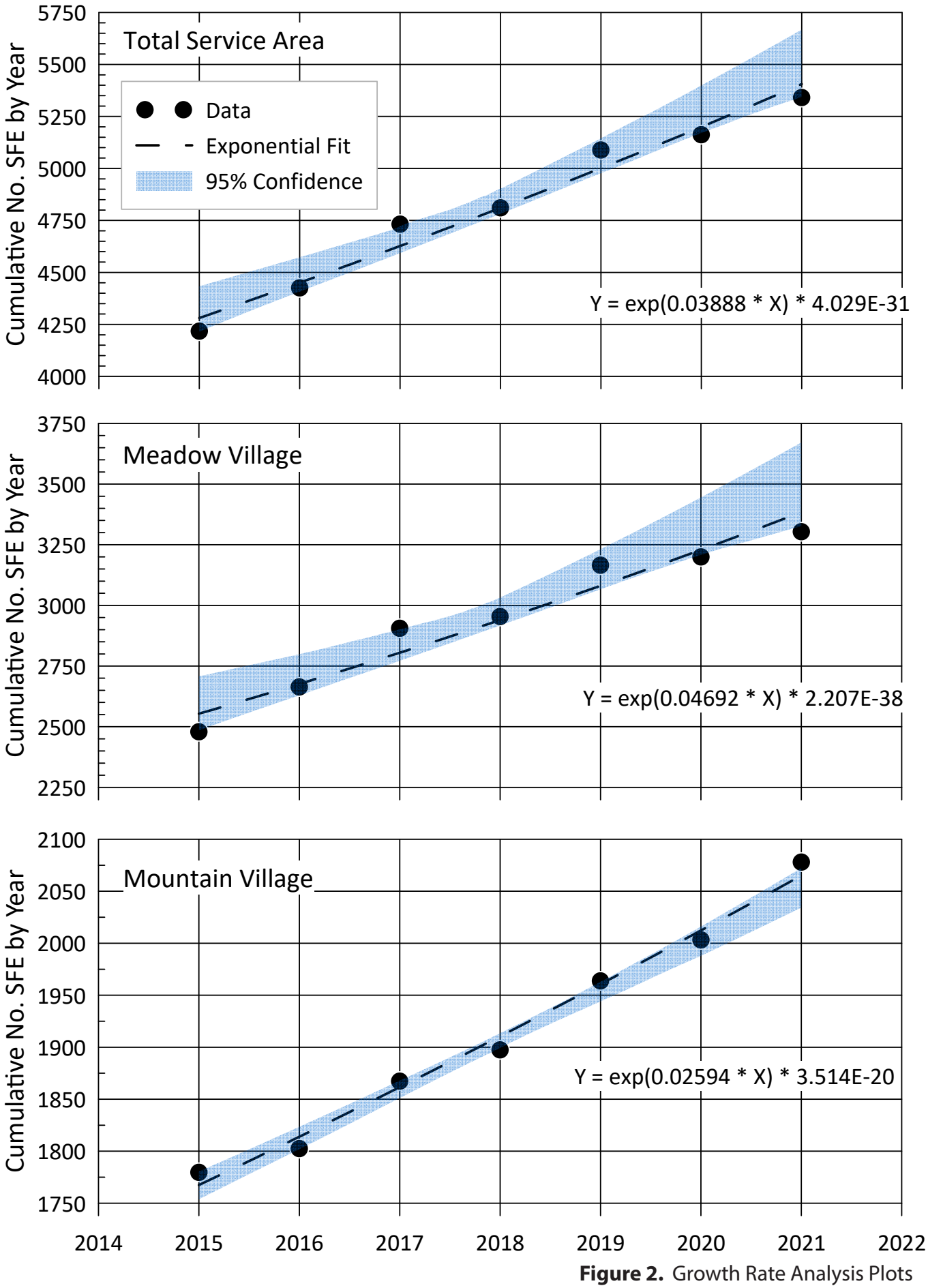

Figure 2. Growth Rate Analysis Plots

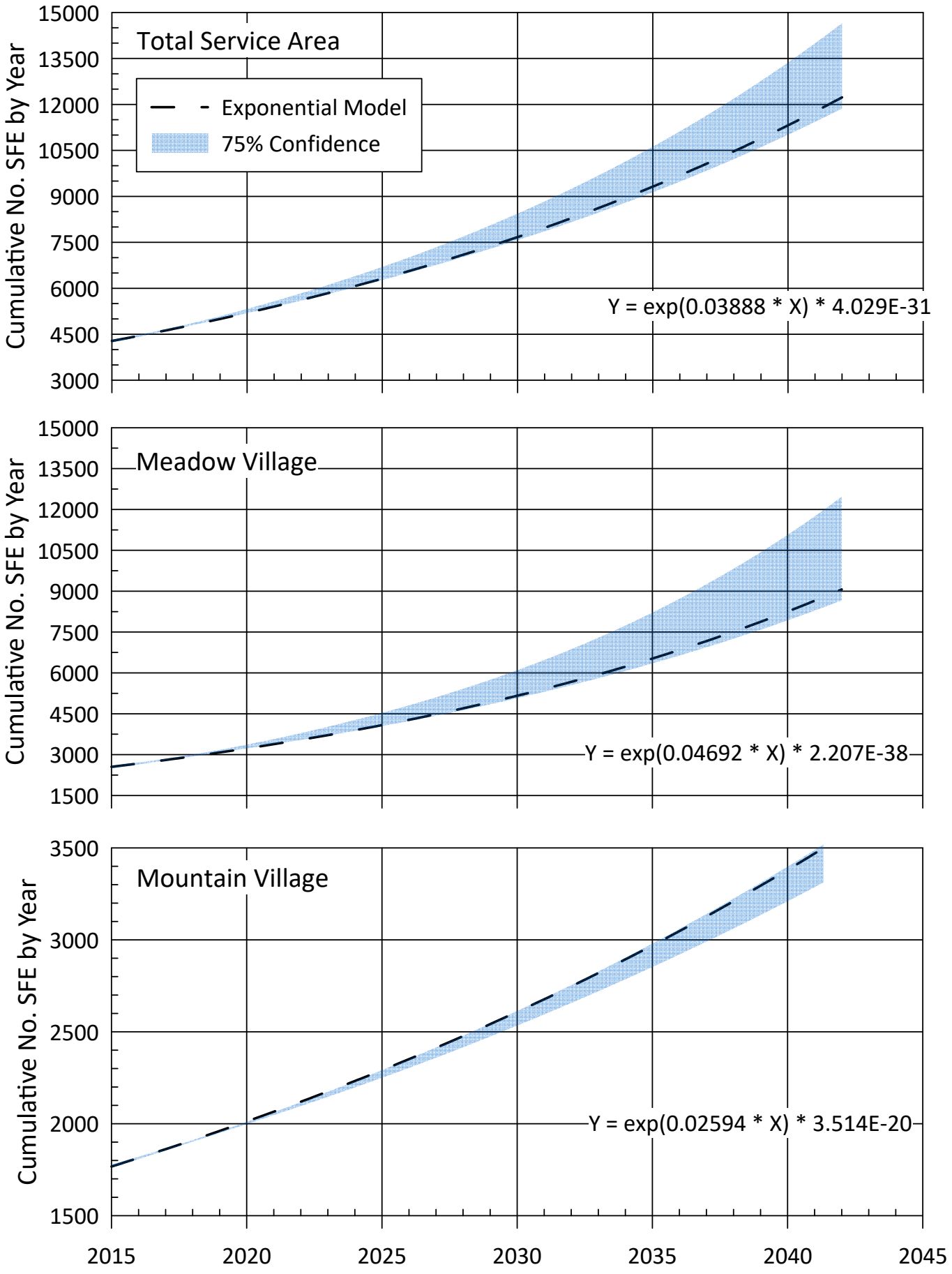

Figure 3. Growth Projection Plots

resulting in an estimated 322 SFE that are committed for Mountain Village and 360 SFE that are committed for Meadow Village.

Lone Moose Meadows condominiums also are only partially developed and have additional SFEs with committed service. The agreement for services with the District (August 1, 2003) identifies a total of 76.80 SFEs corresponding to 48 units. Presently, there are 40.85 SFEs in service, leaving 35.96 SFEs that will connect when the 48 units are completed. There are 28 units in service at this time and 20 units that can be constructed in the future. The additional SFEs for Lone Moose will add to the Mountain Village total.

There is an agreement (March 29, 2001) for sewer services to Lone Moose that provides for the equivalent of 900 SFEs of discharge to the District's wastewater treatment plant, but does not commit the District to providing potable water supply. The agreement specifies that Lone Moose will be able to discharge 38.3 million gallons of sewage per year to the treatment plant and actually does not designate SFEs.

Big Sky Resort, LLC has an SFE pool presently estimated at 600 SFE. These SFE are allocated to Mountain Village and provide water and sewer service commitments. Big Sky Resort, LLC also has SFEs for undeveloped platted subdivision lots that are additional to the 600 SFE. These are included in the Platted Subdivisions tally. Town Center Phase II LLC has 569.44 SFEs allocated for both water and sewer services. These SFEs apply to Meadow Village. Big Sky Community Housing Trust, Inc. has 587 SFEs for water and sewer services. These SFEs are allocated to Mountain Village.

Existing source capacity (see below) for Meadow Village can accomodate 1,858 additional SFEs, including 930 SFEs that are presently committed, and 928 SFEs that are uncommitted at this time. Mountain Village source capacity (see below) can accomodate 1,132 SFEs prior to treatment of wells MTN-3, MTN-5, and MTN-6. With treatment of these wells in place an additional 740 SFEs may be served, bringing the total to 1,872 SFEs. Of this total, 1,545 SFEs are committed, and 327 SFEs are uncommitted. The uncommitted 327 SFEs are not available until treatment of the wells is completed.

Table 2. Undeveloped SFEs with Committed Service

Description	Water SFEs	Sewer SFEs
Meadow Village		
Platted Subdivisions	360	360
Town Center Phase II	570	570
TOTAL	930	930
Mountain Village		
Platted Subdivisions	322	322
Lone Moose Condominiums	36	39
Lone Moose Sewer Only	0	900 (approx.)[A]
Big Sky Resort LLC	600	600
Big Sky Comm. Housing Trust Inc.	587	587
TOTAL	1545	2445
[A] Equivalent SFEs are shown; committed service is for 38.3 Mgal/yr.		

3. WATER SUPPLY SOURCES

This section documents the water supply sources and how they are used in the water system. The information is presented with respect to Meadow Village and Mountain Village. Well logs for the supply wells are provided in **Appendix A**.

3.1 Meadow Village

The Meadow Village system includes the entire Meadow Village area and the Hidden Village subdivision. The District primarily operates wells MV-1, MV-2, and MV-3 in Meadow Village (**Figure 4**, **Table 3**). Wells MV-4 and MV-5 are not presently needed on a regular basis for the current demand, however, both wells will be used more frequently as demand increases. The Meadow Village total source capacity is 975-gpm. Production rates for wells MV-1, MV-2, and MV-3 were determined from meter data. The rates for MV-4 and MV-5 are based long-term pumping rates observed in the SCADA system by District staff.

Table 3. Meadow Village Well Capacities

Well ID	Instantaneous Rate (gpm)	Annual Volume (afy)
MV-1 (F, L, S)	250	403
MV-2 (F, S)	230	371
MV-3 (F, S)	95	153
MV-4 (F, S)	200	323
MV-5 (F, S)	200	323
Total	975	1,573
gpm – gallons per minute; F – flow meter installed; L – water level sensor installed; S – monitored through the Supervisory Control and Data Acquisition (SCADA) system.		

The DEQ source capacity standard for groundwater is maximum day demand with the largest well out of service. Because Meadow Village can be supplied from Mountain Village, the largest well on the system is presently MTN-6 located in Mountain Village (a future split of the Mountain Village system would result in well MTN-1 being designated the largest well). Therefore, the Meadow Village system is credited with the total well capacity of 975 gpm to achieve the maximum day demand.

There are six additional wells in Meadow Village that are not in use, but have been approved for use in the public water system. The Hidden Village (HV #1, HV #2) and Aspen Grove (AG #1, AG #2, AG #3) wells have been used for supply in the past. The Blue Grouse (BG) well is approved as a public water well, but it has not been approved as a completed well and does not have a water right. These wells are not considered in this Plan as water supply sources. The associated water rights, however, are planned for use with additional diversions consisting of either new or existing wells (as discussed in a section below). The District could consider abandoning these wells to avoid maintenance costs.

The Meadow Village water system includes three operating storage tanks with a total storage volume of 1.3M gallons. These include the Hidden Village (1M gal) and Sweet Grass tanks (250K and 50K gal). These tanks are filled directly from the Meadow Village distribution system. The Aspen Grove tank (260K gal) is filled from the Mountain Village pipeline and provides storage within the Aspen Grove subdivision.

Meadow Village wells MV-1 through MV-5 are equipped with ultra-violet (UV) disinfection treatment to achieve 99.99% virus inactivation (also referred to as 4-log), meeting the requirements for full-time microbial

Figure 4. Meadow Village Wells and Tanks

treatment of groundwater. UV treatment is operated only when wells MV-4 and MV-5 are in operation. Under this condition, which corresponds to peak demand, the five Meadow wells (MV-1 thru MV-5) are treated with UV disinfection. Off-peak supply is provided from wells MV-1 through MV-3 without UV disinfection as these wells are approved for use without treatment requirements. There are dual treatment trains to provide redundancy. Each train is rated for 995 gallons per minute. The UV facility is located at the west end of Spotted Elk Road in Meadow Village

3.2 Mountain Village

The Mountain Village system includes the entire Big Sky Resort area, Lone Moose condominiums, and Aspen Grove subdivision, and also sells water to Yellowstone Club. The District routinely operates wells MTN-1, MTN-2, MTN-4, and MTN-7 in Mountain Village (**Figure 5**, **Table 4**). Wells MTN-5 and MTN-6 are rarely used due to poor aesthetic quality caused by naturally occurring hydrogen sulfide gas odor. Well MTN-3 is not being presently used due to recurring coliform detections. As discussed below, wells MTN-3, MTN-5, and MTN-6 can be treated to enable regular use of these sources. The Lone Moose wells LM-1 and LM-2 provide supply only to Lone Moose condominiums (**Figure 6**).

The presently installed pumping capacities are based on observed rates of discharge from the wells obtained from SCADA and prior testing.[5] The effective rates are based on the actual well usage for the current system, where well MTN-6 is only being used as the largest well and otherwise is not used to supply water to the system -- it could be used in an emergency. The recommended pumping rates are adjusted rates based on recent pumping tests for wells MTN-3[6], MTN-5, MTN-6[7], and wells LM-1 and LM-2[8] and apply only when these wells are put into regular service. Annual volumes are the volume of water produced by continuous operation of the well except for wells MTN-5, MTN-6, LM-1 and LM-2. These wells are in flow limiting aquifers and the volumes are based on aquifer modeling of drawdown over a five year period.

Additional hydraulic analysis of MTN-5 was completed based on pumping during snowmaking in the 2021 – 2022 ski season (**Appendix B**). This analysis generally confirmed the design rate of 110 gpm (a rate of 98 gpm was estimated), and that a larger annual volume of 140 acre-feet per year may be feasible.

5 Morrison-Maierle, Inc. (1986) Aquifer Tests with Report of Results, Mountain Village Wells No. 1, 2, and 3, prepared for Lone Mountain Springs Water Company, February 28, 1986. The Hill booster clear well was accurately measured at 10.66 by 22.72 feet horizontal area, and volume of 1811.62 gallons per foot as part of this work.

6 Western Groundwater Services, LLC (2017) Mountain Village Well No. 3 Rehabilitation Report, report to Big Sky County Water and Sewer District No. 363. (Appendix B)

7 Western Groundwater Services (2018) Mountain Wells #5 and #6 Video Log and Pump Testing Report, prepared for Big Sky County Water and Sewer District No. 363. (Appendix B)

8 Western Groundwater Services (2009) Lone Moose Meadows Well No. 1 Pumping Test Report, prepared for Big Sky County Water and Sewer District No. 363. (Appendix B)

Figure 5. Mountain Village Wells, Tanks and Booster Stations

Figure 6. Lone Moose Wells and Tank

Table 4. Mountain Village Well Capacities

Well ID	Installed Rate (gpm)	Effective Rate (gpm)	Recommended Rate (gpm)	Annual Volume (afy)
MTN-1 (F[A])	250	250	250	403
MTN-2 (F[A])	95	95	95	153
MTN-3 (F[A])	115	0	150	242
MTN-4[B] (F, S)	100	100	100	161
MTN-7[C] (F, S)	205	55	55	89
MTN-5 (F)	180	0	110	140
MTN-6 (F)	450	450	110	60
LM-1, LM-2 (F, S)	100	40	40	25
Total	1495	990	910	1274

gpm – gallons per minute; afy – acre feet per year; F – flow meter installed; L – water level sensor installed; S – monitored through the Supervisory Control and Data Acquisition (SCADA) system.
[A] Flow metering of these wells occurs as a combined total through the Hill booster station flow meter. The Cascade booster station also is equipped with a discharge flow meter.
[B] MTN-4 and MTN-7 rates are for sustained simultaneous pumping.
[C] MTN-7 production up to 150 gpm (7-day average) is dedicated to Yellowstone Club.
Mountain Village Subsystems

3.2.1 Future Split System

In order to make all of the Mountain Village wells functional, water treatment is necessary for wells MTN-3, MTN-5, and MTN-6. This improvement is required to meet water demand beyond approximately year 2038 as discussed in a later section of the report.

Based on the existing piping layout, treatment feasibility requires the Mountain Village system be split into two subsystems (**Figure 7**).[9] The lower Resort Area system would be supplied by wells MTN-1, MTN-2, MTN-4, and MTN-7 and will remain untreated. Wells LM-1 and LM-2 would also provide untreated supply to the Lone Moose condominiums. The Resort Area system would also provide untreated supply to Yellowstone Club. Storage for the Resort Area would use the recently refurbished 500K gallon Mountain Village tank.

The upper Cascade system would be supplied by wells MTN-3, MTN-5, and MTN-6 that would be treated at a new facility located at the Cascade booster station. Treatment would include removal of sulfide odor and 4-log virus disinfection. This system would serve existing and new services that connect to the distribution system above the Cascade booster station. The Cascade system would use the 1.5M gallon Cascade Tank.

There would be interties between the Resort Area and Cascade systems to enable supplemental supply from one to the other. The DEQ standard for maximum day demand with the largest well out of service would designate well MTN-1 as the largest well for both systems. **Table 5** summarizes the wells and capacities for the split systems.

In the immediate future, the District can make hydraulic improvements to reduce pumping costs and to facilitate the future intertie between the two systems. These improvements are a recommendation of the Plan are and detailed in a later section.

9 The two systems are different pressure zones within the same single water system operated by the District. The split system does not create a new water system with respsect to DEQ designations.

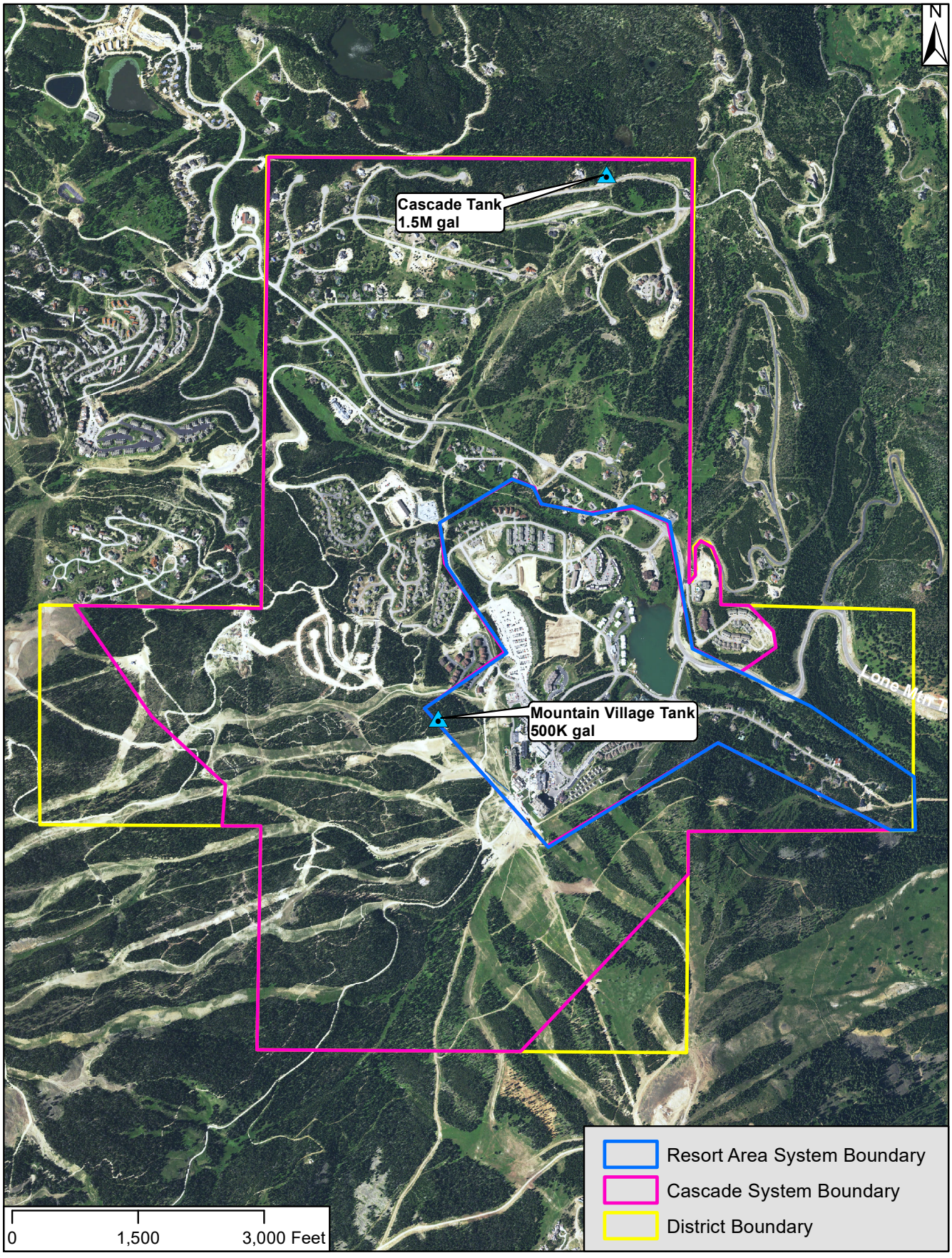

Figure 7. Resort Area and Cascade Systems (Future)

Table 5. Well Capacities for Resort Area and Cascade Systems (Future)

	Resort Area	Cascade
Well ID	Rate (gpm)	Rate (gpm)
MTN-1	250	
MTN-2	95	
MTN-3		150
MTN-4	100	
MTN-7	55	
MTN-5		110
MTN-6		110
LM-1, LM-2	40	
Total	540	370
Total (DEQ)[A]	290	370
[A] Assumes the largest well MTN-1 is out of service.		

3.2.2 Mountain Village Booster Pumping Stations

The existing Mountain Village system uses two booster pumping stations to lift water to the elevation of the 1.5M gallon Cascade tank (Hill and Cascade boosters). Most of this water then returns to the Resort Area part of the system via a series of pressure reducing valves. Splitting of the Mountain Village system into the Resort Area and Cascade systems eliminates the additional pumping of Resort Area water (including Lone Moose, Aspen Grove, and Yellowstone Club) with a cost savings from reduced electrical power use. The Hill booster pumping capacity is presently 750 gpm, while the Cascade booster has a maximum rate of about 850 gpm. These rates are sufficient for the existing water use beyond the present planning period of 2042.

3.2.2.1 Cascade Meter Evaluation July 2022

Flow metering data for the Cascade booster station were confirmed by installing a portable ultrasonic flow meter at the booster station for the period from July 7 to July 18, 2022.[10] The lay length for the ultrasonic meter was not ideal, but generally acceptable (three diameters upstream and two diameters downstream). The setup and calibration of the meter were underestimating sonic velocity, suggesting some deviation from an ideal configuration (sonic velocity was manually corrected based on the values of a water temperature chart provided by the manufacturer).

Over the period of seven days, the ultrasonic meter consistently measured slightly lower flow than was measured by the permanently installed meter of the booster station. The deviation ranged from 5.1% to 7.2%, or about 18,500- to 39,000-gallons per day. Daily pumped volume ranged from 326,000- to 512,000-gallons. The maximum daily flow rates measured by the ultrasonic meter were 11- to 26-gpm below the reported maximum from the SCADA system. The ultrasonic meter data do not indicate there is a significant error in the Cascade meter. The ultrasonic meter in this application is not considered to be more accurate than the Cascade meter--either one could be found to be closer to the actual flow rate.

10 The Siemens FUP1010 meter was furnished and installed by Western Groundwater Services, LLC. It was mounted in direct (minimum) mode onto 8-5/8 inch diameter schedule 40 steel pipe, and used Universal D2 transducers. It was battery powered for the duration of testing. Rate and volume readings were recorded to memory at 1-minute intervals. The meter data have been provided to the District in Excel format.

3.3 Flow and Level Monitoring

The five active wells in Meadow Village (MV-1 thru MV-5) are equipped with flow meters connected into the SCADA system. With the exception of well MV-1, these wells do not have water level instruments. One of the improvements identified in this Plan is to install pumping water level sensors in these wells, and to have these data monitored and archived through the SCADA system.

Flow metering of the Mountain Village wells includes MTN-1, MTN-4 and MTN-7. The Hill and Cascade booster stations also are both equipped with discharge flow meters. Flow rate data from these meters are monitored and archived in the SCADA system. Pumping water level data are not available for any of the Mountain Village wells. One of the improvements identified would install water level sensors for each well (MTN-1 thru MTN-7) with monitoring and archive of these data through the SCADA system. The District is in the process of installing meters on wells MTN-5 and MTN-6, and is encouraged to install meters on MTN-2 and MTN-3 as/when feasible in the future.

4. WATER USE AND DEMAND PROJECTION

This section presents water use data collected through the SCADA system. Data were reviewed from 2014 through 2021. Unit water use rates per SFE are developed from these data and then applied to the SFE growth rates to estimate future water demand.

4.1 Meadow Village

Meadow Village is experiencing increasing water use over the past three years (**Figure 8**). Summary statistics for the period from 2014 through 2021 are provided in (**Table 6**). Maximum water use for this period occurred in year 2021 and totaled 362,000 gpd and 406 afy. This total annual water use is well below the water rights volume of 1,554 afy. Maximum day in 2021 was 850,000 gpd, or equivalently 590 gpm, resulting in an estimated peaking factor of 2.35. The maximum day demand was 61% of installed source capacity (975 gpm).

For demand projection, the key parameters are the unit water use rates for average day demand (ADD/SFE) and maximum day demand (MDD/SFE). The SFEs for 2020 and 2021 are adjusted for lag time to reflect actual SFEs using water. The lag time occurs for the period of construction after the SFE permit is approved. 50% of the 2020 SFEs were used and 0% of the 2021 SFEs were used in assessing these unit water use rates. The 90th percentile values estimated from these data (years 2014 – 2021) are used in future demand projections.

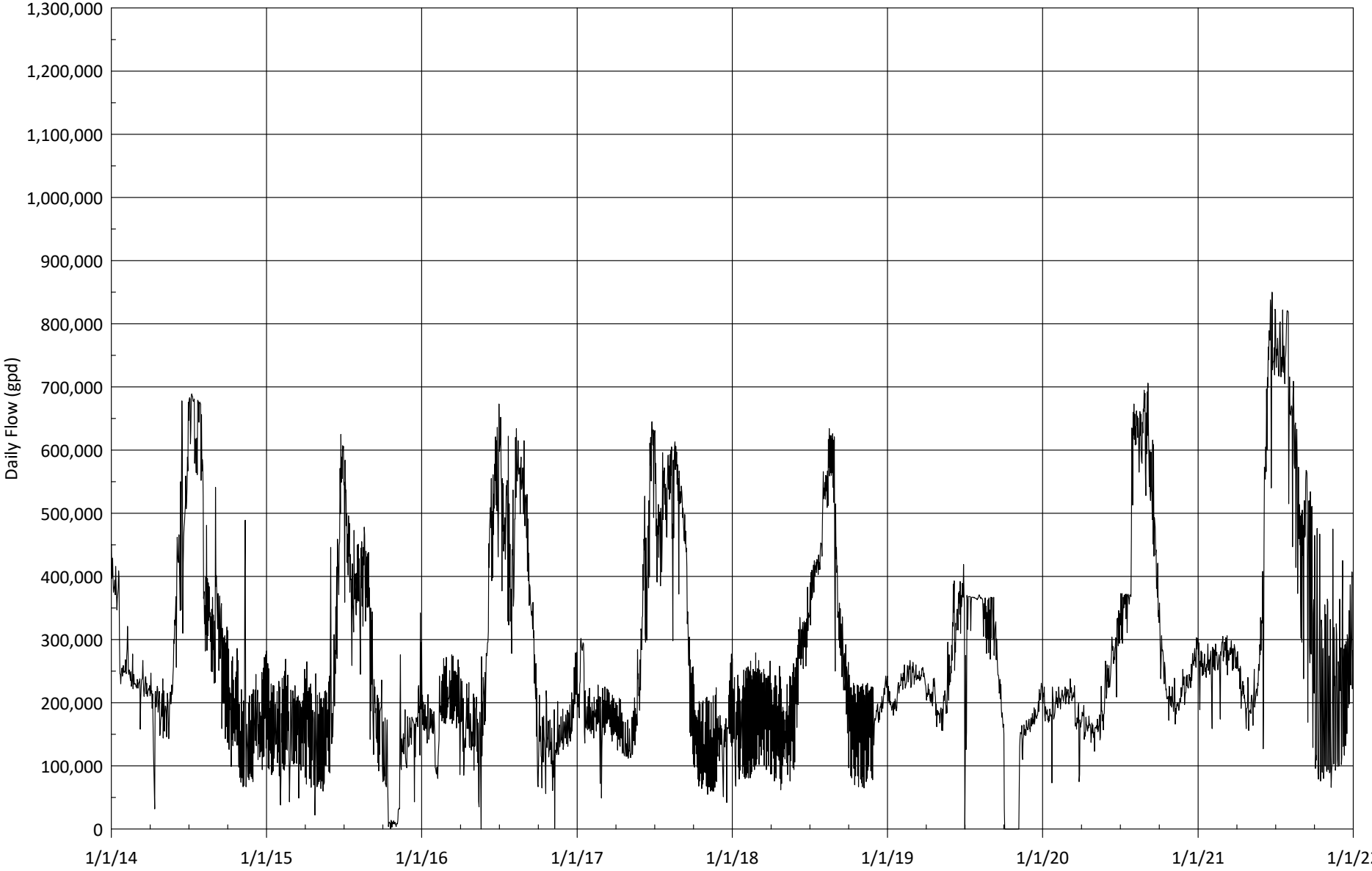

Figure 8. Meadow Village Water Use History

Table 6. Meadow Village Water Use Summary, 2014-2021

Year	ADD gpd	ADD afy	MDD gpd	MDD gpm	PF	SFE	ADD/SFE gpd/SFE	MDD/SFE gpd/SFE
2014	294,462	330	689,000	478	2.34	2363.28	125	292
2015	210,829	236	625,000	434	2.96	2478.93	85	252
2016	264,706	297	673,000	467	2.54	2663.89	99	253
2017	268,468	301	645,000	448	2.40	2905.56	92	222
2018	245,276	275	634,000	440	2.58	2954.08	83	215
2019	225,192	252	419,000	291	1.86	3165.72	71	132
2020	286,287	321	706,000	490	2.47	3182.77	90	222
2021	362,232	406	850,000	590	2.35	3182.77	114	267
						90th Percentiles	**117**	**274**

ADD – average day demand, gallons per day (gpd) and acre-feet per year (afy); MDD – maximum day demand (gpd, gpm); PF – peaking factor, MDD/ADD; SFE – single family equivalent. Unit water use rates for future demand projection shown in **Bold**.

Future water demand was estimated by applying unit water use rates to SFE growth projections (**Table 7**). The ADD value is presented in annual acre-feet so that it can be directly compared to water right volume. Meadow Village annual water use is projected to remain less than the water rights volume until sometime after 2042. The MDD value is presented in gallons per minute to provide direct comparison to installed pumping capacity.

These data show that by 2030 (2032 with SFE construction lag time adjustment), the installed pumping capacity of Meadow Village wells will likely be insufficient to meet maximum day demand (**Figure 9**). The existing supply can accommodate approximately 1,858 additional SFEs, which includes 930 SFEs for which service is committed and 928 new SFEs. These SFEs bring the Meadow Village total to 5,162, a 50% increase in service population from 2021.

Table 7. Meadow Village Water Demand Projection, 2025-2042

Year	SFE	ADD afy	MDD gpm
2025	4,083	535	778
2030	5,162	677	984
2035	6,527	856	1244
2040	8,253	1082	1573
2042	9,065	1189	1727

SFE – single family equivalent; ADD – average day demand, acre-feet per year (afy); MDD – maximum day demand, gallons per minute (gpm)

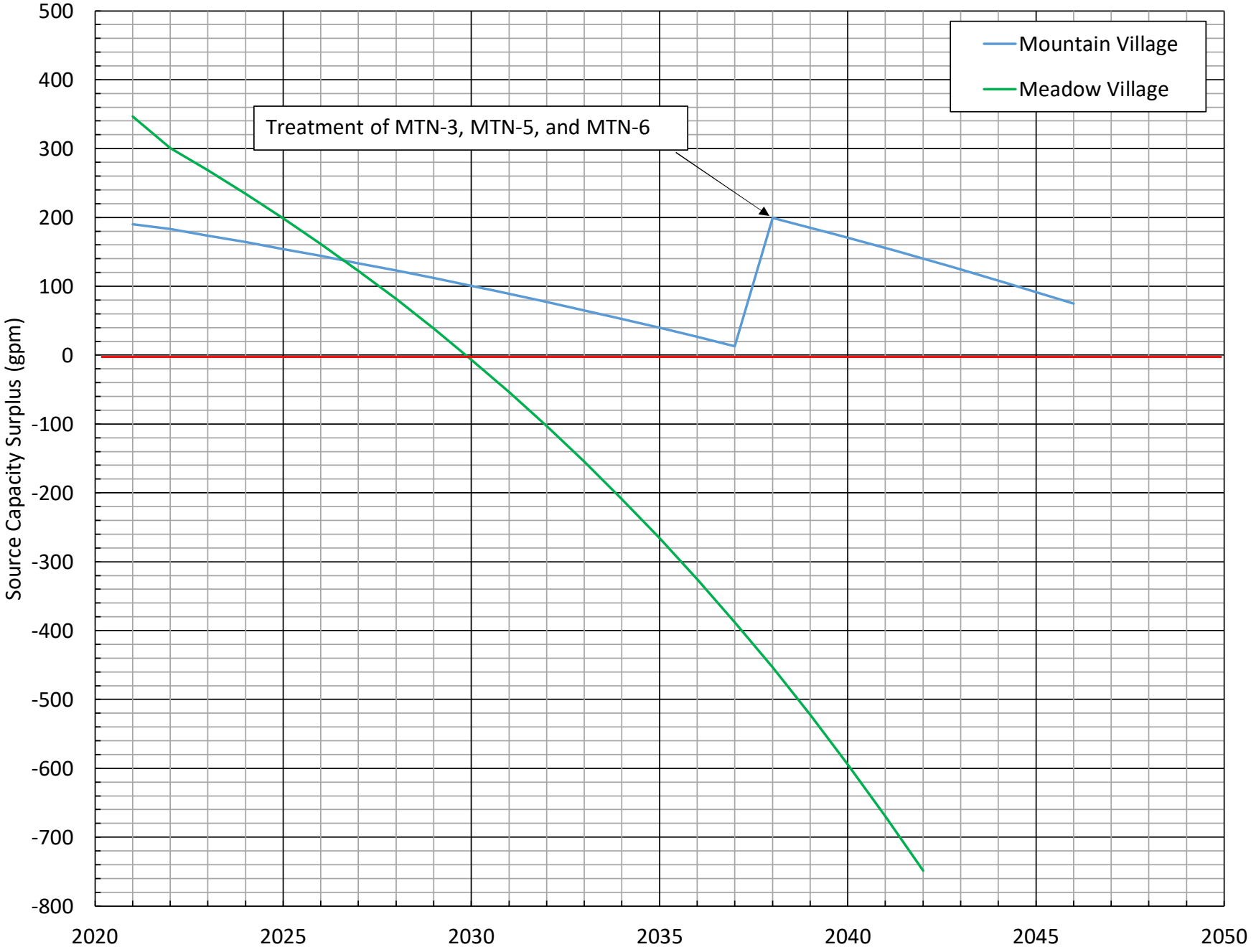

Figure 9. Source Capacity Surplus Projection

4.2 Mountain Village

Mountain Village water use has been declining for the past several years (**Figure 10)**. The plotted data are from the Cascade booster station flow meter, which is a total production measurement including the water that served Lone Moose condominiums, the Aspen Grove subdivision, and that is sold to Yellowstone Club. Summary data for this same period, but excluding water sold to Yellowstone Club (YC), generally indicate the same declining trend, with 2019 being a slight exception (**Table 8**). The declining trend is attributed to effective leak detection and repair, and conservation measures.

Usage data for 2021 indicates a total volume for Mountain Village, including Lone Moose condominiums and the Aspen Grove subdivision, of 276 afy. This annual volume is substantially less than the permitted water right volume. There is some additional volume related to snowmaking that may reach about 60 afy, bringing the total use to about 336 afy for Mountain Village. This annual volume does not include any of the water sold to YC which also includes additional water rights.

Maximum day demand trends from a peak in 2014 of 717 gpd/SFE to a low in 2021 of 241 gpd/SFE. The maximum day demand realized in 2021 had a pumping rate of only 326 gpm. For the purpose of projecting future water demand, the 2021 unit water use rates are used directly for future demand projection. Water demand for selected years to 2042 are provided in **Table 9**.

The existing Mountain Village source capacity, excluding supply from wells MTN-3, MTN-5, and MTN-6 can provide 540 gpm of capacity (using well MTN-6 as the largest well). This includes 55 gpm from well MTN-7 and assuming a sustainable rate of 40 gpm for the Lone Moose wells. This capacity will meet the maximum day demand of Mountain Village until year 2038 (**Figure 9**), accommodating 1,132 additional SFEs, all of which are committed, and bringing the total Mountain Village SFEs to 3,210, a 40% increase in population as compared to 2021.

Additional source capacity for supply beyond 2038 can be obtained by providing water treatment of wells MTN-3, MTN-5, and MTN-6. This additional supply would accommodate 740 SFEs, which would be fully developed in about year 2046. These additional SFEs include 413 SFEs that are already committed and 327 new SFEs. When these wells are treated, a rate reduction for well MTN-6 results in well MTN-1 becoming the largest well. Consequently, the installed capacity would be 910 gpm and the capacity with the largest well out of service would be 660 gpm.

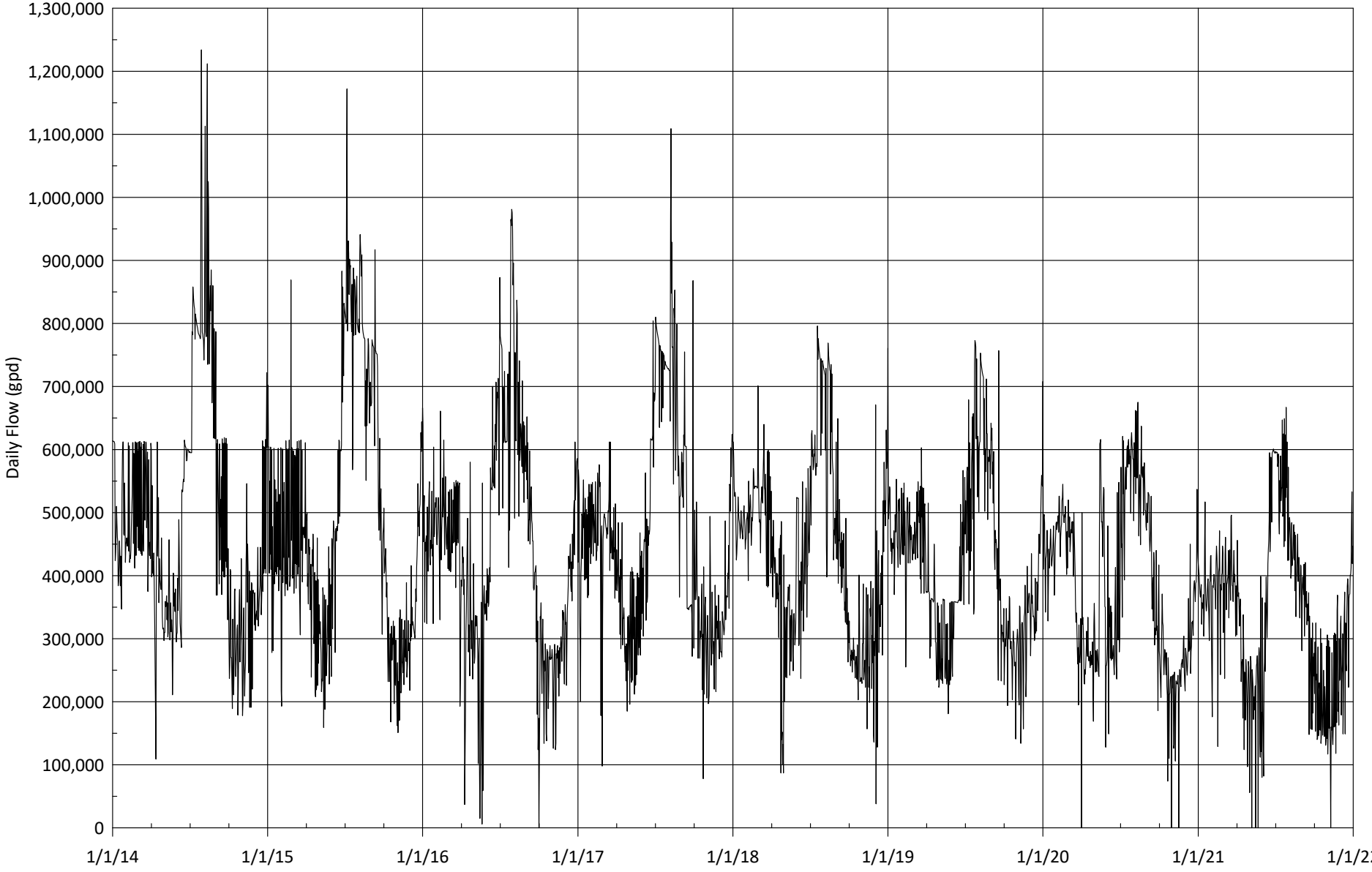

Figure 10. Mountain Village Water Use History

Table 8. Mountain Village Water Use Summary, 2014-2021

Year	ADD gpd	ADD afy	MDD gpd	MDD gpm	PF	SFE	ADD/SFE gpd/SFE	MDD/SFE gpd/SFE
2014	426,352	478	1,234,000	857	2.89	1722.16	248	717
2015	351,077	393	927,000	644	2.64	1738.83	202	533
2016	299,656	336	676,000	469	2.26	1761.67	170	384
2017	293,828	329	727,000	505	2.47	1826.45	161	398
2018	295,064	331	597,000	415	2.02	1856.57	159	322
2019	294,436	330	664,000	461	2.26	1922.89	153	345
2020	278,994	313	568,000	394	2.04	1942.61	144	292
2021	246,185	276	469,000	326	1.91	1942.61	**127**	**241**

ADD – average day demand, gallons per day (gpd) and acre-feet per year (afy); MDD – maximum day demand (gpd, gpm); PF – peaking factor, MDD/ADD; SFE – single family equivalent. Unit water use rates for future demand projection shown in **Bold**.

Table 9. Mountain Village Water Demand Projection, 2025-2042

Year	SFE	ADD afy	MDD gpm
2025	2,291	325	384
2030	2,608	370	437
2035	2,969	422	498
2040	3,381	480	567
2042	3,561	506	597

SFE – single family equivalent; ADD – average day demand, acre-feet per year (afy); MDD – maximum day demand, gallons per minute (gpm)

4.2.1 Resort Area and Cascade Systems (Future)

The Resort Area and Cascade systems may be created in the future in relation to adding water treatment for wells MTN-3, MTN-5, and MTN-6. Hydraulic improvements may also be made in the immediate future to reduce pumping costs and to begin utilizing the 500K Mountain Village storage tank.

SFE distribution in 2021 to the Resort Area and Cascade systems is approximately 1,140 SFE and 938 SFE, respectively. This distribution was determined by allocating SFEs to subdivisions and other selected properties that would be served through the Cascade system. The Cascade SFEs were then subtracted from the Mountain Village total SFE to obtain the Resort Area system SFEs. For growth projection, it was assumed the Resort Area may realize 200 new SFE over the planning period to 2042, with the remainder of the projected growth, or 1,283 SFE, being added to Cascade.

Water demand projections for the Resort Area and Cascade systems are provided in **Table 10**. Well capacities of existing wells with respect to both rate and annual volume are satisfactory to meet the demands in year 2042, indicating there are no new source capacity requirements through this planning period. It is necessary, however, to make improvements for treatment of wells MTN-3, MTN-5, and MTN-6, and this work will include pumping equipment replacements.

Table 10. Resort Area and Cascade Demand Projections

Year	SFE	ADD afy	MDD gpm
Resort Area System			
2021	1,140	162	191
2042	1,340	190	225
Supply Capacity (MTN-1, MTN-2, MTN-4, MTN-7, LM-1, LM-2)		832[A]	290[B]
Cascade System[C]			
2021	938	133	157
2042	2,220	315	372
Supply Capacity (MTN-3, MTN-5, MTN-6)		442	370

SFE – single family equivalent; ADD – average day demand, acre-feet per year (afy); MDD – maximum day demand, gallons per minute (gpm)
[A] Assumes 89 afy from MTN-7 based on 55-gpm of available capacity year round.
[B] This rate does not include well MTN-1 (250 gpm)
[C] Includes additionally Cheyenne Rd, Heavy Runner Rd, Sioux Rd, Summit View Dr, Washakie Rd, and White Otter Rd.

4.2.2 Yellowstone Club Purchased Water Use

The District sells water to Yellowstone Club (YC) through an agreement established in March 2003. The agreement specifies that up to 216,000 gpd of water will be sold to YC based on a seven-day average calculated from Monday through Sunday. Water is conveyed from the Mountain Village resort area via a booster station and pipeline to the YC water system. The booster station discharge is metered and data are archived to the District SCADA system. These data show that YC use over the period from 2014 through 2021 included excursions that exceeded the agreement, but the use has been in compliance since 2018 and exhibits a declining trend (**Figure 11**).

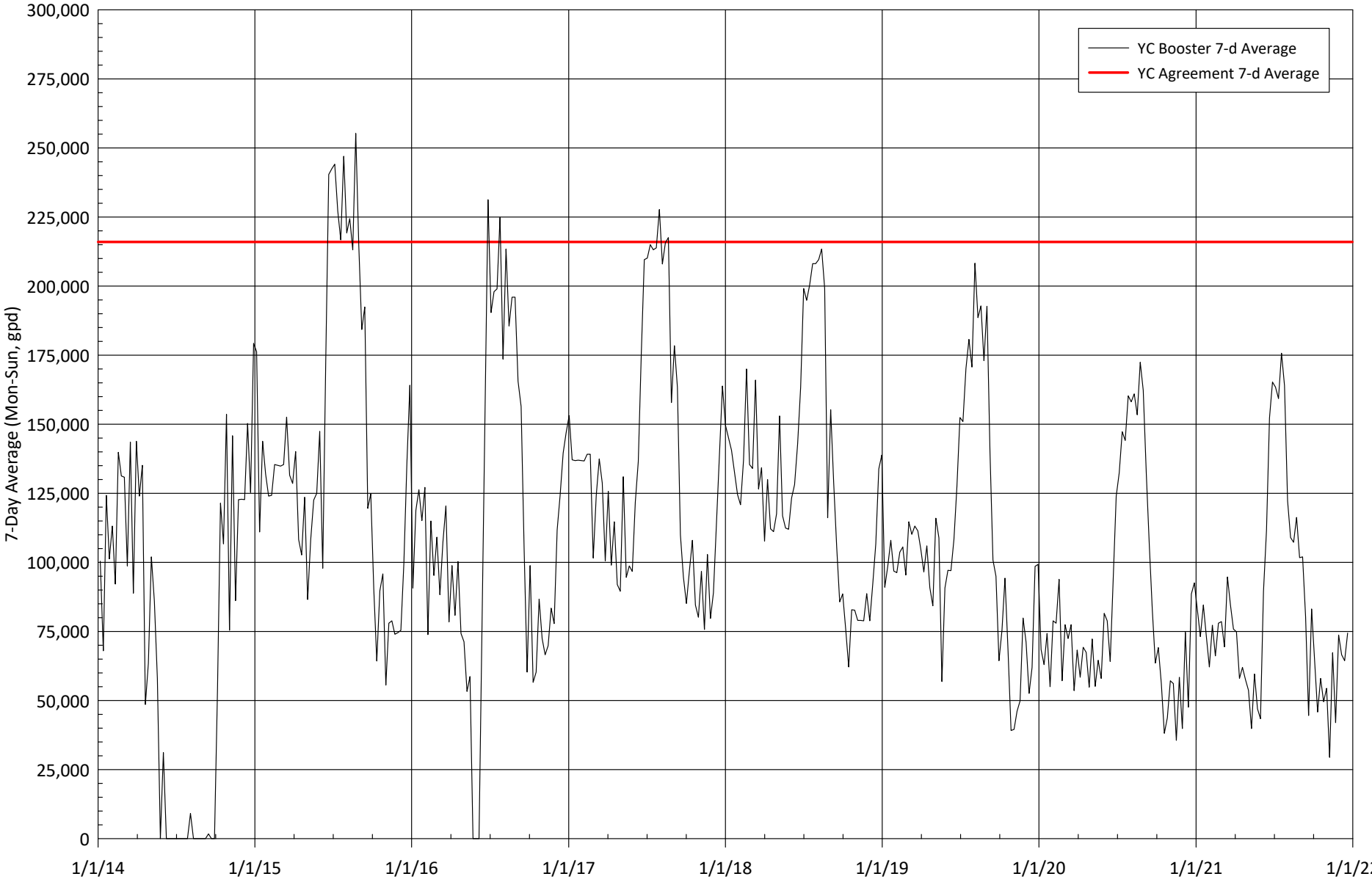

Figure 11. Yellowstone Club Purchased Water Use

5. WATER RIGHTS

The District owns water rights that appropriate sufficient water capacity to serve the public water system. This section is providing summary information on the water rights. Additional information is also provided in **Appendix C**.

5.1 Meadow Village Rights

There are three water rights for Meadow Village including two Statement of Claims and one Provisional Permit (**Table 11**). Change filings were made to these rights to add new and existing diversions. The total rate and volume that is appropriated by these rights exceeds the 2042 projected demand.

5.2 Mountain Village Rights

There are six water rights for Mountain Village including three Statements of Claims and three Provisional Permits (**Table 12**). The permit filing for wells MTN-5 and MTN-6 specified a volume inclusive of these new wells and also existing wells MTN-1, MTN-2, and MTN-3. These five wells are permitted for the total volume of 592 af per year. Volumes shown for MTN-1, MTN-2 and MTN-3 are not included in the total volume (shown in grey). These rights are designated for Commercial use, which should be changed to Municipal use in future filings.[11] The rate and volume appropriated exceeds the 2042 projected demand for Mountain Village.

5.3 Other Groundwater Rights

Other groundwater water rights are owned by the District that can be used in the public water system (**Table 13**). These rights can be used for the designated wells, and can be used to add new diversions onto the public water system. These rights have a mixture of domestic uses. They should be changed to Municipal use in future filings.

5.4 Surface Water Rights

The District also owns two surface water rights that are both Statement of Claims and were filed for the same acreage (**Table 14**). In 2016 the District filed a change on these rights for a project that isolated Little Coyote pond from the West Fork Gallatin River (not yet constructed). The change included reallocation of a fraction of the rights for Municipal use within the District service area. A diversion for municipal use is likely to have limited benefits to the District due to the late priority dates of the rights.

5.5 Place of Use

Water rights owned by the District have a Place of Use (POU) that extends over the Meadow or Mountain Villages where the water is put to beneficial use (**Figure 12**). Meadow Village water rights have a POU that extends throughout the Meadow Village area. Mountain Village water rights have a POU that extends over the Mountain Village area, and into the Yellowstone Club (YC) to the south (outside the service area). This extension to YC occurred in relation to the well MTN-7 water right filing. The existing POU does not, however, extend over the entire service area. In future filings the District should designate the entire service area as the POU and should list all of the water rights as part of a manifold system within the service area.

11 Municipal use allows a replacement well up to 450 gpm to be constructed without filing a change application. A replacement well filing is required using Form 634. Other uses must file a substantially more complex change application that includes a detailed review and public notice.

Table 11. Meadow Village Water Rights

WELL ID	WR NO.	TYPE	PRIORITY DATE	COMPLETION DATE	USE	RATE (gpm)	VOL (af)
HV-1 (MV1, MV2, MV3)	41H 122634 00	CLAIM/CHANGE	04/01/71	12/31/2033	Municipal	85	68.73
MV-1 (MV2, MV3, HV1)	41H 122635 00	CLAIM/CHANGE	04/01/71	12/31/2033	Municipal	220	177.89
MV-1 - MV-5, HV-1	41H 107416 00	PERMIT/CHANGE	11/15/99	12/31/2033	Municipal	985	1,307.38
					TOTAL	1,290	1,554.00

Table 12. Mountain Village Water Rights

WELL ID	WR NO.	TYPE	PRIORITY DATE	COMPLETION DATE	USE	RATE (gpm)	VOL (af)
MTN-1	41H 122636 00	CLAIM	01/30/74	NA	Commercial	240	*194.06*
MTN-2	41H 122637 00	CLAIM	01/30/74	NA	Commercial	80	*64.69*
MTN-3	41H 133733 00	CLAIM	01/30/74	NA	Commercial	180	*145.54*
MTN-4	41H 61672 00	PERMIT	10/21/86	12/31/2033	Commercial	124	150.00
MTN-5, MTN-6	41H 100737 00	PERMIT	04/02/97	12/31/2033	Commercial	925	592.00
MTN-7	41H 30001796	PERMIT	04/25/02	12/31/2033	Commercial	300	*241.84*
[A]Value in parentheses is volume without MTN-7 water right.					TOTAL	1,849	983.84 (742.00)[A]

Table 13. Other Groundwater Water Rights

WELL ID	WR NO.	TYPE	PRIORITY DATE	COMPLETION DATE	USE	RATE (gpm)	VOL (af)
AG-2, AG-3	41H 100681 00	PERMIT	05/13/97	12/31/2032	Mult. Domestic Lawn/Garden	50	33.52
HV-2	41H 61673 00	PERMIT	10/21/86	12/31/2033	Municipal	116	90.00
LM-1, LM-2	41H 115506 00	PERMIT	04/04/01	12/31/2032	Mult. Domestic	190	201.70
					TOTAL	356	325.22

Table 14. Surface Water Rights

SURFACE WATER NAME	WR NO.	TYPE	PRIORITY DATE	COMPLETION DATE	USE	RATE (gpm)	VOL (af)
WEST FORK GALLATIN R	41H 148445 00	CLAIM/CHANGE	6/23/1902	12/31/2037	Fish., Irr., Municipal	9.10	120.46
WEST FORK GALLATIN R	41H 148446 00	CLAIM/CHANGE	5/15/1952	12/31/2037	Fish., Irr., Municipal	9.10	120.46
					TOTAL	18.20	240.92

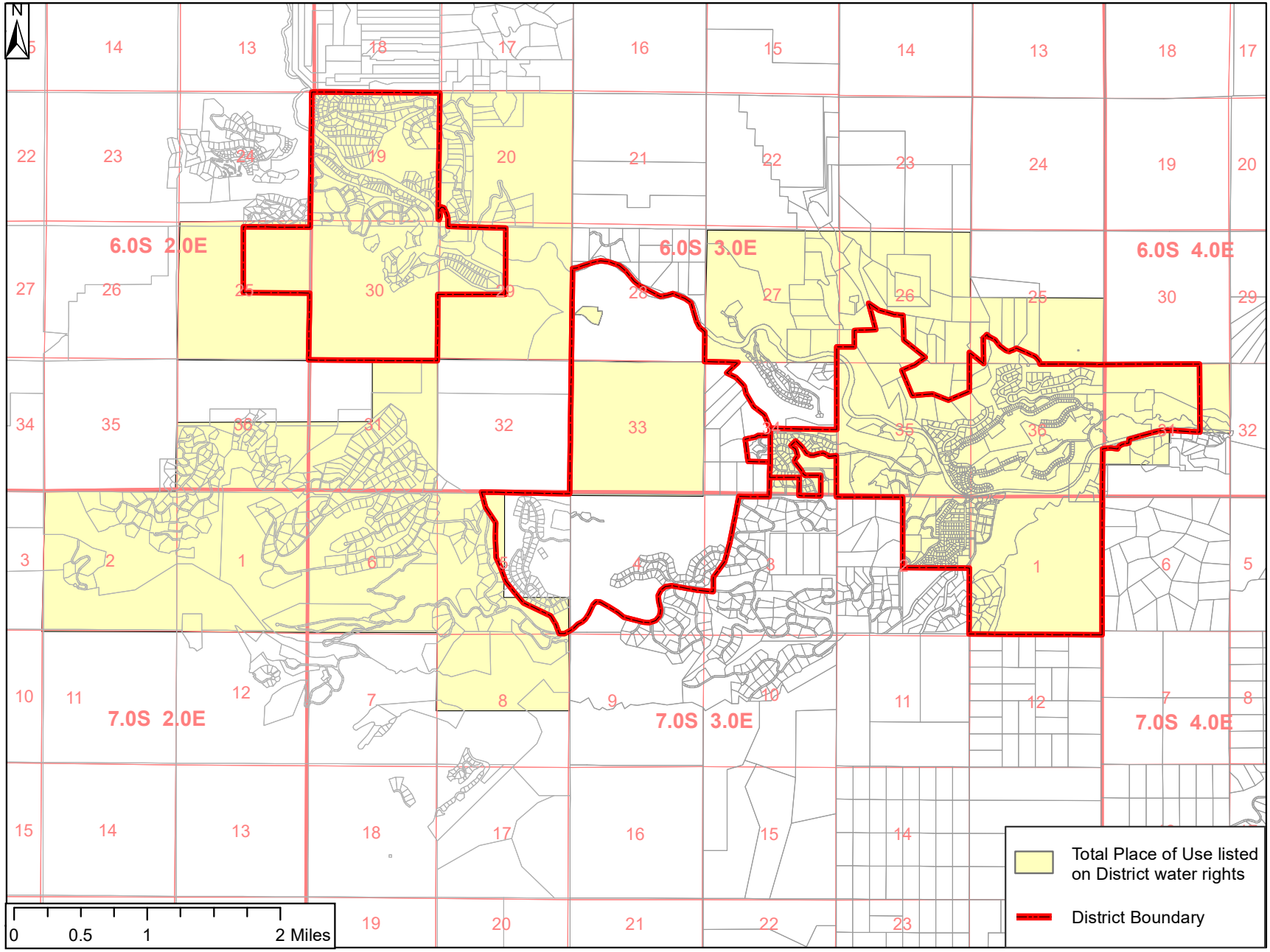

Figure 12. Water Rights Place of Use

6. SOURCE CAPACITY IMPROVEMENTS

6.1 Water Conservation

Water conservation planning and implementation has a primary purpose of reducing water use. This section evaluates conservation measures that will defer new source capacity development through water use reductions.

Water use can be separated into indoor and outdoor uses. Indoor uses account for approximately 67% of water use, with outdoor uses accounting for the remaining 33%.[12] The outdoor use is additive to the indoor use during summer months and is predominantly landscape irrigation. It is a primary driver of source capacity requirements for public water systems.

Reuse of treated wastewater effluent for irrigation can be considered a form of conservation. Communities have used reuse water for domestic lawn and garden irrigation by installing separate distribution systems for this use. Lawn and garden reuse in the Meadow Village area is considered to have a small but costly benefit and is not considered for these reasons.

Reduced irrigation from the public water system is considered the preferred alternative for conservation at Big Sky. It reduces use from the potable system and reduces overall consumptive use of the local water resources.

6.1.1 Indoor Water Use Conservation

Growth occurring in the District after about 1994 would generally be using fixtures with water use ratings consistent with modern fixtures. Indoor water audits of existing residences could be offered by the District as an educational measure for owners, and also for the District to gather data on the types of indoor uses that could be improved to result in water conservation. Gallatin River Task Force provides a rebate program on their website for residential and commercial properties, and also addresses outdoor conservation. The District contributes financially to this effort. There is opportunity for the District to expand this partnership.

6.1.2 Outdoor Water Use Conservation

Outdoor residential water use is dominated by irrigation of lawns. Conservation literature emphasizes a transition to much smaller irrigated areas totaling about 500 square feet (ft^2), or approximately 22- by 22-feet (ft).[13]

Based on air-photo analysis of 16-residences in Meadow Village irrigated areas ranged from 2,463- to 14,025-ft^2, with a mean value of 8,315 ft^2.[14] These areas included lawns, shrubs and trees. They show up as dark green on air-photos and are shown to be artificially irrigated based on contrast with adjacent lands. A reduction to 500-ft^2 of total irrigated area could reduce irrigation water use by 94% on average ((1-500/8315)*100%).

12 In 2021, Meadow Village water use was estimated as 66.67% indoor and 33.33% outdoor.

13 Vickers, A. (2001) Water Use and Conservation, WaterPlow Press, Amherst, MA, 446 pp.
AWWA (2017) Water Conservation Programs – A Planning Manual, Manual of Water Supply Practices M52, 2nd Edition.

14 1 acre = 43,560 ft^2.

The reduction in maximum day demand was estimated for reduced irrigation in Meadow Village for year 2021. Applied only to residential properties (79%) and assuming that only 25% of existing properties modify their landscape plan to achieve a 500 ft^2 irrigated area, the maximum day demand is reduced from 274 gpd/SFE to 258 gpd/SFE. By the same assumptions, the average day demand is reduced from 117 gpd/SFE to 110 gpd/SFE.

To estimate future reductions in maximum day demand, it was assumed the District requires all future residences to limit irrigated area to 500 ft^2, therefore resulting in 100% participation (the District could apply the same restrictions to commercial land uses). Future SFEs would therefore have a maximum day demand of 189 gpd/SFE. The total unit rate of water use for maximum day combines the existing and future SFEs to assess the water use reduction through the planning period to 2042 (**Tables 15** and **16**). Calculations shown assume that 25% of existing residential SFEs (that existed in 2021) reduce irrigated area to 500 ft^2 before year 2025.

Table 15. Reduced Irrigation Impact – Maximum Day Demand

Year	SFE	f	1-f	MDD gpd/SFE[A]	MDD gpm	MDD Reduction
2025	4,083	0.78	0.22	243	688	11.6%
2030	5,162	0.62	0.38	231	830	15.7%
2035	6,527	0.49	0.51	223	1009	18.9%
2040	8,253	0.39	0.61	216	1236	21.4%
2042	9,065	0.35	0.65	213	1343	22.3%

SFE – single family equivalent; f – fractional contribution of year 2021 SFEs; 1-f – fractional contribution of future SFEs; MDD – maximum day demand; MDD Reduction – decline in MDD relative to non-conserving MDD estimates from Table 6.
[A] MDD (gpd/SFE) = f * 258 + (1-f) * 189

Table 16. Reduced Irrigation Impact – Average Day Demand

Year	SFE	f	1-f	ADD gpd/SFE[A]	ADD afy	ADD Reduction
2025	4,083	0.78	0.22	103	473	11.6%
2030	5,162	0.62	0.38	99	571	15.7%
2035	6,527	0.49	0.51	95	694	18.9%
2040	8,253	0.39	0.61	92	850	21.4%
2042	9,065	0.35	0.65	91	924	22.3%

SFE – single family equivalent; f – fractional contribution of year 2021 SFEs; 1-f – fractional contribution of future SFEs; ADD – average day demand; ADD Reduction – decline in ADD relative to non-conserving ADD estimates from Table 6.
[A] ADD (gpd/SFE) = f * 110 + (1-f) * 81; 1 afy = 325,828 gallons/year.

These estimates illustrate a conservation program that reduces residential irrigation to 500 ft^2 may result in a maximum day demand reduction of 22% by year 2042. As compared to status quo residential irrigation (cf. 1,727 gpm, Table 6), maximum day demand is reduced by 384 gpm in year 2042, the equivalent of about two new water supply wells. Present worth of these facilities is approximately $1M. The same reduction percentages are realized for the average day demand, resulting in a reduction of 265 afy (86 million gallons)

by year 2042. In addition to reduced capital costs for new wells, there are also reduced operations and maintenance costs due to reduced pump and treatment runtimes.

The largest benefit from conservation is to require the reduced irrigation area to all properties in the District. A phase in period to 2025 can be used for existing properties. By extending the reduced irrigation requirement to all properties, existing and undeveloped, the water savings in 2042 increases to 537 gpm, which is a 31% reduction in maximum day demand (1,190 gpm v. 1,727 gpm). There is substantial capital and operations savings for the District at basically no cost. Conservation presents a rare opportunity for environmental and fiscal benefits and should be widely accepted by the Big Sky Community.

6.1.3 Conservation Plan and Program

The exercise above demonstrates the potential benefit of residential irrigation reduction. Additional conservation measures will further reduce indoor and outdoor uses. The next steps for the District are to implement conservation measures, the first of which should be reduced irrigation. Additional measures can be implemented in subsequent years. Other conservation measures that could be included in future years include, for example:

- Water audits
- Water wise landscape public education
- Irrigation technology
- Rain sensors (as controls for automatic irrigation)
- Soil tensiometers (as controls for automatic irrigation)
- Indoor fixtures and appliances
- Water billing rate structure
- Leak detection and repair
- Service line replacements

Many programs exist that can be reviewed and used as a basis for assessment and implementation of conservation measures. These programs normally include an array of educational, incentive-based, and mandatory measures. The District should realize that only the mandatory measures result in 100% participation—a critical factor of program success. Educational and incentive programs typically have less than 25% participation and require more effort per unit of participation than mandatory measures. These non-mandatory efforts may be construed more as conservation "lip service" rather than actual conservation. Because conservation reduces overall water use, the District will need to assess revenue impacts and make adjustments to prevent shortfalls.

6.2 Groundwater Development

6.2.1 Meadow Village

The ability to develop new groundwater capacity in Meadow Village is considered limited, although some additional capacity can likely be developed from the alluvial aquifer. Bedrock wells in surrounding upland areas also have limitations due to conflicts with private wells and the ability to obtain water rights. Of the bedrock formations, the Madison appears to be the only option for a bedrock well in Meadow Village.

6.2.1.1 Alluvial Aquifer

Wells at Meadow Village produce from the alluvial aquifer on the north side of the golf course, with an average capacity of 200 gpm. Recent work that included mapping of the alluvium thickness was used to

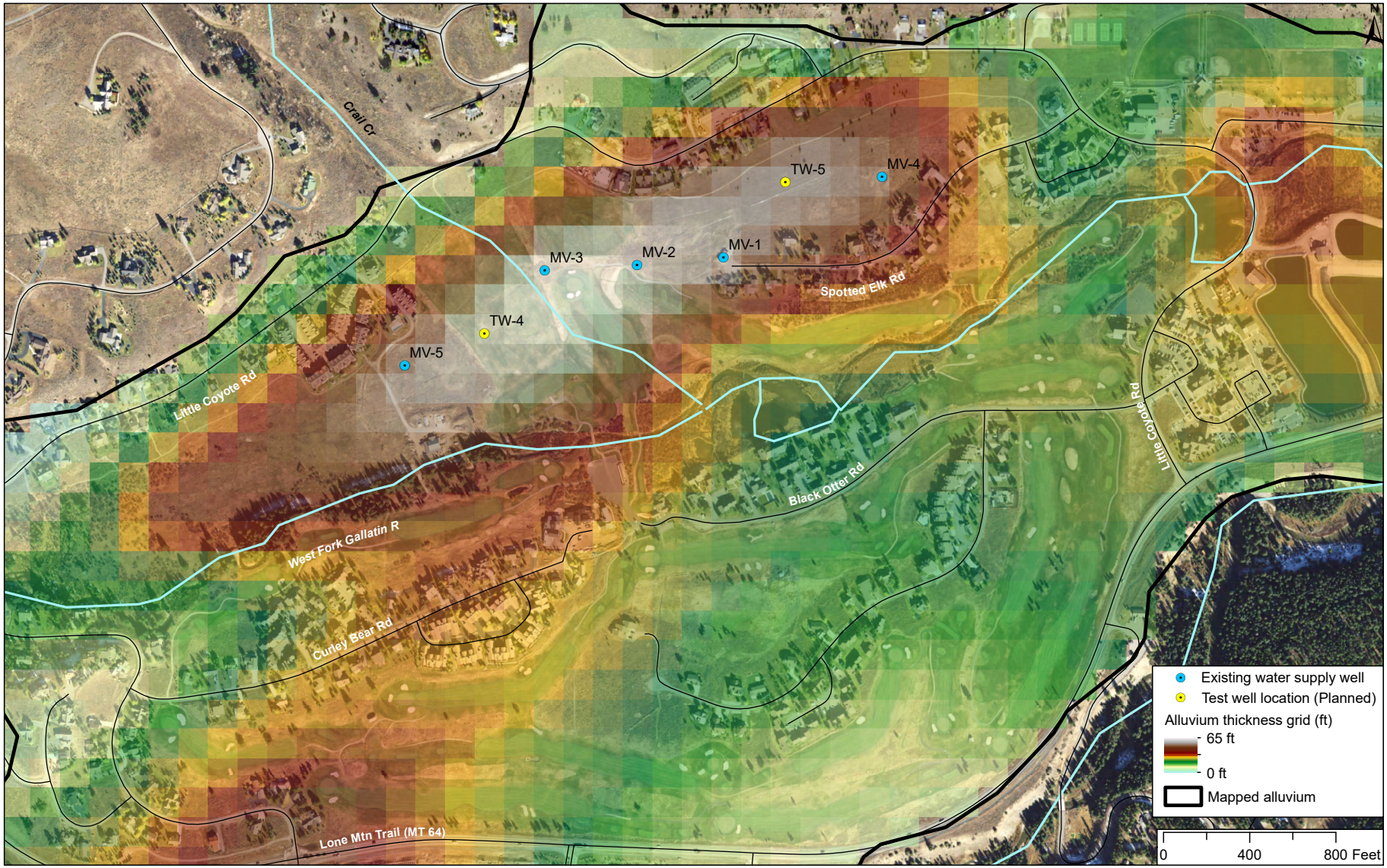

Figure 13. Meadow Village Test Well Locations

assess the potential for new well sites (**Figure 13**).[15] This work shows the alluvium thickness declines east of well MV-4 and west of well MV-5.

Potential new production well sites are shown within the area of suitable alluvium thickness and also with maximum offset from adjacent wells (test wells TW-4 and TW-5). The TW-4 site is located within the golf course driving range and may not be available.

New production wells at these locations would have some interference effect on neighboring existing wells that could result in a decline in capacity. However, the offset distances are similar to existing wells MV-1, MV-2 and MV-3, suggesting that excessive interference may not be realized. Based on a simplified hydraulic analysis possible interference drawdown of 15% to 45% was estimated. The analysis used production rates from the new wells of 100- and 200-gpm. In total, two new wells may develop an additional 200- to 400-gpm of production. The primary risk is lost capacity from existing wells, which could be assessed from the test wells.

The impact on surface water of these sites would be similar to the existing wells, enabling new production wells to be added onto existing water rights (41H 107416 00) by filing of a change application. It would also be necessary to file a beneficial use application to add additional rate for the new wells. These filings require DNRC approval and public notice, and therefore have associated risk. The application filings should be made prior to construction of production wells.

New alluvial wells would likely have a requirement for full-time microbial treatment. The preferred option would be to upgrade the UV treatment system to accomodate the two new wells.

6.2.1.2 Bedrock Aquifers

Potential for water development in bedrock aquifers at Meadow Village has so far been shown to be difficult (**Figure 14**). Development of bedrock wells in Meadow Village is not recommended at this time but may be of greater interest in the future.

In section 1 (T7S, R3E) two wells were drilled for Gallatin Peaks Land Development, LLC. A production well was drilled to 800 feet (Uplands #1), and a test well (Test Well 1) was drilled to 840 feet. Both wells were developing groundwater from the Muddy sandstone and an intrusive sill at the same horizon. Uplands #1 was denied a water right permit due to a determination of insufficient recharge by DNRC. Test Well 1 was drilled through additional sandstone in the Thermopolis shale. Air-lift pumping indicated a maximum rate of 70 gpm and the water had a moderately strong hydrogen sulfide odor.

The District owns the Blue Grouse well that was re-entered and deepened from 960 to 1250 feet to fully penetrate the Kootenai aquifer.[16] Total production from the well was estimated at 35 gpm and there was a moderately high iron concentration of 0.8 milligrams per liter (mg/L). The well is presently not completed and does not have a water right, although it is approved for the public water system.

The Madison aquifer is the remaining target and has not been drilled locally. Prior to moving ahead with a Madison well, a technical analysis should be completed to determine the likelihood of satisfactory yield and quality, and also the ability to add the well onto existing water rights.

15 Western Groundwater Services, LLC (2020) Meadow Village Aquifer Modeling Analysis for Indirect Potable Reuse and Firelight Meadows Subdivision Groundwater Discharge, report to AE2S (9/24/20).

16 Deepening of the well was completed by mud-rotary drilling to maintain a stable borehole and control artesian flow during drillling.

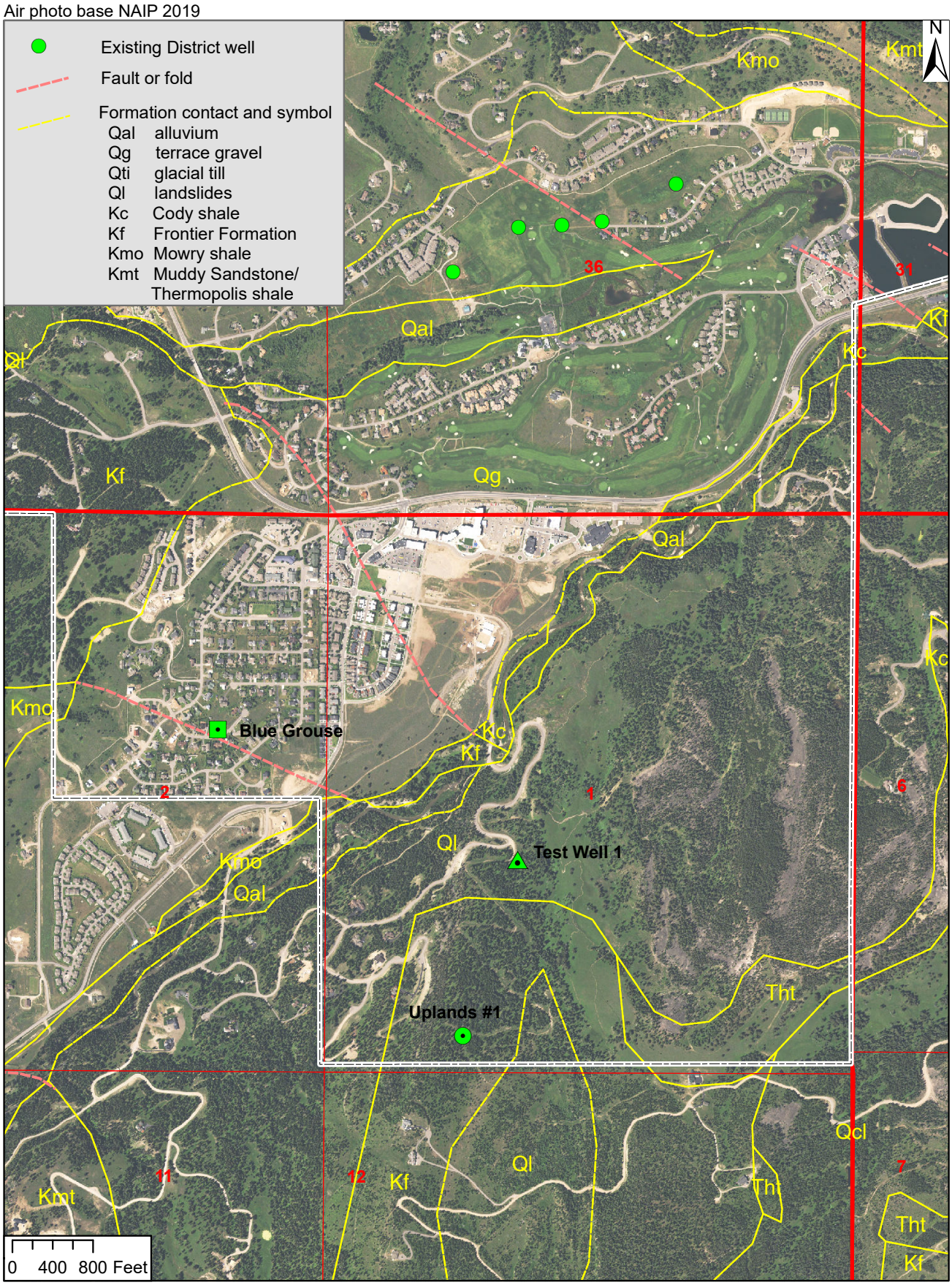

Figure 14. Meadow Village Bedrock Wells

6.2.2 Mountain Village

Starting in 2019 the District has constructed 10 test wells to explore for additional water supply in Mountain Village (**Figure 15**). The explorations targeted aquifers in alluvium, intrusive igneous rocks, and sedimentary rocks.

The last test well (TW#9) included in the drilling contract and targeting sedimentary rocks of the Kootenai formation was started in August 2022. It was drilled and cased to 100 ft and then terminated when the adjacent land owner (Middle Fork Properties, LLC) threatened a restraining order for using the access road through their property, thereby blocking the District from completing the drilling project.
These aquifer targets and the locations drilled generally represent the availability of groundwater in the Mountain Village area. There are no obvious aquifer targets that were not included in the test well drilling project.

Documentation of the results of test well drilling are provided in three memo reports that have been consolidated into a single document.[17] A summary of the test well drilling results follows:

- The alluvium test wells #3 and #4 penetrated clay and clay-bound gravel identified as glacial till and then entered bedrock. There was no productive alluvium aquifer encountered;

- Test wells #1, #5, #6, #10, and #11 were targeting intrusive igneous rocks. The intrusive rock was drilled and found to be non-water bearing, although test well #6 also penetrated the top of the Kootenai formation at 995-ft and was air-lift pumped at approximately 150 gpm;

- Test wells #2 and #7 targeted the Kootenai formation. Test wells #2 and #7 fully penetrated the formation and were air-lifted at rates of 150- to 250-gpm, respectively. Pump testing of both wells indicated a permeable formation local to the wells but that was limited in recharge resulting in much lower sustained capacity;

- Test well #8 was drilled to the top of the Kootenai formation. It was producing in excess of 250 gpm from the overlying Thermopolis formation, from both fractured shale and the basal sandstone. It was pump tested and a similar result was obtained as for test wells #2 and #7, which both responded to pumping in test well #8.

Test wells #7 and #8 were being considered for completion as production wells, but this consideration has been deferred based on water use analysis for Mountain Village and additional hydraulic analysis related to pumping from supply well MTN-5 for snowmaking during the 2021-2022 ski season (**Appendix B**). The snowmaking hydraulic analysis showed that conversion of test wells #7 and #8 to production wells would have limited benefit to the overall Mountain Village supply. At the same time, water use for Mountain Village has declined substantially since 2015, resulting in no immediate need for new capacity until beyond 2042.

The test well project showed that shallow groundwater development accessible using air-rotary drilling (approximately 700-800 ft depths) was unlikely to result in high yield wells. Where good permeability was encountered and moderately high rates of air-lift pumping could be achieved during drilling, sustainability of the discharge was not indicated by pump testing. Well yields were estimated to range from 70- to 110-gpm, and annual volumes were estimated at 25- to 56-acre-feet. There was also substantial interference drawdown among test wells #2, #7, #8, and water supply well MTN-5, resulting in reduced yield for multiple

17 Western Groundwater Services, LLC (2022) Mountain Test Well Drilling Project, 2019 - 2022, report to Big Sky County Water and Sewer District No. .363, 9/9/2022.

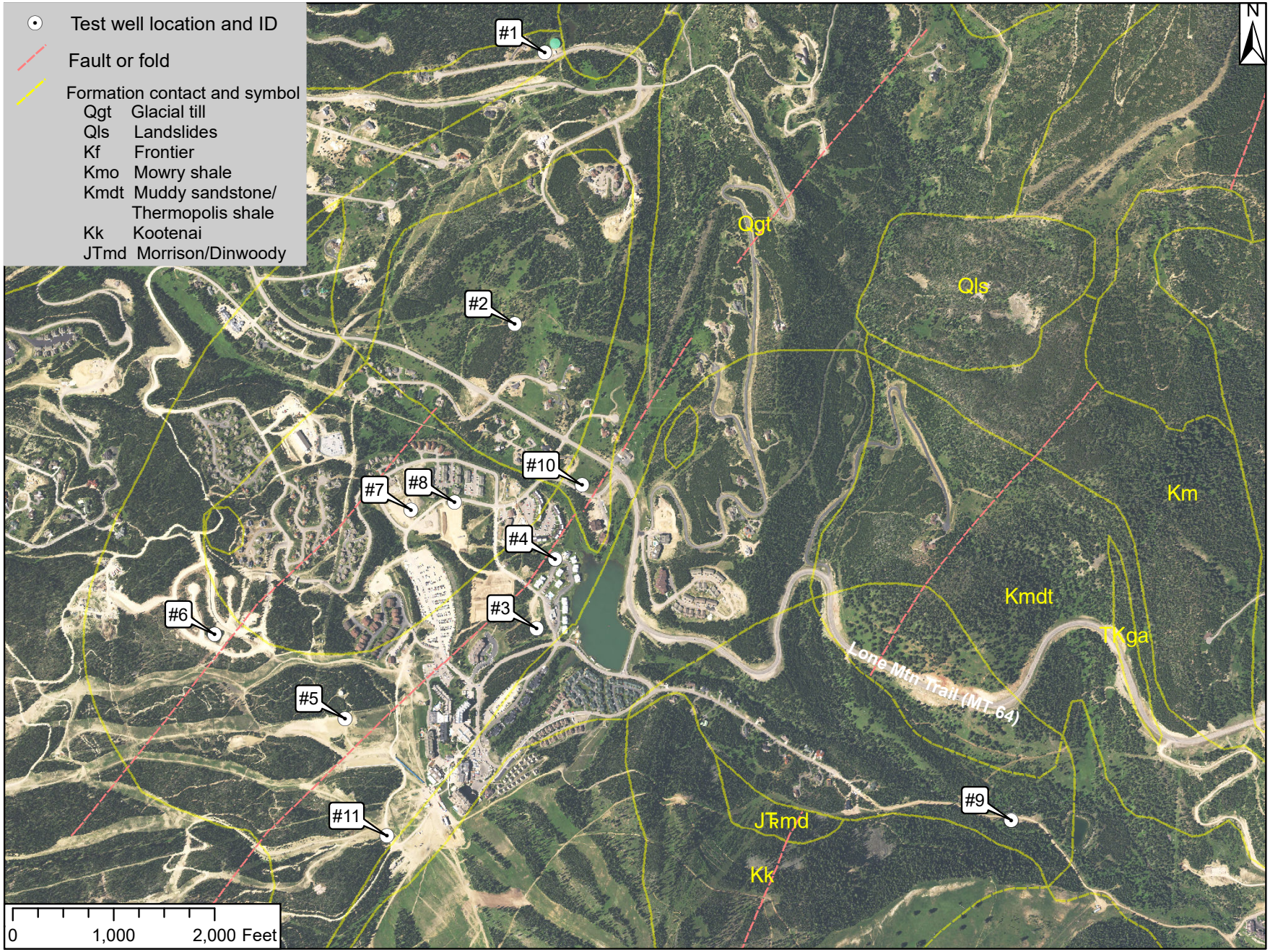

Figure 15. Mountain Village Test Well Location Map

completions (i.e., pumping rates and annual volumes are not directly additive for the wells due to pumping interference drawdown).

Drilling deeper wells to the Kootenai and the Madison aquifer is not recommended at this time, as testing data do not support greater yield potential. The data do not support deeper wells would be found to result in higher well capacity or annual volumes (there is some rate increase potential due to greater available drawdown in deeper wells). The deeper wells also require a change in drilling method to mud rotary in order to ensure a stable borehole can be maintained. The depths range from 1,100 to 2,800 ft. The deeper wells have estimated drilling contractor costs on the order of $400,000 to $2,500,000. These costs are considered prohibitively high for exploration given there is no immediate need for new source development at Mountain Village and prior Kootenai test wells exhibited limited recharge conditions.

Although a Madison test well has not been drilled, there is limited Madison outcrop in the area to the north suggesting potential for limited recharge to the formation. The geological structure also is not anticipated to undergo substantial change between the depth of the Kootenai formation and the depth of the Madison formation suggesting similar limited recharge could be found in the Madison. There is potential that acid stimulation of a Madison well would increase production[18], however, handling the spent acid solution in the Big Sky area is logistically difficult. The spent acid solution has very high total dissolved solids (e.g. 20,000 mg/L TDS) and must be transported to legal disposal sites, possibly to eastern Montana. There would be on the order of 50- to 100-trips to purge the well of the spent acid solution. Significant spill potential exists and presents additional liability to the District.

The location of test well TW#9 is on the Andesite Mountain anticline to the east of where the other test wells were drilled. This location has been shown to support wells with favorable pumping test results.[19] A production well at this location is estimated to yield 200- to 250-gpm of water supply but may contain iron and manganese requiring treatment (actual yield and water quality will not be known until the test well is completed). Due to the geology of this area (east dipping sedimentary rock at angles of 30- to 40-degrees), it is possible to build multiple wells in proximity to one another without drawdown interference. It may be possible to develop 500-gpm of total capacity from two or three wells. Supply from this location would have the most efficient use for Lone Moose, Aspen Grove, and Meadow Village. It would likely not be used in Mountain Village due to the pumping requirements and other required infrastructure. Due to proximity of the Middle Fork channel, water right permitting may be difficult, and therefore, water right filings should be made and approved prior to construction of production wells or related infrastructure.

6.3 Surface Water

6.3.1 West Fork Gallatin River

The District water rights for the West Fork Gallatin River allow for diversion of up to 138.85 afy for municipal use. The total rate of withdrawal for these water rights is 18.2 cfs. Diversions under these water rights have a period of use from June 1 to October 15 annually, a period of 137 days. The total volume if produced over this period averages 229 gpm.

18 The limestone formation can be dissolved by hydrochloric acid resulting in increased permeability to the well.

19 Memorandum, 11/12/2021, Re: Middle Fork Properties LLC – Water Supply Well Transfer Evaluation.

The late priority dates of these water rights (1902, 1952) generally preclude this diversion. For this reason, construction of the necessary infrastructure to use the rights is not recommended. This infrastructure would cost on the order of $2,000,000, as full compliance with the surface water treatment rule is required for use of surface water in the potable system.

6.3.2 Gallatin River Mainstem

The Gallatin River mainstem is accessible for a water supply to the District at a location near to the intersection of Highways 191 and 64. This supply alternative would divert water from the channel for treatment and distribution in the Meadow Village service area. The depletion effect of the diversion on the channel would be offset by discharge of treated effluent from the Water Resources Reclamation Facility (WRRF). This discharge would likely need to be direct in order to offset surface water depletions.

There are at least two critical permitting factors for this supply alternative. Water right permitting may be confounded by the present rules that require a change application to be filed for mitigation to offset depletions to a surface water. The District may need to work with DNRC to pass new legislation that provides a water right for treated effluent from a wastewater treatment plant, or other equivalent options.

The second factor is the ability to obtain a discharge permit for the treated effluent directly discharged to a surface water. The Gallatin River is undergoing review for impaired status, which if designated as impaired, could preclude a direct discharge. Otherwise, a direct discharge may be permitted with a mixing zone, as is typically done around the State. The discharge permit application would likely need to show an overall benefit to the Gallatin watershed is being achieved (e.g., by reducing the concentrations of nutrients from other sources) in order to gain public acceptance.

6.4 Direct Potable Reuse

Direct potable reuse (DPR) is sourced directly from the treated effluent of the District's Water Resources Reclamation Facility (WRRF). The conceptual model for DPR considered for the District would further treat a fraction of the WRRF discharge by reverse osmosis (RO), and then mix the RO treated water (i.e., permeate) directly with groundwater pumped from water supply wells.[20] The RO waste stream (i.e., concentrate) would be mixed into the WRRF discharge and be used for non-potable reuse or permitted discharges to ground- and surface-waters. Disinfection with chlorine and maintaining a chlorine residual in the distribution system would be required for DPR.

The major hurdles for the District to implement DPR will be governmental and societal. Montana presently does not allow DPR in public water systems, and citizens are likely to oppose it. These hurdles can be overcome but take time on the order of 5- to 10-years (as evidenced in CA and TX where DPR has been implemented). Trace levels of contaminants can occur in DPR water with unknown, if any, health effects, individually or synergistically. Such contaminants can become significant obstacles to community acceptance of DPR.

One of the critical limits for DPR is how the concentrate impacts irrigation water quality. The RO concentrate would be discharged back into the treated effluent for irrigation use, or other disposal methods (e.g., snowmaking, groundwater discharge). A target level for DPR could be 150 gpm of permeate for use in the public water system, with 50 gpm of concentrate. The actual rates that could be implemented would be determined through a PER study and pilot testing.

20 Other supplementary treatment processes are included pre- and post-RO treatment.

Obtaining 150 gpm for DPR is a significant benefit to the public water system and also to the treated effluent reuse. The annual reuse of DPR at 150 gpm is slightly more than 78 million gallons, and can occur over the full year. As the WRRF discharge increases, it should be possible to also increase the rate of DPR.

6.4.1 DPR Preliminary Engineering Report (PER)

A preliminary engineering study should be completed to assess treatment processes required to implement DPR in the District and to work with DEQ to develop regulations that permit DPR in Montana. This study is likely to determine other options than RO, or other processes to be used in conjunction with RO (e.g., UV). A critical factor of this study will be assessment of removing and or transforming pharmaceuticals and personal care products, and associated treatment by-products.[21]

7. PREFERRED ALTERNATIVES AND BUDGETS

This section summarizes preferred alternatives for the Source Capacity Plan 2022 Update. Budget estimates are provided in **Table 17**, and an implementation schedule is provided on **Figure 16**.

A timeline plot shows improvements to the Meadow Village source capacity required to meet demand in 2042 (**Figure 17**). These improvements include new Meadow Village wells and implementation of DPR, both of which would occur in future Source Capacity Plan updates. The timeline assumes Meadow test wells are successful and lead to new vertical wells with 250 gpm of combined total capacity put into service in 2035. It is also assumed DPR becomes a viable water source and is put into service by 2040 at 150 gpm.

Water development at the test well TW#9 site is not presently included in the District's source development planning. However; should this site become accessible, additional groundwater source capacity would be available primarily as a source to Meadow Village.

7.1 Conservation

This alternative would limit outside irrigation using water from the public water system to no more than 500 square feet (ft^2). It is recommended the District apply this requirement to all properties and use types in the District. There could be a three- to five-year phase in period for existing developed properties. There would be an approximately 31% reduction in water use by year 2042 in Meadow Village alone, reducing the source capacity requirement by 537 gpm in 2042 (Mountain Village was not evaluated but would also realize some benefit). The District could develop and implement this program in-house. Conservation is the most effective means for the District to reduce source capacity needs and has both environmental and fiscal benefits. No other source capacity alternative is as effective as conservation that reduces or eliminates landscape irrigation.

7.2 Meadow Village Alluvial Test Wells

This alternative constructs two test wells in the Meadow Village alluvial aquifer and includes two pumping tests to evaluate interference among the test well locations and existing Meadow Village wells. If the results of testing are favorable, the District can proceed to file for water rights. Pending approval of the water right filings, the District can construct permanent production wells and connect the wells to the public water system. The budget for this alternative is including only the test well constructions and pumping tests. If conditions were favorable, a water right filing would be the next step. Once approved, the District would then move ahead with construction of new production wells.

21 Unregulated compounds and treatment by products are also referred to as contaminants of emerging concern (CECs).

Table 17. Preferred Alternatives Budget Estimates

Activity	Contractor	Engineer	Contingency	Total
Conservation	not applicable	in-house	not applicable	in-house
Meadow Village Alluvial Test Wells	$59,500	$34,700	$14,130	$108,330
Direct Potable Reuse PER	$195,795	$48,949	$24,474	$269,218
Well Water Level Instruments/SCADA	NA	$50,000	NA	$50,000
Water Right Filing	not applicable	$15,000	$15,000	$30,000
Mountain Village Hydraulic Study	not applicable	$30,000	not applicable	$30,000
			TOTAL	$487,548

Figure 16. Implementation Schedule

7.3 Direct Potable Reuse (DPR)

This alternative prepares a preliminary engineering report (PER) to implement DPR in the Meadow Village water system. The purpose of the alternative is to work with DEQ to formulate regulations for DPR in public water systems. The PER will also develop the initial planning and budgeting for a DPR pilot facility to be operated over a period of several years. The actual scope of work may vary and would be determined by the consulting engineer for the project. The budget for this alternative is for the preparation of the PER.

7.4 Well Water Level Instruments

This alternative installs water level measuring instruments into the District wells (14 wells in total) and connects the instruments to the SCADA system.[22] The instrument readings will be available real-time for operation of the system and will be archived for subsequent analysis. The budget for this alternative includes the work to install and make fully operable the water level sensors including[23]:

- Pump work to install deployment tubes down the wells;
- Conduit installation from the wells to the SCADA panel;
- Communication wiring from each sensor to SCADA;
- Downhole pressure transducers (i.e., sensors); and
- SCADA programming services.

7.5 Water Right Filing

This alternative files change applications to change the type of use to Municipal and the place of use (POU) to the District service area. The applications include: 41H 61672 00 (MTN-4); 41H 100737 00 (MTN-5,-6); 41H 30001796 (MTN-7); 41H 100681 00 (AG-2,-3); 41H 61673 00 (HV-2); and 41H 115506 00 (LM-1,-2). A pre-application meeting should be conducted with DNRC to discuss the purpose of the filing and to make changes to the plan based on DNRC comments. The Municipal use simplifies future well replacements.[24] The POU designation will correctly enable Mountain Village wells to provide water supply to Meadow Village, and vice versa. In this filing, the MTN-7 water right will need to include the Yellowstone Club areas as part of its POU, as is present in the existing water right, additional to the District's service area.

7.6 Mountain Village Hydraulic Study

This alternative completes a pre-design study for hydraulic improvements to the Mountain Village water system that would put the Mountain Village 500K storage tank into service and would reduce pumped volume and rate to the Cascade portion of the system. The study would address:

- Operation of the core wells MTN-1, MTN-2, MTN-4, and MTN-7 based on the 500K tank level;
- The means to supply water to the Cascade booster station based on the 1.5M Cascade storage tank level (e.g., pressure sustaining solenoid control valve);
- Downsizing of the Cascade booster pumps to match demand;
- Cycling or mixing of stored water in the Cascade tank to prevent water quality impacts;
- Adjustments to pressure reducing valve settings between the Cascade and Resort Area systems; and
- Other factors as deemed necessary.

These hydraulic improvements should also be suitable to remain in place when future treatment of wells MTN-3, MTN-5, and MTN-6 is completed.

22 Meadow Village Wells #1 to #5, Mountain Village Wells #1 to #7, Lone Moose Wells #1 and #2.
23 Alternative methods may exist that use wireless communications.
24 Wells producing less than 450 gpm do not require a change application for replacement wells if the use is Muncipal.

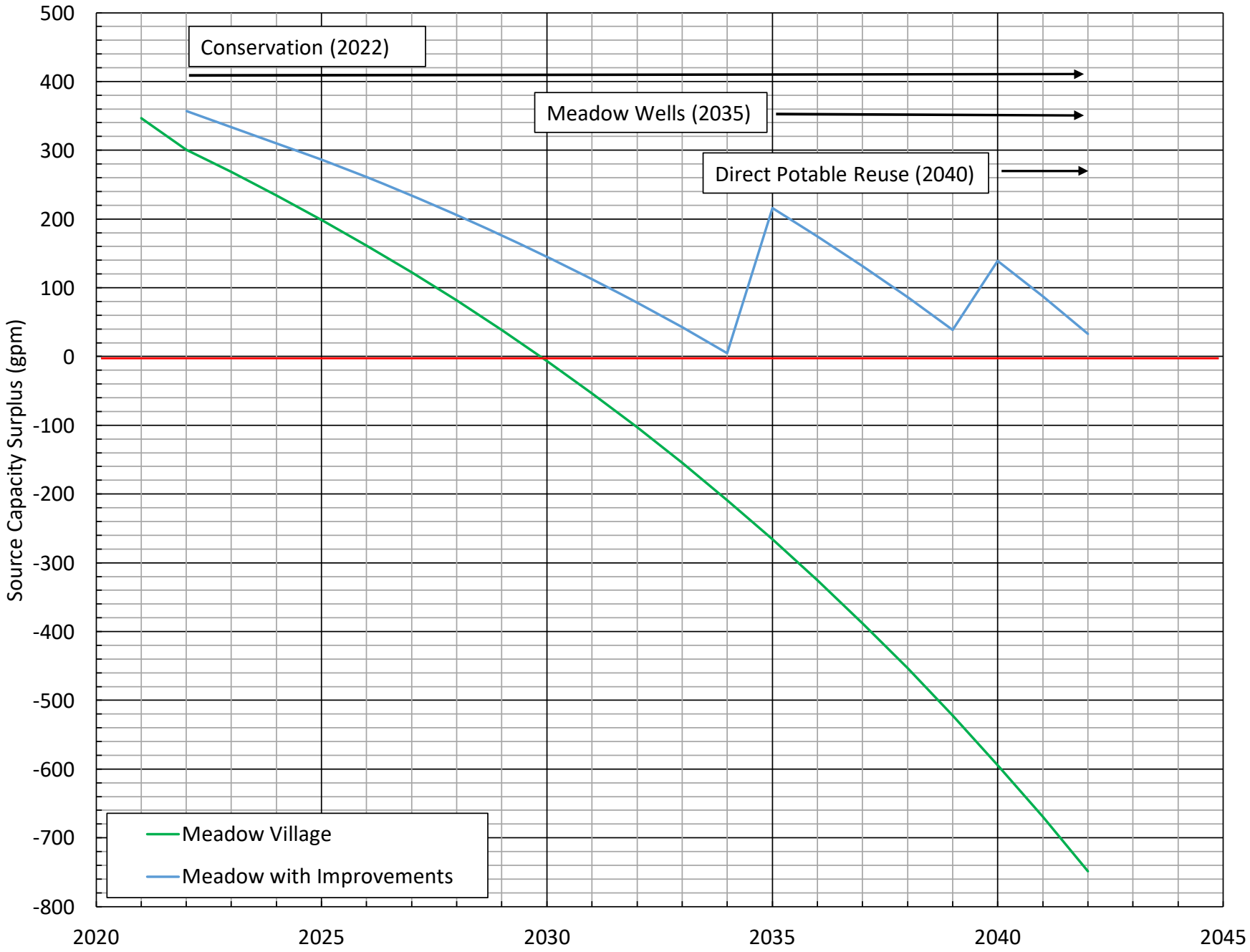

Figure 17. Meadow Village Improvements