Technical Analysis Report Supporting the Spring Valley and Delamar, Dry Lake, and Cave Valleys, Nevada, 3M Plans

PRESENTATION TO THE OFFICE OF THE NEVADA STATE ENGINEER

Prepared by

SOUTHERN NEVADA WATER AUTHORITY

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Pertaining to:
Groundwater Applications 53987 through 53992 inclusive
and
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TABLES

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ACRONYMS

AUM	Animal Unit Months
ACEC	Area of Critical Environmental Concern
BLM	Bureau of Land Management
BLM EIS	BLM Final Environmental Impact Statement for the SNWA GDP
BRT	Biologic Resources Team
BWG	Biological Work Group
CFR	Code of Federal Regulations
CPB	Corporation of the Presiding Bishop of the Church of Jesus Christ of Latter-Day Saints
CTGR	Confederated Tribes of the Goshute Reservation
DDC	Delamar, Dry Lake and Cave Valleys
DEM	digital elevation model
DOI	U.S. Department of the Interior
ESA	Endangered Species Act
ET	evapotranspiration
GDP	Clark, Lincoln, and White Pine Counties Groundwater Development Project
HA	hydrographic area
IBMA	Initial Biological Monitoring Area
NAC	Nevada Administrative Code
NAIP	National Agricultural Imagery Program
NDOW	Nevada Department of Wildlife
NDVI	Normalized Difference Vegetation Index
NDWR	Nevada Division of Water Resources
NEPA	National Environmental Policy Act
NNHP	Nevada Natural Heritage Program
NRS	Nevada Revised Statute
NSE	Nevada State Engineer
NWR	National Wildlife Refuge
PI	Prediction Interval
POD	Point of Diversion
PSZ	Pahranagat Shear Zone
SALR	Seasonally Adjusted Linear Regression
SNPLMA	Southern Nevada Public Land Management Act
SNWA	Southern Nevada Water Authority
TRP	Technical Review Panel

ACRONYMS (CONTINUED)

UDWR	Utah Division of Wildlife Resources
UDWRi	Utah Division of Water Rights
UGS	Utah Geological Survey
USFWS	U.S. Fish and Wildlife Service
USFWS BO	U.S. Fish and Wildlife Service Biological Opinion for the SNWA GDP
USGS	U.S. Geological Survey
WMA	Wildlife Management Area

ABBREVIATIONS

°C	degrees Celsius
° F	degrees Fahrenheit
afa	acre-feet per annum
afy	acre-feet per year
amsl	above mean sea level
bgs	below ground surface
cfs	cubic feet per second
ft	foot
gpm	gallons per minute

1.0 INTRODUCTION

1.1 Remand of Rulings 6164-6167

Nevada State Engineer (NSE) Rulings 6164-6167 granted Southern Nevada Water Authority (SNWA) groundwater rights in Spring, Cave, Dry Lake, and Delamar valleys (Hydrographic Areas 184, 180, 181, and 182, respectively) (Nevada Division of Water Resources (NDWR), 2012a-d). These water rights are to be used for the SNWA Clark, Lincoln, and White Pine Counties Groundwater Development Project (GDP) (SNWA, 2012f).

On December 13, 2013, the Seventh Judicial District Court of the State of Nevada remanded Rulings 6164-6167 on four issues (*White Pine County and Consolidated Cases, et. al. v. Nevada State Engineer*) (Remand Order). One of the four issues was to "Define standards, thresholds or triggers so that mitigation of unreasonable effects from pumping of water are neither arbitrary nor capricious in Spring Valley, Cave Valley, Dry Lake Valley and Delamar Valley". A second issue was "The addition of Millard and Juab counties, Utah in the mitigation plan so far as water basins in Utah are affected by pumping of water from Spring Valley Basin, Nevada" (Seventh Judicial District Court of the State of Nevada, 2013, at page 23).

This report presents the evidence and scientific rationale for thresholds, triggers, and monitoring, management, and mitigation actions in the 2017 Delamar, Dry Lake and Cave Valleys (DDC) and Spring Valley Monitoring, Management, and Mitigation (3M) Plans (SNWA, 2017d and e). In accordance with the Remand Order, the thresholds, triggers and actions are designed to avoid unreasonable effects from SNWA GDP pumping to hydrologic and environmental resources in Nevada and Utah.

The approach and process used to develop the 3M Plans are consistent with the Remand Order and modern approaches to responsible groundwater development. First, unreasonable effects to hydrologic and environmental resources are defined. Next, objective thresholds and triggers are established to determine when management and mitigation actions will be implemented, and management and mitigation actions are identified to avoid unreasonable effects and comply with Nevada water law. Finally, a hydrologic monitoring network and hydrologic and environmental monitoring activities are established to enable effective implementation of the triggers and actions and support responsible groundwater development.

1.2 Requests to the Nevada State Engineer

SNWA submits the following requests to the NSE:

Spring Valley and DDC 3M Plans. The 2017 DDC and Spring Valley 3M Plans are submitted concurrently with this report (SNWA, 2017d and e). SNWA requests that the NSE adopt these 3M Plans as part of the rulings issued after the Remand Order hearings are complete.

Staged groundwater development in Cave Valley. In the process of securing federal rights-of-way for the main GDP pipeline and associated facilities, SNWA committed to following a staged groundwater development schedule in Cave Valley (SNWA, 2012d). SNWA requests that the NSE adopt a similar staged groundwater development schedule as part of the ruling issued for Cave Valley after the Remand Order hearings are complete. Details regarding this request are included in Section 8.1.

1.3 Report Organization and Contents

This report consists of 11 sections and 6 appendices.

Section 1.0 summarizes the Remand Order requirements addressed in this report and presents SNWA's requests to the NSE.

Section 2.0 summarizes conditions associated with statutory requirements to protect senior water rights, protectable interests in existing domestic wells, the public interest, and environmental soundness under Nevada water law, and defines unreasonable effects to hydrologic and environmental resources.

Section 3.0 presents the conceptual approach used in this report to establish thresholds, triggers, and monitoring, management, and mitigation actions to avoid unreasonable effects from SNWA GDP pumping.

Section 4.0 presents criteria used to delineate the analysis area and select hydrologic and environmental resources to include in the analysis.

Section 5.0 presents the environmental resources analyzed in this report.

Section 6.0 analyzes and establishes thresholds, triggers, and monitoring, management, and mitigation actions to avoid unreasonable effects to hydrologic and environmental resources in Spring Valley.

Section 7.0 analyzes and establishes thresholds, triggers, and monitoring, management, and mitigation actions to avoid unreasonable effects to hydrologic and environmental resources in northern Hamlin and southern Snake valleys.

Section 8.0 analyzes and establishes thresholds, triggers, and monitoring, management, and mitigation actions to avoid unreasonable effects to hydrologic and environmental resources in Cave and southern White River valleys.

Section 9.0 analyzes and establishes thresholds, triggers, and monitoring, management, and mitigation actions to avoid unreasonable effects to hydrologic and environmental resources in Dry Lake, Delamar, and Pahranagat valleys.

Section 10.0 summarizes monitoring activities that will enable effective implementation of the triggers and actions and support responsible groundwater development.

Section 11.0 lists references cited in this report.

Appendix A presents hydrologic data and statistical methods for establishing senior water right triggers.

Appendix B presents domestic water wells in the project basins and senior water rights in southern White River and Pahranagat valleys. The appendix also includes available well logs for senior underground water rights and domestic wells in the project basins. The senior water rights for the individual project basins are presented in Sections 6.0 - 9.0.

Appendix C presents hydrographs with current baseline data and lower control limits for hydrologic monitor network wells.

Appendix D presents remote sensing and statistical methods for shrubland and terrestrial woodland habitat triggers.

Appendix E presents a compilation table of environmental sites within the analysis area.

Appendix F presents site assessments of springs with vested claims V10073 - V10085 located in central Spring Valley conducted in September 2016.

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2.0 Senior Water Right Protection, Environmental Soundness, and Unreasonable Effects

This section provides a summary of senior water right protection and environmental soundness under Nevada water law and defines unreasonable effects for the SNWA GDP. Unreasonable effects as defined in this section provide the basis for the thresholds, triggers, and monitoring, management, and mitigation actions presented in this report. This approach complies with the Remand Order requirement to "Define standards, thresholds or triggers so that mitigation of unreasonable effects from pumping of water are neither arbitrary nor capricious in Spring Valley, Cave Valley, Dry Lake Valley and Delamar Valley" (Seventh Judicial District Court of the State of Nevada, 2013, at page 23). The definition of unreasonable effects is consistent with requirements to protect senior water rights, protectable interests in existing domestic wells, the public interest, and environmental soundness under Nevada water law.[1]

2.1 Senior Water Right Protection and Environmental Soundness

Nevada Revised Statute (NRS) § 533.370(2) states that the NSE shall reject an application that proposes a use of water that "conflicts with existing rights or with protectable interests in existing domestic wells." NRS § 533.024(1)(b) states that it is the policy of the State of Nevada to "recognize the importance of domestic wells as appurtenances to private homes, to create a protectable interest in such wells and to protect their supply of water from unreasonable adverse effects which are caused by municipal, quasi-municipal or industrial uses and which cannot reasonably be mitigated." Furthermore, NRS § 534.110(4) states that "It is a condition of each appropriation of groundwater... that the right must allow for a reasonable lowering of the static water level at the appropriator's point of diversion."

In Nevada, water appropriations are based on the principle of first in time, first in right (NRS § 534.110(6); NDWR, 2012a, at page 101). Water right seniority is based on application filing dates as defined in NRS § 534.080(3), implementation dates of vested rights as defined in NRS § 534.100(1), or drilling dates of domestic wells as defined in NRS § 534.080(4). As such, senior water rights are identified in this report as those that existed prior to the filing date of SNWA GDP applications 54003 - 54015 and 53987 - 53992 (October 17, 1989) in accordance with NRS § 534.080(3), NRS § 534.100(1), and NRS § 534.080(4).

NRS § 533.370(3) states that "In determining whether an application for an interbasin transfer of groundwater must be rejected," the NSE shall consider, "(c) Whether the proposed action is

1. NSE Rulings 6164-6167 interchangeably refer to unreasonable effects, unreasonable adverse effects, and unreasonable impacts to existing water rights and environmental resources under Nevada water law (NDWR, 2012a-d). The term "unreasonable effects" as is used in this report is synonymous with these terms.

environmentally sound as it relates to the basin from which the water is exported." As stated in Ruling 5726, "Water-level decline in and of itself is not environmentally unsound, rather it is the effects of water-level decline on the hydrologic-related natural resources that must be considered" (NDWR, 2007, at page 48).

The NSE presented his interpretation of the meaning of environmental soundness in various rulings regarding SNWA groundwater applications. In Ruling 5726, the NSE interpreted environmental soundness in the context of Nevada water law, legislative history, and NSE rulings and orders (NDWR, 2007, at pages 46-48).[1] The NSE found that, under Nevada water law, "whether the use of the water is environmentally sound for the basin of origin" means "whether the use of the water is sustainable over the long-term without unreasonable impacts to the water resources and the hydrologic-related natural resources that are dependent on those water resources" (NDWR, 2007, at page 47). In Rulings 6164-6167, the NSE equated "environmentally sound" with "the basins will remain environmentally viable," "a viable ecosystem will remain," and "viable plant and wildlife communities will remain" (NDWR, 2012a, at pages 187 and 191; NDWR, 2012b, at pages 147-148; NDWR, 2012c, at pages 142-143; NDWR, 2012d, at pages 140-141).

2.2 Unreasonable Effects

The definition of unreasonable effects, for the purposes of this report, is as follows:

> For the SNWA GDP, unreasonable effects are effects to hydrologic and environmental resources that
>
> a. conflict with senior water rights or protectable interests in existing domestic wells;
> b. jeopardize the continued existence of federally threatened and endangered species;
> c. cause extirpation of native aquatic-dependent special status animal species from a hydrographic basin's groundwater discharge area;
> d. cause elimination of habitat types from a hydrographic basin's groundwater discharge area; or
> e. cause excessive loss of shrub cover that results in extensive bare ground.

This definition of unreasonable effects is defined here in the context of the Remand Order and is specific to SNWA water rights in Spring and DDC valleys as part of the SNWA GDP. It responds to the concerns outlined in the Remand Order and is protective of senior water rights, protectable interests in existing domestic wells, and the public interest while allowing for reasonable lowering of the static water level as provided under Nevada water law (Section 2.1). The definition also incorporates the NSE's interpretation of environmental soundness under Nevada water law (Section 2.1), and identifies specific unreasonable environmental effects to avoid from SNWA GDP pumping. The definition of unreasonable effects is thus in accordance with the Remand Order and Nevada water law. However, this definition may not be applicable for other water rights in other

1. Ruling 5726 granted SNWA water rights in Spring Valley in 2007 and was vacated in 2010 because of a Nevada Supreme Court opinion that the NSE must re notice SNWA's original groundwater applications and reopen the protest period (Great Basin Water Network, et al., v. NSE, et al., June 17, 2010). A second water rights hearing was held, and the NSE issued Ruling 6164 granting SNWA water rights in Spring Valley in 2012.

hydrographic areas in Nevada, which have different rights, resources, and conditions, and are not subject to the Remand Order.

Unreasonable effects are described in more detail as follows:

- **Conflict with senior water rights or protectable interests in existing domestic wells**. A conflict occurs when, as a result of water use by a junior water right holder, a senior water right holder cannot access the specific quantity of water for the legally approved beneficial use, or an owner of an existing domestic well cannot access water needed for culinary and household purposes as defined in NRS § 534.350(8)(a). A conflict also occurs in the event of an unreasonable lowering of the static water level, which results in unreasonable cost increases to pump senior water rights or existing domestic well water. "In determining a reasonable lowering of the static water level in a particular area, the State Engineer shall consider the economics of pumping water for the general type of crops growing and may also consider the effect of using water on the economy of the area in general" (NRS § 534.110(4)).

- **Jeopardy to the continued existence of federally threatened and endangered species**. In accordance with the Endangered Species Act (ESA), SNWA GDP pumping must avoid jeopardizing the continued existence of federally threatened and endangered (listed) species.[1] Under the ESA, "*Jeopardize the continued existence of* means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a federally listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 Code of Federal Regulations (CFR) § 402.02). Definitions of endangered and threatened species under the ESA, and their occurrence in the analysis area, are presented in Section 5.0.

- **Extirpation of native aquatic-dependent special status animal species from a hydrographic basin's groundwater discharge area**. Species extirpation occurs when a species ceases to exist in a particular geographic region while it continues to exist elsewhere. The geographic region of concern discussed here is a hydrographic basin's groundwater discharge area because potential environmental effects from SNWA GDP pumping are possible within this area (Section 4.2), and the NSE manages groundwater at the basin scale in accordance with NRS § 533.364(1)(b) (for estimating water available for appropriation) and NRS § 533.370(3)(c) (for determining environmental soundness). Native aquatic-dependent special status animal species considered under this standard include federally proposed and candidate species, Nevada state-protected species, Nevada Bureau of Land Management (BLM) sensitive species, Nevada species of conservation priority, Utah state sensitive species, and species ranked critically imperiled or imperiled across their entire range by NatureServe[2]. Federally listed species are addressed under the standard above. Descriptions of the status categories and native aquatic-dependent sensitive status animal species within the analysis area are provided in Section 5.0. Although other wildlife are not specifically addressed in this

1. ESA compliance is a federal process separate from Nevada water law, as discussed in Section 10.6.
2. NatureServe is a nonprofit scientific network that collects and analyzes decision-quality data about imperiled species and ecosystems and serves as an industry-standard data source for environmental information. (NatureServe, 2017).

analysis, their needs are protected by avoiding unreasonable effects to senior water rights, federally listed species and native aquatic-dependent special status animal species with which they are generally co-located, and the habitat types that they use (as described below).

- **Elimination of habitat types from a hydrographic basin's groundwater discharge area**. Habitat types in the analysis area that could potentially be affected by SNWA GDP pumping include mesic, shrubland, terrestrial woodland, and lake habitat types. Elimination of one of these habitat types would occur if that habitat type ceases to exist in a hydrographic basin's groundwater discharge area. As discussed above, a hydrographic basin's groundwater discharge area is the geographic region of concern because potential environmental effects from SNWA GDP pumping are possible within this area, and the NSE manages groundwater at the basin scale. Descriptions of the habitat types, and their occurrence in the analysis area, are presented in Section 5.0.

- **Excessive loss of shrub cover that results in extensive bare ground**. Shrublands cover large areas of land in the analysis area. Excessive loss of shrub cover that results in extensive bare ground can lead to soil erosion and weed expansion. The proliferation of weeds is common in the analysis area and may occur regardless of SNWA GWD pumping. However, this standard is designed to avoid unreasonable effects to shrubland habitat from SNWA GDP pumping.

The thresholds, triggers, and monitoring, management, and mitigation actions identified in this report are designed to avoid the unreasonable effects defined above. The conceptual approach to avoid these unreasonable effects is presented in Section 3.0 and specific thresholds, triggers, and monitoring, management, and mitigation actions are presented in Sections 6.0 through 10.0.

3.0 Conceptual Approach to Establish Thresholds, Triggers, and Monitoring, Management, and Mitigation Actions

This section presents the conceptual approach used to identify thresholds, triggers, and monitoring, management, and mitigation actions. In compliance with the Remand Order, objective standards are applied to determine when and how mitigation will be implemented (Seventh Judicial District Court of the State of Nevada, 2013). This approach includes defining unreasonable effects (Section 2.2), establishing objective thresholds and quantitative mitigation triggers, identifying mitigation actions to avoid unreasonable effects, and complying with Nevada water law. As part of this approach, monitoring activities are established that will signal trigger activation and assess mitigation efficacy. Although not required by the Remand Order, the approach also establishes investigation triggers and identifies preemptive, discretionary management actions that will avoid or minimize the risk of activating mitigation triggers, and will support responsible groundwater development.

3.1 Systematic Process for Establishing Thresholds, Triggers, and 3M Actions

A systematic process was used to establish thresholds, quantitative triggers, and monitoring, management, and mitigation actions to avoid unreasonable effects from SNWA GDP pumping, and comply with Nevada water law. The process is consistent with modern approaches and recent literature recommendations regarding responsible development of groundwater resources. The process is also consistent with global 3M Plans and groundwater management programs.

The systematic process is illustrated in Figure 3-1 and is described as follows:

1. Delineate the analysis area and identify hydrologic and environmental resources that should be included in the analysis (Section 4.0).

2. Define what constitutes an unreasonable effect to hydrologic and environmental resources within the analysis area (Section 2.0).

3. Establish thresholds to provide buffers from and reduce the risk of unreasonable effects to identified resources.

4. Establish investigation triggers above the thresholds to prompt investigation actions and potential preemptive management actions.

5. Identify investigation actions to determine cause, condition, and significance of observed changes, and inform management and mitigation actions.

6. Identify management actions to avoid or minimize the risk of activating mitigation triggers.

7. Establish mitigation triggers at the thresholds to prompt mitigation actions before reaching an unreasonable effect.

8. Identify mitigation actions to avoid unreasonable effects, and comply with Nevada water law.

9. Establish monitoring activities to signal trigger activation, assess management and mitigation efficacy, and support adaptive management.

Sections 3.1.1 through 3.1.4 provide conceptual definitions of thresholds, investigation and mitigation triggers, and monitoring, management and mitigation actions that are used in this report. Section 3.2 presents the approach to avoid conflicts with senior water rights, including details explaining how thresholds, triggers, and actions are established for different types of water rights. This approach is then applied to senior water rights within the analysis area in Sections 6.0 through 9.0. Section 3.3 summarizes the approach to avoid unreasonable effects to environmental resources. Details explaining how thresholds, triggers, and actions are established for environmental resources within the analysis area are presented in Sections 6.0 through 9.0.

3.1.1 Thresholds

A threshold is defined in this report as a condition of a hydrologic or environmental resource that, when crossed, requires a mitigation action (Figure 3-1). Specific thresholds are established in this report to avoid unreasonable effects to water rights and environmental resources as defined in Section 2.2. The crossing of a threshold is detected by using quantitative mitigation triggers, as described in Section 3.1.2. Thresholds were determined by analyzing baseline data and considering resource sensitivity and the unreasonable effects descriptions in Section 2.2.

To reduce risk, thresholds were established at levels that provide buffers from unreasonable effects. For example, thresholds for senior water rights were established above permitted diversion rates when conditions allowed (Section 3.2.6.2). By establishing thresholds in this manner, time and resources will be available to implement mitigation actions and avoid unreasonable effects.

This approach is consistent with recent literature recommendations regarding groundwater management. For example, as described by the Union of Concerned Scientists, “[T]hresholds represent a defined target level or state that will avoid unacceptable outcomes. When a monitored variable approaches or crosses its threshold, a management entity may respond with a variety of reasonable actions to reverse the trend to avoid unacceptable outcomes” (Christian-Smith and Abhold 2015 at page 1).

Identifying thresholds is a common practice in applied hydrologic and environmental sciences. Thresholds as described in the literature take many forms. These forms include, but are not limited to thresholds that: signify general or specific changes in a resource state or condition; are related to resource limitations; are related to subjective management objectives; or inform or prompt decision making (Christian-Smith and Abhold 2015; Martin et al., 2009). In some cases, thresholds are at levels where small changes in parameters may bring about substantial changes in system dynamics or

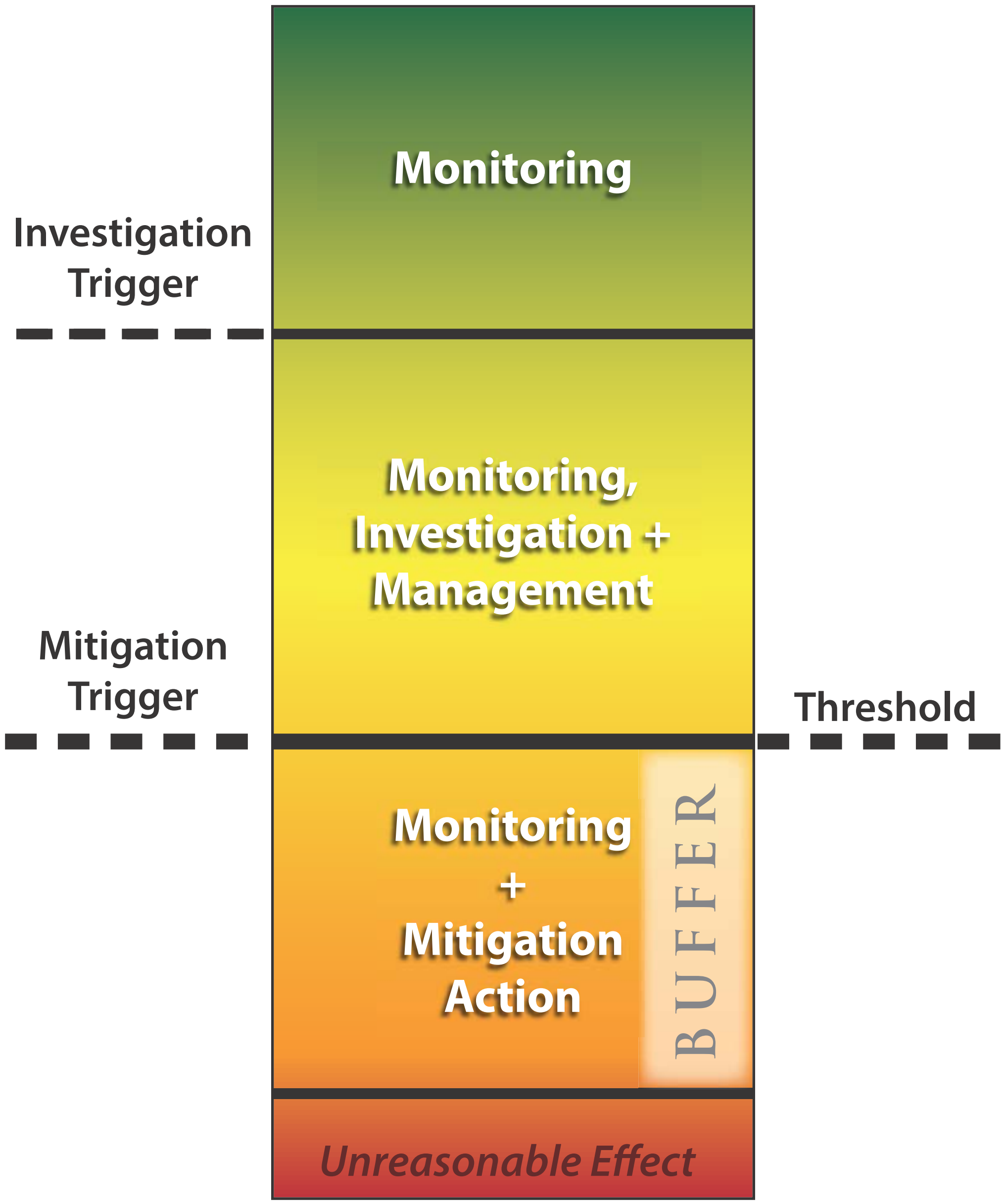


Figure 3-1
Threshold, Trigger, and Monitoring, Management, and Mitigation Approach

outcomes. These types of thresholds enhance understanding of hydrologic and biological system dynamics, but they are problematic if they result in managing at a point just shy of an undesirable outcome. In other cases, thresholds are at levels where decision making and actions can be implemented to bring about desired outcomes, and avoid undesired outcomes. Thresholds in this report are consistent with the latter: they are established at levels where decision making and actions can be implemented in time to avoid unreasonable effects to hydrologic and environmental resources.

3.1.2 Triggers

A trigger, as defined in this report, is a quantitative hydrologic or environmental parameter value that prompts action. Specific quantitative triggers are established in this report. Two types of triggers are employed: investigation triggers and mitigation triggers. Investigation triggers are established above thresholds levels and prompt investigation actions (Figure 3-1). Based on investigation findings, preemptive management actions may be implemented to avoid or minimize the risk of activating mitigation triggers. Mitigation triggers are established at threshold levels (Section 3.1.1) and prompt mitigation actions (Section 3.1.3) to avoid unreasonable effects and comply with Nevada water law (Figure 3-1).

Investigation triggers are included in the approach as a best management practice. Investigation triggers provide a variety of benefits, including increased protection to sensitive resources, enhanced ability to determine cause, condition, and significance of observed changes, and the provision of additional data and analyses to inform management and mitigation actions. Specific quantitative investigation triggers are established in this report by analyzing baseline data and considering the established thresholds (Section 3.1.1). Activation of the investigation triggers occurs when measured parameter values fall below defined investigation trigger levels for specified durations of time. Investigation trigger levels in this report are values (e.g., a water level at a well) or ranges of values (e.g., a shrubland cover prediction interval that spans a range of precipitation levels). Durations of time are included to lessen noise from temporary variation and measurement error so that meaningful change is detected. Investigation triggers can occur at resource point locations [e.g., a water right point of diversion (POD)] or resource areas (e.g., a shrubland habitat area), as well as at intermediate monitor wells between resources and SNWA GDP pumping locations. Investigation triggers are anticipated to be activated and used to track the occurrence and propagation of drawdown from SNWA GDP pumping.

Mitigation triggers are used to signal that thresholds have been crossed (Section 3.1.1). Specific quantitative mitigation triggers are established in this report. Activation of the mitigation triggers occurs when measured parameter values fall below defined mitigation trigger levels for a specified duration of time. As with investigation triggers, mitigation trigger levels in this report are values or ranges of values, with durations of time specified so that meaningful change is detected. Mitigation triggers can occur at resource point locations or resource areas (e.g., a water right POD or a shrubland area). This mitigation trigger approach is consistent with recent literature recommendations regarding responsible groundwater management. For example, as described by the Union of Concerned Scientists, "[T]riggers identify in advance how, when, and why management actions take place" (Christian-Smith and Abhold 2015 at page 9).

The investigation and mitigation triggers for hydrologic resources are (1) a quantitative fixed trigger which is related to a specific value, such as water level or discharge rate, or (2) a quantitative trigger linked to the behavior of the baseline data record. Quantitative fixed triggers can be associated with a specific permitted water right diversion rate. However, they do not adjust for trends or reoccurring patterns, such as seasonality, in the baseline data set. Quantitative triggers linked to the behavior of the baseline dataset can account for trends and seasonal variability which are more responsive in accounting for variation in natural hydrologic conditions. The investigation and mitigation triggers for environmental resources are (1) a hydrologic trigger as discussed above, or (2) a quantitative environmental trigger linked to the behavior of the baseline data record.

Like thresholds, identifying triggers is a common practice in applied hydrologic and environmental science. Triggers that are described in the literature take many forms. They range from qualitative triggers based on subjective management objectives, to quantitative triggers that require action to bring about desired outcomes. They can be established above, at, or below threshold levels, or with no consideration of thresholds at all. Triggers in this report are quantitative, are established above and at thresholds, and prompt management and mitigation actions to avoid unreasonable effects and comply with Nevada water law.

3.1.3 Actions

Activation of triggers can prompt three types of actions: investigation actions, management actions, and mitigation actions.

Investigation actions are prompted by investigation triggers (Section 3.1.2) and can also be requested by the NSE. The purpose of conducting investigations is to determine cause, condition, and significance of observed changes, and inform management and mitigation actions. Investigation actions focus on data analyses, refinement of predictive tools, and may incorporate additional data collection efforts. For example, investigation actions that result from activating an investigation trigger might involve analyses of groundwater level and spring discharge data, SNWA GDP pumping data, and precipitation data to understand groundwater levels in the context of regional patterns. A critical aspect of investigation actions is to determine the cause and significance of water level changes at the trigger location, and identify prudent preemptive management actions.

Preemptive, discretionary management actions may be prompted by investigation findings, and will be employed as best management practices for the SNWA GDP. The purpose of implementing preemptive management actions is to avoid or minimize the risk of activating mitigation triggers, and support responsible groundwater development. Management actions that are known to be effective and are available to SNWA are identified in this report. Specific implementation of individual management actions will depend on the resource and situation. For example, if an investigation trigger is activated at an intermediate monitor well, management actions might involve reducing pumping rates at specific locations to reduce drawdown propagation toward a resource.

Mitigation actions are prompted by mitigation triggers, as described in Section 3.1.2. Specific quantitative triggers are established in this report. Mitigation actions may also be implemented preemptively if data trends indicate that the activation of a mitigation trigger is imminent. In some cases, mitigation may be conducted prior to SNWA GDP pumping (e.g., for resources close to pumping locations with a potential high risk of impact, or for highly sensitive resources). The purpose of implementing mitigation actions is to avoid unreasonable effects, and comply with Nevada water law. Mitigation actions that are known to be effective and are available to SNWA are specified for senior water rights and environmental resources in this report. Specific implementation of individual mitigation actions will depend on the resource and situation. For example, if a mitigation trigger is activated at a flowing artesian well with a senior water right, a pump may be installed to ensure continued access to the permitted water for the legally-approved beneficial use.

3.1.4 Monitoring and Adaptive Management

Monitoring activities in this report are designed to signal trigger activation, conduct investigations, inform management and mitigation actions, and assess management and mitigation efficacy. Monitoring data collected prior to the initiation of SNWA GDP pumping will document baseline conditions, and data collected during SNWA GDP pumping will detect changing conditions. The hydrologic monitoring network will also document basin-wide system responses to a range of precipitation and background conditions. Baseline monitoring data have been collected since 2006, and continue to be collected as part of the SNWA GDP. Commitments and time lines for additional hydrologic and environmental monitoring prior to and during SNWA GDP pumping are summarized in Section 10.0 and detailed in the SNWA 3M Plans (SNWA, 2017d and e).

Specific and quantitative investigation and mitigation triggers are calculated in this report using available data. More baseline data will become available after full implementation of the 3M Plans and prior to initiation of SNWA GDP pumping. Trigger values that are linked to the baseline data record (as discussed in Section 3.1.2) will be re-calculated using new data acquired through the baseline monitoring period following the same methods. Trigger values may also be re-calculated using additional data collected during SNWA GDP pumping, as long as data demonstrate that drawdown propagation to the region of interest has not occurred and the NSE approves. The purpose of re-calculation is to base triggers on the appropriate baseline dataset and range of variation.

Adaptive management is an integral part of the SNWA GDP, and is the most up-to-date scientific approach to long-term projects (Marshall and Luptowitz, 2011). Adaptive management does not mean simple trial and error, hypothesis testing, or delayed decision making. It also does not mean that triggers and actions established in this report will be changed without justification. As defined by the Code of Federal Regulations (43 C.F.R. § 46.30): “Adaptive management is a system of management practices based on clearly identified outcomes and monitoring to determine whether management actions are meeting desired outcomes; and, if not, facilitating management changes that will best ensure that outcomes are met or re-evaluated.” The U.S. Department of the Interior (DOI) encourages the use of adaptive management “particularly in circumstances where long-term impacts may be uncertain and future monitoring will be needed to make adjustments in subsequent implementation decisions” (43 C.F.R. § 46.145; also in Williams et al., 2009).

Implementing adaptive management for the SNWA GDP will reduce uncertainty, increase responsiveness to changing conditions, and enhance management and mitigation efficacy. An example of adaptive management is the use of aquifer response data to update predictive tools, which will lead to enhanced understanding and management of drawdown propagation. Another example is the use of monitoring data to assess mitigation efficacy, which may lead to modifications in mitigation actions to avoid unreasonable effects, and comply with Nevada water law.

3.1.5 Trigger Approaches Applied in other Groundwater Management Programs

Thresholds and triggers for management and mitigation actions are utilized in basin groundwater management programs throughout the world for several purposes including identification of drought conditions, basin sustainability management, and resource and groundwater development projects. The methods used to establish the triggers depend upon the objectives of the management programs. Several examples associated with groundwater management programs are presented in this section.

Christian-Smith and Abhold (2015) reviewed relevant literature and existing groundwater management plans with measurable objectives and provided examples for management programs and use of triggers including:

- South Westside Basin GW Management Plan in California, which used fixed trigger action levels based on the historical groundwater level (San Francisco Public Utilities Commission, 2012).
- Lower Platte South Natural Resources District, which used a fixed trigger based on a percent value of static groundwater elevations decline using the upper limit of saturated thickness as a reference point for basin management (Lower Platte South Natural Resources District, 2014).
- Glenn County Sub Area 8 Basin Management Program used a simple statistical analysis of the baseline data using standard deviation from the average value over the period of record to set action triggers (Glenn County Department of Water Resources, 2010).

Other 3M or groundwater management plans including mining projects in Australia use statistically derived triggers to initiate management or mitigation actions including:

- BHP Billiton Surface and Ground Water Response Plan managing potential impacts from coal extraction, approved by the Department of Planning and Environment, New South Wales, Australia in April 2015, used 95 percent and 99 percent lower control limits to establish triggers for investigation and corrective/preventative actions, (BHP Billiton, 2015a and b).

Christian-Smith and Abhold (2015) presents an example, shown in Figure 3-2, of a statistically derived lower control limit to determine a departure from baseline conditions as a basis to establish a trigger.

These and other 3M-type plans from the United States, Australia, and Canada (Lower Athabasca Region, Alberta Canada, 2013) demonstrate the current best management practice for approach and application of triggers and management/ mitigation actions. The SNWA GDP 3M plan approach and method for establishing triggers and management actions are consistent with these practices.

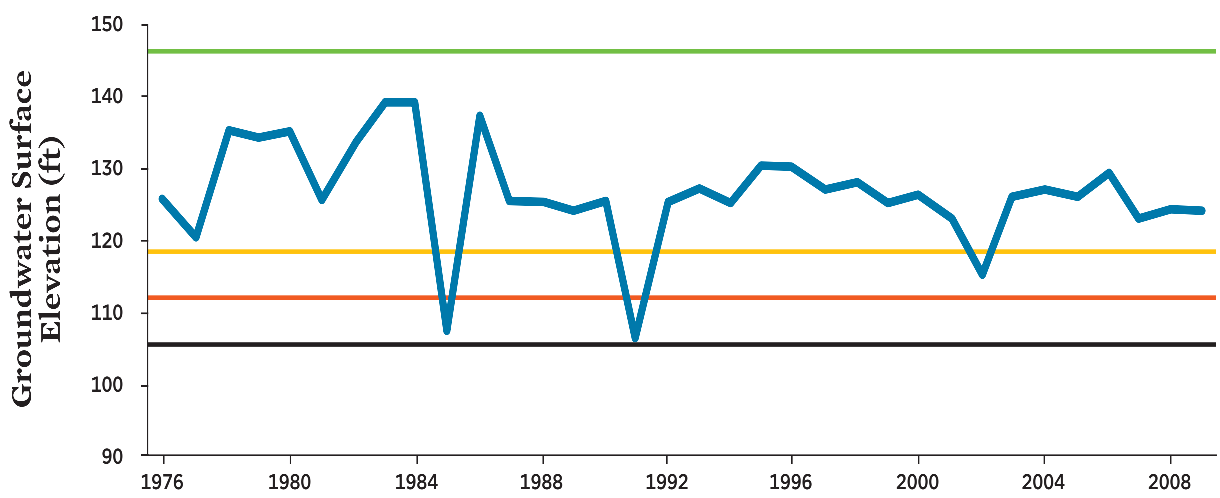


Figure 3-2
Example of Statistically Derived Trigger Action Levels for Groundwater Management from: Christian-Smith and Abhold (2015)

3.2 Approach to Avoid or Eliminate Conflicts with Senior Water Rights

The 3M Plan approach uses monitoring activities, management tools, investigation and mitigation triggers, and management and mitigation actions to avoid or eliminate conflicts with existing water rights. As described in Section 2.2, unreasonable effects include conflicts with senior water rights or protectable interests in existing domestic wells. Specific applications of the 3M Plan approach to individual senior water rights and domestic wells located within the analysis area are presented in Sections 6.0 through 9.0. The major elements for protection of senior water rights are summarized below:

- Identify the water rights to be included in the 3M Plan. The analysis area and criteria for inclusion of a water right into the 3M Plan is presented in Section 4.0.

- Quantify the volume of water rights associated with each senior water right. Request adjudication of selected vested claims prior to SNWA GDP pumping in order to determine the decreed volume that must be protected. Until an adjudication is completed, the quantified vested claim volume will be protected.

- For each senior water right in the 3M Plans, establish an associated investigation trigger to prompt investigation actions, and a mitigation trigger for when a mitigation action is required.

- For each senior water right in the 3M Plans, identify management and mitigation actions that are effective and available to SNWA.
- Implement appropriate monitoring to identify and document baseline hydrologic conditions (e.g., water levels, spring and stream flow, and precipitation) prior to SNWA GDP pumping, and to identify and document conditions during SNWA GDP operations.
- Assess and document baseline hydraulic characteristics, conditions, and production capacity of senior water right PODs prior to SNWA GDP pumping.
- Monitor the senior water right or assigned associated monitoring location to detect if an investigation trigger is activated.
- Conduct an investigation if an investigation trigger is activated. The investigation will determine cause, condition, and significance of observed changes in relation to potential future effects on senior water rights and will inform potential management actions.
- Preemptively implement management actions and expanded monitoring based upon the investigation findings to avoid reaching a mitigation trigger at a senior water right. Mitigation actions may also be preemptively conducted if data trends indicate that mitigation trigger activation is imminent.
- Monitor if a mitigation trigger at a senior water right or assigned location is activated.
- Implement mitigation actions at the senior water right POD, place of beneficial use, and/or SNWA GDP POD to avoid or eliminate the conflict.
- Assess management and mitigation efficacy using monitoring data, and modify actions if needed to avoid or eliminate conflicts.

3.2.1 Investigation Triggers

Investigation triggers for senior water rights are an SNWA management tool to evaluate observed changes in trigger parameter values, and preemptively implement discretionary management actions to avoid or minimize the risk of activating mitigation triggers. The investigation triggers are activated if trigger parameter values are outside the normal range of the historical baseline, as specified below. When an investigation trigger is activated, SNWA will conduct an investigation and submit the findings to the NSE (see investigation in Section 3.2.2, and reporting in Section 10.5). The purpose of the investigation is to determine the cause, condition, and significance of the observed changes in relation to potential future effects on senior water rights, and to inform potential management actions.

Investigation triggers are specific and quantified and are set at different types of locations to assist in managing SNWA GDP pumping in order to avoid mitigation triggers and unreasonable effects. Specific investigation triggers for the senior water rights are presented in the Spring Valley and DDC 3M Plans (SNWA 2017c-d), respectively, and in Sections 6.0 through 9.0 of this report. The types of locations where an investigation trigger is assigned in the 3M Plans are presented below:

- A specific senior water right.
- A specific spring or well which acts as a proxy for multiple senior water rights in the vicinity of that location.
- An intermediate monitor well, piezometer, or spring location between an individual or group of senior water rights and SNWA GDP PODs. The intermediate location acts as an early warning to detect the presence and amount of change in water level or spring discharge prior to being observed at a measurable level at a distant senior water right.
- A sentinel monitor well, which is located on the outside fringe of SNWA GDP pumping areas, to detect the presence and amount of drawdown propagating from the pumping areas. An example of sentinel wells is the designated monitor wells located along the hydrographic boundary between Spring and Hamlin valleys. The sentinel wells provide data to determine if management actions are needed or if additional monitoring should be expanded a greater distance away from the pumping area in order to protect more distant senior water rights.

The measured parameters associated with a designated investigation trigger depend upon the location and type of site. The measured parameters may include groundwater level, well production rate, spring flow, or stream flow.

The activation conditions assigned to a specific investigation trigger location are dependent on the length, quality, and characteristics of the baseline record. The primary investigation trigger is a decrease in the measured parameter (such as water level or spring flow) that is collected after SNWA GDP pumping begins, which for six continuous months is below the 99.7 percent lower control limit using the seasonally adjusted linear regression method for the baseline data collected prior to SNWA GDP pumping.

The SNWA GDP 3M Plan uses the seasonally adjusted linear regression (SALR) method to identify a lower control limit for the baseline dataset. A linear regression is a simple method that can be used to construct a model to fit time-series data (Chandler and Scott, 2011). The method uses ordinary least-squares, which calculates a best-fit line for the observed data by minimizing the sum of the squares of the vertical deviations from each data point to the line. “Linear least squares regression is by far the most widely used modeling method. It is what most people mean when they say they have used "regression", "linear regression" or "least squares" to fit a model to their data” (NIST/SEMATECH, 2017).

Evaluating hydrologic time-series data using a linear regression model provides the ability to assess the trend of the data over a period of time and captures the aggregate effects of the natural and human induced processes on the baseline measurement data. The SALR method also evaluates recurring seasonal variability in the record. A description of the SALR method and examples demonstrating the activation of an investigation trigger is presented in Appendix A.

Activation conditions assigned to individual senior water rights or monitoring locations may also include one of the following:

- A series of measured parameter values collected after SNWA GDP pumping begins which significantly deviate from values expected based upon predictive tools (e.g. numerical groundwater flow models and analytical forward solutions).

- A series of measured parameter values which deviate from expected values when compared to index monitoring sites, which have otherwise responded in a similar manner to the identified monitoring location throughout the baseline period.

- At the request of the NSE.

The number of measurements in a series or the length of time that the measured parameters falls outside the expected range, which activates an investigation trigger, is dependent upon the site sensitivity, conditions, and baseline record. A time duration is set as a trigger condition for each individual site. The time duration for SNWA GDP 3M Plans is usually a six month period. A standard used by other 3M Plans in the scientific literature is a period of one year outside the trigger level to take into account measurement error or short term variability in the resource (BHP Billiton, 2015a and b).

Also the USGS regularly takes six months to perform quality control/quality assurance on measurement data before the data is moved from "provisional" to "final" category on the National Water Information System (NWIS) for surface water sites. For locations monitored continuously with transducers, data is downloaded from the data logger and manual verification physical measurements are typically taken once every three months to confirm validity of electronic measurements. If there is instrumentation malfunction or error in the record it requires additional time to verify the measurements. Additionally, water levels naturally rise and fall with the seasons due to precipitation and the recharge cycle. To account for these factors, the 3M Plans for the SNWA GDP will usually use a six month time frame for activation of an investigation trigger.

A variety of causes unrelated to SNWA GDP pumping may result in divergence of parameter values from the historical baseline range and predicted trend. These include natural variation outside the recorded baseline (such as changes in precipitation or extended drought), measurement error or instrument malfunction, change in conditions at the monitoring site, change in nearby irrigation practice, fire, and/or other natural conditions or human activities. Surface water discharge measurement error can be over 10 percent due to human interaction and instrument calibration or measuring device errors (Rantz et al., 1982; and Harmel et al., 2006).

The crossing of an investigation trigger level for the assigned period of time will result in the activation of an investigation to determine the cause, condition, and significance of the divergence. The activation of investigation triggers at certain monitoring locations, especially those located in the immediate vicinity of pumping areas, are anticipated as SNWA GDP pumping occurs. The triggers provide for a systematic analysis of the first observation of significant deviation from baseline condition both for expected and unexpected cases. This will enable predictive tools to be revised based on observed drawdown data and appropriate management actions to be considered and implemented before mitigation triggers are activated to avoid unreasonable effects in a timely and scientifically sound manner.

3.2.2 Investigation Methodology

Investigations will be conducted when investigation and mitigation triggers are activated, or at the request of the NSE (Section 3.2.1). The purpose of conducting investigations is to determine cause, condition, and significance of observed changes, and inform management and mitigation actions. SNWA will also perform regular internal technical reviews of data for the improvement and optimization of project operation and management which will follow a similar investigation methodology.

The investigation methodology includes the following components:

- Assemble and document information on the current and historical conditions in the investigation area including: SNWA pumping locations, rates, and duration; physical attributes of water right POD; monitoring system and instrumentation; hydrologic data; historical water and land use in the area; other non-SNWA pumping; changes in irrigation activities; and other factors which may influence the investigation area.

- Evaluate the hydrogeologic conditions at the site including source aquifer, recharge location, water chemistry, and effects from local conditions or activities. The investigation evaluates the likelihood and degree of hydrologic connection between the site and the producing aquifer in which SNWA GDP production wells will be installed.

- Compare investigation area data with SNWA GDP pumping activities and background hydrologic information. Evaluate the variability in water level in the wells or spring discharge compared to historical regional hydrologic conditions including regional and local precipitation, barometric pressure, stream flow, spring flow, land use, and irrigation practices. Compare hydrologic conditions at the site to area reference index sites, if available, which behaved in a similar manner to the site of investigation over time.

- Review the quality control / quality assurance and calibration data documentation associated with the monitoring instrumentation and measurements.

- Quantify the amount of drawdown in wells between the site and production locations and compare with SNWA GDP pumping rates, duration, and schedule.

- Identify other pumping or natural stress which may influence the site.

- Utilize management tools such as the USGS SeriesSEE (Halford et al., 2012) analysis package to identify and detrend influences such as precipitation, barometric pressure, and tidal effects on historical time series data sets associated with the senior water right or monitoring locations. SeriesSEE can be used to compare water level or spring flow at the site to multiple regional reference locations outside the SNWA GDP pumping area in order to detect divergence from those reference sites. It is used to help filter regional influences from pumping effects.

- Compare the drawdown estimated by analytical solutions and the numerical groundwater flow model for the documented SNWA GDP pumping rate, distribution, and duration history to the change in water level observed at the site and area monitoring locations.

- If the investigation trigger is associated with an underground water right, evaluate the well efficiency and performance to pre-SNWA GDP pumping conditions.

- Prepare a technical memorandum of findings from the investigation (Section 10.5).

- Additional investigation actions for environmental resources are described in Section 3.3.

3.2.3 Management Actions and Tools

3.2.3.1 Management Actions

Preemptive management actions may be taken to avoid reaching a mitigation trigger and causing unreasonable effects. Management actions may be implemented based on investigation findings that result from the activation of investigation triggers. SNWA may also develop and implement management actions for the ongoing improvement and optimization of SNWA GDP operations. The specific management actions are dependent upon the risk of impact, significance of the change (in water level, production rate, spring flow, or stream flow), potential of the mitigation trigger being reached at a senior water right, and sensitivity of the resource.

Examples of management actions which may be used include, but are not limited to, the following:

- Additional data collection and evaluation including expanded monitoring activities such as installation of additional monitoring wells or spring monitoring sites.

- Increase measurement frequency or install higher resolution monitoring instrumentation.

- Expand use of management predictive tools such as analytical methods and numerical groundwater flow models to analyze the significance and relationship of drawdown at the investigation trigger location, and projected drawdown.

- Develop higher resolution local flow models (child models) if sufficient data exists within the regional groundwater flow model to provide a tool for analysis in the specific area of interest.

- Establish a new or refined quantitative investigation trigger(s) to track a continuing trend outside the baseline in relation to potential effects on senior water rights. The new investigative trigger will be specific for the location and may be based upon the data set adjusted for the background influence of precipitation, tidal effects, and barometric pressure.

- Establish a management action linked to maximum drawdown level to avoid reaching a mitigation trigger. The management action is established at an intermediate monitor or sentinel well location using predictive tools to determine the maximum drawdown level at that location allowed in order to avoid approaching a mitigation trigger at a distant resource site.

- Evaluate modification of SNWA pumping distribution locations along with well production rates and duration on drawdown levels.
- Modify SNWA pumping to avoid a mitigation trigger as described in Section 3.2.4.
- Preemptively implement a mitigation action prior to reaching a mitigation trigger.

3.2.3.2 Use of Predictive Tools

The 3M Plan approach uses analytical forward solutions and numerical groundwater flow modeling as predictive tools to assist with management of groundwater development. Prior to SNWA GDP initiation, data on aquifer properties and the degree of hydraulic connection between the SNWA GDP POD(s), monitor wells, senior water rights, and environmental resource areas is estimated based upon borehole lithology and aquifer testing data. Presence of boundary conditions and change of aquifer properties over distance are estimated from results of available geologic mapping, geophysical studies, and other bore hole data.

The 3M Plan requires the numerical groundwater flow model to be updated at least every five years after the beginning of SNWA GDP pumping. However, model refinement and calibration are also linked to SNWA staged development and investigation triggers which may result in more frequent updates. The staged development transient water levels and refined model will be used to optimize project pumping distribution, and more accurately predict aquifer response over time and distance, in order to avoid mitigation triggers and unreasonable effects.

The numerical groundwater flow model will be updated prior to SNWA GDP pumping to incorporate new data collected during the baseline period including aquifer test data. The model will also be updated with any approved location changes of SNWA GDP PODs.

After GDP pumping begins, predictive tools will be calibrated using aquifer response data to become more effective in estimating drawdown at a certain distance and time at monitoring locations, senior water rights, and environmental resource areas under various production well operating scenarios. As staged development occurs and the production operations are optimized, the transient drawdown aquifer response data from pumping will be expanded and the numerical model will be refined. Investigation triggers and management actions will be reviewed and refined as more operational and aquifer response data become available.

Local higher resolution flow models (child models) within the SNWA GDP regional numerical flow model domain may be developed in areas requiring more detailed management and predictive capabilities, if sufficient data exists to support their development. The numerical groundwater flow model and other predictive tools will also be used in evaluating the efficacy of a management or mitigation action by predicting the change in drawdown or rates of recovery under different modified pumping scenarios or mitigation actions.

3.2.4 Management Actions Regarding SNWA GDP Pumping Operations

SNWA GDP pumping operations will be managed and adjusted as necessary to manage drawdown in areas based upon recorded aquifer response from pumping operations and numerical groundwater flow model projections. Management actions associated with SNWA GDP pumping operations may be used to optimize SNWA GDP operations and respond to drawdown in certain areas. Pumping operations may also be modified based upon larger than normal recharge events or extended drought periods. Areas within the SNWA GDP basins may be rested for periods of time to allow recovery. Management actions associated with pumping operations include the following:

- Change in pumping rates of selected production wells or well fields.
- Reduction in total groundwater extraction for a basin.
- Change in pumping duration - seasonal cycling.
- Change in daily pumping duration - daily cycling of production wells.
- Rotation of pumping between individual wells and/or well fields.
- Distribution of pumping within the basin.
- Rotation of pumping between basins.
- Change in pumping rates and durations related to precipitation and recharge conditions.
- Suspension of pumping at individual production well sites, well fields, basin wide, or project wide.

3.2.5 Senior Water Right Groundwater Management Categories

Each senior water right (including domestic wells) included in the 3M Plan was evaluated and classified into groundwater management categories that reflect the approach for monitoring and managing SNWA GDP pumping effects and mitigating these effects if necessary. The categories considered the following factors:

- The distance from the closest SNWA GDP POD to the senior water right.
- Presence of intermediate monitor well(s) between the senior water right and SNWA GDP POD.
- Hydrogeologic condition and hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed.
- Spring and stream senior water right POD hydrogeologic setting and elevation compared to the groundwater level at the SNWA GDP POD.

- Status, source, and use of the water right.

Sections 6.0 through 9.0 present the locations of the senior water rights in individual basin areas in relation to SNWA GDP PODs and current hydrologic monitoring network wells and springs. The categories and associated monitoring and management strategies are presented in Table 3-1.

The SNWA GDP 3M Plan uses a staged development approach in Spring Valley and requests a similar approach in Cave Valley. Staged development begins the project operations with a limited amount of pumping to observe and evaluate the aquifer response at various monitoring point locations under different pumping rates, durations, and distribution between production wells. The rate of change of drawdown decreases with time and with distance logarithmically from the pumping well. Therefore, the rate of change is greatest and quickest in the immediate vicinity of the production well during the beginning of pumping. The farther away from a pumping well, the less drawdown and lower the rate of change over time is observed. As a result, the greater the distance from a pumping well, the more time is available to evaluate the propagation and changes in drawdown with distance from the pumping well or to take management actions to avoid mitigation triggers.

The management categories align with the use of staged development of production with more emphasis initially focused on senior water rights located near the SNWA GDP production areas. Management categories are portrayed in Figures 3-3 and 3-4. Management Category A is assigned to senior water rights within 3 miles of a SNWA GDP POD. Management Category B is assigned to senior water rights between 3 and 10 miles of a SNWA GDP POD.

Category A and B senior water rights will be monitored directly at the POD or at a proxy monitoring site if there are multiple water rights grouped together or if a more reliable measurement representative of the senior water right POD can be collected. Category B will be monitored directly at the senior water right POD or at a proxy monitor well in the vicinity of the senior rights which can detect propagation of drawdown for a group of senior rights.

Management Categories C and D rely on an intermediate well located between the senior water right and the SNWA GDP POD to detect and measure propagation of drawdown. Management Category C consists of senior water rights within the same basin as and located over 10 miles from the closest SNWA GDP POD (for example, water rights located in northern Dry Lake and northern Spring valleys). Management Category D is assigned to senior water rights located in an adjacent basin (Hamlin, Snake, White River, and Pahranagat valleys) where an intermediate well is designated as a sentinel monitor well (as described in Section 3.2.1) near the basin boundary.

Management Category E is assigned to senior water rights that are not hydraulically connected with the producing aquifer in which SNWA GDP production wells will be installed. This categorization is based upon previous hearing testimony, the hydrogeologic conditions of the site, and the difference in spring or stream elevation compared to the SNWA GDP POD water level. Examples of these locations are high elevation springs in northern Cave and Dry Lake valleys.

Table 3-1
Management Category Summary[a]
(Page 1 of 2)

Category	Description	Monitoring Strategy	Management Strategy
A	Senior water right <3 miles from closest SNWA GDP POD	- Perform water resource assessment at least three years prior to SNWA GDP pumping with owner permission (Section 3.2.7) -Direct monitoring at senior water right site or proxy monitoring site at least quarterly	-Investigation trigger at senior water right site or proxy monitoring location is below the 99.7 percent lower control limit for six months using the seasonally adjusted linear regression method (Section 3.2.1) -Mitigation trigger set at senior water right site (Section 3.2.6) -Preemptive mitigation preparation
B	Senior water right 3 to 10 miles from closest SNWA GDP POD	- Perform water resource assessment at least three years prior to SNWA GDP pumping with owner permission (Section 3.2.7) -Direct monitoring at senior water right site or proxy monitoring site at least quarterly -Monitoring at intermediate monitor well, if available	--Investigation trigger at senior water right site or proxy monitoring location is below the 99.7 percent lower control limit for six months using the seasonally adjusted linear regression method (Section 3.2.1) -Mitigation trigger set at senior water right site (Section 3.2.6) -Preemptive mitigation preparation
C	Distant senior water right site >10 miles from closest SNWA GDP POD, and is within the same basin	-Monitoring at sentinel well and senior water right or nearby proxy site	-Investigation trigger is activated if water level in sentinel or intermediate well is below the 99.7 percent lower control limit for six months using the seasonally adjusted linear regression method (Section 3.2.1) -Refine predictive tools with aquifer response data to estimate drawdown at other more distant monitor wells -Identify and implement management actions if needed (Section 3.2.3) -Mitigation trigger set at senior water right site (Section 3.2.6)

Table 3-1
Management Category Summary[a]
(Page 2 of 2)

Category	Description	Monitoring Strategy	Management Strategy
D	Senior water right site located in a hydrographic area adjacent to SNWA GDP basins	-Monitoring at sentinel well near basin boundary -Monitoring at multiple monitor wells at different distances between senior water right site and SNWA GDP POD -Monitoring at senior water right site or proxy site	-Investigation trigger at senior water right site or proxy monitoring location is below the 99.7 percent lower control limit for six months using the seasonally adjusted linear regression method (Section 3.2.1) -Refine predictive tools with aquifer response data to estimate drawdown at other monitor wells and at senior water right site to determine if amount of drawdown in sentinel or other monitoring wells is significant compared to senior water right site -Identify and implement management actions if needed (Section 3.2.3) -Mitigation trigger set at senior water right site (Section 3.2.6)
E	Senior water right site not in hydraulic connection with SNWA GDP producing aquifer in which SNWA GDP production wells will be installed	-Effects from SNWA GDP pumping are unlikely -Monitoring at intermediate, sentinel well, and/or area proxy well for verification	Effects from SNWA GDP pumping are unlikely

a.The assigned management category for each senior water right in the 3M Plan area is presented in the individual basin senior water right summary tables presented in Sections 6.0 - 9.0 and Appendix B.

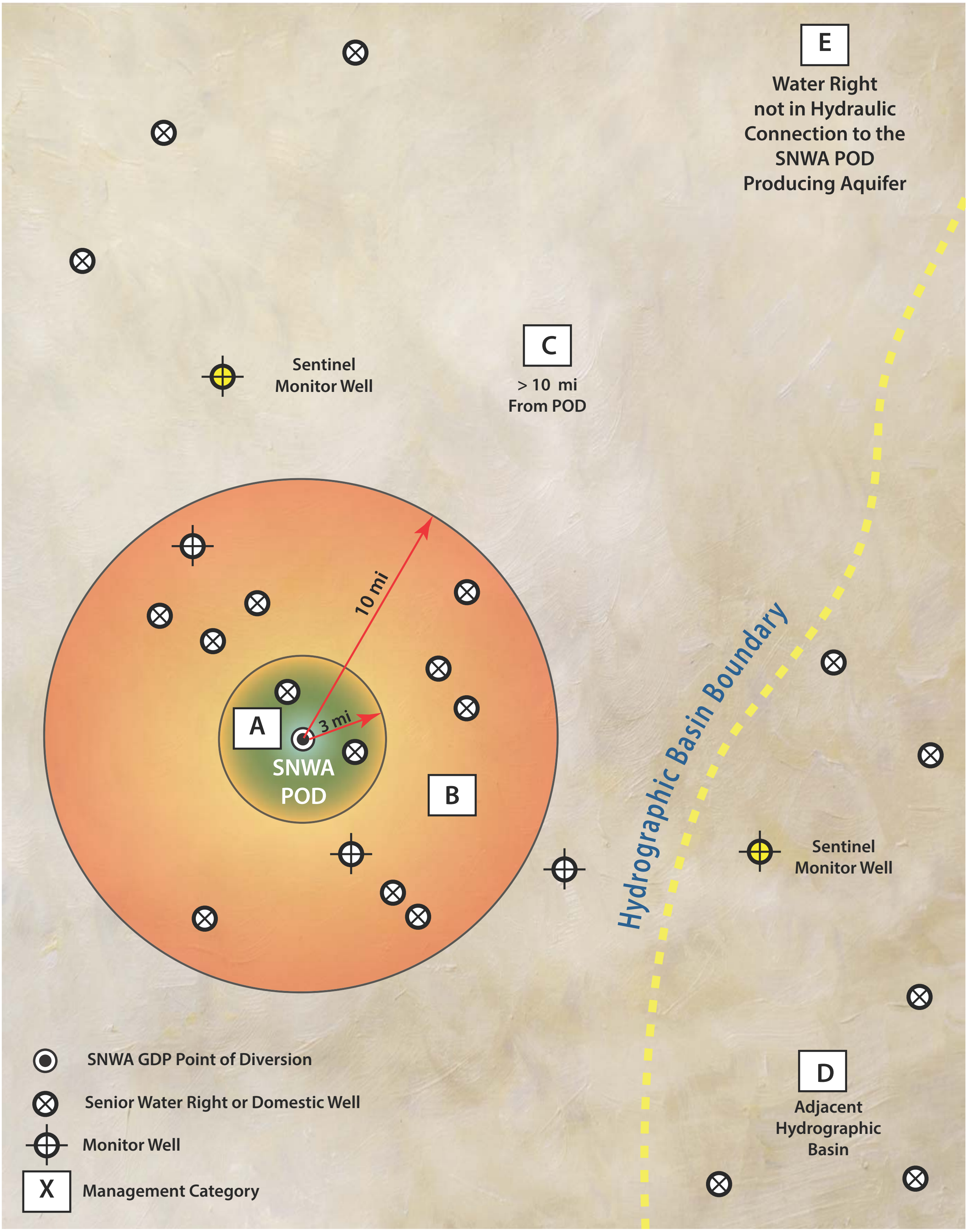


Figure 3-3
Plan View Illustration of Management Strategy Categories

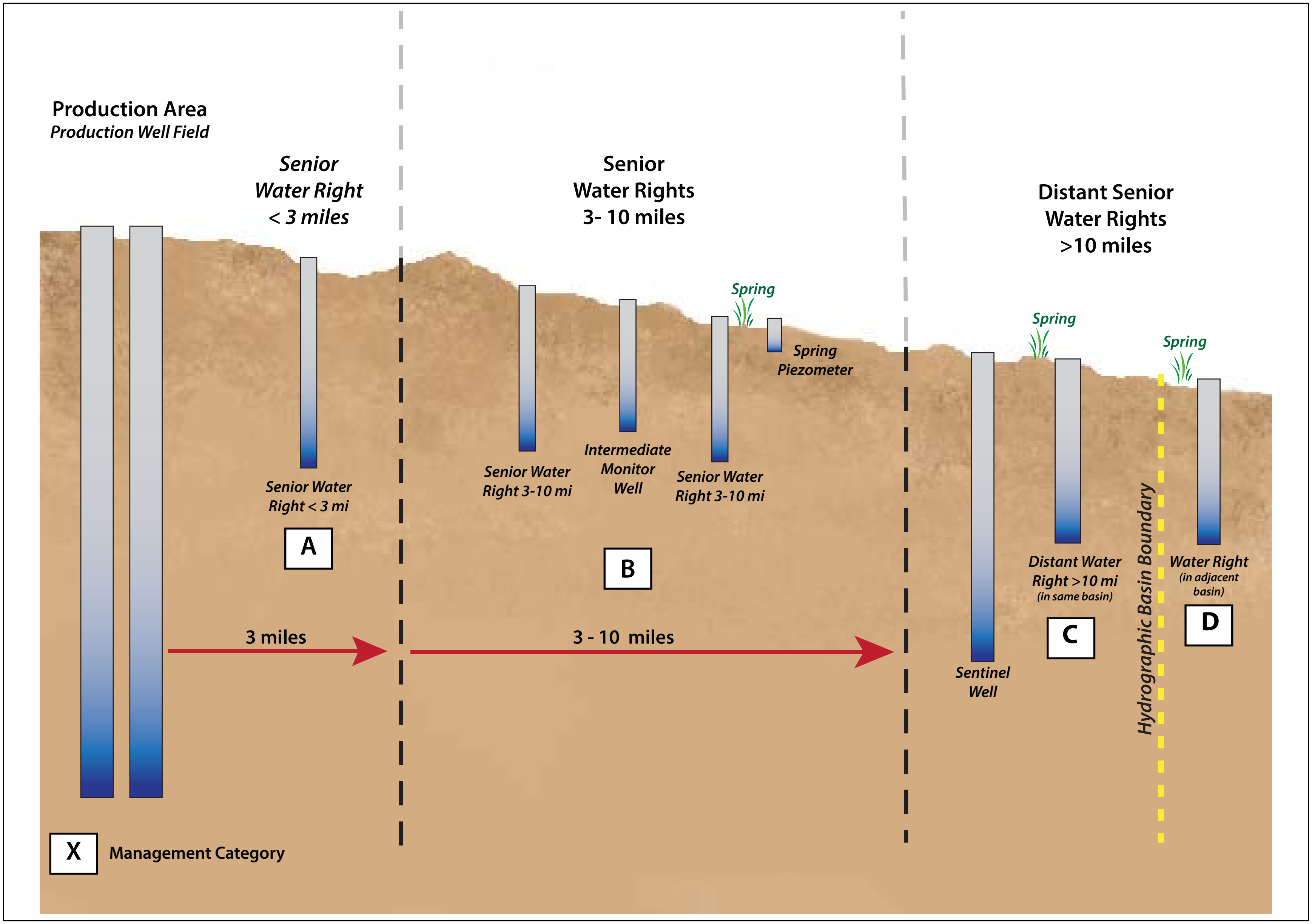


Figure 3-4
Profile Illustration of Management Strategy Categories

3.2.6 Mitigation Triggers for Senior Water Rights

SNWA has set specific quantitative triggers for each individual senior water right in the 3M Plans. The mitigation trigger is set in reference to the ability of the senior water right POD to produce the permitted diversion rate and/or annual duty and is designed to protect the volume of water committed to beneficial use. Activation of a mitigation trigger initiates mitigation action(s) to avoid or eliminate a conflict with the senior water right. A memorandum will be submitted to the NSE within 30 days of activating a mitigation trigger. The memorandum will describe the mitigation trigger and planned mitigation actions. Mitigation actions will be implemented no later than 30 days after a mitigation trigger is activated to avoid unreasonable effects and comply with Nevada water law.

3.2.6.1 Senior Underground Water Right Mitigation Trigger

Wells associated with a senior underground water right are grouped into two categories where: (1) the well and current pump production capacity is above the water right diversion rate, and (2) the well and current pump production capacity is at or below the water right diversion rate. The management and mitigation process flow chart for senior underground water rights is presented on Figure 3-5.

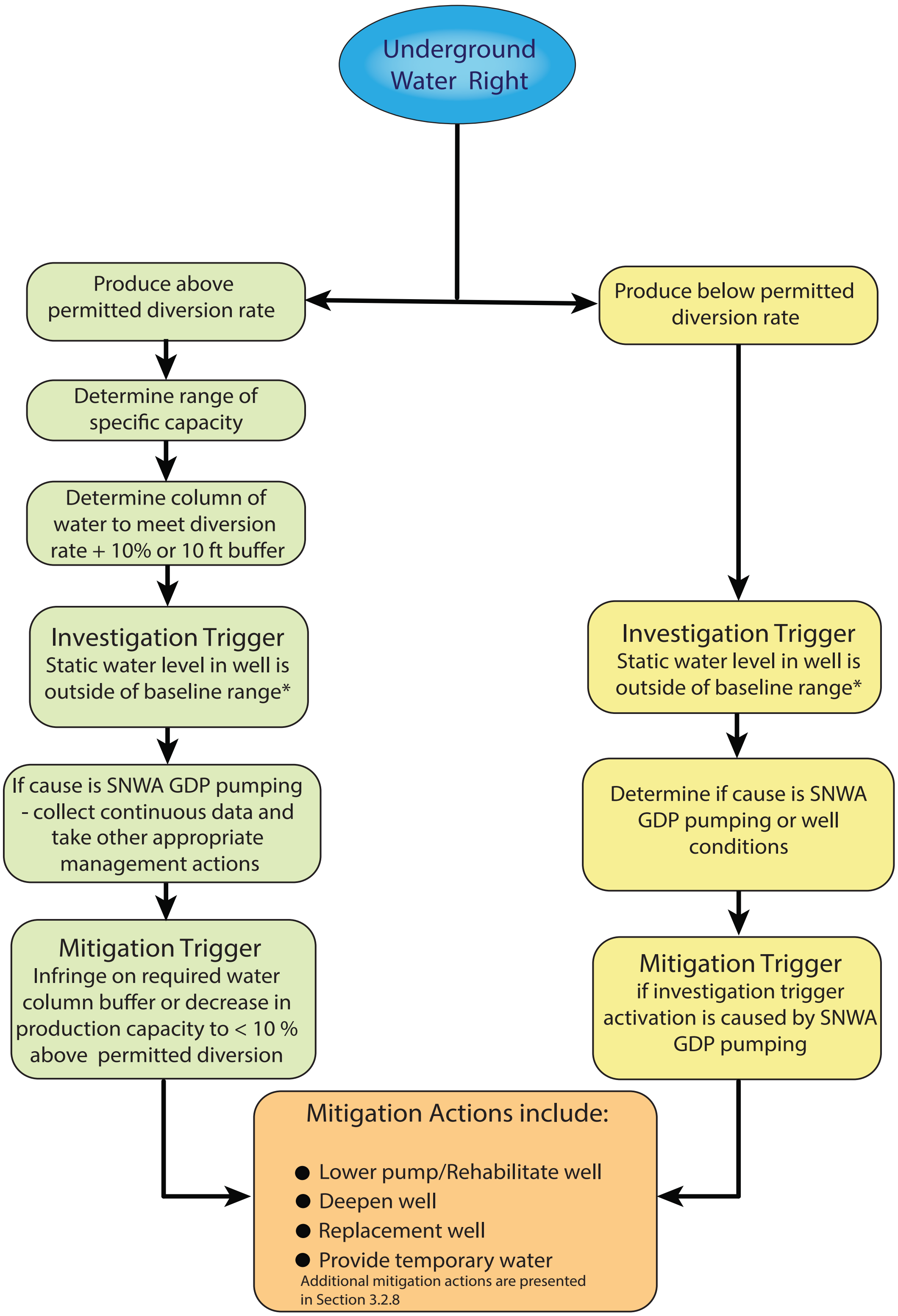
In both cases, compensation by SNWA for the incremental increase in power usage to a well owner due to the unreasonable lowering of the water table by SNWA GDP pumping will occur if the usage increase is greater than 25 percent to produce a similar volume of water. The 25 percent criteria is a reasonable difference in power usage that corresponds to lower water levels which can be measured.

Well production > permitted diversion rate prior to SNWA GDP pumping

The mitigation trigger at a well which has production capacity above the permitted diversion rate is a decrease in groundwater level that reduces the column of water in the well needed to produce the permitted diversion rate based on the well's specific capacity range plus either a 10 percent or 10 foot buffer, which ever is greater. The buffer provides time to implement the mitigation action prior to reaching a conflict. An alternative fixed mitigation trigger for the well is activated if the maximum production capacity from the well decreases to less than 10 percent above the permitted diversion rate and the static groundwater level has decreased as a result of SNWA GDP pumping. An evaluation would be made to determine if the changes were a result of SNWA GDP pumping or were due to a deterioration in the well or pump conditions and efficiency.

The specific capacity is the production rate in gallons per minute divided by the amount of drawdown (static water level minus the stable pumping water level) at the senior water right POD well. The range of specific capacity derived from different pumping rates and associated pumping water levels are used to establish a mitigation trigger. The completion of the well in an unconfined or confined aquifer and the variability of specific capacity with pumping level is considered. The variability of lithology and hydraulic conductivity is also considered especially if the pumping water level declines below the high production zone identified from the lithologic log.

A water resource assessment, as described in Section 3.2.7 will be performed with the owner's permission at least three years prior to SNWA GDP pumping at all senior underground water right locations assigned management categories A and B. These are sites located within 10 miles of an



* Below the 99.7% lower control limit using the seaonally adjusted linear regression method as described in Appendix A

Figure 3-5
Management and Mitigation Flow Chart for Senior Underground Water Right

SNWA GDP permit POD. The wells will be tested to determine well and pump capacity. The existing pump in the well can be used or a test pump will be provided for the assessment. Well specific capacity will be calculated for a range of production rates. Additional information on well construction and current conditions will be documented. Wells located in Management Categories C and D will have a water resource assessment performed as a management action from activation of an investigation trigger at an assigned sentinel well or at the request of the NSE.

An example of the mitigation trigger process using specific capacity is a well with a static depth to groundwater (static water level) measured at 20 feet below ground surface (bgs). If the well is then pumped at 50 gpm and the pumping depth to groundwater once stabilized (pumping water level) is measured at 30 feet bgs, the drawdown at 50 gpm is 10 feet (calculated by 30 ft minus 20 ft). The specific capacity is 5 gpm per foot of drawdown (calculated by dividing 50 gpm by 10 ft of drawdown). To verify specific capacity, the well can be test pumped again but at 75 gpm, and if the measured stable pumping water level is 35 ft, which is 15 feet of drawdown (calculated by 35 ft minus 20 ft), the specific capacity is verified to be 5 gpm per foot of drawdown (75 gpm/15 ft).

Specific capacity is a measure that can assist in determining the ability of a well to produce the water right diversion rate. Specific capacity can also be used to determine how much change in static water level can occur before that change affects the ability of the well to produce at the water right diversion rate. Using the same example as above, the specific capacity of the well has been documented to be 5 gpm per foot of drawdown. Assuming the underground water right associated with the well has a diversion rate of 75 gpm (0.17 cfs), using the specific capacity of 5 gpm/ft derived above, the well would need at least a dedicated 15 foot column of water to meet the 75 gpm diversion rate (75 gpm divided by 5gpm/ft) in addition to a buffer.

The well depth and pump setting can be compared to the baseline static water level to determine the column of water above the pump intake and base of well. Using the same example well, assume the well is 200 feet deep with the pump set at 100 feet and has a specific capacity of 5gpm/ft of drawdown. At the static depth to water of 20 feet, there is a water column of 80 feet above the pump and 180 feet above the bottom of the well. The dedicated column of water needed for this well is calculated for a pumping rate of 75 gpm (water right diversion rate), where there is 15 feet of drawdown and a stable pumping water level of 35 ft bgs. At that point there is a 65 foot column of water above the pump intake and 165 feet above the bottom of the well.

In this example, there is 65 feet of extra water column minus a buffer that is in excess of what is needed to meet the diversion rate. If SNWA GDP pumping reduces static water level greater than 65 feet, the pump will no longer be able to convey the water at the diversion rate to the surface. The pump would have to be lowered for the water right to be produced. If the well is too shallow to lower the pump to meet the diversion rate, SNWA could mitigate the potential conflict by deepening or replacing the well. A template demonstrating the calculations and an example is presented on Figure 3-6.

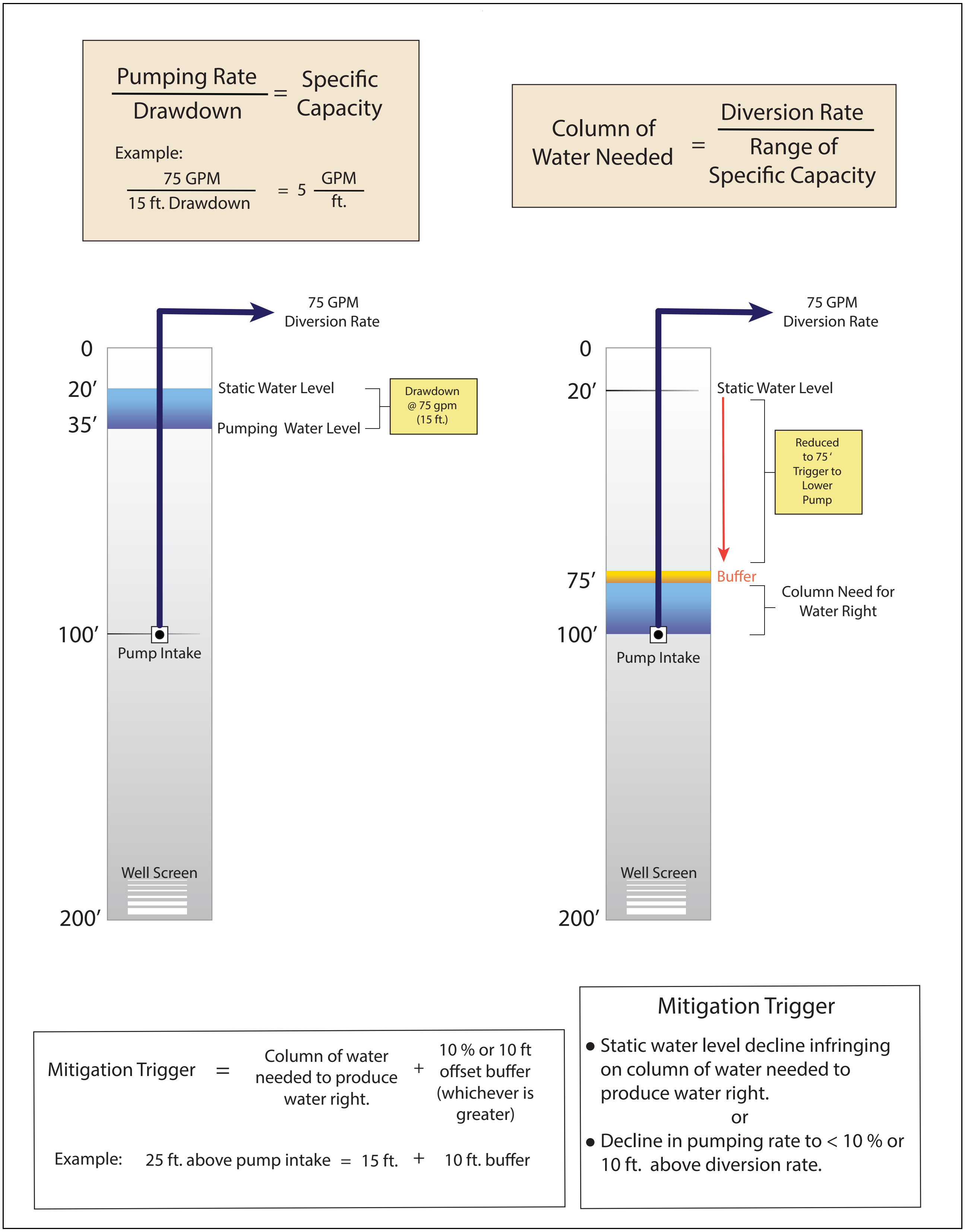


Figure 3-6
Specific Capacity Template for a Mitigation Trigger at an Underground Water Right

Well production < permitted diversion rate prior to SNWA GDP pumping

The mitigation trigger is the same as the investigation trigger and is activated for wells with production capacity less than the permitted diversion rate if the evaluation associated with the investigation trigger determines the cause of the change to be from SNWA GDP pumping. The trigger is activated when the static water level decreases below the 99.7 percent lower control limit for the baseline data for six continuous months using the seasonally adjusted linear regression method, as described in Appendix A. If a mitigation trigger is activated, in addition other mitigation actions, the potential to redevelop the well to increase specific capacity in order to increase production will be evaluated based upon the original water resource assessment and more recent well performance data.

3.2.6.2 Senior Spring and Stream Water Right Mitigation Trigger

The mitigation trigger for a senior spring or stream water-right is presented under two cases: (1) spring or stream flow at the POD which has been measured consistently above the permitted diversion rate, or (2) spring or stream flow at the POD which has been measured consistently at or below the permitted diversion rate. A process flow chart is illustrated on Figure 3-7 and described below:

- If measured baseline spring or stream flow has been consistently above the permitted diversion rate, the mitigation trigger is 10 percent above the permitted diversion rate and is activated if spring or stream discharge decreases below this mitigation trigger level for six consecutive months as a result of SNWA GDP pumping. The 10 percent buffer allows time to implement mitigation, and accounts for error inherent in collecting discharge measurements.

- If measured baseline spring or stream flow has been consistently at or less than the permitted diversion rate, the mitigation trigger is activated if the evaluation associated with the investigation trigger determines the cause of the change to be SNWA GDP pumping.

A third case consist of springs which have intermittent flow or are consistently dry. A spring which has non-measurable intermittent flow or that is dry over extended periods of time will be studied as a special case using nearby shallow piezometers, if present, or visual observations. The spring conditions will be compared to water levels and regional precipitation conditions to determine the conditions under which the spring normally flows. After SNWA GDP pumping begins, the spring will be monitored to determine if there is a change in the observed spring flow compared what has been observed under similar baseline regional hydrologic conditions.

3.2.7 Water Resource Assessment

A baseline assessment will be performed by SNWA prior to GDP pumping at each senior water right POD included in the 3M Plan that is located within 10 miles of the closest SNWA GDP POD, with permission of the owner. The 10 mile extent provides an initial assessment area beyond which effects are not expected during initial development time frames. The 10 mile limit will be extended as a management action if monitoring network observations indicate potential for drawdown effects from

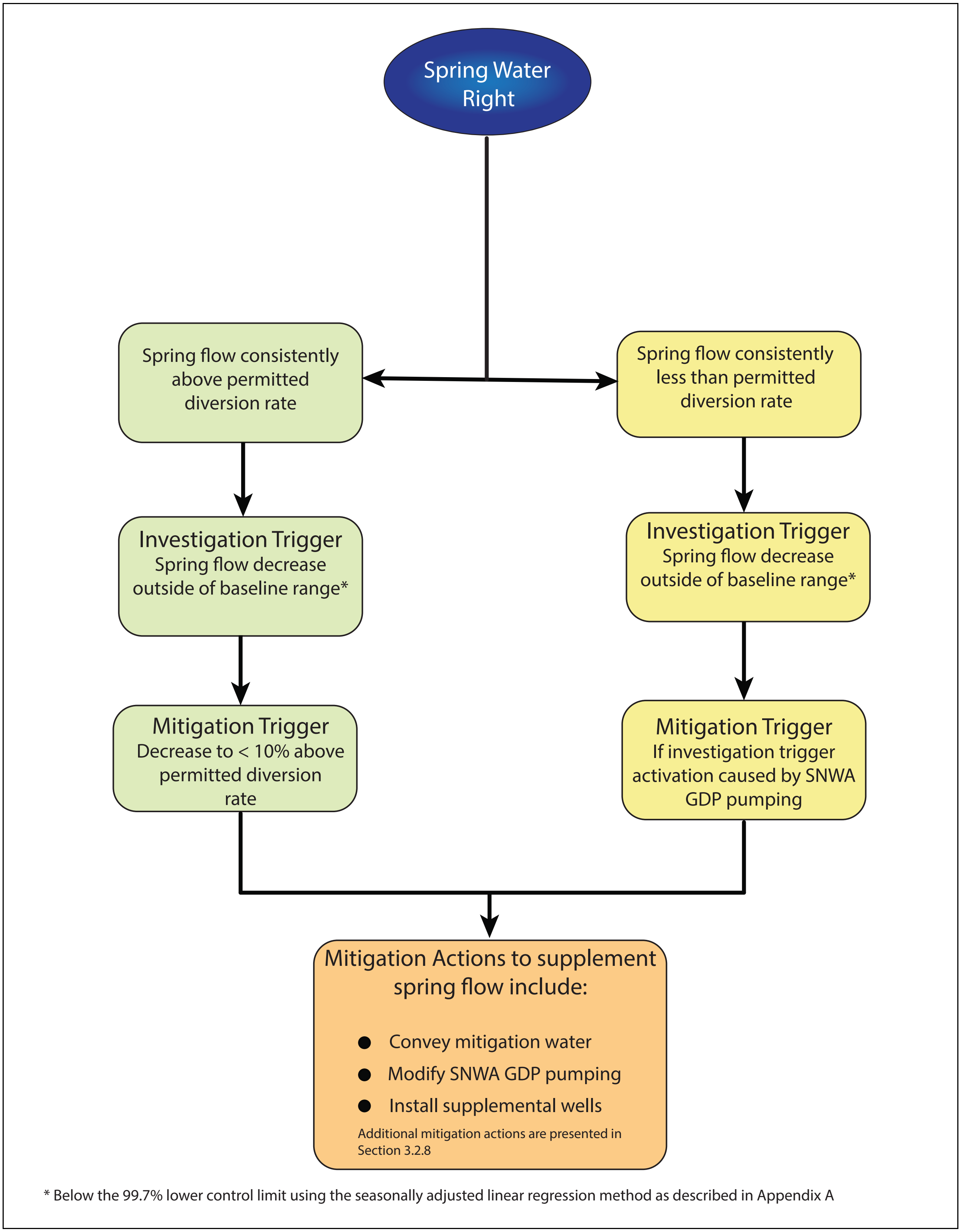


Figure 3-7
Management and Mitigation Flow Chart for Senior Spring or Stream Water Right

the SNWA GDP PODs will extend beyond 10 miles to more distant senior water rights. The assessment will document the characteristics, condition, and production capacity of the senior water right POD. The baseline assessment is in addition to long term baseline measurements of water levels or spring/stream flow at the water right PODs or proxy monitoring locations.

3.2.7.1 Underground Water Rights

Wells associated with senior underground water rights will be inventoried and assessed, with permission of the owner, by SNWA prior to SNWA GDP pumping. The purpose of the well assessment is to document the condition of the senior water right POD. The results of the well assessment will be used to verify the potential for impacts from SNWA GDP pumping and confirm investigation and mitigation triggers. The well assessment includes the following activities performed by SNWA:

- Review of available driller completion reports providing information on well construction, depth, lithology, and production data at time of well installation.
- Perform a downhole video log, if the well is accessible, to verify the construction log, document pump setting, screen or perforation interval, well depth, and condition of the well and pump.
- Perform a well step-drawdown test (step test) using the current pump to document existing pump capacity; static water level; and pumping water levels, well performance and specific capacity at various pumping rates. A temporary test pump will be used with the owner's permission if there is no existing pump in the well or if the current pump is not functioning.
- Determine the potential for the well to be redeveloped in order to increase well efficiency.
- Determine the potential for the pump to be lowered in the well.
- Prepare a short technical memo documenting the findings.

The wells will be grouped into two categories: (1) the well discharge rate is above the water right diversion rate; and (2) the well discharge rate is at or below the water right diversion rate. If no data is available, the well production capacity will be assumed to produce at the water right diversion rate.

3.2.7.2 Spring and Stream Water Rights

An assessment of spring and stream water rights located in the assessment area will be performed by SNWA to document hydraulic characteristics, conditions, and production capacity and variability. Baseline spring flow data will be collected for individual springs, or at an assigned proxy spring or monitoring well site which is representative of the spring water right. The assessment will include documentation of the springhead and any observed or documented modifications. Spring and stream sites will be grouped into categories where: (1) the spring or stream flow rate is consistently above the water right diversion rate; (2) the spring or stream flow rate is consistently at or below the water right diversion rate; and (3) springs which have intermittent flow or are consistently dry.

3.2.8 Mitigation Actions for Senior Water Rights

Mitigation actions will be implemented if a mitigation trigger is activated, caused by SNWA GDP pumping, in order to avoid or eliminate a conflict. Mitigation actions may also be conducted preemptively if data trends indicate that mitigation trigger activation is imminent. As described in Section 3.2.6, SNWA will submit a technical memorandum within 30 days after mitigation trigger activation. SNWA will implement mitigation actions no later than 30 days after activation of the mitigation trigger to avoid or eliminate a conflict with a senior water right.

As part of development of this 3M Plan, mitigation actions for each senior water right have been identified and screened for appropriateness considering the hydrogeologic conditions at the site as they are currently known. If mitigation water is the mitigation action chosen to be implemented, the potential mitigation water volume needed to avoid or eliminate a conflict with a senior water right is determined by the quantity of water committed to the beneficial use of the senior water right. Baseline data and conditions documented at some water rights locations indicate that the spring or stream sources for some water rights or vested claims have not historically produced the full water right amount or have been periodically dry. However, the 3M Plan provides replacement water for the full volume of the senior water right or vested claim until such time as an adjudication occurs and a decreed replacement volume is determined. SNWA will initiate temporary and long term mitigation actions with an access agreement with the senior water right holder. The 3M Plan provides replacement water at the POD or beneficial place of use for the annual or seasonal use permitted in the senior water right.

The management and mitigation actions for each specific senior water right in the 3M Plan analysis area are presented in Sections 6.0 through 9.0. A summary of other mitigation actions that can be applied to all senior water rights include the following:

- Management actions to modify SNWA GDP pumping distribution, rates, and duration at one or more production wells as described in Section 3.2.4.

- Using SNWA water rights from SNWA GDP permits and existing SNWA stream, spring, and underground water rights not related to the SNWA GDP as replacement water. The water would be temporarily transferred, conveyed, or exchanged to offset impacts at a specific location.

- Conveying water to the senior water right POD or place of beneficial use via piping or connection to the SNWA GDP pipeline. Water for the piping may be supplied by a dedicated well or diversion from an existing SNWA well or surface water source.

- Construction of an individual or a series of reservoir(s) at an individual spring or diffuse spring sites to store water from a dedicated well or piping system to provide the required diversion rate.

- Transfer or exchange of the impacted senior water right for an SNWA water right of an equal or better priority at another location.

- Temporary use of an SNWA water right until mitigation efforts restore the senior water right.

- Change location of an SNWA GDP POD to a greater distance away from the senior water right.

- Temporary mitigation measures may be implemented as a short term bridge until other mitigation actions are permitted, constructed, or result in recovery of the impacted senior water right. This includes the deployment of temporary storage tanks supplied by water truck or by the senior water right well pumping for a longer period below the permitted diversion rate.

In addition to those listed above, mitigation actions for underground senior water rights include the following:

- Lowering or replacing the pump associated with a senior water right POD.

- Rehabilitating or redeveloping the existing well to increase well efficiency (e.g. specific capacity).

- Deepening or replacement of the existing well.

- Compensate well owners for the incremental increase in power usage if the usage increase is greater than 25 percent to produce a similar volume of water.

In addition to those listed above, mitigation actions for spring or stream senior water rights include the following:

- Drilling a supply well to offset decrease in spring flow.

- Modifying the springhead or constructing a reservoir at the spring.

Another action to offset effects on an irrigation senior water right is irrigation improvements provided by SNWA for the senior water right holder facilities to increase effectiveness of irrigation for the impacted water right. Irrigation improvements actions include the following:

- Lining of irrigation ditches.

- Providing aqueducts to reduce losses between the POD and place of beneficial use.

- Improving sprinkler efficiency.

Additional mitigation actions for stock water right uses include the following:

- Providing alternative ranch grazing land owned or controlled by SNWA.
- Temporary trucking of stock water.
- Providing stock water improvements to offset impacts to a senior water right.

Any time a mitigation action is implemented, an assessment will be conducted to determine mitigation effectiveness. Based on the assessment, mitigation actions may be modified as needed to avoid or eliminate the conflict. For example, if lowering a pump in the well is unsuccessful, a secondary option of redeveloping the well to increase well efficiency, deepening the well, or replacing the well will be evaluated. As described in Sections 10.5, SNWA will submit updates on mitigation actions taken and assessments of mitigation effectiveness in the annual 3M Plan report to the NSE.

The mitigation action will be assessed as additional data on the aquifer conditions and the senior water right POD becomes available. A detailed feasibility assessment and implementation plan for mitigation actions will be prepared for each senior water right within 10 miles of an SNWA GDP POD (Management Categories A and B) prior to initiation of SNWA GDP pumping. Sites within 3 miles of an SNWA GDP POD (Management Category A) will have a plan for mitigation in place or mitigation will be preemptively implemented at the time of SNWA GDP pumping startup. For all other senior water rights (Management Categories C and D), mitigation feasibility and implementation planning will occur upon activation of the investigation trigger at designated sentinel monitor wells. Mitigation actions will be assessed for effectiveness and modified if needed to avoid or eliminate conflicts with senior water rights.

3.3 Approach to Avoid Unreasonable Effects to Environmental Resources

The 3M Plan approach uses thresholds, triggers, and monitoring, management, and mitigation actions to avoid the unreasonable effects to environmental resources defined in Section 2.2. An overview of the approach is as follows:

- All federally listed species in the groundwater discharge areas of the analysis area occur at sites with senior water rights (see Section 5.3 for species occurrences). The approach to avoid jeopardizing federally listed species thus primarily relies on avoiding unreasonable effects to senior water rights. By avoiding unreasonable effects to senior water rights, the water that federally listed species depend on will continue to be available. As described in detail in Section 3.2, this approach includes investigation triggers established at intermediate wells between SNWA GDP PODs and senior water rights, preemptive management actions to avoid or minimize the risk of activating mitigation triggers at senior water right PODs, and mitigation actions to avoid conflicts with senior water rights. Environmental triggers and mitigation actions are also included in the approach to ensure that unreasonable effects to federally listed species are avoided.

- Avoiding unreasonable effects to senior water rights also helps avoid extirpation of native aquatic-dependent special status animal species from the basin groundwater discharge areas (see Section 5.3 for species occurrences). Environmental mitigation actions are also included in the approach to ensure that the unreasonable effect to the species are avoided. To provide further assurance, an SNWA land holding in central Spring Valley that has extensive mesic habitat and a native aquatic-dependent special status animal species will be managed to maintain and enhance mesic habitat for the benefit of the special status species and other wildlife. Although other wildlife are not specifically addressed in this analysis, their needs are protected by avoiding unreasonable effects to senior water rights, federally listed species and native aquatic-dependent special status animal species with which they are generally co-located, and the habitat types that they use (as discussed below).

- The approach described above also avoids elimination of mesic and lake habitat from the basin groundwater discharge areas (see Section 5.2 for habitat descriptions). It also helps avoid elimination of shrubland and terrestrial woodland habitat from the basin groundwater discharge areas, and excessive loss of shrub cover that results in extensive bare ground, by attenuating groundwater drawdown and propagation. Additional environmental triggers and management and mitigation actions are established to maintain shrubland cover above a threshold level and to maintain a viable terrestrial woodland population within the Spring Valley groundwater discharge area.

Investigations will be conducted upon activation of investigation triggers or at the request of the NSE. The purpose of conducting investigations is to determine cause, condition, and significance of observed changes, and inform management and mitigation actions. Specific investigation actions related to senior water right triggers are outlined in Section 3.2.3.1. If an environmental investigation trigger is activated, additional investigation actions will include analyses of environmental data with the hydrologic data. For example, if a shrubland investigation trigger is activated, investigation actions would include analyses of vegetation monitoring data with groundwater level data, SNWA GDP pumping data, and precipitation data to determine the cause and nature of the vegetation changes and inform management and mitigation actions. Mitigation actions will be prepared during investigation in advance of activating a mitigation trigger, including purchasing equipment, establishing contracts, and obtaining any necessary landowner permissions and permits. Mitigation actions will be implemented no later than 30 days after a mitigation trigger is activated to avoid unreasonable effects to environmental resources and comply with Nevada water law. The process for submitting investigation findings and mitigation plans to the NSE is described in Section 10.5.

The approach to avoid unreasonable effects to environmental resources is outlined by basin area below. Details explaining how thresholds, triggers, and actions are established for environmental resources within the basin areas are presented in Sections 6.0 through 9.0.

Spring Valley (Section 6.0)

- Triggers and management and mitigation actions are established to ensure continued flow of a senior water right and avoid jeopardizing the continued existence of a federally endangered species in the basin (Section 6.3.1).

- Triggers and management and mitigation actions are established to avoid elimination of mesic habitat and extirpation of native aquatic-dependent special status animal species from the groundwater discharge area (Section 6.3.2).

  - Triggers and management and mitigation actions established for senior water rights help avoid unreasonable effects to these environmental resources.

  - An SNWA land holding in central Spring Valley will be managed to maintain and enhance mesic habitat for the benefit of a native aquatic-dependent special status animal species therein.

- Triggers and management and mitigation actions are established to maintain shrub cover above a threshold level, in order to avoid elimination of shrubland habitat from the groundwater discharge area and excessive loss of shrub cover that results in extensive bare ground (Section 6.3.3).

- Triggers and management and mitigation actions are established to maintain tree cover area above a threshold level in a terrestrial woodland population, in order to avoid elimination of terrestrial woodland habitat from the groundwater discharge area (Section 6.3.4).

Northern Hamlin and Southern Snake Valleys (Section 7.0)

- Triggers and management and mitigation actions established for senior water rights help avoid unreasonable effects to the environmental resources.

- Although it is unlikely that environmental mitigation will be required, environmental triggers and mitigation actions are established in southern Snake Valley to avoid extirpation of a native aquatic-dependent special status animal species from the groundwater discharge area, and in northern Hamlin and southern Snake valleys to avoid excessive loss of shrub cover that results in extensive bare ground (Section 7.3).

Cave and Southern White River Valleys (Section 8.0)

- Effects to environmental resources within Cave Valley from SNWA GDP pumping are improbable (see discussion in Section 8.3.1). Therefore, triggers and mitigation actions to avoid unreasonable effects to environmental resources are not established in Cave Valley.

- Staged groundwater development in Cave Valley and triggers and management and mitigation actions established for senior water rights help avoid unreasonable effects to environmental resources in southern White River Valley.

- Effects to environmental resources in southern White River Valley are unlikely given staged GDP development, reserved groundwater, and hydrologic management and mitigation (see discussion in Section 8.2.3). Nonetheless, environmental triggers and mitigation actions are established in southern White River Valley to avoid jeopardy to the continued existence of federally endangered species and extirpation of native aquatic-dependent special status animal species from the groundwater discharge area (Section 8.3).

Dry Lake, Delamar, and Pahranagat Valleys (Section 9.0)

- Effects to environmental resources within Dry Lake and Delamar valleys from SNWA GDP pumping are improbable (see discussion in Section 9.3). Therefore, triggers and mitigation actions to avoid unreasonable effects to environmental resources are not established in Dry Lake and Delamar valleys.

- Triggers and management and mitigation actions established for senior water rights help avoid unreasonable effects to environmental resources in Pahranagat Valley. Effects are unlikely to occur in Pahranagat Valley.

- Although it is unlikely that environmental mitigation will be required, environmental triggers and mitigation actions are established in Pahranagat Valley to avoid jeopardy to the continued existence of federally endangered species and extirpation of native aquatic-dependent special status animal species from the groundwater discharge area (Section 9.3).

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4.0 ANALYSIS AREA DELINEATION AND HYDROLOGIC AND ENVIRONMENTAL RESOURCES IDENTIFICATION

This section delineates the analysis area used in this report and describes the process for selecting hydrologic and environmental resources to include in the analysis. Thresholds, triggers, and monitoring, management, and mitigation actions to avoid unreasonable effects and comply with Nevada water law are presented in Sections 6.0 through 10.0.

4.1 Analysis Area

The analysis area encompasses the four project basins (Spring Valley and DDC) and four adjacent basin areas: northern Hamlin Valley, southern Snake Valley, southern White River Valley, and Pahranagat Valley (Figure 4-1). The analysis area was initially delineated based on likelihood of interbasin flow as presented in NSE Rulings 6164-6167. The analysis area was then refined by considering analyses of potential effects from SNWA GDP pumping.

In Rulings 6164-6167, the NSE made findings on interbasin flow using multiple lines of evidence, including regional and intermediate groundwater flow systems, hydrogeologic boundaries, and hydraulic gradients (NDWR, 2012a, at pages 79-89; NDWR, 2012b, at pages 47-49 and 77-80; NDWR, 2012c, at pages 46-48 and 76-78; and NDWR, 2012d, at pages 47-49 and 77-78). Based on this information, the following criteria were used to delineate the analysis area:

1. In cases where the NSE found insubstantial outflow, potential for only minor amounts of flow, insufficient evidence of outflow, or major barriers to flow, the adjacent basin areas were excluded from the analysis area.

2. In other cases where the NSE found outflow from project basins to adjacent basin areas, those adjacent basin areas were included in the analysis area.

The groundwater flow paths that met criterion no. 2 are as follows:

- Outflow from southern Spring Valley to northern Hamlin Valley via the Limestone Hills (NDWR, 2012a, at pages 81-85). This outflow joins the north-trending flow in northern Hamlin Valley, which then enters southern Snake Valley (NDWR, 2012a, at page 83).

    - The SNWA effects analysis presented in the 2011 water rights hearing (hereafter referred to as the SNWA 2011 effects analysis) determined that effects from SNWA GDP pumping in Snake Valley are unlikely (Watrus and Drici, 2011). However, the BLM Final Environmental Impact Statement for the SNWA GDP (the BLM EIS) identified the Big Springs Creek/Lake Creek system in southern Snake Valley as an area of potential effect

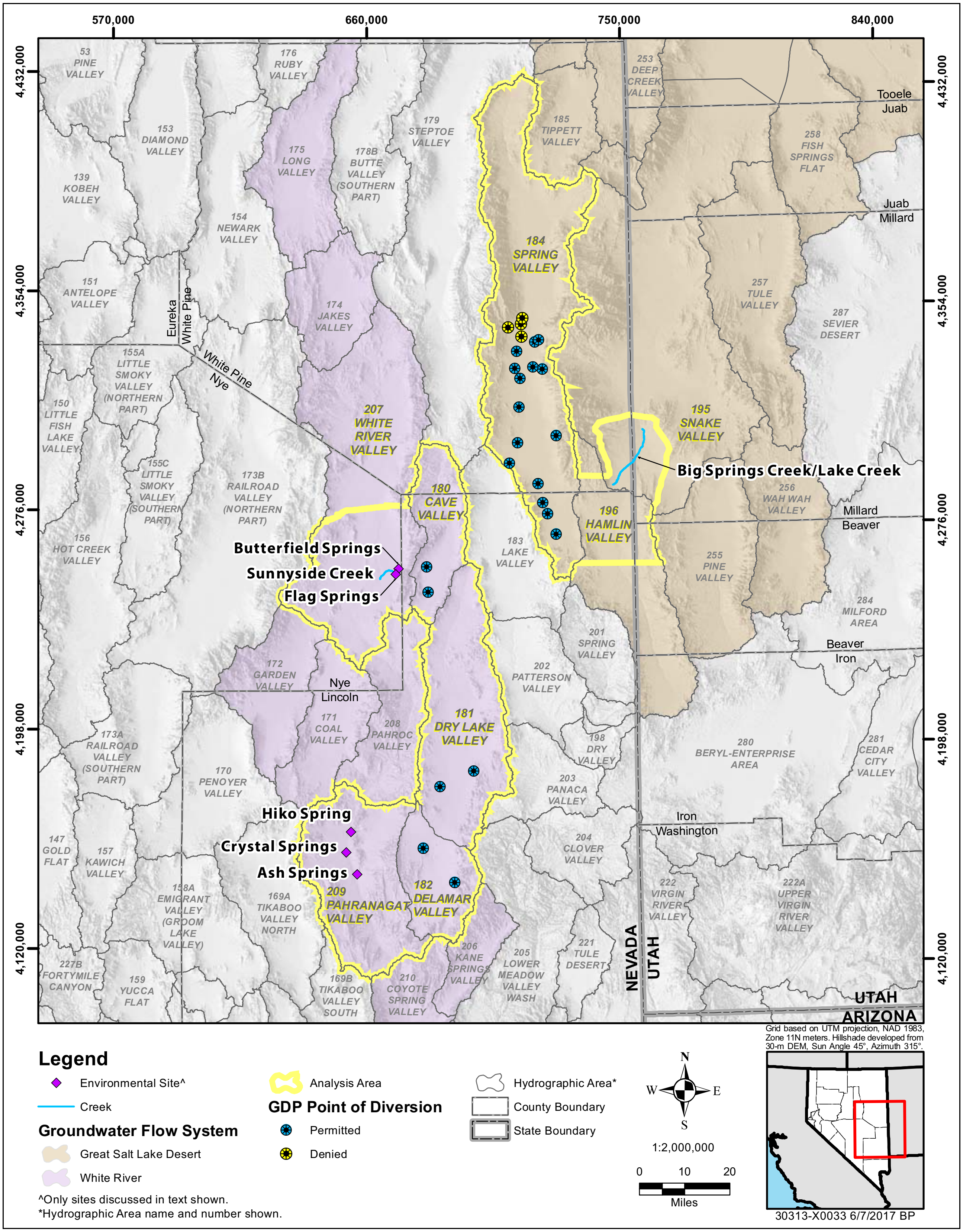

Figure 4-1
Analysis Area with Flow Systems

(BLM, 2012a). Therefore, northern Hamlin Valley and southern Snake Valley were included in the analysis area.

- The BLM EIS did not identify any areas of potential effect north of the Big Springs Creek/Lake Creek system in Snake Valley (BLM, 2012a). Furthermore, in Ruling 6164, the NSE found that "hydrologic and geologic data all support the conclusion that there is not substantial outflow from northern Spring Valley to northern Snake Valley" (NDWR, 2012a, at page 88). Therefore, central and northern Snake Valley were excluded from the analysis area.

• Outflow from Cave Valley to southern White River Valley via Shingle Pass (NDWR, 2012b, at pages 77-80). This outflow joins the south-trending flow in southern White River Valley, which then enters Pahroc Valley (Hydrographic Area 208) (NDWR, 2012b, at pages 77-80).

- The SNWA 2011 effects analysis and the BLM EIS identified Butterfield and Flag Springs in southern White River Valley as areas of potential effect (BLM, 2012a; Watrus and Drici, 2011). The U.S. Fish and Wildlife Service Biological Opinion for the SNWA GDP (the USFWS BO) also identified Flag Springs and the downstream Sunnyside Creek, which support a federally endangered fish species, as an area of potential effect (USFWS, 2012). In Ruling 6165, the NSE reserved 7,300 acre-feet per annum (afa) of Cave Valley groundwater for the purpose of protecting these spring flows (NDWR, 2012b, at pages 77 and 80). Therefore, southern White River Valley was included in the analysis area.

- Pahroc Valley is located over 20 miles south of Shingle Pass and has no surface-water features and limited underground water rights. The SNWA 2011 effects analysis and the BLM EIS determined that effects from SNWA GDP pumping in Pahroc Valley are unlikely (BLM, 2012a; Watrus and Drici, 2011). Therefore, Pahroc Valley was excluded from the analysis area.

• Outflow from Delamar Valley to Pahranagat Valley via the Pahranagat Shear Zone (PSZ) (NDWR, 2012d, at pages 77-78). This outflow joins the south-trending flow in southern Pahranagat Valley and then enters Coyote Spring Valley (Hydrographic Area 210) (NDWR, 2012d, at pages 77-78). Three regional warm springs in northern and central Pahranagat Valley (Hiko, Crystal, and Ash springs) are sourced from the carbonate aquifer, as evidenced by hydrogeologic and isotope data (SNWA, 2009c, at Section 5.3).

- The SNWA 2011 effects analysis and the BLM EIS determined that effects from SNWA GDP pumping in Pahranagat Valley are unlikely (BLM, 2012a; Watrus and Drici, 2011). However, in the BO, the USFWS determined that it could not rule out the possibility of measurable effects to federally endangered species in Pahranagat Valley, although it was unsure of the likelihood or magnitude of such effects (USFWS, 2012). Therefore, Pahranagat Valley was included in the analysis area.

- Coyote Spring Valley is located over 15 miles south of PSZ and has limited surface-water features. The SNWA 2011 effects analysis and the BLM EIS determined that effects from

SNWA GDP pumping in Coyote Spring Valley are unlikely (BLM, 2012a; Watrus and Drici, 2011). Therefore, Coyote Spring Valley was excluded from the analysis area.

The groundwater flow model simulations used in the SNWA 2011 effects analysis included pumping at all application GDP PODs at full application volumes (Watrus and Drici, 2011), including the 4 PODs that were denied in Ruling 6164 (NDWR, 2012a, at page 216). The BLM EIS and USFWS BO also considered a variety of other pumping volumes, locations, and time frames (BLM, 2012a; USFWS 2012).[1] None of the effects analyses considered adaptive management or mitigation, which are integral components of the SNWA GDP. Because of these factors, it is likely that the analysis area is over-inclusive of areas of potential effect from SNWA GDP pumping.

To ensure that adjacent basin areas were not overlooked, the delineated analysis area was compared to the SNWA 2011 environmental effects analysis area and the SNWA-DOI Spring Valley and DDC Stipulated Agreements (Stipulations) monitoring areas.[2]

The SNWA 2011 environmental effects analysis area encompassed the four project basins, the adjacent basin areas identified above, and northern Lake Valley (Hydrographic Area 183) (Marshall and Luptowitz, 2011, at page 2-1).[3] Northern Lake Valley was identified as an area of potential effect in the BLM EIS (BLM, 2012a). However, the NSE identified multiple barriers to interbasin flow between the project basins and Lake Valley in Rulings 6164 and 6167 (NDWR, 2012a, at pages 85-87; NDWR, 2012d, at page 77), and Lake Valley is in a different regional groundwater flow system than the project basins (Figure 4-1). Therefore, with the exception of Lake Valley, all basin areas in the SNWA 2011 effects analysis were included in the analysis area for this report.

The Spring Valley Stipulation identifies an Initial Biological Monitoring Area (IBMA) that includes Spring Valley, northern Hamlin Valley, and southern Snake Valley (Stipulation, 2006, at Exhibit B, Figure 2). The IBMA currently serves as the biological monitoring area for the Spring Valley Stipulation (Biological Work Group (BWG), 2009). Hydrologic monitoring is also conducted in Spring, northern Hamlin, and southern Snake valleys and does not extend beyond the IBMA (SNWA, 2011b). The DDC Stipulation identifies an Area of Interest that includes DDC, southern White River Valley, and Pahranagat Valley (Stipulation, 2008, at Figure 1). The Area of Interest currently serves as the hydrologic and biological monitoring areas for the DDC Stipulation (Biologic Resources Team (BRT), 2011; SNWA, 2011a). For consistency, the Hamlin and Snake valley boundaries in the Spring Valley Stipulation IBMA, and the White River Valley boundary in the DDC Stipulation Area of Interest, were duplicated in the analysis area for this report.

In summary, the analysis area includes the following basin areas, as depicted in Figure 4-1:

- The four project basins (Spring Valley and DDC) in their entirety
- Northern Hamlin Valley, crossing the Limestone Hills area

1. The USFWS BO also considered an uncalibrated "high diffusivity" simulation, which assigned lower storage and greater conductivity and transmissivity values than the calibrated simulations (USFWS, 2012).
2. The Stipulations are associated with other compliance processes for the SNWA GDP separate from Nevada water law (Section 10.6). A summary of the Stipulations was provided in Marshall and Luptowitz (2011, at Section 3).
3. The 2011 environmental analysis area was referred to as the "area of focus."

- Southern Snake Valley, encompassing the Big Springs Creek/Lake Creek system
- Southern White River Valley, starting just north of Shingle Pass
- Pahranagat Valley in its entirety

4.2 Hydrologic and Environmental Resources

This section describes the process for selecting hydrologic and environmental resources to include in the analysis. Section 4.2.1 describes the criteria used in the selection process, and Section 4.2.2 describes the process for compiling the hydrologic and environmental resources.

4.2.1 Criteria for Including Hydrologic and Environmental Resources in the Analysis

The selection of hydrologic and environmental resources to include in the analysis was based on the following criteria:

1. Occurrence within the analysis area (Figure 4-1).
2. Water right seniority.
3. Likelihood of hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed. For a hydrologic or environmental resource to be affected by SNWA GDP pumping, it must be in hydraulic connection with the producing aquifer.

All senior water rights within the analysis area were initially considered for inclusion in the analysis. There is no reasonable evidence that hydrologic resources in the mountain block are hydraulically connected to the producing aquifer; thus, effects to those resources from SNWA GDP pumping are unlikely (see below). In addition, because water rights appropriation is based on the principle of first in time, first in right (NRS § 534.110(6)), SNWA is not responsible for mitigation to junior water rights.[1] Therefore, senior water rights and domestic wells located in the mountain block, reservoir rights, and water rights junior to SNWA GDP permits, were excluded from analysis. All other senior water rights and domestic wells were included in the analysis. In addition, SNWA water rights were included in the analysis to identify source water for mitigation actions.

Environmental resources within the groundwater discharge areas may by hydraulically connected to the producing aquifers. Groundwater in these areas discharges to the surface primarily through spring flow and evapotranspiration (SNWA, 2009b, at page 7-1).[2] Some environmental resources are supported by the surface-water discharge (e.g., fish in springs), and some are supported by the

1. In the event it is determined that SNWA is responsible for mitigation to junior water rights, those rights may be included in the 3M Plans by reference to their location and the Management Categories described in Section 3.2.5.
2. Evapotranspiration includes surface-water evaporation, soil evaporation, and plant transpiration (SNWA, 2009b, at page 7-1).

groundwater (e.g., phreatophytic shrubs).[1] Given the potential for effects from SNWA GDP pumping, environmental resources located within the groundwater discharge areas of the analysis area were included in the analysis.

Within the analysis area, there is no evidence that environmental resources outside of the groundwater discharge areas are connected to the producing aquifers. Therefore, environmental resources outside of the groundwater discharge areas were excluded from the analysis, as follows:

- Mountain block springs and streams are controlled by discharge from local or perched groundwater systems, and there is no evidence that these systems are hydraulically connected to the producing aquifers (Watrus and Drici, 2011, at page 6-3). This same reasoning holds for other mesic habitats in the mountain block (e.g., wetlands). Therefore, environmental resources in the mountain block were excluded from analysis.

- For streams that originate in the mountain block and flow down the alluvial fan, hydraulic connectivity is dependent on saturated material existing continuously between the stream bed and the producing aquifer (Prieur, 2011b, at page 2060; Watrus and Drici, 2011, at page 6-2). Based on hydrogeologic conditions and depth to water, there is no evidence that stream flows on the alluvial fans of the analysis area are hydraulically connected to the producing aquifers. Therefore, environmental resources associated with stream flows on the alluvial fans outside of the groundwater discharge areas were excluded from the analysis.

  - In limited cases, mountain-block streams in the analysis area reach the groundwater discharge areas on the valley floor or alluvial fan/valley floor interface. As discussed above, environmental resources in the groundwater discharge areas may be hydraulically connected to the producing aquifers. Given the potential for effects from SNWA GDP pumping, environmental resources associated with stream flows within the groundwater discharge areas were included in the analysis.

- Groundwater levels outside of the groundwater discharge areas are deeper than maximum terrestrial plant rooting depths. Because the groundwater is not accessible to the plants, changes in groundwater levels will not affect plant survivorship and growth or the terrestrial habitat at large (e.g., shrublands) (BLM, 2012a, at page 3.5-45; McLendon, 2011a).[2] Therefore, terrestrial habitats outside of the groundwater discharge areas were excluded from the analysis.

- Reservoir water rights are associated with permission to store water in impoundments that collect intermittent precipitation runoff. The source intermittent surface-water flows are not hydraulically connected to the producing aquifers and thus will not be affected by SNWA GDP pumping. Therefore, reservoir water rights were excluded from the analysis.

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1. Some environmental resources in the groundwater discharge areas are not supported by surface water or groundwater (e.g., precipitation-dependent vegetation).
2. Maximum rooting depth of facultative phreatophytes in the region is approximately 50 feet (BLM, 2012a, at page 3.5-13; McLendon, 2011a). Facultative phreatophytic species use groundwater as a secondary water source after precipitation but also exist on sites where groundwater is not available (McLendon, 2011a). Plant species that rely entirely on precipitation also occur within the groundwater discharge areas.

Hydrologic and environmental resources included in the analysis are not equally susceptible to effects from SNWA GDP pumping. Potential for effects is dependent upon three factors: (1) whether there is continuous saturated material between the resource and the producing aquifer (i.e., hydraulic connection); (2) whether there is high enough hydraulic conductivity to propagate effects through the geologic sediments; and (3) whether the resource is within the area of influence of pumping (NDWR, 2012a, at page 108; Prieur, 2011b, at page 2060; Watrus and Drici, 2011, at pages 6-2 and 6-3). Potential for effects is reduced in a variety of circumstances, such as when resources are supported by perched groundwater, protected by geologic barriers to flow, or are at a distance from SNWA GDP pumping. Such factors influenced the development of triggers and monitoring, management, and mitigation actions in this report (see approach in Section 3.0, details in Sections 6.0 through 9.0).

4.2.2 Compilation of Hydrologic and Environmental Resources

Water rights and domestic wells within the SNWA GDP basins and the analysis area in Hamlin and Snake valleys, Nevada were compiled by performing a hydrographic abstract water rights search in November, 2016 using the NDWR online water-rights database. Water rights were compiled in March, 2017 for southern White River and Pahranagat valleys using the NDWR online water-rights database. Water rights within the analysis area in Snake and Hamlin valleys, Utah were complied in November, 2016 using the Utah Division of Water Rights (UDWRi) database website.

The water rights were filtered for valid water rights (certificated, decreed, permitted, vested, and reserved water rights, and domestic wells as defined in NRS § 534.350(8)(a)). The search results were attributed with geographic setting (mountain block, alluvial fan, valley floor) and priority status (senior or junior to SNWA GDP permits). In accordance with NRS § 534.080(3), NRS § 534.100(1), and NRS § 534.080(4), water rights were considered senior if they existed prior to the filing date of SNWA GDP applications 54003 - 54015, 54019 - 54020, and 53987 - 53992 (October 17, 1989) (see Section 2.1). Water rights junior to SNWA GDP permits, and senior water rights located in the mountain block, were excluded from analysis (see Section 4.2.1). Senior water rights included in the analysis are presented in Sections 6.0 - 9.0 and Appendix B.

Habitat types within the groundwater discharge areas of the analysis area (mesic, shrubland, terrestrial woodland, playa, lake) were delineated using a digital land cover map, a digital terrestrial woodland map, and high-resolution aerial imagery (Section 5.1). Some habitats span large geographical areas (e.g., shrublands), and others occur at local environmental sites (e.g., mesic habitat at a spring complex). Local environmental sites within the analysis area were further compiled from the following sources: the SNWA 2011 environmental analysis (Marshall and Luptowitz, 2011, at Section 2); the BLM EIS (BLM, 2012a, at Chapters 3.5, 3.6, 3.7, and associated appendices); the BLM Biological Assessment for the GDP (BA) (BLM, 2012c); the USFWS BO (USFWS, 2012); and environmental data examined for this report. Each local environmental site was attributed with the geographic setting (mountain block, alluvial fan, valley floor) and federally listed and native aquatic-dependent special status animal species (Appendix E). Environmental sites outside of the groundwater discharge areas were then excluded from analysis (see Section 4.2.1). Habitats, local environmental sites, and associated species included in the analysis are presented in Section 5.0.

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5.0 ENVIRONMENTAL RESOURCES IN THE ANALYSIS AREA

This section presents the environmental resources analyzed in this report. As discussed in Section 4.2, these environmental resources are located within the groundwater discharge areas of the analysis area. As such, they may be hydraulically connected to the producing aquifers and could potentially be affected by SNWA GDP pumping. Thresholds, triggers, and monitoring, management, and mitigation actions to avoid unreasonable effects and comply with Nevada water law are presented in Sections 6.0 through 10.0.

5.1 Delineation of Habitats and Identification of Local Environmental Sites

Mesic, shrubland, terrestrial woodland, and lake habitats occur within the groundwater discharge areas of the analysis area, along with playa and agriculture. Some habitats span large geographical areas (e.g., shrublands), and others occur at local environmental sites (e.g., mesic habitat at a spring complex). Delineation of these habitats is described below. Additional information on the local environmental sites and associated federally listed and native aquatic-dependent special status animal species was compiled from a variety of sources, including the SNWA 2011 environmental analysis, the BLM EIS, the BLM BA, and the USFWS BO (Marshall and Luptowitz, 2011; BLM, 2012a and 2012c; and USFWS, 2012) (see details in Section 4.2.2).[1] An overview map of the habitats, local environmental sites, and GDP permitted points of diversion (PODs) is displayed in Figure 5-1. Detailed maps are presented by basin areas in Section 5.2 (at Figures 5-2, 5-3, and 5-4), and a list of the local environmental sites and associated species is presented in Section 5.3 (at Table 5-2 below).

The habitats were delineated using a digital land cover map, a digital terrestrial woodland habitat map, and high-resolution aerial imagery. The land cover map had been previously developed for determining water budgets, and had a 30 m x 30 m pixel resolution, with each pixel assigned a land cover classification value (SNWA, 2007; see discussion in Burns and Drici, 2011, at Section 5)[2]. The land cover classification values were converted to habitat values for the purposes of this report, using high-resolution aerial imagery to support this process (see discussion below).[3] The terrestrial woodland habitat map, which was created for this report, was composed of digital polygons encompassing the "Swamp Cedar" woodland populations in the groundwater discharge area of Spring Valley (see details in Appendix D, D.2.1).

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1. The informational sources for each site are identified in the complete compilation table of environmental sites within the analysis area (Appendix E).
2. For more information on the land cover map, see Burns and Drici (2011, at Section 5) and SNWA (2009b, at Section 7).
3. National Agricultural Imagery Program aerial imagery (NAIP, 2006 and 2015 1-m resolution imagery) and SNWA aerial imagery (SNWA 2007 and 2016 6-inch resolution imagery).

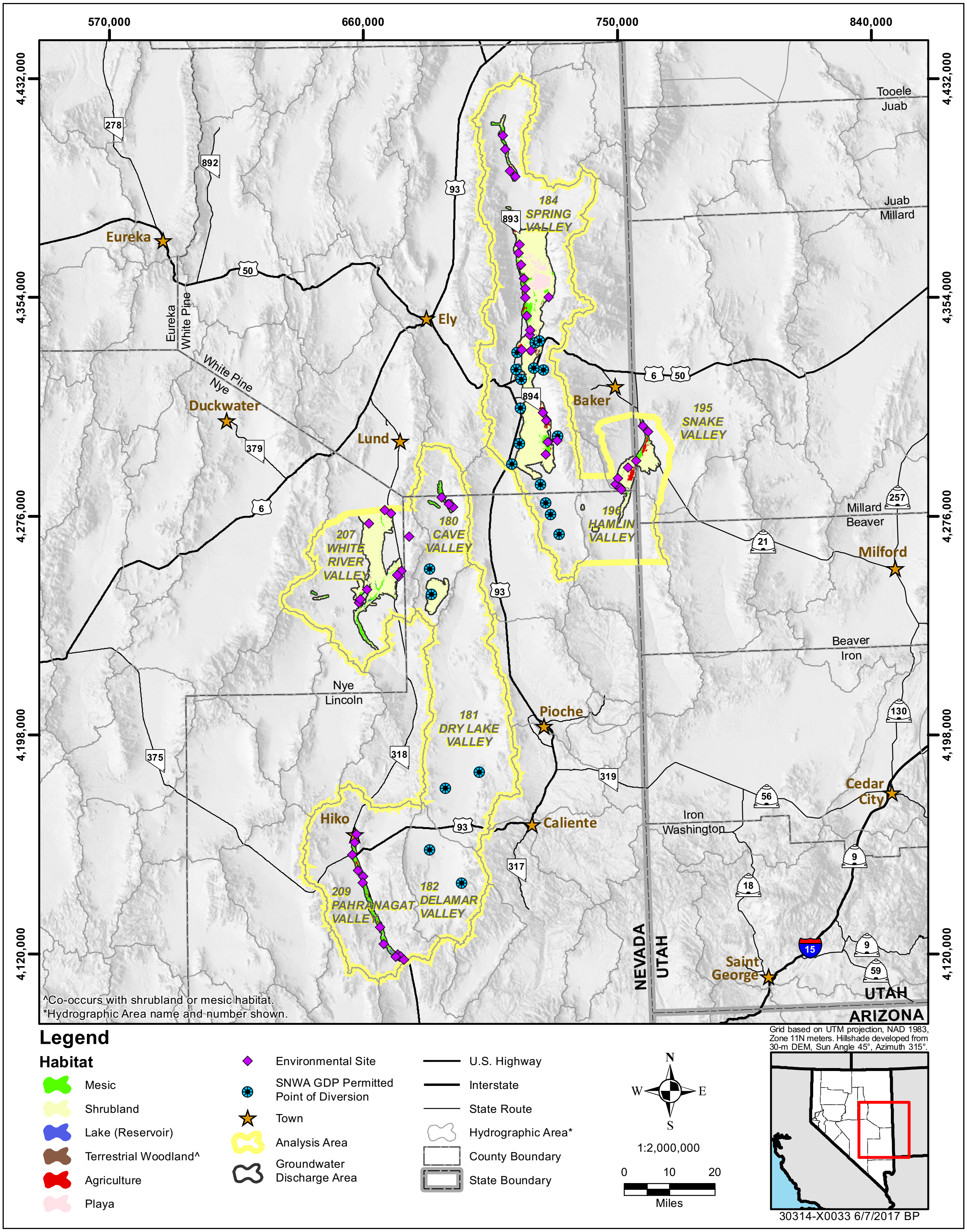

Figure 5-1
Environmental Resources and GDP Points of Diversion in the Analysis Area

Habitats within the groundwater discharge areas of the analysis area were delineated as follows:

Mesic habitat was delineated to include almost all areas in the land cover map that were classified as "wetland/meadow" (see exception below) and any spring, pond and creek areas that were classified as "open water." The wetland/meadow classification in the land cover map was described as areas of shallow groundwater near bodies of open water consisting of wetland vegetation, marshland, woodland, or dense meadows, including riparian corridors (Burns and Drici, 2011, at Section 5). The open water classification was described as bodies of open water fed by groundwater sources.

Shrubland habitat was delineated to include almost all areas in the land cover map that were classified as "phreatophytic/medium density vegetation" or "bare ground/low density vegetation" (see exception below). A small number of scattered pixels in shrubland habitat that were temporarily wet at the time of satellite imagery capture and classified as "open water" were also included.[1] Areas classified as "phreatophytic/medium density vegetation" (described as shrubland with greater than 20 percent plant cover in Burns and Drici, 2011, at Section 5) were further delineated as "medium-density shrubland" for the purpose of the shrubland analysis (Section 6.3.3.2 and Appendix D, D.1.1.1). Areas classified as "bare ground/low density vegetation" (described as shrubland with less than or equal to 20 percent plant cover in Burns and Drici, 2011, at Section 5) were further delineated as "low-density or sparse shrubland". Sparse shrubland was then distinguished from low-density shrubland for the shrubland analysis (Appendix D, D.1.1.1).

Terrestrial woodland habitat was delineated to include the "Swamp Cedar" tree populations in Spring Valley. This woodland habitat co-occurs with shrubland habitat (i.e., the trees are intermixed with shrubs) and mesic habitat. Terrestrial woodland habitat areas that co-occur with shrubland habitat were classified in the land cover map as "phreatophytic/medium density vegetation" or "bare ground/low density vegetation." Terrestrial woodland habitat areas that co-occur with mesic habitat were classified in the land cover map as "wetland/meadow." To support the development of triggers and actions intended to avoid elimination of terrestrial woodland habitat from the groundwater discharge area (an unreasonable effect identified in Section 2.2), a separate terrestrial woodland habitat map was created. The development of this digital map is described in Appendix D, D.2.1.

Lake habitat was delineated to include all lake areas in the land cover map that were classified as "open water." A lake that was drained at the time of mapping, and was classified in the land cover map as "phreatophytic/medium density vegetation" and "bare ground/low density vegetation," was also included.[2] This lake currently holds water.

Playa was delineated to include all areas in the land cover map that were classified as "playa." Minor playa areas that were temporarily wet at the time of satellite imagery capture, and were classified as "open water," were also included.[3] The playa classification in the land cover map was described as bare-soil flat areas located in the bottoms of some basins (Burns and Drici, 2011, at Section 5). These areas encompass the Spring Valley ephemeral playas, which are too dry for wetland species once they

1. These areas were identified using high-resolution aerial imagery.
2. Lower Lake in the Pahranagat National Wildlife Refuge was drained for maintenance and management purposes. High-resolution aerial imagery was used to identify the land cover polygons to include as lake habitat.
3. These areas were identified using high-resolution aerial imagery.

dry out and too wet for dry-site species when they contain water (McLendon, 2011b). Additional factors that limit vegetation in the playa areas include high levels of salinity (Blank and Young, 2004). Because no perennial plants become established in the playa areas, no associated vegetative habitat exists that would be affected by groundwater drawdown (BLM, 2012a at page 3.5-46; McLendon, 2011b). The playa soil binding properties are also not expected to change as a result of groundwater drawdown, as determined in the BLM EIS (BLM, 2012a, at page 3.1-38). Therefore, playa is not analyzed further in this report.

Agriculture was delineated to include all areas in the land cover map that were classified as "agriculture." The agriculture classification in the land cover map was described as areas where crops are grown and harvested (e.g., alfalfa), but not grassland/meadowland areas (Burns and Drici, 2011, at Section 5). A few areas that were converted from shrubland to pivot agriculture after the land cover map was made were not newly digitized, but they were excluded from the shrubland analysis (Section 6.3.3.2 and Appendix D, D.1.1.1). Agriculture is supported by senior water rights, which are analyzed in this report.

Descriptions of the habitats within the groundwater discharge areas of the analysis area, and summaries of the wildlife that use those habitats, are presented in Section 5.2. Federally listed and native aquatic-dependent special status animal species are further discussed in Section 5.3.

5.2 Descriptions of Habitat Types and Identification of Associated Wildlife

Mesic Habitat

Mesic habitat has a moderate or well-balanced supply of moisture. This is in contrast to xeric (very dry) and hydric (very wet) habitats, which have either a small amount or an abundance of moisture, respectively. In the groundwater discharge areas of the analysis area, mesic habitat is composed of springs, seeps, ponds, marshes, streams, riparian woodland galleries, and wetland/meadow habitat components.[1] In some cases, these habitat components are intermixed to form habitat complexes. In other cases they stand alone, with springs, seeps and streams having narrow margins of herbaceous or woody riparian vegetation.

The mesic habitats in the analysis area are maintained by a variety of natural and human-made factors. These factors include spring discharge, surface-water runoff from surrounding areas and mountains, subsurface inflow from the mountains, shallow groundwater, precipitation, water diversions, well outflow, and irrigation. Historic and existing water management influences the mesic habitat in a variety of ways, including (1) taking water away from systems, thereby reducing or

1. Spring: Body of water fed by emergence of groundwater. Seep: Area where groundwater slowly discharges to the surface. Pond: Small confined water body. Stream: Small flowing-water systems, which can be perennial, ephemeral (seasonal), or intermittent. Marsh: Area that is flooded in wet seasons and typically remains waterlogged at all times. Wetland: Area with soils that are saturated to the surface most of the time. Meadow: Plant community dominated by grasses or grass-like plants that has saturated soil within the rooting zone in most or all months of the year. Riparian corridor: Plant community (with grasses, shrubs, and/or trees) occurring along standing or flowing water (springs, seeps, ponds, streams). Most riparian corridors in the groundwater discharge areas are narrow margins of usually herbaceous vegetation. Wider riparian woodland galleries also occur in Pahranagat Valley.

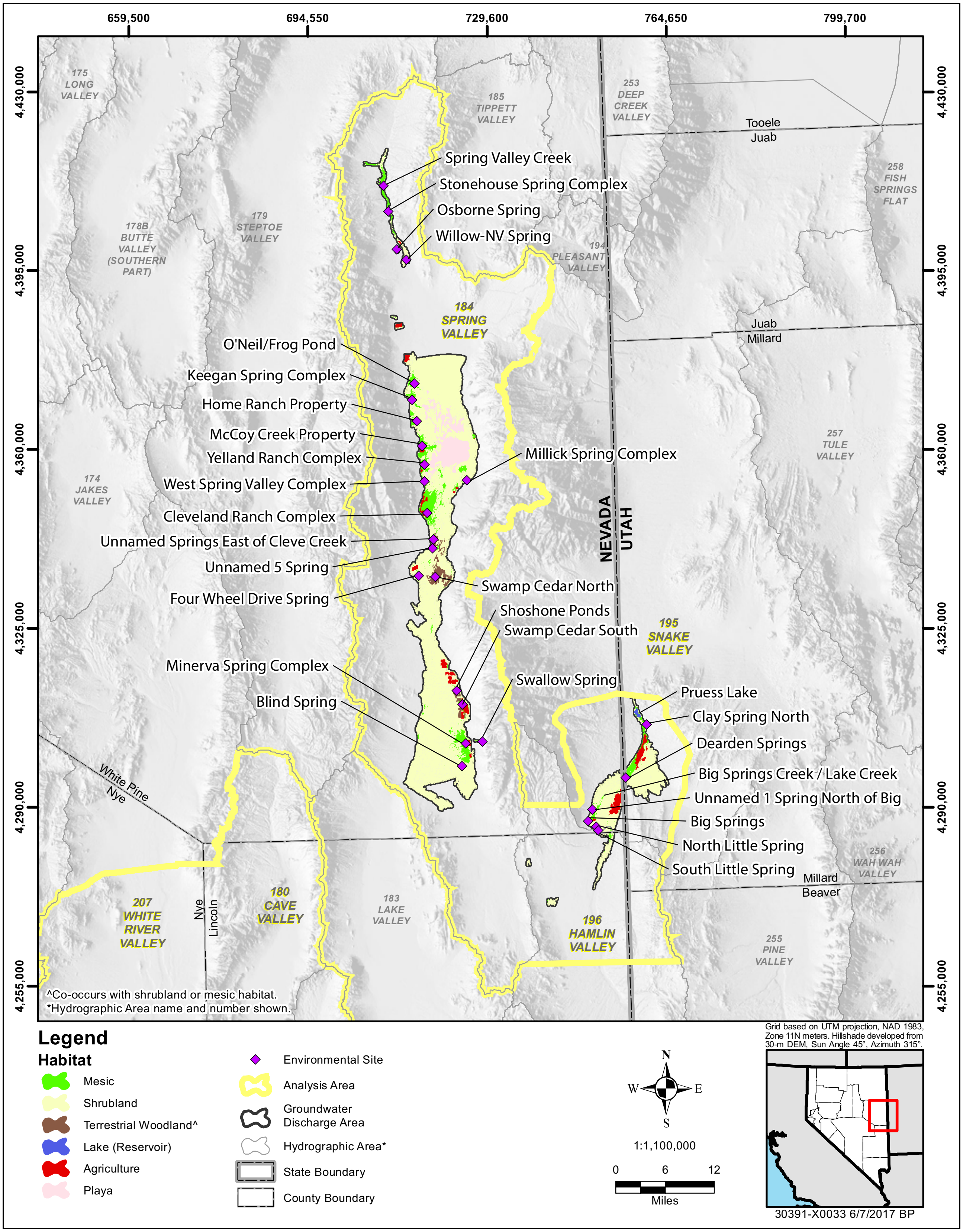

Figure 5-2
Habitats and Environmental Sites in Spring, Hamlin, and Snake Valleys

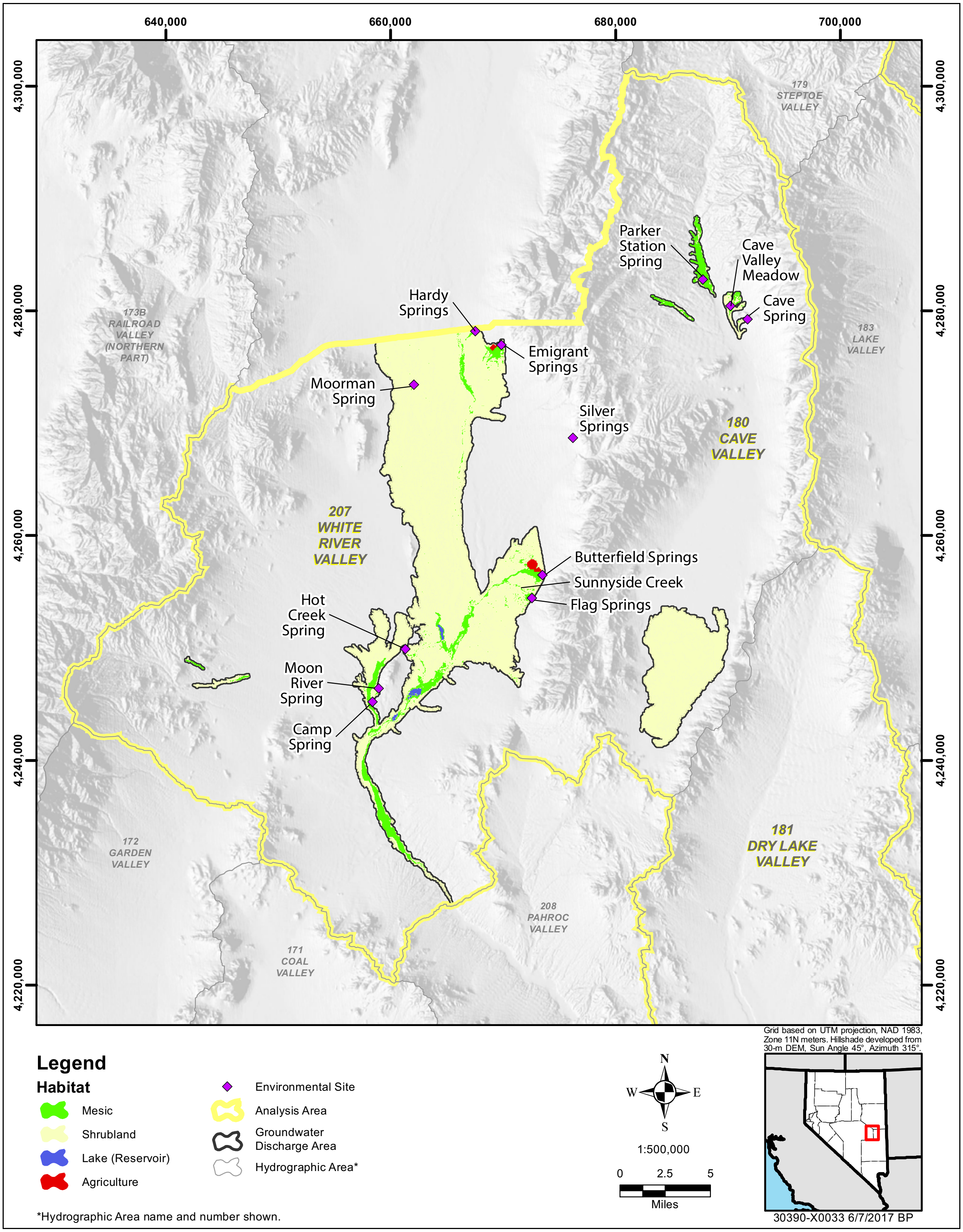

Figure 5-3
Habitats and Environmental Sites in Cave and White River Valleys

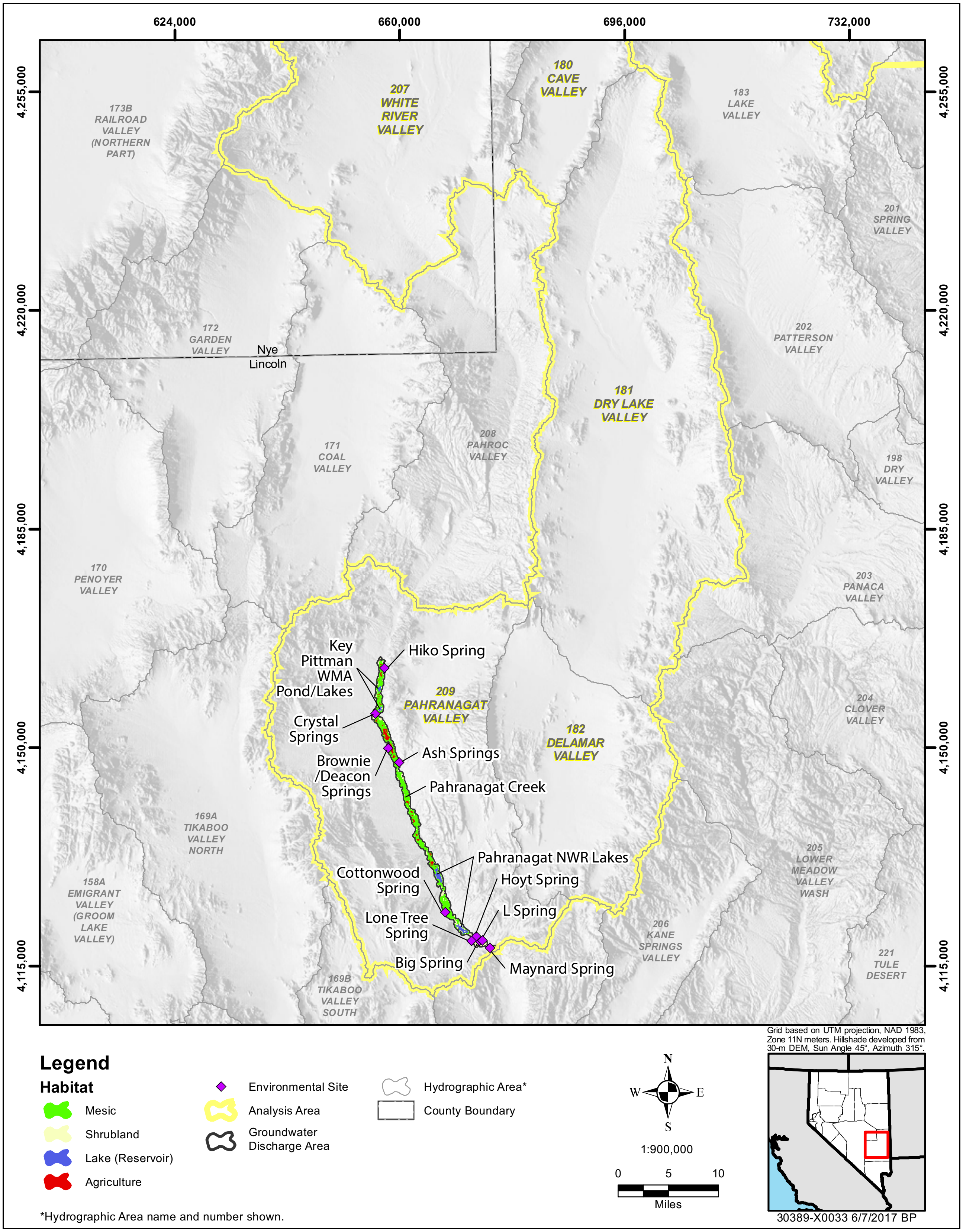

Figure 5-4
Habitats and Environmental Sites in Delamar, Dry Lake, and Pahranagat Valleys

eliminating the habitat; (2) adding surface water to or sub-irrigating systems, thereby enhancing or creating the habitat; and (3) redistributing water in systems, thereby changing the composition and distribution of the habitat.

A number of federally listed fish species and two federally listed bird species use mesic habitat within the groundwater discharge areas of the analysis area (Tables 5-1 and 5-2 below). Other native aquatic-dependent special status animal species that use this mesic habitat include frogs, fish, and invertebrates (Tables 5-1 and 5-2 below). The federally listed species and other native aquatic-dependent special status species are addressed in this analysis. Other wildlife that use this mesic habitat include fish, resident and migratory birds, bats, other small- to medium-sized mammals, and big game. Although these other wildlife are not specifically addressed in this analysis, their needs are protected by avoiding unreasonable effects to senior water rights, federally listed species and native aquatic-dependent special status animal species with which they are generally co-located and mesic habitat.

Shrubland Habitat

Shrubland accounts for most of the habitat acreage within the groundwater discharge areas of the analysis area. In some areas, shrubland is intermixed with other habitat types (e.g., shrub patches in areas of mesic habitat, shrubland habitat co-occurring with terrestrial woodland habitat). In other areas, shrublands stand alone and span extensive distances. These shrublands have facultative phreatophytic shrub species as well as shrub species that rely on precipitation. The deep-rooted facultative shrub species use precipitation as a primary water source and groundwater as a secondary water source; they can also exist on sites where groundwater is inaccessible (McLendon, 2011a).

There are no federally listed species or native aquatic-dependent special status animal species in shrubland habitat within the groundwater discharge areas of the analysis area. Wildlife that use this shrubland habitat include reptiles, resident and migratory birds, bats, other small- to medium-sized mammals, and big game. Although these wildlife are not specifically addressed in this analysis, avoiding unreasonable effects to the shrubland habitat also protects their needs.

Terrestrial Woodland Habitat

Terrestrial woodland habitat occurs in the groundwater discharge area of Spring Valley. These terrestrial woodlands are referred to as Swamp Cedars, which is a name with historical and cultural significance. Biologically speaking, however, the terrestrial woodland habitat is not a true swamp and the trees are not cedars. As discussed in Section 5.1, the terrestrial woodland habitat co-occurs with shrubland and mesic habitat. The dominant tree species is Rocky Mountain juniper (*Juniperus scopulorum*), which has a broad ecological range, is not groundwater dependent, and is adapted to both dry and wet extremes within its wide range. This species is known to exploit additional moisture when available, which can result in higher productivity (McLendon, 2011a). Terrestrial woodland habitat areas in Spring Valley are influenced by shallow (and, in some areas, likely perched) groundwater, precipitation, surface runoff, and subsurface drainage.

There are no federally listed species or native aquatic-dependent special status animal species in terrestrial woodland habitat within the groundwater discharge areas of the analysis area. Wildlife that use this terrestrial woodland habitat include reptiles, resident and migratory birds, other small-to medium-sized mammals, and big game. Although these wildlife are not specifically addressed in this analysis, avoiding unreasonable effects to the terrestrial woodland habitat also protects their needs.

Lake Habitat

A few lakes occur in the form of reservoirs in the groundwater discharge areas of southern Snake and Pahranagat valleys. Springs provide the headwaters for Pruess Lake and the Pahranagat National Wildlife Refuge (NWR) lakes, and springs and wells provide the headwaters for the Key Pittman Wildlife Management Area (WMA) lakes.[1] The source waters flow to the lakes in creeks, ditches, and pipes that are actively managed for irrigation, and the lakes are managed for irrigation and wildlife. Water management activities conducted by water right holders and land managers result in large baseline water level fluctuations at all of the lakes.

No federally listed species and one native aquatic-dependent special status invertebrate species occur in lake habitat within the groundwater discharge areas of the analysis area (Tables 5-1 and 5-2 below). Wildlife that use this lake habitat include fish, resident and migratory birds, bats, other small- to medium-sized mammals, and big game. Triggers and management and mitigation actions applied at the source waters protect the downstream lake habitats and the needs of the special status species and wildlife that use the habitat.

5.3 Federally Listed and Other Special Status Species Designations

Federally listed species and native aquatic-dependent special status animal species were identified within the groundwater discharge areas of the analysis area. Native species are those that occur within the basin as the result of natural processes rather than human intervention. Federal and State special status designations were considered as described below.

Federally listed species are listed as endangered or threatened under the ESA. “Listed species means any species of fish, wildlife, or plant which has been determined to be endangered or threatened under section 4 of the [ESA]” (50 CFR § 402.02). The term ‘species’ “includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature” (50 CFR § 81.1(h)). The term ‘endangered species’ means “Any species which is in danger of extinction throughout all or a significant portion of its range”[2] (50 CFR § 81.1(c)). The term ‘threatened species’ means “Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range” (50 CFR § 81.1(l)).

Species can also be categorized as candidate or proposed for listing under the ESA. Federal candidate species are species for which the USFWS has sufficient information on biological vulnerability and threats to propose them as endangered or threatened under the ESA but for which development of a

1. Pahranagat NWR Upper and Lower lakes, and Key Pittman WMA Nesbitt and Frenchy lakes.
2. “...(other than a species of the Class Insecta as determined by the Secretary to constitute a pest whose protection under the provisions of [the ESA] would present an overwhelming and overriding risk to man)” (50 CFR § 81.1(c)).

proposed listing regulation is precluded by higher priority listing actions (USFWS and National Marine Fisheries Science, 1998). Proposed species have been proposed in the Federal Register to be listed under the ESA and are awaiting final listing determination (USFWS and National Marine Fisheries Science, 1998).

Nevada state-protected species are species (or subspecies) classified as “protected” by the Nevada Board of Wildlife Commissioners (Nevada Administrative Code (NAC) 503.0035). Criteria for classification of wildlife as protected are stated under NAC § 503.103. A Nevada state-protected species list is maintained in the Nevada Natural Heritage Program (NNPH) database (NNHP, 2016).

Nevada BLM sensitive species are species found on BLM-administered lands that have been designated by BLM-Nevada for special management consideration. A BLM sensitive species list is maintained in the NNHP database (NNHP, 2016).

Nevada species of conservation priority are species determined by the Nevada Department of Wildlife (NDOW) to be vulnerable to emerging and expanding stressors and requiring special management consideration (Nevada Wildlife Action Plan Team, 2012).

Utah sensitive species are species determined by Utah Division of Wildlife Resources (UDWR) to be of concern and requiring special management consideration (UDWR, 2015).

Species ranked by NatureServe as G1 (critically imperiled across their entire range) are assessed to be at very high risk of extinction, and species ranked as G2 (imperiled across their entire range) are assessed to be at high risk of extinction (NNHP, 2016). NatureServe is a scientific network that collects and analyzes data about imperiled species and ecosystems to guide decision-making and enhance conservation. NatureServe G1 and G2 species lists are maintained in the NNHP database (NNHP, 2016).

A list of the federally listed species and native aquatic-dependent special status animal species included in the analysis is provided in Table 5-1, along with the status of the species and the basins where they occur. A list of the local environmental sites and associated species is presented in Table 5-2.

Table 5-1
Federally Listed and Native Aquatic-Dependent Special Status Animal Species

	Species Common Name[a]	Species Latin Name	Special Status[b]	Basin Occurrence[c]
Bird				
	Southwestern willow flycatcher	*Empidonax traillii extimus*	FE	Pahranagat
	Western yellow-billed cuckoo	*Coccyzus americanus*	FT	Pahranagat
Fish				
	Hiko White River springfish	*Crenichthys baileyi grandis*	FE	Pahranagat
	Moorman White River springfish	*Crenichthys baileyi thermophilus*	NVP	White River
	Pahranagat roundtail chub	*Gila robusta jordani*	FE	Pahranagat
	Pahranagat speckled dace	*Rhinichthys osculus velifer*	NVP, BLM	Pahranagat
	Pahrump poolfish[d]	*Empetrichthys latos*	FE	Spring
	White River desert sucker	*Catostomus clarki*	NVP	White River
	White River sculpin	*Cottus* sp.	NS	White River
	White River speckled dace	*Rhinichthys osculus*	BLM	White River
	White River spinedace	*Lepidomeda albivallis*	FE	White River
	White River springfish	*Crenichthys baileyi baileyi*	FE	Pahranagat
Frog				
	Northern leopard frog	*Rana pipiens*	NVP, BLM	Spring, Pahranagat
Invertebrate				
	Ash Springs riffle beetle	*Stenelmis lariversi*	NS	Pahranagat
	Bifid duct pyrg	*Pyrgulopsis peculiaris*	BLM	Snake
	Butterfield pyrg	*Pyrgulopsis lata*	BLM	White River
	California floater	*Anodonta californiensis*	UT	Snake
	Emigrant pyrg	*Pyrgulopsis gracilis*	BLM	White River
	Flag pyrg	*Pyrgulopsis breviloba*	BLM	White River
	Grated tryonia	*Tryonia clathrata*	BLM	White River, Pahranagat
	Hardy pyrg	*Pyrgulopsis marcida*	BLM	Cave, White River
	Hubbs pyrg	*Pyrgulopsis hubbsi*	BLM	Pahranagat
	Longitudinal gland pyrg	*Pyrgulopsis anguina*	BLM, UT	Snake
	Pahranagat naucorid bug	*Pelocoris biimpressus shoshone*	BLM	Pahranagat
	Pahranagat pebblesnail	*Pyrgulopsis merriami*	BLM	White River, Pahranagat
	White River Valley pyrg	*Pyrgulopsis sathos*	BLM	White River

[a] Only species within groundwater discharge areas of the analysis area included.
[b] Only highest ranks listed. FE = Federally Endangered. FT = Federally Threatened. NVP = Nevada State Protected. UT = Utah Sensitive. BLM = Nevada BLM Sensitive. NS = NatureServe critically imperiled (G1) or imperiled (G2) across range.
[c] Within the groundwater discharge areas of the analysis area.
[d] Pahrump poolfish were transplanted into Spring Valley.

Table 5-2
Local Environmental Sites and Associated Species
(Page 1 of 3)

Hydrographic Basin		Federally Listed and Native Aquatic-Dependent Special Status Animal Species[a]	Location[b]		
			UTM_N	UTM_E	Elevation
Cave Valley (HB 180)					
	Cave Spring	None	4279234	691760	6486
	Cave Valley Meadow	None	4280420	690235	6467
	Parker Station Spring	Invertebrate (Hardy pyrg)	4282783	687749	6490
Delamar Valley (HB 182)					
	None	None			
Dry Lake Valley (HB 181)					
	None	None			
Northern Hamlin Valley (HB 196)					
	South Little Spring	None	4285394	751328	5578
Pahranagat Valley (HB 209)					
	Ash Springs	Fish (White River springfish); Invertebrate (Pahranagat pebblesnail, Grated tryonia, Ash Springs riffle beetle, Pahranagat naucorid bug)	4147658	659915	3603
	Big Spring[c]	Fish (Pahranagat speckled dace)	4119046	672756	3156
	Brownie/Deacon Springs	Fish (Pahranagat speckled dace)	4149891	658155	3695
	Cottonwood Spring[c]	Fish (Pahranagat roundtail chub)	4123638	667261	3238
	Crystal Springs	Fish (Hiko White River springfish); Invertebrate (Hubbs pyrg)	4155375	656095	3803
	Hiko Spring	Fish (Hiko White River springfish)	4162750	657560	3878
	Hoyt Spring[c]	Frog (Northern leopard frog)	4119766	672238	3180
	Key Pittman WMA pond/lakes[d]	Fish (Pahranagat roundtail chub)[d]; Bird (Southwestern willow flycatcher, Western yellow-billed cuckoo)	4159787	656880	3834
	L Spring[c]	Fish (Pahranagat speckled dace); Frog (Northern leopard frog)	4119155	673202	3159
	Lone Tree Spring[c]	None	4119014	671456	3197
	Maynard Spring	Frog (Northern leopard frog)	4117909	674444	3107
	Pahranagat Creek	Fish (Pahranagat roundtail chub); Bird (Southwestern willow flycatcher)	4145350	659798	3559
	Pahranagat NWR lakes[c]	Bird (Southwestern willow flycatcher, Western yellow-billed cuckoo)	4129420	665817	3353

Table 5-2
Local Environmental Sites and Associated Species
(Page 2 of 3)

Hydrographic Basin		Federally Listed and Native Aquatic-Dependent Special Status Animal Species[a]	Location[b]		
			UTM_N	UTM_E	Elevation
Southern Snake Valley (HB 195)					
	Big Springs	Invertebrate (Longitudinal gland pyrg)[e,f]	4287284	749419	5578
	Big Springs Creek/Lake Creek	None[f]	4293341	753805	5479
	Clay Spring North	Invertebrate (Longitudinal gland pyrg)	4306154	760853	5446
	Dearden (Stateline) Springs[g]	Invertebrate (Longitudinal gland pyrg)	4295798	756730	5423
	North Little Spring	None	4286207	751009	5562
	Pruess Lake	Invertebrate (California floater)	4308130	759066	5348
	Unnamed 1 Spring North of Big	Invertebrate (Bifid duct pyrg)[e]	4289477	750196	5572
Spring Valley (HB 184)					
	Blind Spring[h]	Frog (Northern leopard frog)	4298021	724721	5773
	Cleveland Ranch Complex[i]	Frog (Northern leopard frog)	4347511	717940	5597
	Four Wheel Drive Spring	None	4335259	716246	5754
	Home Ranch Property[j]	Frog (Northern leopard frog)	4365486	715824	5585
	Keegan Spring Complex	Frog (Northern leopard frog)	4369729	714947	5617
	McCoy Creek Property	Frog (Northern leopard frog)	4360707	716897	5592
	Millick Spring Complex	Frog (Northern leopard frog)	4353957	725673	5590
	Minerva Spring Complex	Frog (Northern leopard frog)	4302423	725413	5825
	O'Neil/Frog Pond	Frog (Northern leopard frog)	4372899	715403	5600
	Osborne Spring	None	4399091	711963	6127
	Shoshone Ponds	Fish (Pahrump poolfish); Frog (Northern leopard frog)[k]	4312843	723711	5781
	Spring Valley Creek	None	4411581	709337	6351
	Stonehouse Spring Complex	None	4406616	710222	6256
	Swallow Spring	None	4302864	728689	6080
	Swamp Cedar North	None	4335053	719489	5645
	Swamp Cedar South	None	4310128	724802	5813
	Unnamed 5 Spring	Frog (Northern leopard frog)	4340639	718897	5645
	Unnamed Springs East of Cleve Creek	None	4342419	719111	5652

Table 5-2
Local Environmental Sites and Associated Species
(Page 3 of 3)

Hydrographic Basin		Federally Listed and Native Aquatic-Dependent Special Status Animal Species[a]	Location[b]		
			UTM_N	UTM_E	Elevation
	West Spring Valley Complex	Frog (Northern leopard frog)	4353810	717315	5603
	Willow-NV Spring	None	4397069	713758	5987
	Yelland Ranch Complex	Frog (Northern leopard frog)	4357010	717336	5570
Southern White River Valley (HB 207)					
	Butterfield Springs	Fish (White River speckled dace, White River sculpin); Invertebrate (Butterfield pyrg, Hardy pyrg)	4256498	673511	5324
	Camp Spring	Fish (White River speckled dace); Invertebrate (White River Valley pyrg)	4245192	658387	5181
	Emigrant Springs	Fish (White River speckled dace); Invertebrate (Hardy pyrg, Emigrant pyrg)	4276964	669869	5464
	Flag Springs[l]	Fish (White River spinedace, White River speckled dace, White River desert sucker); Invertebrate (Flag pyrg, White River Valley pyrg)	4254223	672662	5294
	Hardy Springs	Invertebrate (Hardy pyrg)	4278175	667545	5354
	Hot Creek Spring	Fish (Moorman White River springfish); Invertebrate (Pahranagat pebblesnail, Grated tryonia)	4249920	661285	5229
	Moon River Spring	Fish (Moorman White River springfish); Invertebrate (Pahranagat pebblesnail, Grated tryonia[e])	4246389	658933	5223
	Moorman Spring	Fish (Moorman White River springfish); Invertebrate (Pahranagat pebblesnail, Grated tryonia)	4273421	662057	5299
	Silver Springs	Invertebrate (Hardy pyrg)	4268700	676190	5970
	Sunnyside Creek[l]	Fish (White River spinedace, White River speckled dace, White River desert sucker)	4255021	672010	5230

[a] Only species within groundwater discharge areas pf the analysis area included.
[b] UTM projection: NAD83, Zone 11N. Elevation in feet.
[c] Within the Pahranagat National Wildlife Refuge (NWR). The population of Pahranagat roundtail chub at Cottonwood Spring was recently established. Discharge from Crystal and Ash springs flows into the NWR Upper and Lower lakes. Southwestern willow flycatcher breeds and western yellow-billed cuckoo occurs in the woody riparian area around Upper Lake (USFWS, 2012).
[d] A well in Key Pittman Wildlife Management Area (WMA) provides the source water for the pond where Pahranagat roundtail chub occur. Water from the pond and Hiko and Crystal springs contribute to the WMA Nesbitt and Frenchy lakes.Southwestern willow flycatcher breeds in and western yellow-billed cuckoo has been documented in the woody riparian area around Nesbitt Lake.
[e] Previous reports included longitudinal gland pyrg and bifid duct pyrg in Big Springs and longitudinal gland pyrg in Unnamed 1 Spring North of Big (Golden et al., 2007; BLM, 2012a; Marshall and Luptowitz, 2011). Recent review of records suggests that only longitudinal gland pyrg is in Big Springs, and bifid duct pyrg is in Unnamed 1 Spring North of Big (Sada, 2017b); re-sampling and identification is suggested. Also, the FEIS listed only Pahranagat pebblesnail at Moon River Spring, but surveys have also documented grated tryonia at the site (Sada, 2017a).
[f] Redside shiner, Utah chub, and Utah sucker are no longer on the Utah Sensitive Species List (UDWR, 2015).
[g] Also known as Stateline Springs.
[h] Blind Spring is a dugout retention area with wetland vegetation.
[i] The EIS included a site named North of Cleveland Ranch (UTM N 4351695, E 719545) (BLM, 2012a). Mesic habitat at the site is a downstream continuation of mesic habitat at Cleveland Ranch Complex and thus is subsumed here.
[j] The Home Ranch Property habitat was entirely created by irrigation water from Odgers Creek (piped from mountain block).
[k] NDOW removed relict dace from Shoshone Ponds and transplanted them to their native Steptoe Valley.
[l] Flag Springs discharge converges to form Sunnyside Creek, which also receives water downstream from Butterfield Springs discharge.

6.0 TRIGGERS, MANAGEMENT AND MITIGATION: SPRING VALLEY (HYDROGRAPHIC AREA 184)

6.1 Introduction

This section provides the technical background and rationale for the Spring Valley 3M Plan associated with SNWA GDP permit numbers 54003 to 54015, 54019, and 54020.

Analyses are presented for the thresholds, triggers, and monitoring, management, and mitigation actions that are established to avoid unreasonable effects to senior water rights and environmental resources within Spring Valley. Section 6.2 focuses on hydrologic resources, and Section 6.3 focuses on environmental resources. The analyses were conducted in accordance with the conceptual approach described in Section 3.0. The analyses for Hamlin and Snake valleys are presented in Section 7.0.

Spring Valley was divided into five Management Blocks to provide a useful structure for developing triggers and monitoring, management, and mitigation actions in the basin (Figure 6-1). The Management Blocks were delineated based on distribution of senior water rights, SNWA water rights, environmental resources, and SNWA GDP PODs, as follows:

- Management Block 1 is located in southern Spring Valley, and includes 8 of the 15 permitted Spring Valley GDP PODs. The majority of existing water rights and land holdings on the valley floor and alluvial fan are owned by SNWA. The groundwater discharge area in Management Block 1 encompasses approximately 60,000 acres [shrubland habitat = 55,000 acres (90%); mesic habitat = 2,500 acres (4%); terrestrial woodland habitat = 1,000 acres (2%); and agriculture = 3,000 acres (5%)].[1]

- Management Block 2 is located in south-central Spring Valley, and includes 7 of the 15 permitted Spring Valley GDP PODs. A combination of SNWA-owned and privately-owned existing water rights and land holdings occur on the valley floor and alluvial fan. The groundwater discharge area in Management Block 2 encompasses approximately 50,000 acres [shrubland habitat = 37,000 acres (75%); playa habitat = 7,000 acres (15%); terrestrial

1. Shrublands include facultative phreatophytic shrub species, as well as shrub species that rely solely on precipitation. Mesic habitat in Spring Valley is composed of springs, seeps, ponds, marshes, streams, and wetland/meadow habitat components, which are sometimes intermixed to form habitat complexes. Most of the terrestrial woodland habitat co-occurs with shrubland habitat, and some co-occurs with mesic habitat. Agriculture is defined as crops that are grown and harvested. See detailed habitat descriptions in Section 5.2.

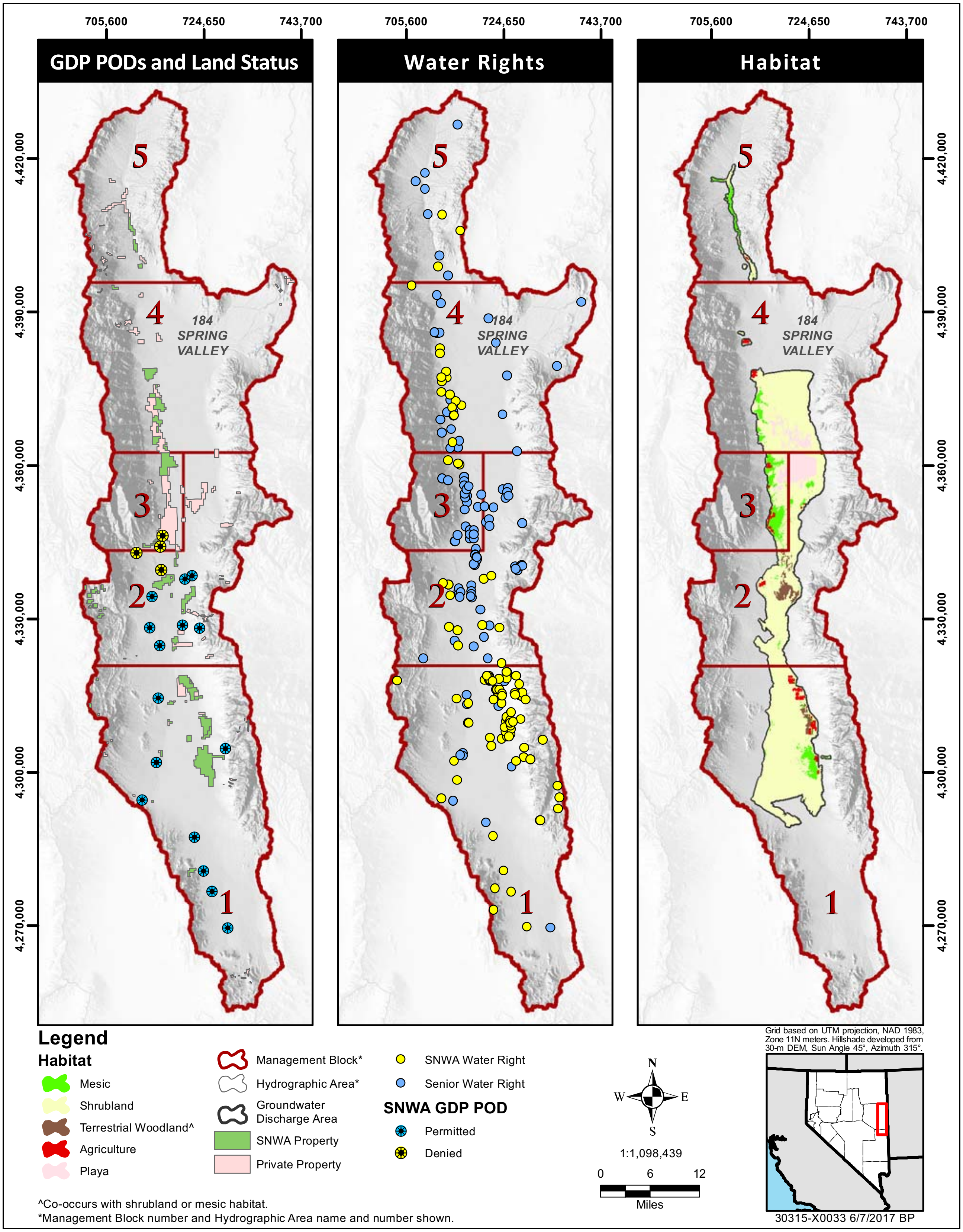

Figure 6-1
Management Blocks within the Spring Valley Hydrographic Area

woodland habitat = 3,000 acres (6%); mesic habitat = 1,000 acres (2%); and agriculture = 400 acres (1%)].[1]

- Management Block 3 is located in west-central Spring Valley. The northernmost SNWA GDP POD is approximately three and a half miles south of the block, and the four previously denied GDP PODs (application numbers 54016 to 54018 and 54021) are within and south of the block. The majority of existing water rights and land holdings on the valley floor and alluvial fan are privately owned, with property and existing water rights in the north owned by SNWA. The groundwater discharge area in Management Block 3 encompasses approximately 17,000 acres [shrubland habitat = 10,000 acres (60%); mesic habitat = 4,500 acres (25%); playa habitat = 2,000 acres (10%); terrestrial woodland habitat = 100 acres (1%); and agriculture = 1,000 acres (5%)]. Approximately half of the mesic habitat in the Spring Valley groundwater discharge area occurs in Management Block 3.

- Management Block 4 is located in north-central Spring Valley, over 15 miles from the northernmost permitted Spring Valley GDP POD. A combination of SNWA-owned and privately-owned existing water rights and land holdings occur on the valley floor and alluvial fan. The groundwater discharge area in Management Block 4 encompasses approximately 42,000 acres [shrubland habitat = 35,000 acres (85%); playa habitat = 4,000 acres (10%); mesic habitat = 1,500 acres (4%); and agriculture = 500 acres (1%)].

- Management Block 5 is located in northern Spring Valley, over 35 miles from the northernmost permitted Spring Valley GDP POD. A combination of SNWA-owned and privately-owned existing water rights and land holdings occur on the valley floor and alluvial fan. The groundwater discharge area in Management Block 5 encompasses approximately 2,800 acres [shrubland habitat = 1,900 acres (70%); mesic habitat = 850 acres (30%); and agriculture = 50 acres (2%)]. This area is at a higher elevation compared to the rest of the Spring Valley groundwater discharge area (approximate mean elevation: 6,200 ft in Block 5 vs. 5,700 ft in Blocks 1-4).

SNWA GDP pumping in Spring Valley is planned to be implemented in three stages as authorized in NSE Ruling 6164 (NDWR, 2012a, at pages 216-217). The stages consist of incremental increases in pumping volume to a maximum of 61,127 afa (Table 6-1). The staged groundwater development approach limits GDP pumping while aquifer response data is monitored.

6.2 Hydrologic Monitoring and Senior Water Rights

This section presents the rationale and analysis for the monitoring and management strategy, mitigation triggers, and mitigation actions for senior water rights located in each management block in Spring Valley. A query of the NDWR Water Rights Database for all active water rights in Spring Valley was performed. Active water rights are those that are not in application status, but it includes vested claims. Based on this query, there are 399 active water rights in Spring Valley, as of November 2016, that had status of certificated, decreed, permitted, reserved, or vested. The data set was adjusted by removing 265 water rights that are located in the basin mountain block, have priority dates junior

1. The playa habitat is ephemeral and without perennial vegetation.

Table 6-1
Spring Valley Staged Groundwater Development Schedule

Stage of Development	Incremental Volume (afa)	Total (afa)	Time Period (Years)
1[a]	38,000	38,000	0-8
2[a]	12,000	50,000	8-16
3	11,127	61,127	>16

a. To advance to the next stage, SNWA is required to pump at least 85 percent but not more than 100 percent of the total afa for a minimum of eight years. Data from those eight years of pumping and updated numerical groundwater flow modeling results will be submitted to the NSE as part of the annual monitoring report. The NSE will then make a determination as to whether SNWA can proceed to the next development stage.

to the SNWA GDP permits, reservoir rights, and those owned by SNWA. The water rights located in the basin mountain block were removed because they are not in hydraulic connection to the producing aquifer in which SNWA GDP production wells will be installed, and are therefore unlikely to be impacted by SNWA GDP permits. The resulting data set of 134 senior water rights are presented separately for each management block.

A total of 18 non-SNWA domestic wells were identified in Spring Valley using the NDWR well log database. The wells are listed by management block in Appendix B Table B-1. A water resource survey of the 12 domestic wells within 10 miles of a SNWA GDP PODs will be performed at least three years prior to initiation of SNWA GDP pumping to confirm the existence and condition of the wells.

6.2.1 Senior Water Rights in Management Block 1

Management Block 1 consists of the southern portion of Spring Valley which contains the SNWA GDP PODs associated with permit numbers 54003 through 54009 and 54019. The SNWA GDP POD locations, senior water rights, and 3M Plan hydrologic monitoring network in Management Block 1 are shown on Figure 6-2.

A tally of water rights in Management Block 1 senior to SNWA permits by source, status, and hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed, are presented in Table 6-2. Individual senior water rights are listed in Table 6-3, which includes information on water right status, source, manner of use, priority date, diversion rate, annual duty, ownership, distance to the closest SNWA GDP POD, digital elevation model (DEM) elevation, and management category (as described in Section 3.2.5). The management category for each senior water right defines monitoring, management, and mitigation strategy and actions associated with the water right. No non-SNWA domestic wells were identified in Management Block 1. Within this management block, there are ten certificated underground senior water rights (296 afa) and one reserved senior spring water right (2 afa) for a total duty of 298 afa in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed.

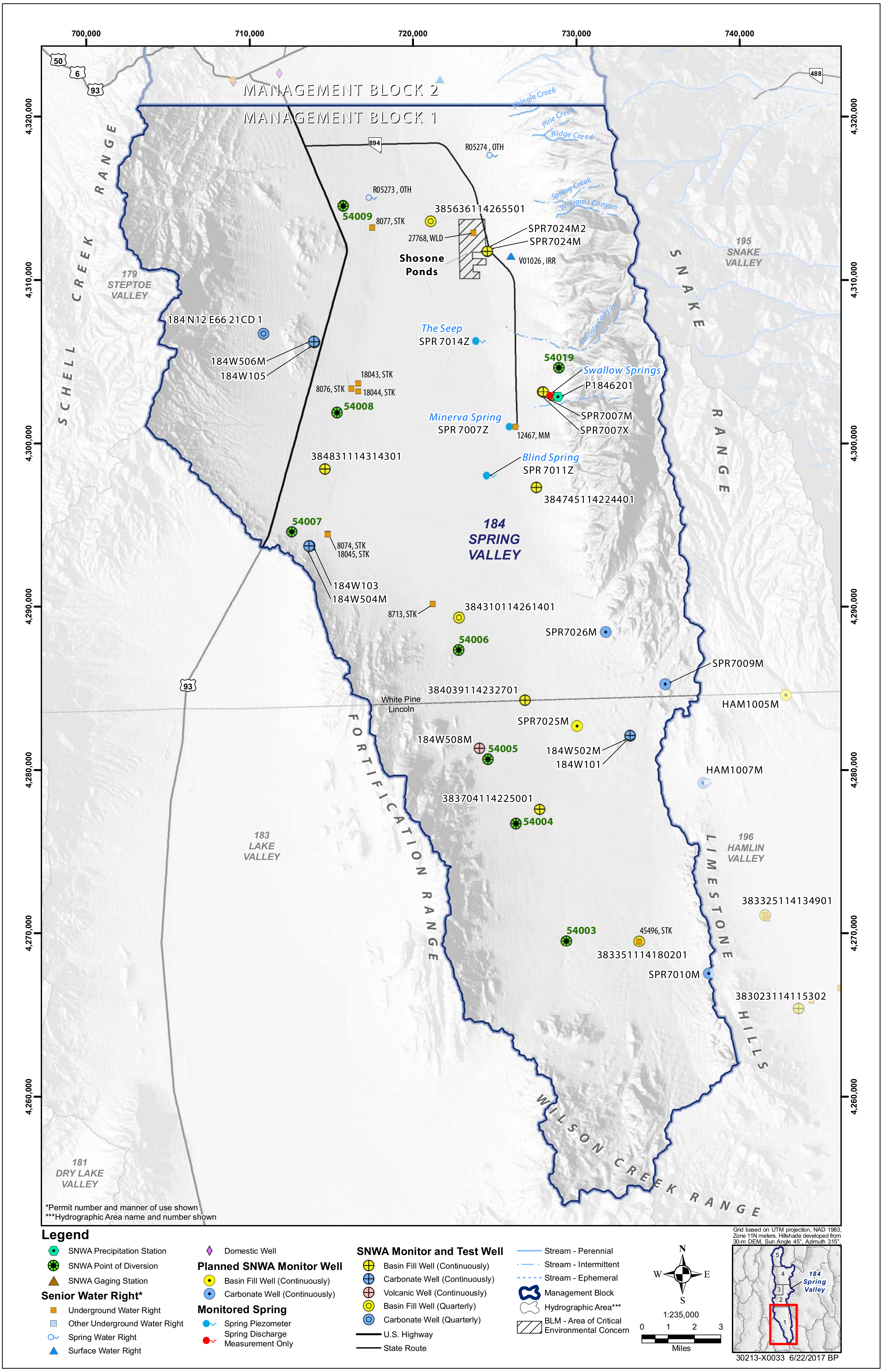

Figure 6-2
Management Block 1 GDP PODs, Senior Water Rights, and Hydrologic Monitoring Network

Table 6-2
Spring Valley Management Block 1 Water Rights by Source and Status Senior to SNWA GDP Permits

Source	Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)				Not Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)			
	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)
Spring	0 / 0.00	0 / 0.00	1 / 2.15	0 / 0.00	0 / 0.00	0 / 0.00	1 / 1.84	0 / 0.00
Stream	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	1 / 16[a]
Underground	10 / 296.07[b]	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00

[a]Acre-ft per season.
[b]The reported duty includes both acre-ft per season and acre-ft per annum.

Table 6-3
Water Rights within Management Block 1 Senior to SNWA GDP Permits

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
8074	CER	UG	STK	1927	0.05	26.9*,g	Collis, Chris & Karen	Valley Floor	1.4	5,790	A
8076	CER	UG	STK	1927	0.05	36.2*,g	Collis, Chris & Karen	Valley Floor	1.1	5,790	A
8077	CER	UG	STK	1927	0.05	27.0*,g	Robison, Doyle C.	Valley Floor	1.4	5,790	A
8713	CER	UG	STK	1928	0.013	9.4*	Swallow, George N.	Valley Floor	2.0	5,830	A
12467	CER	UG	MM	1948	0.1	72.4*	Minerva Scheelite Mining Co.	Valley Floor / Alluvial Fan	2.8	5,840	A
18043	CER	UG	STK	1959	0.006	4.5*	Collis, Chris & Karen	Valley Floor	1.4	5,760	A
18044	CER	UG	STK	1959	0.006	4.5*	Collis, Chris & Karen	Valley Floor	1.1	5,770	A
18045	CER	UG	STK	1959	0.01	9.0*	Collis, Chris & Karen	Valley Floor	1.4	5,790	A
45496	CER	UG	STK	1982	0.12	86.2*	Okelberry, Ray	Alluvial Fan / Valley Floor	2.8	6,180	A
R05273	RES	SPR	OTH	1926	0.003	2.1*	BLM	Valley Floor / Alluvial Fan	1.1	5,840	A
R05274	RES	SPR	OTH	1926	0.003	1.8*	BLM	Alluvial Fan	6.0	6,240	E
V01026	VST	STR	IRR	1898	0	16.0*,g	Swallow, George	Alluvial Fan	4.6	6,080	E
Shoshone Ponds Area of Critical Environmental Concern											
27768	CER	UG	WLD	1973	0.027	20.0	Nevada-Department of Wildlife	Valley Floor / Alluvial Fan	5.0	5,780	B

[a]CER - Certificated, RES - Reserved, VST - Vested
[b]SPR - Spring, STR - Stream, UG - Underground
[c]IRR - Irrigation, MM - Mining & Milling, OTH - Other, STK - Stock watering, WLD - Wildlife
[d]Rounded to the nearest tenth of a mile.
[e]Rounded to the nearest 10 ft.
[f]See Section 3.2.5 for a detailed explanation of the Management Categories; A - Resource within 3 miles of SNWA GDP POD, B - Resource between 3 miles and 10 miles of SNWA GDP POD, E - Resource not in hydraulic connection with producing aquifer in which SNWA GDP production wells will be installed.
[g]acre-ft per season
*The reported annual duty is not explicitly documented on the certificate, reserved right, or vested claim, but reported as such by the NDWR Hydrographic Abstract query.

Monitoring Strategy

Nine of the certificated underground rights and one reserved water right listed on Table 6-3 are assigned Management Category A (as described on Table 3-1) because they are located within 3 miles of the nearest SNWA GDP POD. The closest of these senior water rights are permit numbers 8076 and R05273 which are located over a mile from the SNWA GDP POD for permit number 54009. One other certificated underground right in this management block is assigned Management Category B because it is located between 3 and 10 miles of the nearest SNWA GDP POD permit number 27768. This senior water right associated with Shoshone Ponds, which is discussed separately in Section 6.3.1.

One of the reserved spring water rights R05274 and the stream vested claim V01026, located approximately 5 and 6 miles from the nearest SNWA GDP POD, are assigned Management Category E because these sites are not in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed. This is due to the location, hydrogeologic setting, and elevation difference between the water rights and the SNWA GDP PODs and therefore effects from SNWA GDP pumping are unlikely.

The monitoring strategy for categories A and B consists of the following:

- Measure static water level at the ten wells listed in Table 6-3 on a quarterly basis beginning at least three years prior to SNWA GDP pumping if physically accessible and permission is granted by the owner. The time period will provide at least three measurements each season to provide a baseline for comparison with monitor wells in the network with longer term baseline records.

- Monitor spring water right R05273 directly if discharge is measurable. If not measurable, document conditions of the spring compared to any observed changes in the groundwater level at the well associated with underground stock water right 8077.

- Measure all monitoring network well and spring locations in Management Block 1 including four shrubland piezometers (Section 6.3.3.4) to document hydrologic and aquifer conditions.

- Performing a water resource assessment, as described in Section 3.2.7, on the ten wells and one spring listed in Table 6-3 at least three years prior to SNWA GDP pumping.

Investigation Triggers and Management Actions

An investigation trigger will be activated if the static water level in any of the wells associated with the senior underground water rights listed in Table 6-3 decrease below the 99.7 percent lower control limit, as described in Appendix A.

It is anticipated that an investigation trigger will be activated at several of the locations in the management block due to the short distance between the sites and the SNWA GDP PODs. Activation of an investigation trigger does not indicate a conflict exists, but will result in an evaluation to determine the cause and significance of the water level change observed using protocols described in

Section 3.2.2. Should the cause of the water level change be caused by SNWA GDP pumping, the following management actions may be taken:

- Increase monitoring frequency to continuous (hourly) if feasible to install a pressure traducer in the senior water right POD wells.
- Prepare implementation of mitigation actions to avoid conflict at the senior water right POD or place of beneficial use, including purchasing equipment, establishing contracts, and obtaining any necessary landowner permissions and permits.
- Consider preemptive mitigation actions for senior water rights in Management Category A (less than 3 miles from SNWA GDP POD) to avoid the activation of a mitigation trigger. The decision to preemptively implement mitigation actions at a site will be dependent upon the results of the water resource assessment, probability of effects, sensitivity of resource, and hydrogeologic setting.
- Update the numerical groundwater flow model and other predictive tools with aquifer response data.

Mitigation Triggers

A mitigation trigger is set for all the senior water rights as described below and in Section 3.2.6. Mitigation triggers determine when a mitigation action is implemented if the cause of the trigger being activated is SNWA GDP pumping.

<u>Underground Senior Water Rights</u>

The mitigation trigger for underground senior water rights are defined for two categories where: (1) the well and current pump production capacity is capable of producing more water than the water right's diversion rate allows; and (2) the well and current pump production capacity is capable of producing water only equal to or less than what the water right's diversion rate allows.

The mitigation triggers are based upon change in static groundwater level and specific capacity as described in Section 3.2.6.1. The mitigation triggers are detailed below:

- Well production > permitted diversion rate prior to SNWA GDP pumping: A decrease in groundwater level that reduces the column of water in the well needed to produce the permitted diversion rate based on the well's specific capacity range plus either a 10 percent or 10 foot buffer, which ever is greater. The buffer provides time to implement the mitigation action prior to reaching a conflict. An example of a mitigation trigger for this case is presented in Section 3.2.6.1. An alternative fixed mitigation trigger for the well is activated if the maximum production capacity from the well decreases to less than 10 percent above the permitted diversion rate and the static groundwater level has decreased as a result of SNWA GDP pumping. An evaluation would be made to determine if the changes were a result of SNWA GDP pumping or were due to a deterioration in the well or pump conditions and efficiency.

- Well production < permitted diversion rate prior to SNWA GDP pumping: The mitigation trigger is activated if the evaluation associated with the investigation trigger determines the cause of the change in water level to be SNWA GDP pumping.

- Increase of more than 25 percent in power usage for the pump to produce the same amount of water as a result of decreased water levels from SNWA GDP pumping.

<u>Spring and Stream Senior Water Rights</u>

The mitigation trigger for spring and stream rights is based upon change in flow rate in relation to the permitted diversion rate or historical baseline flow rate as described in Section 3.2.6.2. The mitigation trigger for a senior spring or stream water-right is presented under two cases: (1) spring or stream flow at the POD which has been measured consistently above the permitted diversion rate, or (2) spring or stream flow at the POD which has been measured consistently at or below the permitted diversion rate. The mitigation triggers are detailed below:

- If measured baseline spring or stream flow has been consistently above the permitted diversion rate, the mitigation trigger is 10 percent above the permitted diversion rate to provide a buffer and is activated if spring or stream discharge decreases below this mitigation trigger level as a result of SNWA GDP pumping.

- If measured baseline spring or stream flow has been consistently at or less than the permitted diversion rate, the mitigation trigger is activated if the evaluation associated with the investigation trigger determines the cause of the change to be SNWA GDP pumping.

A third case consist of springs which have intermittent flow or are consistently dry. A spring which has non-measurable intermittent flow or that is dry over extended periods of time will be studied as a special case using nearby shallow piezometers, if present, or visual observations. The spring conditions will be compared to water levels and regional precipitation conditions to determine the conditions under which the spring flows. After SNWA GDP pumping begins, the spring will be monitored to determine if there is a change in the observed spring flow compared what has been observed under similar baseline regional hydrologic conditions.

Mitigation Actions

If the senior water right mitigation trigger in Spring Valley Management Block 1 is activated, and caused by SNWA GDP pumping, mitigation will be implemented. The mitigation actions for wells include:

- Lowering of the pump if the well has the depth and capacity to produce the water right.

- Rehabilitate the well to increase well efficiency in order to increase production.

- Deepen the well if the aquifer has the ability to yield the water right.

- Drilling and equipping a replacement well.

- Compensate well owners for the incremental increase in power usage if the usage increases greater than 25 percent to produce a similar volume of water.

- Modify SNWA GDP pumping duration, rate, or distribution.

- Temporary storage tank to supplement the well's production while other mitigation actions are implemented. Water supplying the tank can be sourced by pumping the well for a longer period of time at a lower pumping rate or by a water truck delivering water.

The mitigation actions for springs or streams include:

- Constructing a well or piping to convey the water right to the POD or place of beneficial use.

- Temporary storage tank to supplement the spring or stream flow while other mitigation actions are implemented. Water supplying the tank can be sourced by temporary piping from another source provided by SNWA or by deliveries from a water truck.

Additional mitigation actions are presented in Section 3.2.8. Mitigation actions for the senior underground water rights located within the management block will be effective because well modifications or replacements will be designed to produce the amounts required for the senior water rights under conditions that exist during SNWA pumping. SNWA non-GDP and GDP permitted water rights are available to be used as mitigation resources if needed. SNWA water rights in Block 1 are presented in Table 6-4 and Figure 6-3.

Table 6-4
Spring Valley Management Block 1 SNWA Water Rights by Source and Status

	Status (Number of Rights/Annual Duty)		
Source	**Certificated (afa)**	**Permitted (afa)**	**Vested (afa)**
Lake	1 / 1,120	0 / 0.00	0 / 0.00
Spring	4 / 221.38[a,b]	7 / 588.16[a,b]	7 / 3,015.68[c]
Stream	19 / 21,920.57[b,d]	2 / 622.6[a]	3 / 6,195.44
Underground	27 / 5,960.71[a,b,d]	17 / 4,702.37[a,b,d]	0 / 0.00

[a]The reported duty includes one or more groups of water rights that have not to exceed total combined duties.
[b]The reported duty includes both acre-ft per season and acre-ft per annum.
[c]The reported duty includes 1 vested right with a duty of 0 as reported by the NDWR Hydrographic Abstract.
[d]The reported duty overestimates the available water due to two groups of water rights with not to exceed total combined duties. For these rights, the NDWR reported duty was used in the total duties.

Note: The reported totals do not include any portion of the 61,127 afa of SNWA permitted, underground GDP rights.

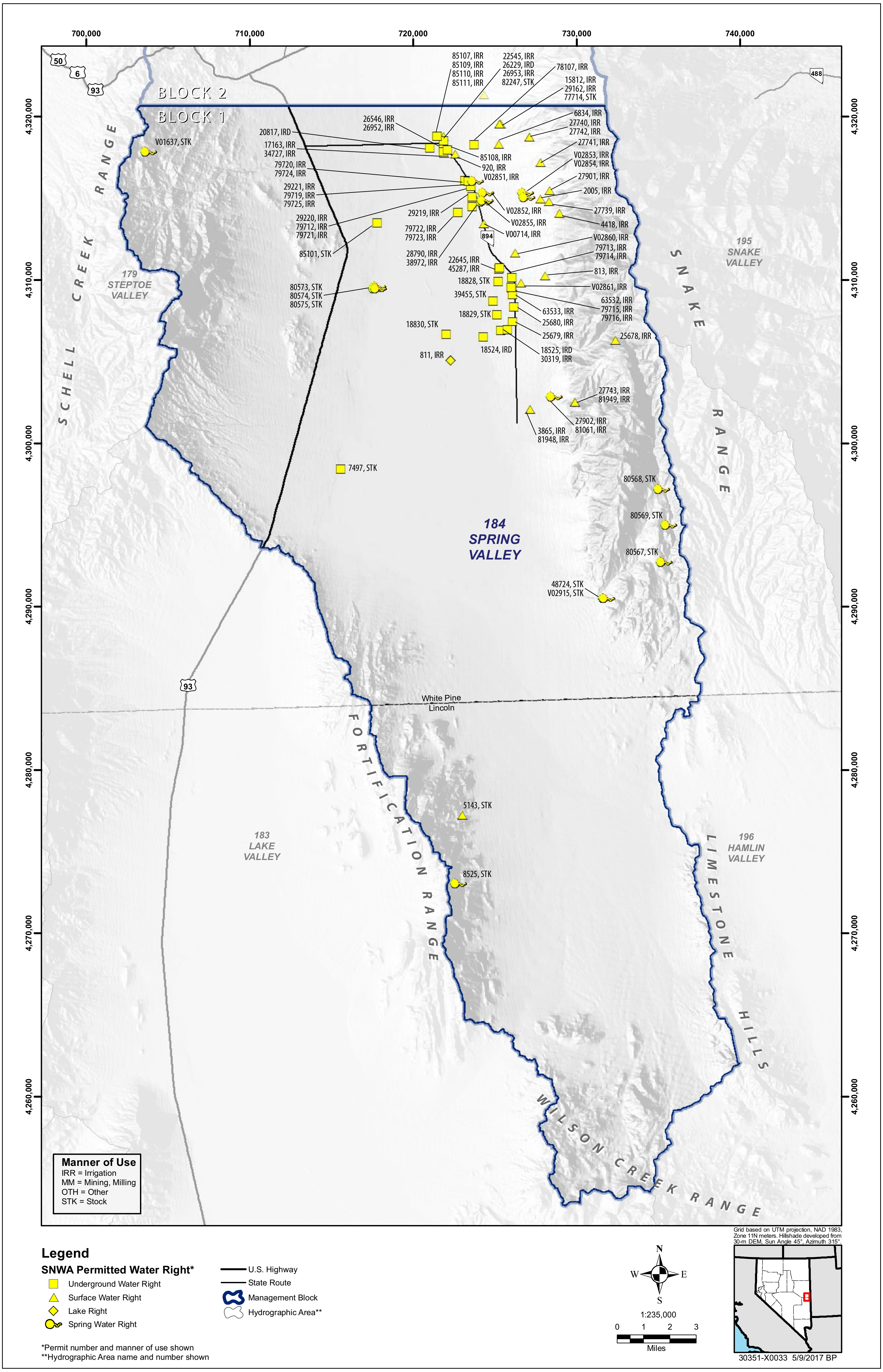

Figure 6-3
SNWA Water Rights Management Block 1

6.2.2 Senior Water Rights in Management Block 2

Management Block 2 consists of the central portion of Spring Valley which contains the SNWA GDP PODs associated with permit numbers 54010 through 54015 and 54020. The SNWA GDP PODs, senior water rights, and 3M Plan hydrologic monitoring network in Management Block 2 are shown on Figure 6-4. The monitoring, management, and mitigation plan for the Swamp Cedar ACEC area is presented in Section 6.3.4. A tally of water rights in Management Block 2 senior to SNWA GDP permits by source, status, and hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed, are presented in Table 6-5. Individual senior water rights are listed in Table 6-6 including information on water right status, source, manner of use, priority date, diversion rate, annual duty, ownership, distance to the closest SNWA GDP POD, DEM elevation, and management category (as described in Section 3.2.5).

Table 6-5
Spring Valley Management Block 2 Water Rights by Source and Status Senior to SNWA GDP Permits

	Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)				Not Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)			
Source	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)
Spring	6 / 2,305.07[a,e]	0 / 0.00	8 / 175.63	16 / 471.12[b]	1 / 0.675[f]	0 / 0.00	5 / 129.63	0 / 0.00
Stream	1/ 919	0 / 0.00	0 / 0.00	0 / 0.00	1 / 724	4 / 1,812.53[g]	0 / 0.00	0 / 0.00
Underground	8 / 1,093.53[c,e]	1 / 2,080[d]	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00

[a]The reported duty includes a not to exceed total combined duty for permits 10921, 10923, and 80902 of 2,080 afa.
[b]Reported duty takes into account a total combined duty of 28.28 afa as documented in Stanka (2017).
[c]The reported duty takes into account the total combined duty of permits 29371 and 29567 (TCD = 803.4 afa).
[d]The reported duty includes a not to exceed total combined duty for permits 10921, 10993, and 80902 of 2,080 afa.
[e]The reported duty includes both acre-ft per season and acre-ft per annum.
[f]Acre-ft per season.
[g]The reported duty takes into account a not to exceed total combined duty for permits 80453, 80454, 80455, and 80456 (TCD = 1,812.53 afa).

Within Management Block 2, there are eight certificated (1,094 afa) and one permitted (2,080 afa) senior underground water rights; six certificated (2,305 afa) and eight reserved (176 afa) senior spring water rights; 16 spring vested claims (471 afa); and one certificated senior stream right (919 afa) for a total of 7,044 afa for the 40 senior water rights in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed.

Six other spring (130 afa) and five stream (2,537 afa) senior water rights for a total duty of 2,667 afa within the analysis are not in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed due to location and hydrogeologic setting. Stream water right numbers 80453 to 80456 are located on Negro Creek which are piped via an aqueduct to the valley floor. Spring water right permit numbers R05281 to R05285 and 21832, are located within the mountain block, however, they are in the vicinity of Rock Spring gaging station. Stream water right permit number 983 is located on the alluvial fan not in hydraulic connection with groundwater.

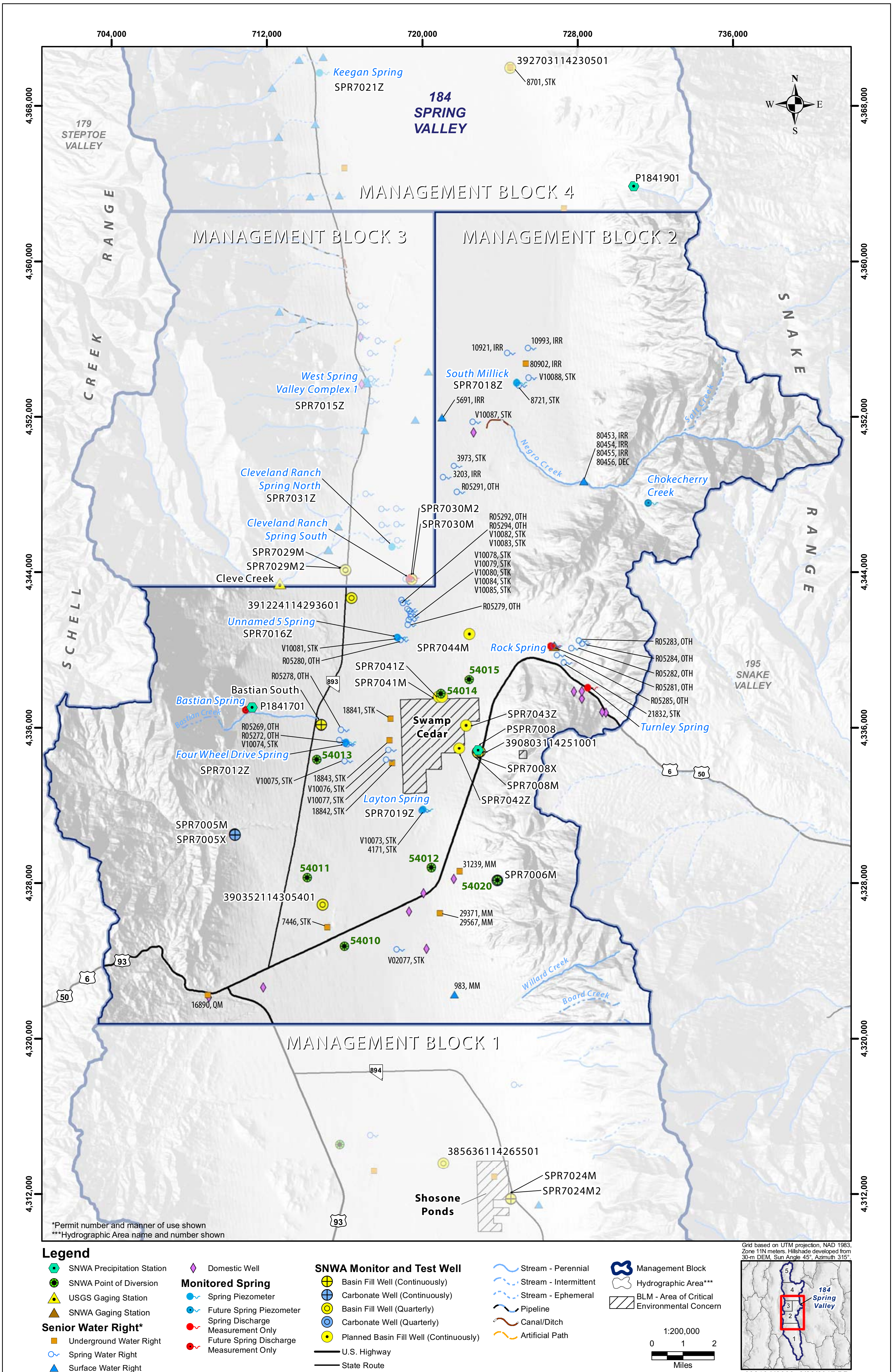

Figure 6-4
Management Block 2 GDP PODs, Senior Water Rights, and Hydrologic Monitoring Network

Table 6-6
Water Rights within Management Block 2 Senior to SNWA GDP Permits
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App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
983	CER	STR	MM	1908	1	724.0*	Pilot Knob Gold Mining & Milling Co.	Alluvial Fan	3.8	6,020	E
3203	CER	SPR	IRR	1914	0.35	190.6[g]	George Eldridge & Son, Inc.	Valley Floor	6.5	5,580	B
3973	CER	SPR	STK	1916	0.008	5.7*	LDS	Valley Floor	6.8	5,580	B
4171	CER	SPR	STK	1916	0.02	14.3*	Robison Brothers	Valley Floor	1.8	5,700	A
5691	CER	STR	IRR	1919	1.895	919.0	George Eldridge & Son, Inc.	Valley Floor	8.4	5,560	B
7446	CER	UG	STK	1925	0.019	13.4*[g]	Production Credit Corp. of Berkeley	Valley Floor	0.8	5,830	A
8721	CER	SPR	STK	1928	0.02	14.5*	Corp. of Church of Latter-Day Saints	Valley Floor	9.6	5,580	B
10921	CER	SPR	IRR	1943	0.79	570.7	George Eldridge & Son, Inc.	Valley Floor	10.5	5,560	C
10993	CER	SPR	IRR	1943	0.6	433.6	George Eldridge & Son, Inc.	Valley Floor	10.8	5,560	C
16890	CER	UG	QM	1956	0.1	72.4*	Pierce, L.L.	Alluvial Fan	4.6	6,530	B
18841	CER	UG	STK	1960	0.011	9.0*	Vogler, Henry Conrad IV	Valley Floor	1.8	5,640	A
18842	CER	UG	STK	1960	0.013	9.0*	Vogler, Henry Conrad IV	Valley Floor	2.4	5,670	A
18843	CER	UG	STK	1960	0.013	9.0*	Vogler, Henry Conrad IV	Valley Floor	2.2	5,650	A
21832	CER	SPR	STK	1964	0.001	0.7*	Eldridge, David and Helen	Alluvial Fan / Mountain Block	3.2	6,410	E
29371	CER	UG	MM	1975	1.11	803.4	The Infinity Mine, LLC	Alluvial Fan / Valley Floor	1.5	5,790	A
29567	CER	UG	MM	1975	1.11	699.9	The Infinity Mine, LLC	Alluvial Fan / Valley Floor	1.5	5,790	A
31239	CER	UG	MM	1977	0.49	177.4	Ostlund, Robert	Alluvial Fan	0.9	5,950	A
80453	PER	STR	IRR	1914	1.6	583.9	LDS	Alluvial Fan	7.3	6,070	E
80454	PER	STR	IRR	1927	1.512	544.9	LDS	Alluvial Fan	7.3	6,070	E
80455	PER	STR	IRR	1940	2.873	1,149.2	LDS	Alluvial Fan	7.3	6,070	E
80456	PER	STR	DEC	1887	0.26	77.9	LDS	Alluvial Fan	7.3	6,070	E
80902	PER	UG	IRR	1989	3	2,080.0	George Eldridge & Son, Inc.	Valley Floor	10.3	5,570	C

Table 6-6
Water Rights within Management Block 2 Senior to SNWA GDP Permits
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App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
R05269	RES	SPR	OTH	1926	0.005	3.6*	BLM	Alluvial Fan / Valley Floor	1.1	5,760	A
R05272	RES	SPR	OTH	1926	0.093	67.2*	BLM	Alluvial Fan / Valley Floor	1.0	5,780	A
R05278	RES	SPR	OTH	1926	0.093	67.2*	BLM	Alluvial Fan / Valley Floor	1.3	5,750	A
R05279	RES	SPR	OTH	1926	0.011	7.9*	BLM	Valley Floor	2.4	5,630	A
R05280	RES	SPR	OTH	1926	0.011	7.9*	BLM	Valley Floor / Alluvial Fan	2.1	5,640	A
R05281	RES	SPR	OTH	1926	0.042	8.1*	BLM	Alluvial Fan / Mountain Block	3.0	6,420	E
R05282	RES	SPR	OTH	1926	0.042	30.4*	BLM	Alluvial Fan / Mountain Block	3.5	6,540	E
R05283	RES	SPR	OTH	1926	0.042	30.4*	BLM	Alluvial Fan / Mountain Block	3.8	6,680	E
R05284	RES	SPR	OTH	1926	0.042	30.4*	BLM	Alluvial Fan / Mountain Block	3.9	6,730	E
R05285	RES	SPR	OTH	1926	0.042	30.4*	BLM	Alluvial Fan / Mountain Block	3.0	6,340	E
R05291	RES	SPR	OTH	1926	0.008	5.8*	BLM	Valley Floor / Alluvial Fan	6.0	5,590	B
R05292	RES	SPR	OTH	1926	0.011	7.9*	BLM	Valley Floor / Alluvial Fan	3.1	5,640	A
R05294	RES	SPR	OTH	1926	0.011	7.9*	BLM	Valley Floor / Alluvial Fan	3.2	5,640	A
V02077	VST	SPR	STK	1890	0.05	11.2*	Robison, Doyle C.	Valley Floor	1.8	5,750	A
V10073	VST	SPR	STK	1873	0.039[h]	28.28[h]	LDS	Valley Floor	1.8	5,700	A
V10074	VST	SPR	STK	1873	0.12	48.0*	LDS	Alluvial Fan	1.2	5,760	A
V10075	VST	SPR	STK	1873	0.12	48.0*	LDS	Alluvial Fan	1.0	5,800	A
V10076	VST	SPR	STK	1873	0.12	48.0*	LDS	Valley Floor	2.4	5,660	A

Table 6-6
Water Rights within Management Block 2 Senior to SNWA GDP Permits
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App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
V10077	VST	SPR	STK	1873	0.12	48.0*	LDS	Valley Floor	2.3	5,680	A
V10078	VST	SPR	STK	1873	0.12	48.0*	LDS	Valley Floor	2.7	5,620	A
V10079	VST	SPR	STK	1873	0.12	48.0*	LDS	Valley Floor	2.6	5,620	A
V10080	VST	SPR	STK	1873	0.12	48.0*	LDS	Valley Floor	2.5	5,630	A
V10081	VST	SPR	STK	1873	0.12	48.0*	LDS	Valley Floor	2.2	5,650	A
V10082	VST	SPR	STK	1873	0.039[h]	28.28[h]	LDS	Valley Floor	3.2	5,640	B
V10083	VST	SPR	STK	1873	0.039[h]	28.28[h]	LDS	Valley Floor	3.1	5,640	B
V10084	VST	SPR	STK	1873	0.039[h]	28.28[h]	LDS	Valley Floor	2.9	5,620	A
V10085	VST	SPR	STK	1873	0.12	48.0*	LDS	Valley Floor	2.8	5,620	A
V10087	VST	SPR	STK	1873	0.039[h]	28.28[h]	LDS	Valley Floor	8.2	5,580	B
V10088	VST	SPR	STK	1873	0.039[h]	28.28[h]	LDS	Valley Floor	9.9	5,580	B

[a]CER - Certificated, PER - Permitted, RES - Reserved, VST - Vested
[b]SPR - Spring, STR - Stream, UG - Underground
[c]DEC - As Decreed, IRR - Irrigation, MM - Mining & Milling, OTH - Other, QM - Quasi-municipal, STK - Stock watering
[d]Rounded to the nearest tenth of a mile.
[e]Rounded to the nearest 10 ft.
[f]See Section 3.2.5 for a detailed explanation of the Management Categories; A - Resource within 3 miles of SNWA GDP POD, B - Resource between 3 miles and 10 miles of SNWA GDP POD, C - Distant resource > 10 miles, E - Resource not in hydraulic connection with SNWA GDP POD producing aquifer in which SNWA GDP production wells will be installed.
[g]Acre-ft per season.
[h]Reported number was derived from an analysis documented in Stanka (2017).
*The reported annual duty is not explicitly documented on the certificate, reserved right, or vested claim, but reported as such by the NDWR Hydrographic Abstract query.

Monitoring Strategy

The distances between the 40 senior water rights and vested claims within Management Block 2 in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed and the SNWA GDP PODs range from 0.8 to 10.8 miles. Twenty seven of these senior water rights consisting of seven underground certificated, eight spring (one of which is certificated and seven reserved), and 12 spring vested claims listed on Table 6-6 are assigned Management Category A because they are located within 3 miles of the nearest SNWA GDP POD.

Ten senior water rights located between 3 and 10 miles of the nearest SNWA GDP POD and are assigned Management Category B (as described on Table 3-1). These consist of one underground certificated, three spring certificated, one stream certificated, one spring reserved, and four vested spring claims. There are three senior water rights located over 10 miles from the nearest SNWA GDP POD consisting of two certificated spring and one permitted underground water right assigned Management Category C.

The monitoring program for senior water rights in Management Block 2 is summarized in Table 6-7. Monitoring actions for senior water rights assigned Management Categories A and B (located within 10 miles of closest SNWA GDP POD) consists of the following:

- Each senior water right in Management Category A and B will be monitored directly at the POD or at a nearby proxy well as described below.

- Measure static water level at the eight wells in Management Category A and B for the senior underground water rights listed in Table 6-6 on a quarterly basis beginning at least three years prior to SNWA GDP pumping if physically accessible and permission is granted by the owner.The time period will provide three measurements each season to provide a baseline for comparison with monitor wells in the network with longer term baseline records.

- Measure spring discharge at the 28 springs and one stream in Management Categories A and B listed in Table 6-6 on a quarterly basis beginning at least three years prior to SNWA GDP pumping if the springs can be accurately measured, are physically accessible and have permission granted by the land owner. The measurements will be compared to water levels at nearby proxy monitor wells listed in Table 6-7 to determine if the wells can provide more accurate data on aquifer conditions and spring discharge for those senior spring water rights.

- There are five monitor wells and one gaging station which will be monitored continuously and will serve as a proxy for groundwater conditions associated with senior water rights as listed in Table 6-7. This will be successful because water levels measured in the existing monitor wells or piezometers in the area respond directly and in a similar manner to variations in recharge and spring discharge. In addition, water rights with no proxy monitor well will be monitored directly. If the springs not measurable, the condition of the spring will be documented and groundwater levels at the closest monitor well will be measure as listed on Table 6-7.

- Measure all monitoring network well and spring locations as described in the 3M Plan to document hydrologic and aquifer conditions.

- Perform a water resource assessment, as described in Section 3.2.7, on the 37 Management Category A and B senior water rights in Management Block 2, listed in Table 6-6, at least three years prior to SNWA GDP pumping.

Table 6-7
Spring Valley Management Block 2 Monitoring Program

Senior Water Right/Monitoring Area	Associated Monitor Well
V10078-V10085; R05279-R05280; R05292; R05294	Continuous water level at Unnamed 5 Spring Piezometer (SPR7016Z)
V10074-V10075; R05269; R05272; R05278	Four Wheel Drive Spring Piezometer (SPR7012Z) and Bastian South Well
18841-18843; V10076-V10077; V02077; 16890; 31239; 29567; 29371; 7446	Direct monitoring at water right site
4171; V10073	Layton Spring Piezometer (SPR7019Z)
3203;3973; 5691; R05291; V10087	Sentinel Monitor Wells SPR7030M, SPR7030M2, and SPR7044M (planned well)
8721; 80902;10993; 10921; V10088	South Millick piezometer (SPR7018Z) and Sentinel Monitor Wells SPR7030M, SPR7030M2, and SPR7044M (planned well)
Aquifer Conditions in Management Block	SPR7005M, SPR7008M, 390803114251001
Swamp Cedar ACEC (See Section 6.3.4)	SPR7041M, SPR7041Z, SPR7042Z, and SPR7043Z (proposed wells)
Shrubland Piezometer (See Section 6.3.3)	To be determined (proposed wells)
21832; R05281-R05285 (mountain block)	Springs not in hydraulic connection with producing aquifer in which SNWA GDP production wells will be installed Rock Spring gaging station and Turnley Spring for measurement verification
983; 80453-80456	No Monitoring, stream not in hydraulic connection with SNWA GDP POD producing aquifer in which SNWA GDP production wells will be installed

Several springs, including Layton and Bastian springs, in the central portion of Management Block 2 have been documented to be dry over extended periods of time. Field reconnaissance was performed at selected spring vested claim sites in central Spring Valley (V10073- V10085) in September 2016. Results and photos of the site visits are presented in Appendix F.

The monitoring strategy for senior water rights in Management Category C, located over 10 miles from SNWA GDP PODs, are similar to the strategy for Management Blocks 4 and 5 as described in Sections 6.2.4 and 6.2.5.

Monitor well SPR7044M will be installed one mile north of the northern most SNWA GDP production well at least three years prior to SNWA GDP pumping. This well is designated as a sentinel well (Section 3.2.2) and will be used to detect whether drawdown is propagating in the direction of the Management Category D designated senior water rights.

Unreasonable effects at senior water rights in Management Category E are unlikely because these rights are not in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed. Continuous gaging stations at Rock Spring (operating), Chokecherry Spring (planned), Bastian Creek Spring (planned), and periodic physical measurements at Turnley Spring will document aquifer conditions in the mountain block and verify that no impacts occur. A supplemental gaging station and precipitation station operated on Bastian Creek also are used to document hydrologic conditions in the area.

Additional groundwater monitoring consisting of three shallow piezometers (SPR7041Z, SPR7042Z, and SPR7043Z) and one deep monitor well (SPR7041M) is proposed in the vicinity of the Swamp Cedar ACEC as described in Section 6.3.4. The purpose of the wells is to evaluate the relationship between precipitation, shallow groundwater levels, and the deeper producing aquifer in which SNWA GDP production wells will be installed. The wells will provide data to evaluate the vertical hydraulic conductivity, leakage across the clays, and changes in shallow groundwater level.

Investigation Triggers and Management Actions

An investigation trigger will be activated if the static water level in any of the designated monitor wells associated with the senior underground water rights listed in Table 6-6 decrease below the 99.7 percent lower control limit. The hydrograph at piezometer SPR7012Z at 4WD spring is presented in Figure 6-5 as an example of the lower control limit and investigation trigger.

It is anticipated that an investigation trigger will be activated at some of the locations due to the short distance between the sites and the SNWA GDP PODs. Activation of an investigation trigger does not indicate a conflict exists, but will result in an evaluation to determine the cause and significance of the water level change observed using protocols described in Section 3.2.2. Should the cause of the water level change be attributed to SNWA GDP pumping, the following management actions may be taken:

- Increase monitoring frequency to continuous (hourly) if feasible to install a pressure traducer in the senior water right POD wells.

- Prepare implementation of mitigation actions to avoid conflict at the senior water right POD or place of beneficial use, including purchasing equipment, establishing contracts, and obtaining any necessary landowner permissions and permits.

- Consider preemptive mitigation actions for senior water rights in Management Category A (less than 3 miles from SNWA GDP POD) to avoid the activation of a mitigation trigger. The decision to preemptively implement mitigation actions at a site will be dependent upon the results of the water resource assessment, probability of effects, sensitivity of resource, and hydrogeologic setting.

- Update the numerical groundwater flow model and other predictive tools with aquifer response data.

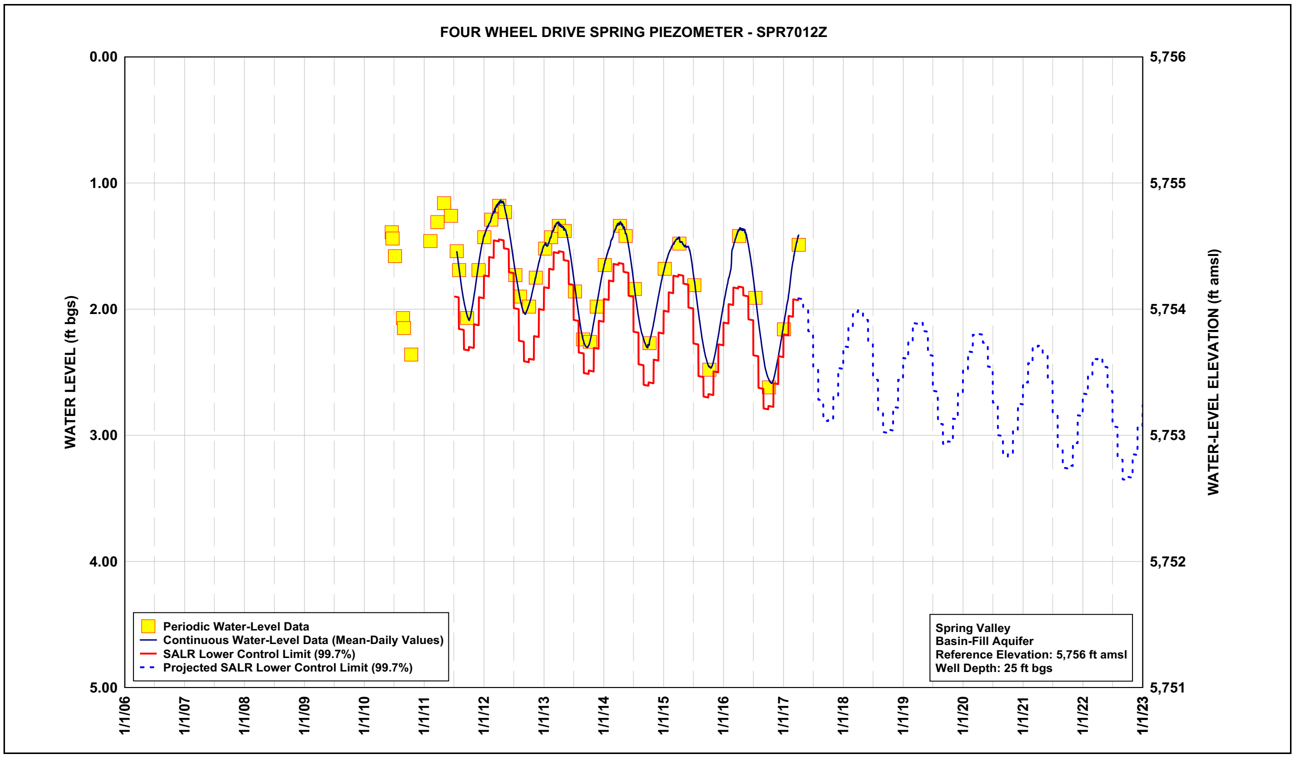

Figure 6-5
SPR7012Z 4WD Spring - Trigger

Mitigation Triggers and Mitigation Actions

The mitigation trigger for all the senior water rights in this management block are the same as Management Block 1, and also described in Section 3.2.6. Mitigation triggers determine when a mitigation action is implemented if the cause of the trigger being activated is SNWA GDP pumping.

Mitigation actions for Management Block 2 underground, spring, and stream rights are the same as those listed in Management Block 1. Additional mitigation actions include:

- Transfer of SNWA permitted surface water rights from Bastian Creek permit numbers 81072, 81908, and 81909 (1,123 afa) and stream vested claim V02078 (11 afa).

- Transfer of SNWA permitted underground water rights from Management Block 1 (Table 6-4 and Figure 6-3) on to Bastian Ranch irrigation well (located east of the above SNWA water rights) and addition of distribution piping to senior water rights in the vicinity of Bastian Ranch.

- Construction of one or a series of new wells along the Schell Creek range front to provide and distribute water to the existing rights on diffuse springs. SNWA permitted water rights from Management Block 1 (Table 6-4 and Figure 6-3) will be transferred to the mitigation wells.

Additional mitigation actions are presented in Section 3.2.8. Mitigation actions for the senior underground water rights located within the management block will be effective because well modifications or replacements will be designed to produce the amounts required for the senior water rights under conditions that exist during SNWA pumping. SNWA non-GDP and GDP permitted water rights are available to be used as mitigation resources if needed. SNWA water rights in Block 2 are presented in Table 6-8 and Figure 6-6.

Table 6-8
Spring Valley Management Block 2 SNWA Water Rights by Source and Status

Source	Status (Number of Rights/Annual Duty)			
	Certificated (afa)	Decreed (afa)	Permitted (afa)	Vested (afa)
Lake	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00
Spring	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00
Stream	1 / 752.8[a]	0 / 0.00	3 / 1,057.8[b]	1 / 11.20
Underground	1 / 27.27	0 / 0.00	0 / 0.00[c]	0 / 0.00

[a]The reported duty overestimates the available water due to the certificated right being part of a not to exceed total combined duty. For this right, the NDWR reported duty was used in the total.
[b]The reported duty includes one or more groups of water rights that have not to exceed total combined duties.
[c]The reported duty does not include any portion of the 61,127 afa of SNWA permitted, underground municipal rights.

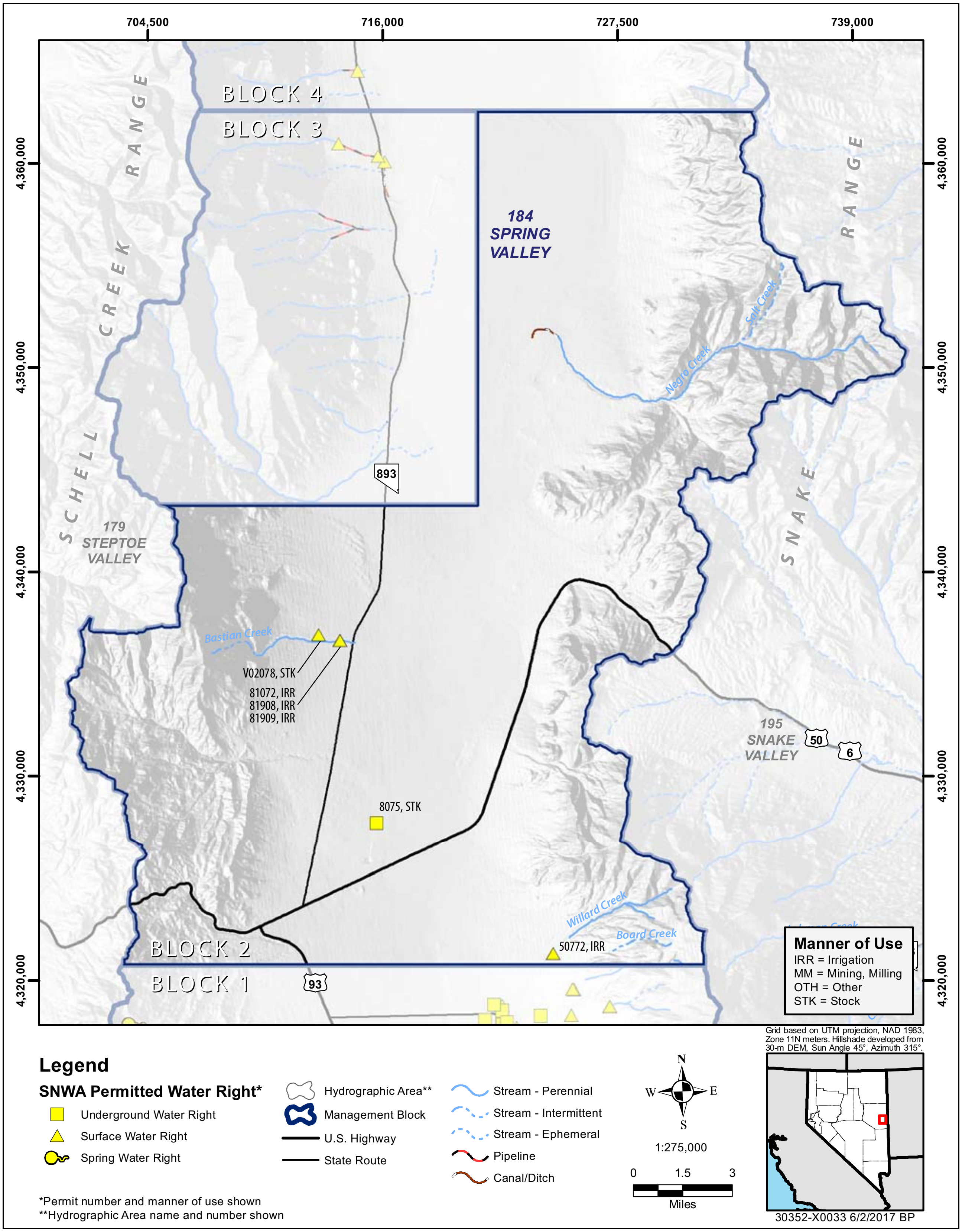

Figure 6-6
SNWA Water Rights in Management Block 2

6.2.3 Senior Water Rights in Management Block 3

Management Block 3 consists of the west central portion of Spring Valley north to McCoy Creek which includes Cleveland Ranch. The water rights senior to SNWA GDP permits and the 3M Plan hydrologic monitoring network in Management Block 3 are shown on Figure 6-7.

A tally of water rights in Management Block 3 senior to SNWA GDP permits by source, status, and hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed are presented in Table 6-9. Individual senior water rights are listed in Table 6-10, which includes information on water right status, source, manner of use, priority date, diversion rate, annual duty, ownership, distance to the closest SNWA GDP POD, DEM elevation, and management category (as described in Section 3.2.5). Within Management Block 3, there are two certificated spring water rights (275 afa), two certificated stream water rights (1,036 afa), one reserved spring water right (8 afa) and 21 spring vested claims (4,588 afa) for a total duty of 5,907 afa of existing senior rights that are in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed.

Table 6-9
Spring Valley Management Block 3 Water Rights by Source and Status Senior to SNWA GDP Permits

Source	Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)				Not Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)			
	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)
Spring	2 / 275[a]	0 / 0.00	1 / 7.95	21 / 4,588[b]	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00
Stream	2 / 1,035.6	0 / 0.00	0 / 0.00	0 / 0.00	4 / 4,727.37[c]	0 / 0.00	0 / 0.00	4 / 27,722.7
Underground	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00

[a]The reported duty includes both acre-ft per season and acre-ft per annum.
[b]The reported duty includes the 12 vested rights associated with claims V02817 to V02828. The duty for these vested claims was calculated and documented in Stanka (2011) as 4,560 afa. It also includes the eight vested rights associated with claims V09665-V09672. The Nevada State Engineer stated that these claims were not properly filed and not entitled to protection from impairment (NDWR, 2012a). Finally, the reported duty includes one vested right that is part of a total combined duty of 28.28 afa as documented in Stanka (2017).
[c]Acre-ft per season.

Four other senior certificated stream water rights (4,727 afa) and four stream vested claims (27,723) with a total duty of 32,450 afa in Management Block 3 but are not in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed. This is due to the location and hydrogeologic setting of the stream rights because, as described below, Cleve Creek is a losing stream where the stream water right PODs are located and depth to groundwater at nearby monitor well SPR7029M is over 200 feet below ground surface.

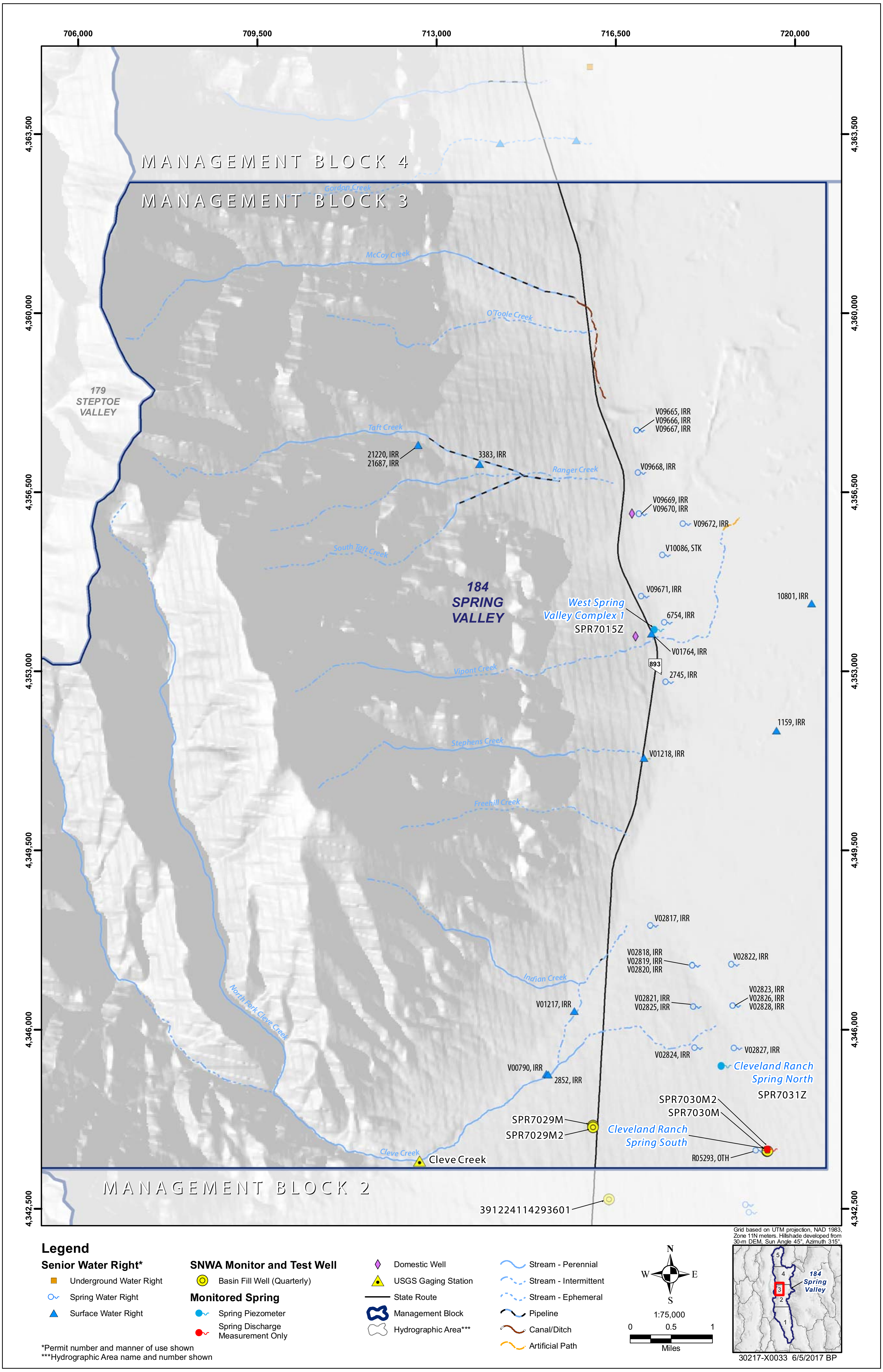

Figure 6-7
Management Block 3 Senior Water Rights and Hydrologic Monitoring Network

Table 6-10
Water Rights within Management Block 3 Senior to SNWA GDP Permits
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App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
1159	CER	STR	IRR	1908	2.09	758.4*	George Eldridge & Son, Inc.	Valley Floor	8.5	5,570	B
2745	CER	SPR	IRR	1913	0.2	80.0*	Adams-McGill Company	Valley Floor	9.4	5,580	B
2852	CER	STR	IRR	1913	8.02	2,406.5[g]	LDS	Alluvial Fan	5.8	5,900	E
3383	CER	STR	IRR	1915	0.200	59.9[g]	Andrae, Arthur & Audrae	Alluvial Fan	12.7	6,540	E
6754	CER	SPR	IRR	1922	0.538	195.0[g]	Cazier, James	Valley Floor / Alluvial Fan	10.1	5,580	C
10801	CER	STR	IRR	1942	6	277.2	Moriah Ranches Inc	Valley Floor	9.9	5,560	B
21220	CER	STR	IRR	1870	4	721.0[g]	Andrae, Arthur J.	Alluvial Fan	13.2	7,090	E
21687	CER	STR	IRR	1943	3.5	1,540.0[g]	Andrae, Arthur J.	Alluvial Fan	13.2	7,090	E
R05293	RES	SPR	OTH	1926	0.011	7.9*	BLM	Valley Floor / Alluvial Fan	3.8	5,630	B
V00790	VST	STR	IRR	1873	2.5	10,847.7*	LDS	Alluvial Fan	5.8	5,900	E
V01217	VST	STR	IRR	1873	1	12,035.0*	LDS	Alluvial Fan	6.3	5,780	E
V01218	VST	STR	IRR	1873	0	4,800.0*	LDS	Valley Floor	8.6	5,650	E
V01764	VST	STR	IRR	1902	0	40.0*	Casier, Elaine E.	Alluvial Fan	10.0	5,620	E
V02817	VST	SPR	IRR	1884	10	9,600.0*	LDS	Valley Floor	6.8	5,610	B
V02818	VST	SPR	IRR	1884	10	9,600.0*	LDS	Valley Floor / Alluvial Fan	6.1	5,600	B
V02819	VST	SPR	IRR	1884	10	9,600.0*	LDS	Valley Floor	6.1	5,600	B
V02820	VST	SPR	IRR	1884	10	9,600.0*	LDS	Valley Floor	6.1	5,600	B
V02821	VST	SPR	IRR	1884	10	9,600.0*	LDS	Valley Floor	5.6	5,630	B
V02822	VST	SPR	IRR	1884	10	9,600.0*	LDS	Valley Floor	5.9	5,590	B
V02823	VST	SPR	IRR	1884	10	9,600.0*	LDS	Valley Floor	5.4	5,590	B
V02824	VST	SPR	IRR	1884	10	9,600.0*	LDS	Alluvial Fan / Valley Floor	5.2	5,660	B
V02825	VST	SPR	IRR	1884	10	9,600.0*	LDS	Valley Floor	5.6	5,630	B
V02826	VST	SPR	IRR	1884	10	9,600.0*	LDS	Valley Floor	5.4	5,590	B

Table 6-10
Water Rights within Management Block 3 Senior to SNWA GDP Permits
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App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
V02827	VST	SPR	IRR	1884	10	9,600.0*	LDS	Valley Floor	5.0	5,610	B
V02828	VST	SPR	IRR	1884	10	9,600.0*	LDS	Valley Floor	5.4	5,590	B
V09665	VST	SPR	IRR	1900	2	0.0*	Andrae, Arthur and Audrae	Valley Floor / Alluvial Fan	12.4	5,600	C
V09666	VST	SPR	IRR	1900	2	0.0*	Andrae, Arthur and Audrae	Valley Floor / Alluvial Fan	12.4	5,600	C
V09667	VST	SPR	IRR	1900	2	0.0*	Andrae, Arthur and Audrae	Valley Floor / Alluvial Fan	12.4	5,600	C
V09668	VST	SPR	IRR	1900	2	0.0*	Andrae, Arthur and Audrae	Valley Floor / Alluvial Fan	11.9	5,590	C
V09669	VST	SPR	IRR	1900	2	0.0*	Andrae, Arthur and Audrae	Valley Floor / Alluvial Fan	11.4	5,570	C
V09670	VST	SPR	IRR	1900	2	0.0*	Andrae, Arthur and Audrae	Valley Floor / Alluvial Fan	11.4	5,570	C
V09671	VST	SPR	IRR	1900	2	0.0*	Andrae, Arthur and Audrae	Valley Floor / Alluvial Fan	10.5	5,610	C
V09672	VST	SPR	IRR	1900	2	0.0*	Andrae, Arthur and Audrae	Valley Floor / Alluvial Fan	11.2	5,560	C
V10086	VST	SPR	STK	1873	0.039[h]	28.28[h]	LDS	Valley Floor	10.9	5,570	C

[a]CER - Certificated, VST - Vested
[b]SPR - Spring, STR - Stream
[c]IRR - Irrigation, STK - Stock watering
[d]Rounded to the nearest tenth of a mile.
[e]Rounded to the nearest 10 ft.
[f]See Section 3.2.5 for a detailed explanation of the Management Categories; B - Distance 3 to 10 miles between resource and SNWA GDP POD, C - Distant resource > 10 miles SNWA GDP POD, E - Resource not in hydraulic connection with SNWA GDP POD producing aquifer in which SNWA GDP production wells will be installed.
[g]Acre-ft per season.
[h]Reported number was derived from an analysis documented in Stanka (2017).
*The reported annual duty is not explicitly documented on the certificate, reserved right, or vested claim, but reported as such by the NDWR Hydrographic Abstract query.

Background Hydrogeology in Vicinity of Cleveland Ranch

The hydrogeologic setting along the eastern range front of the Schell Creek Range transitions from mountain block to range front fault zones to alluvial fan sediments to the valley floor. The upper alluvial fan generally consists of coarse sands and gravel which transition to finer grained sands, silts and clays to the east with distance where the alluvial fan sediments encounter clay lacustrine (lake) deposits.

Surface water from stream flow and mountain runoff infiltrates into the alluvial fan to recharge groundwater. Groundwater flows to the east and encounters the lower hydraulic conductivity sediments. The finer sediments are interfingered with coarser materials on the valley floor resulting in local confined conditions as observed in the drilling log from construction of SPR7029M2 and SPR7029M2. The coarser grained sediments and clay contact on the valley floor cause groundwater to discharge through a series of diffuse springs orientated in a north - south direction. Additional information on the area hydrogeology is presented by (Rowley et al., 2011).

The drilling and geologic report for wells SPR7029M and SPR7029M2 is presented in (Mace, 2011a). The hydraulic testing results for the wells are presented by (Prieur and Ashinhurst, 2011). The drilling and geologic report for wells SPR7030M and SPR7030M2 is presented in (Mace, 2011b).

At Cleveland Ranch, the primary upgradient mountain block watershed of Cleve Creek is composed primarily of low hydraulic conductivity quartize which limits infiltration within the higher elevations. Cleve Creek becomes a losing stream through the alluvial fan, infiltrating surface water through the stream bed and unsaturated sediments to the water table. Surface water from Cleve Creek is diverted to the Cleveland Ranch for irrigation using the summer and winter ditches.

Major creeks and the current hydrologic monitoring sites in the vicinity of Cleveland Ranch and between the ranch and SNWA GDP PODs to the south are presented in Figure 6-8. A higher resolution map of the Cleveland Ranch area including Cleve Creek diversions is presented on Figure 6-9. The USGS stream gage, shown on Figure 6-9, measures stream flow on Cleve Creek near the contact between the mountain block and alluvial fan. The gage has a period of record extending back to the early 1980s and a partial record in the 1960s and 1910s. The Cleve Creek stream flow record is the longest in Spring Valley and provides a reference for historical hydrologic conditions. The complete historical and 2011 to 2016 period of record hydrographs for Cleve Creek are presented in Figures 6-10 and 6-11, respectively.

A gain/ loss study conducted by SNWA on Cleve Creek indicated minimal infiltration above the gage and approximately 0.5 cfs lost below the gage. Water infiltrates from the creek bed, diversion ditches, and irrigation applications to the water table and flows east until it encounters the finer grained sediments which act as a barrier. The result of this subsurface movement of Cleve Creek infiltration water is sub-irrigation of the meadows and the diffuse spring discharge.

The irrigation practices at Cleveland Ranch were described by Bruce Scott during his 2011 testimony on transcript pages 6159 to 6160. Exhibit CPB_001 Map 1.2 shows the Cleveland Ranch Pastures, infrastructure and water delivery. Exhibits CPB_009 Map 1.3 A and CPB_009 Map 1.3B show the summer and winter irrigation practices.

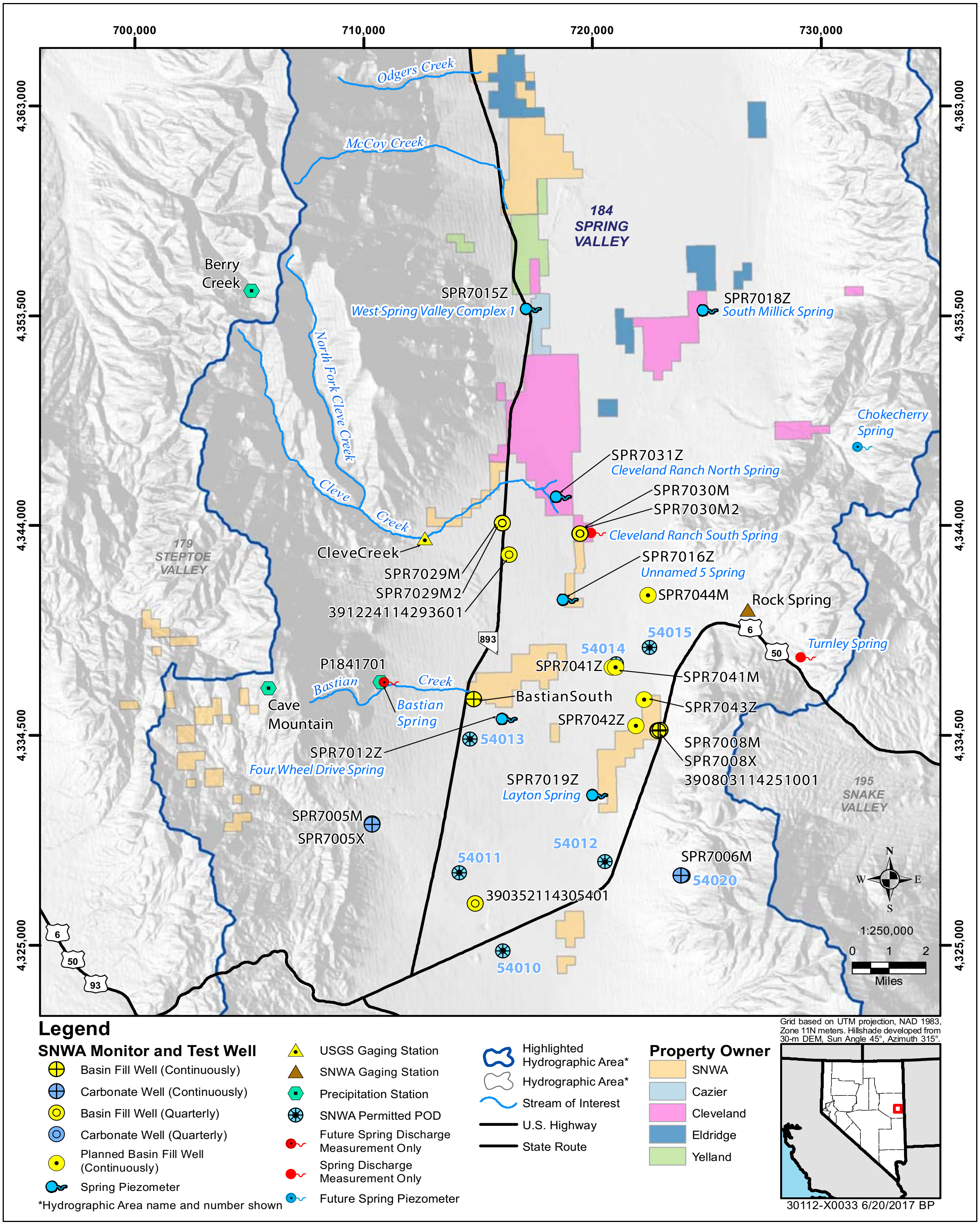


Figure 6-8
Cleveland Ranch/McCoy Creek area with SNWA GDP PODs and Hydrologic Monitoring Locations

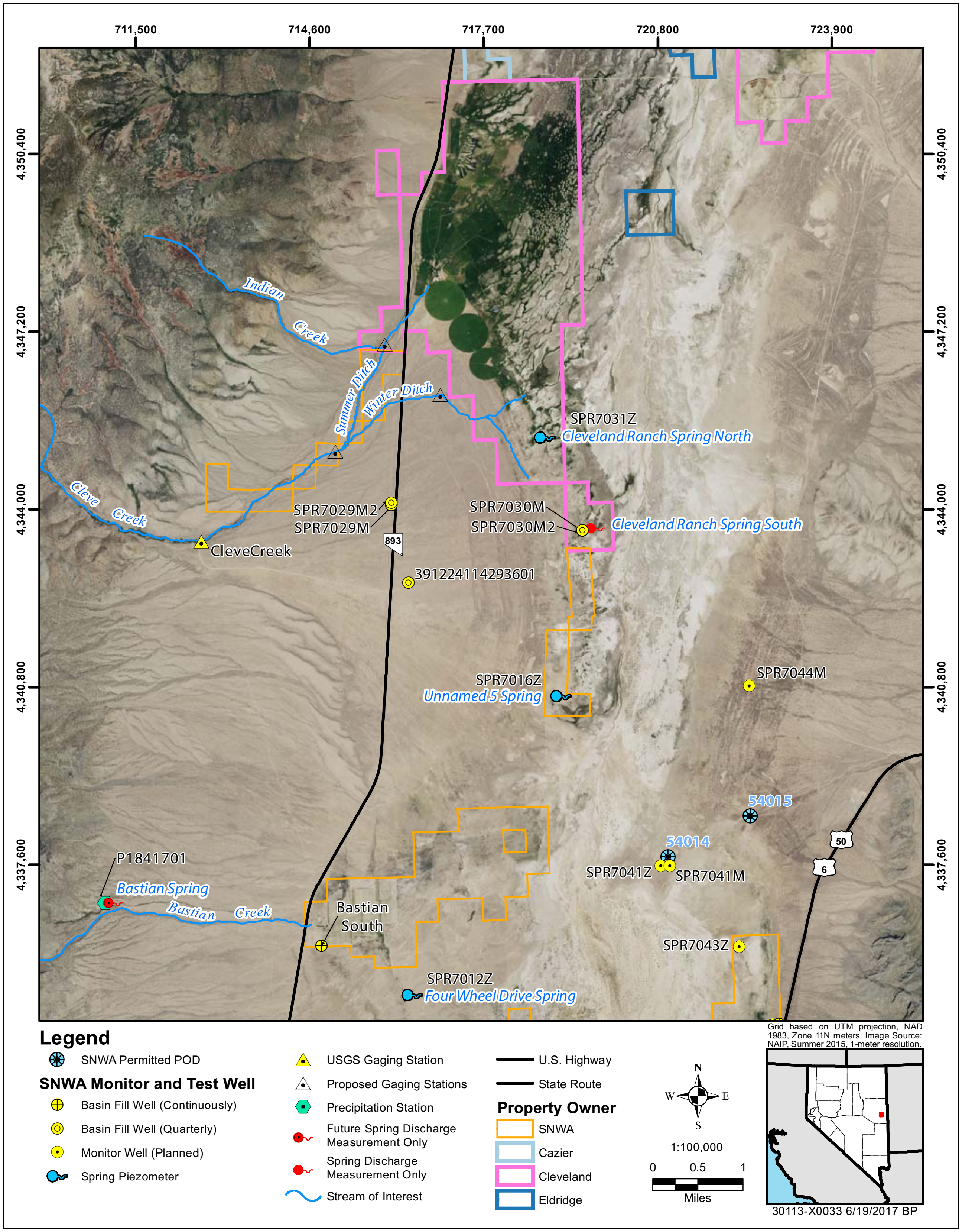


Figure 6-9
Cleveland Ranch Area Hydrologic Monitoring Locations

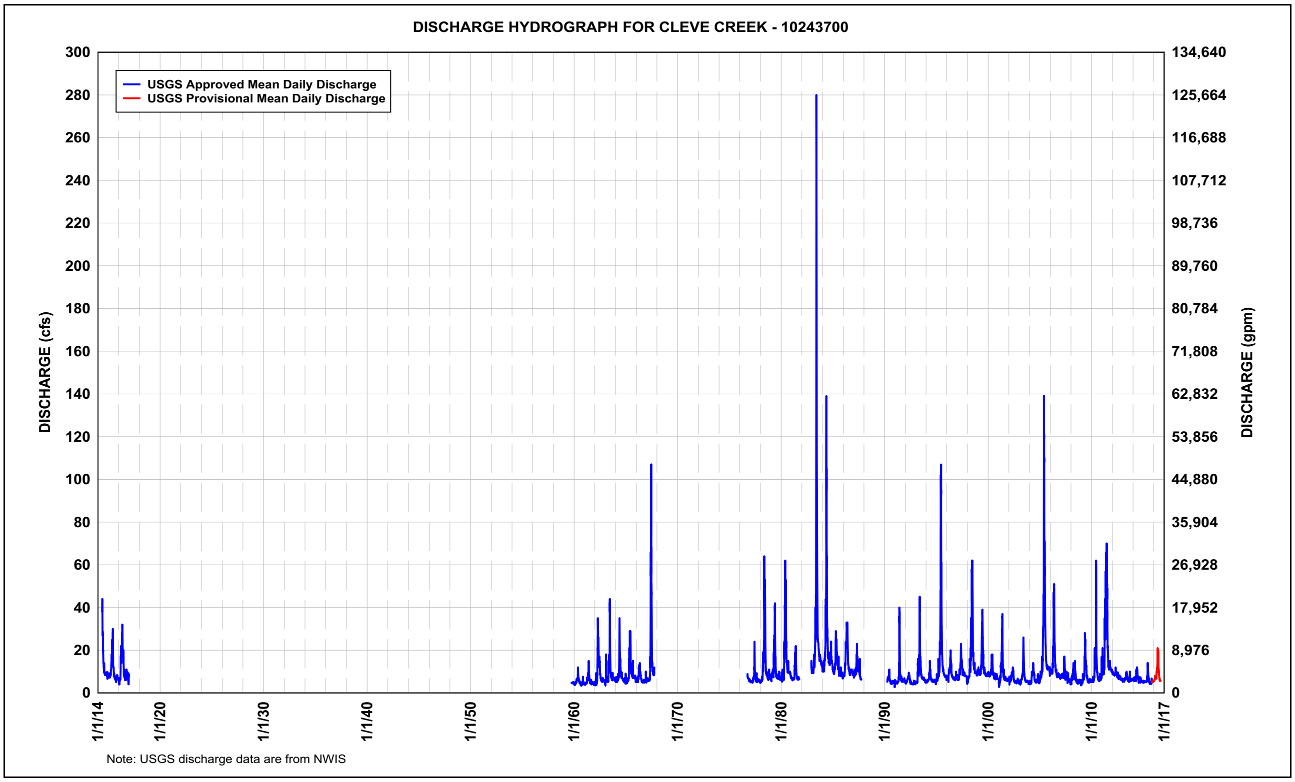


Figure 6-10
Cleve Creek USGS Gage Period of Record

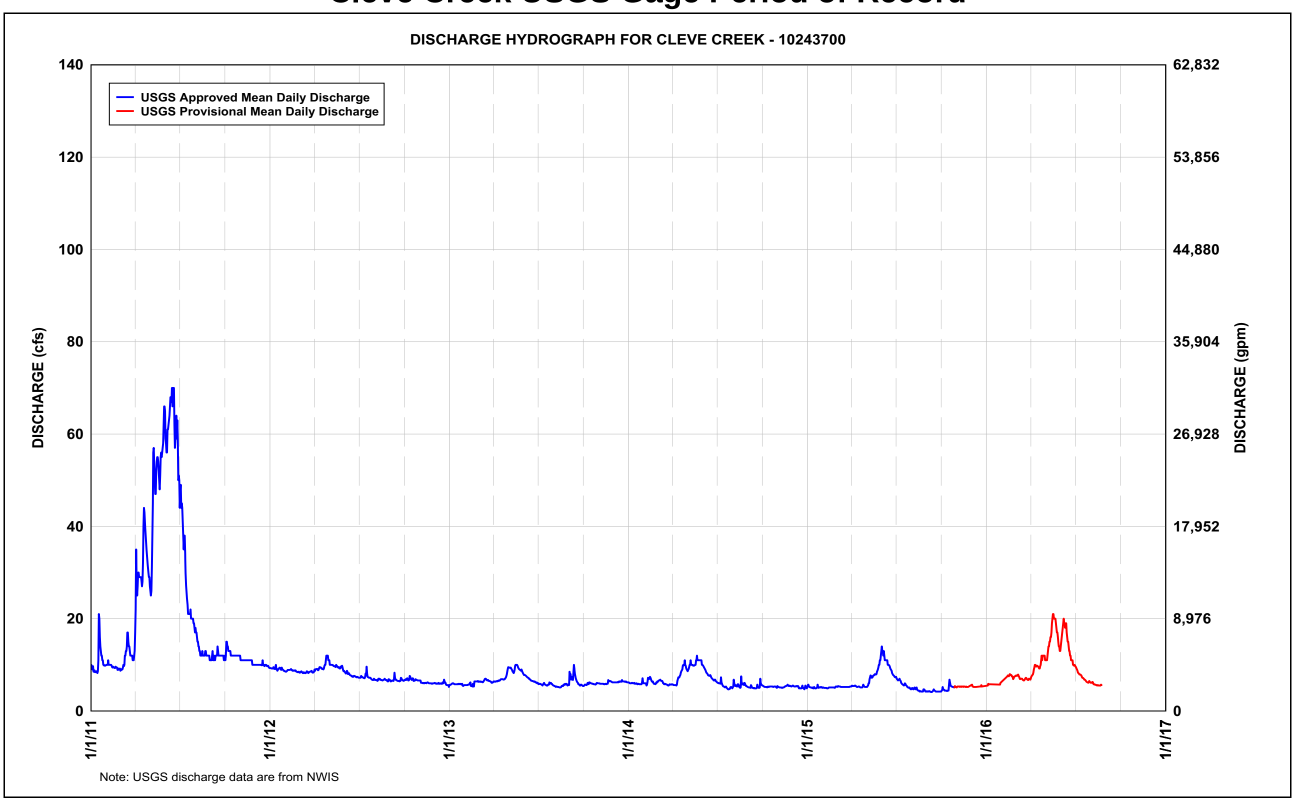


Figure 6-11
Cleve Creek USGS gage 2011 to present

Cleve Creek is diverted in winter to the winter ditch which flood irrigates the southern portion of the Cleveland Ranch. The testimony of Mr. Scott indicated that during the wet 2011 year flood irrigation occurred down through and past the bottom of the ranch to the south. In spring and summer, Cleve Creek provides water to a reservoir west of the ranch where additional water from Indian Creek is stored. Water from the reservoir is conveyed via the summer ditch to the northern and central portions of the ranch. Diffuse spring discharge is collected on the Ranch through ditches and directed to the northern portion of the Ranch.

The volume and distribution of flood irrigation and sub irrigation on the Cleveland Ranch effects the diffuse spring discharge. The influence of flood irrigation in the southern portion of the Cleveland Ranch is illustrated by the data for shallow piezometer SPR7031Z which shows a repeating pattern of depth to water of 3 feet during summer and less than one foot during the winter months during 2011 to 2017 as shown in Figure 6-12. The increase in diffuse spring discharge is related to overall hydrologic conditions. Increases in Cleve Creek discharge during wet years such as 2011 resulted in increases in the measured water levels at Cleveland Ranch north springs and piezometers at the Ranch.

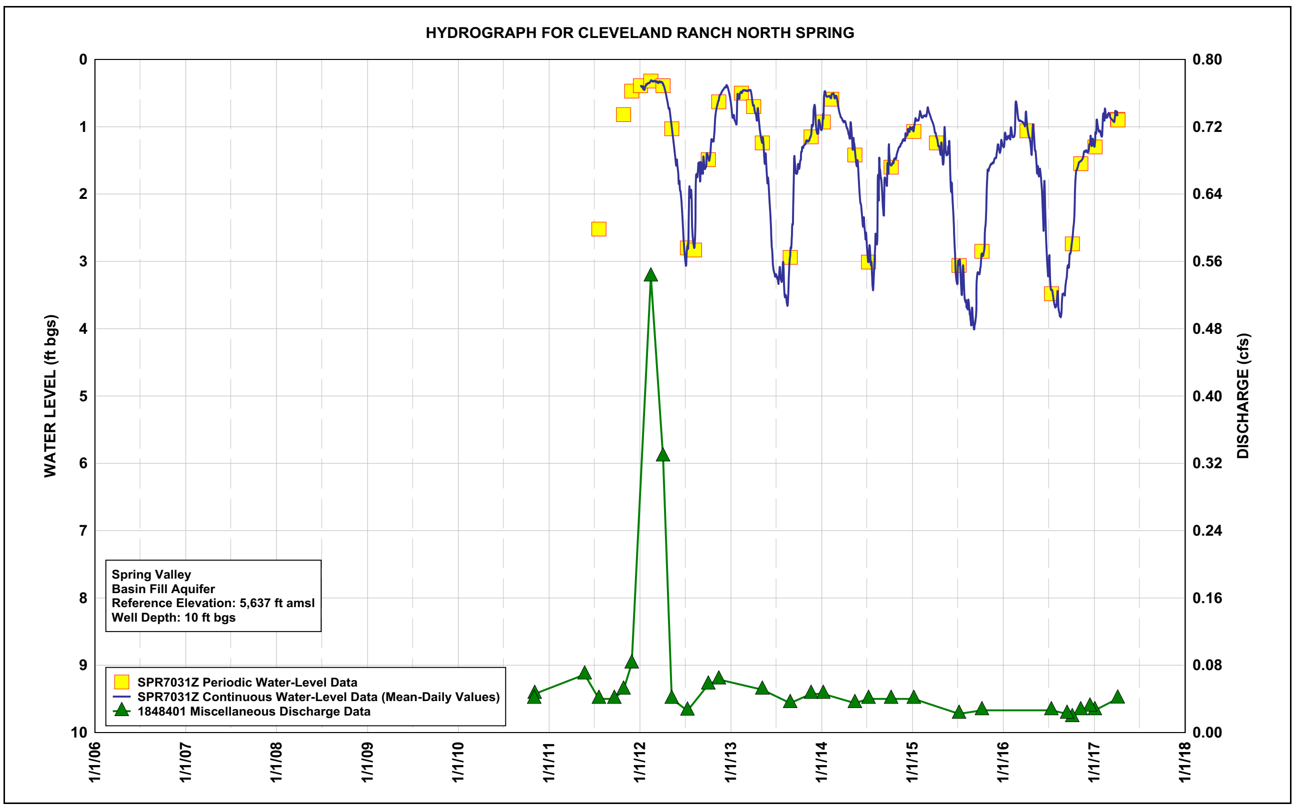


Figure 6-12
Cleveland Ranch North Spring Hydrograph

No effect is expected on Cleve Creek from SNWA GDP pumping operation. Effects to streams and springs are dependent upon three criteria: 1) whether there is continuous saturated material in the aquifer between the pumping location and the spring; 2) whether there is a high enough hydraulic conductivity to propagate effects through the geologic sediments; and 3) whether the spring is within the area of influence of pumping. Cleve Creek and the diversion ditches lose flow through the stream bed across the alluvial fan and recharge groundwater. There is no saturated continuum between the water table and the stream as demonstrated by observed depth to groundwater in SPR7029M.

Several unique features of the Cleveland Ranch are important to consider in implementing a management and mitigation strategy. Vested claimed water rights are presented in CPB exhibits 001 - 016 and were reviewed in Ruling 6164. CPB has vested and certificated rights on Cleveland Ranch itself and on other parcels located in the vicinity of Cleveland Ranch. Spring vested claims totaling 9,600 afa are reported in the CPB exhibits for diffuse springs associated with the ranch. In transcripts, the CPB expert described the difficulty of measuring the diffuse springs and estimated the discharge at 5,004 afa. This value is used to develop the 3M plan associated with this area. The area is also heavily influenced by flood irrigation and diversions from the Cleve Creek winter ditch. Changes in irrigation practices potentially could result in an effect and change of distribution of the diffuse spring flow.

Ruling 6164 denied SNWA application numbers 54016, 54017, 54018, and 54021 located on the Cleve Creek alluvial fan upgradient of numerous CPB water rights (NDWR, 2012a, at page 216). The elimination of these PODs provides a buffer between SNWA GDP POD locations to the south and Cleveland Ranch.

There are several factors associated with spring discharge at Cleveland Ranch. which influence the SNWA GDP 3M Plan actions. These include the following:

- How springs respond and are controlled by Cleveland Ranch irrigation practices.
- How springs are effected by infiltration of stream flow variation from Cleve Creek and management of diversions by Cleveland Ranch.
- The volume of vested claims on and in the vicinity of Cleveland Ranch compared to available and normal spring flow.
- When vested claim spring locations have been observed to be dry or have minimal discharge over extended periods of time.

The Cleveland Ranch has extensive irrigation practices which influence groundwater conditions at water right locations on the ranch. These practices, including diversions of Cleve Creek between the winter and summer ditch and application areas and rates at different irrigated areas on the ranch, may affect the discharge from the various spring locations. Because Cleve Creek and its western diversion ditches are losing water to the subsurface and do not have a saturated continuum between the stream and the groundwater, there would not be an effect on them from SNWA GDP pumping operations.

It is important to measure and monitor irrigation practices to determine the effects on spring discharge variability in conjunction with natural hydrologic baseline variability prior to and during SNWA GDP pumping. Surface water gaging stations are proposed for Cleve Creek in the following three locations as shown on Figure 6-9: upstream of the diversion splitter with the winter ditch, downstream of the summer ditch, and on the winter ditch at the ranch. Regional baseline hydrologic data and aerial imagery on and away from the ranch will be compared to irrigation diversions between the summer and winter ditches of Cleve Creek to establish influence of irrigation practices on spring discharge.

Monitoring Strategy

One reserved and one certificated senior spring water right, two certificated stream water rights and 12 spring vested claims listed on Table 6-10 are in Management Category B (as described on Section 3.2.5) because they are located between 3 and 10 miles of the nearest SNWA GDP POD. One certificated spring water right and nine spring vested claims are in Management Category C because they are located greater than 10 miles from the nearest SNWA GDP POD. Eight other stream water rights are in Management Category E because they are not in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed because of location and hydrogeologic setting.

The monitoring strategy for Management Block 3 is summarized in Table 6-11 and includes using five sentinel monitor wells, as explained in Section 3.2.1, near the southern end of Cleveland Ranch along with other monitoring sites to track hydrologic conditions and detect change, if any. The sentinel wells are located between the SNWA GDP PODs and the more distant senior water rights to detect and measure propagation of drawdown. The sentinel wells are a key component of the monitoring and management strategy to avoid activating mitigation triggers at senior water rights.

Table 6-11
Spring Valley Management Block 3 Monitoring Program

Senior Water Right/ Monitoring Area	Monitor Well or Spring
Monitoring between Cleveland Ranch and SNWA GDP PODS	391224114293601; SPR7016Z; SPR7012Z; Bastian South Well
Sentinel Monitor Wells between Cleveland Ranch and SNWA GDP PODS	SPR7029M; SPR7029M2; SPR7030M; SPR7030M2; SPR7044M (planned well)
Additional Current Monitoring on Cleveland Ranch	Cleveland Ranch Spring South; SPR 7031Z; and Cleveland Ranch Spring North

The current monitoring program at the southern portion of Cleveland Ranch consists of four monitor wells (SPR7029M, SPR7029M2, SPR7030M, and SPR7030M2) which are designated as sentinel monitor wells. The paired wells are completed at different depths to evaluate variations in vertical hydraulic gradient. One set of paired wells are completed in coarse grained sediments located on the alluvial fan while the other paired wells are completed at the toe of the alluvial fan near the Cleveland Ranch South Spring. One additional planned well, SPR7044M, to be completed southeast of Cleveland Ranch is also designated as a sentinel monitor well.

The Cleveland Ranch South Spring discharge is also monitored with a permanent flume. A piezometer (SPR7031Z) and flume is also in-place in southern Cleveland Ranch within the area of diffuse springs to measure discharge and groundwater level to evaluate the interrelationship between groundwater level and diffuse spring flow. The monitoring locations were selected in consensus with the NSE and the Corporation of the Presiding Bishop of The Church of Jesus Christ of Latter-day Saints (LDS Church), the owner of Cleveland Ranch.

Monitoring locations in the vicinity of Cleveland Ranch are shown on Figure 6-8 and Figure 6-9. The hydrologic monitoring and management strategy associated with Management Block 3 consists of the following:

- Existing SNWA monitor wells SPR7029M, SPR7029M2, SPR7030M, SPR7030M2 and planned monitor well SPR7044M are located south of Cleveland Ranch and designated as sentinel wells to detect and measure northern propagation of drawdown from SNWA GDP pumping to the south.

- Additional monitoring performed in Management Block 2 between Cleveland Ranch and SNWA GDP PODs includes monitor wells 391224114293601, SPR7016Z, SPR7012Z, South Bastian Well to detect and measure changes in water level.

- Measure static water level or spring discharge on Cleveland Ranch at piezometer SPR7031Z and north Cleveland Ranch Spring and South Cleveland Ranch flumes.

- Monitor stream flow at USGS Cleve Creek gaging station as a reference site to compare groundwater levels and spring discharge.

- Install three stream gages: upstream of the diversion splitter with the winter ditch; downstream of the summer ditch; and on the winter ditch at the ranch.

- Monitor SPR7015Z at the West Springs Complex located north of Cleveland Ranch for aquifer conditions.

- Performing a water resource assessment on the senior water rights listed on Table 6-10 in Management Category B, (within ten miles of SNWA GDP PODs) as described in Section 3.2.5 prior to SNWA GDP pumping.

Investigation Triggers and Management Actions

The investigation trigger is a decrease in water level below the 99.7 percent lower control limit, as described in Appendix A. Investigation triggers for SPR7029M, SPR7029M2, SPR7030M, SPR7030M2, and Cleveland Ranch South Spring are presented on Figures 6-13 through 6-17. Hydrographs of the water levels in SPR7030M and SPR7030M2 wells (which are completed to a depth of 97 and 236 ft bgs, respectively) and nearby Cleveland Ranch South Spring show the relationship between water level and spring flow at the south portion of Cleveland Ranch.

Activation of an investigation trigger at these wells will result in an evaluation to determine the cause and significance of the water level change observed using protocols described in Section 3.2.2. Should the cause of the water level change be attributed to SNWA GDP pumping, the following management actions may be taken:

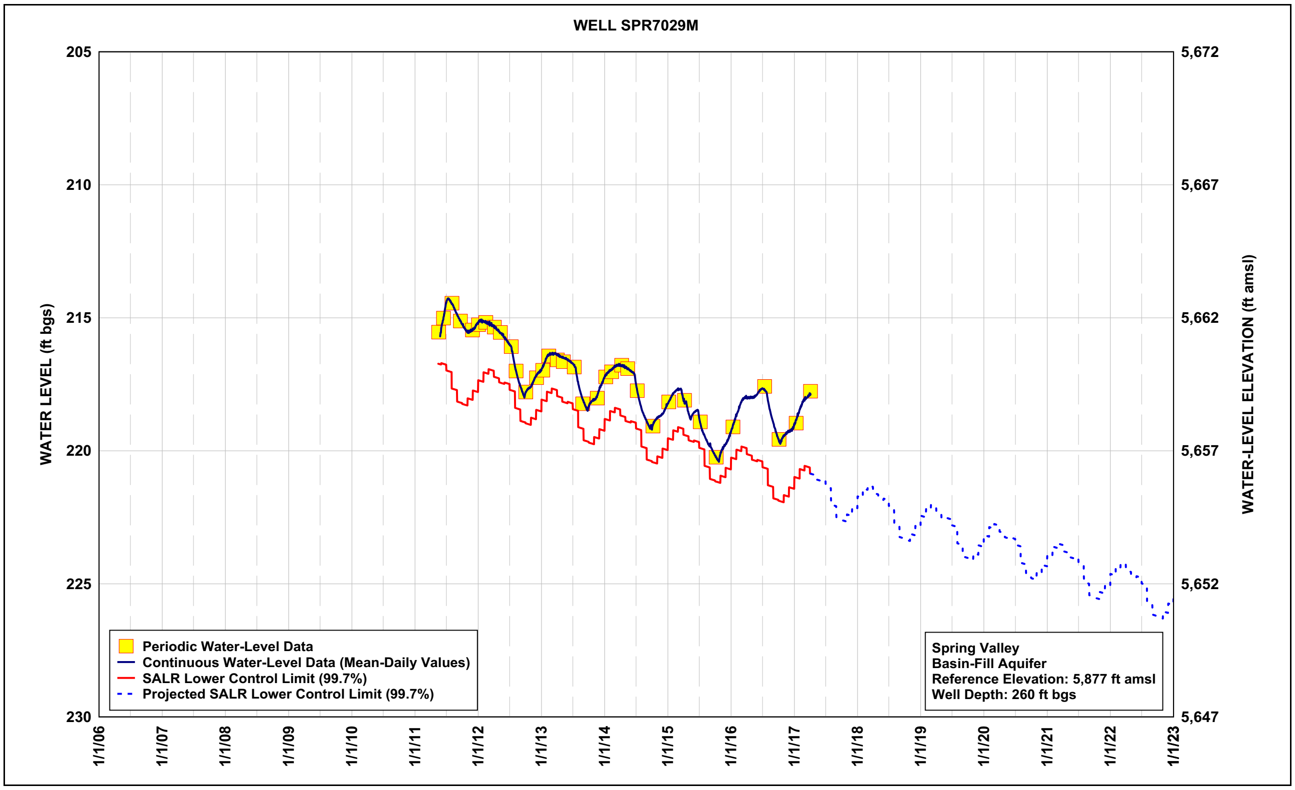


Figure 6-13
SPR7029M - Trigger

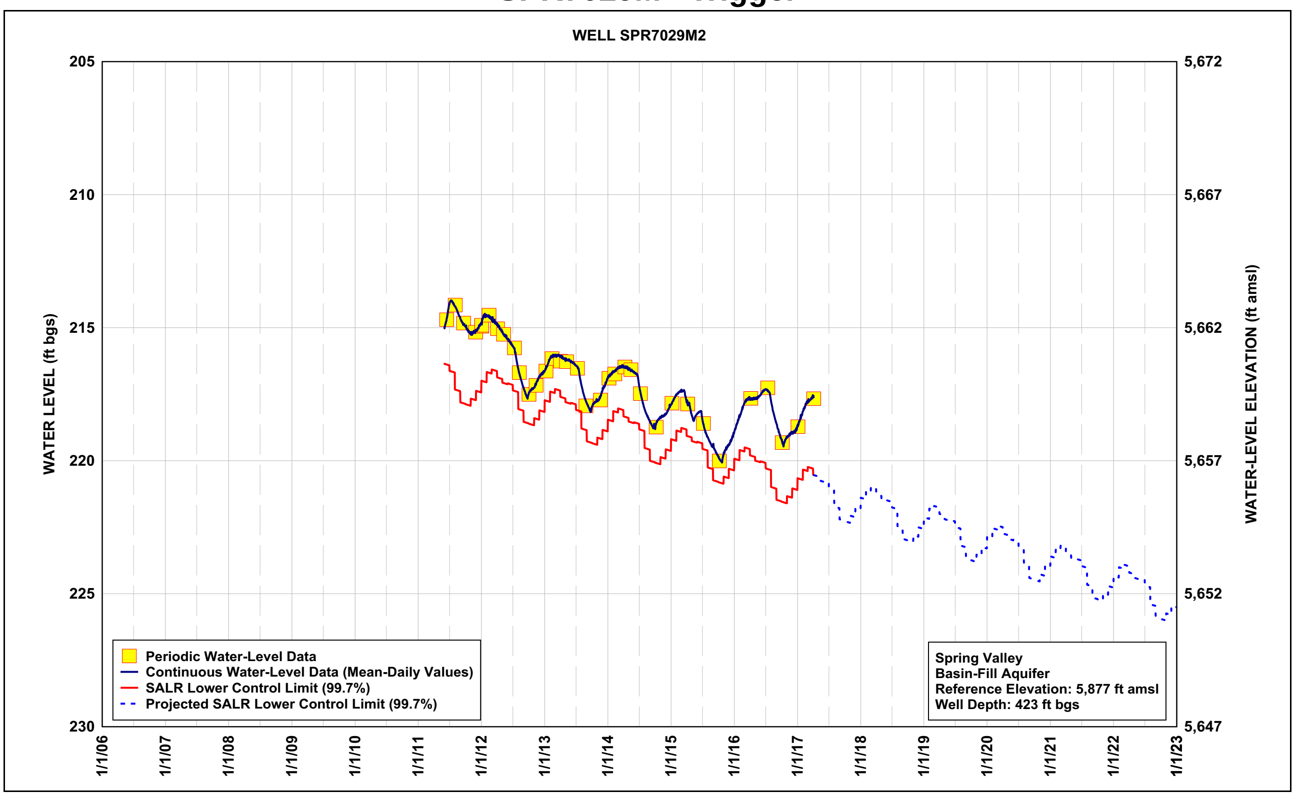


Figure 6-14
SPR7029M2 - Trigger

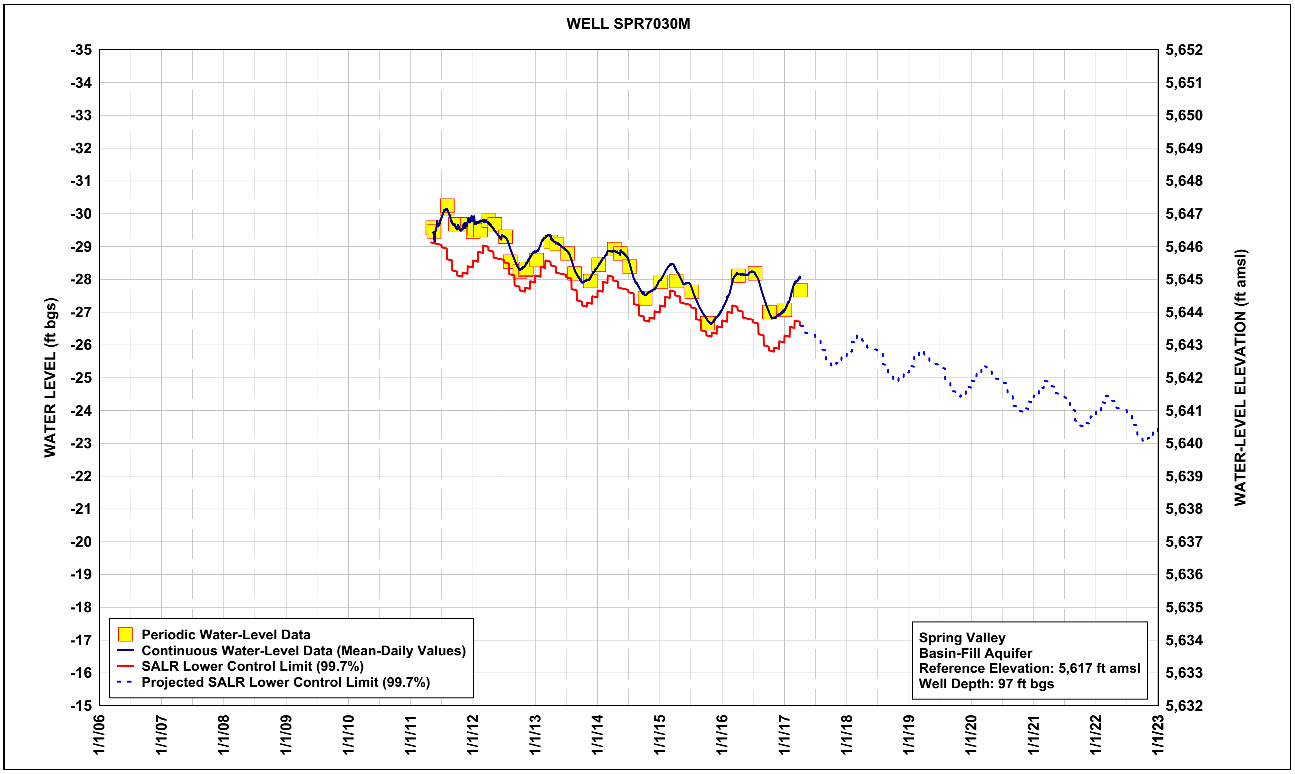


Figure 6-15
SPR7030M - Trigger

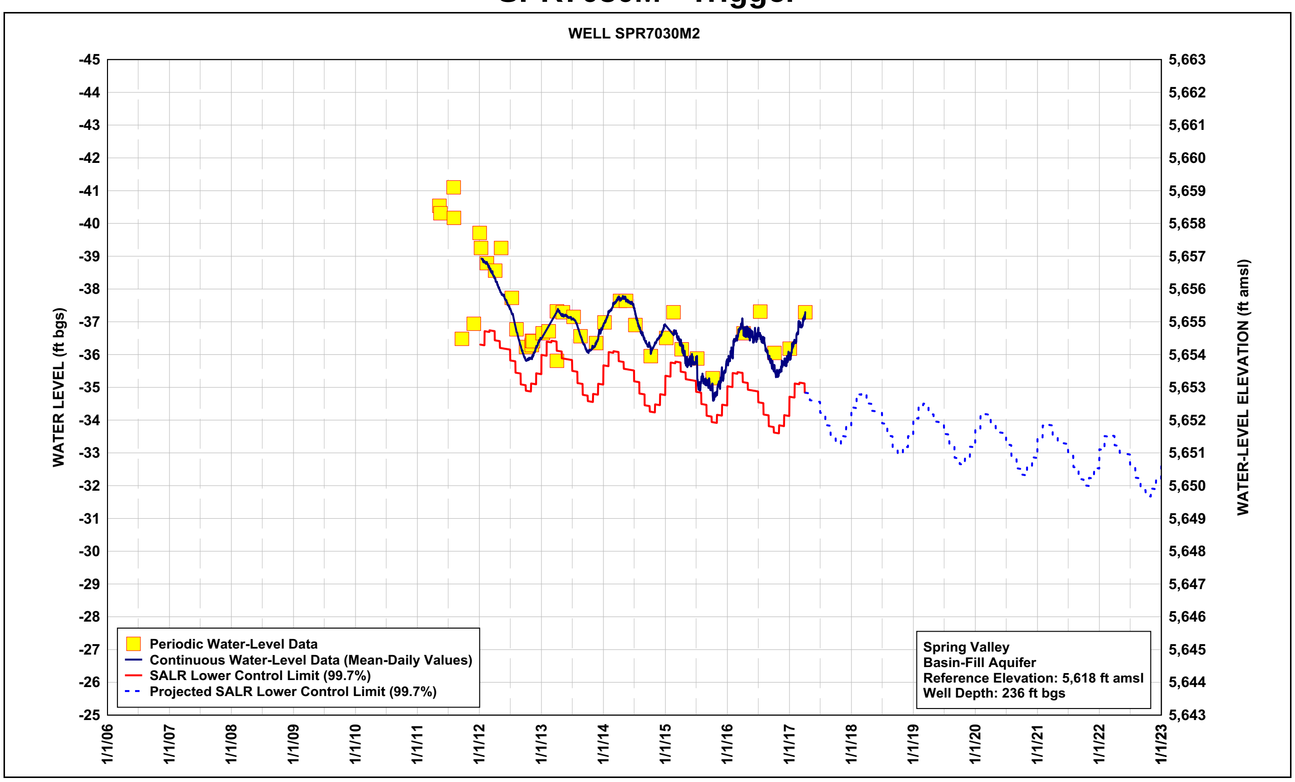


Figure 6-16
SPR7030M2 - Trigger

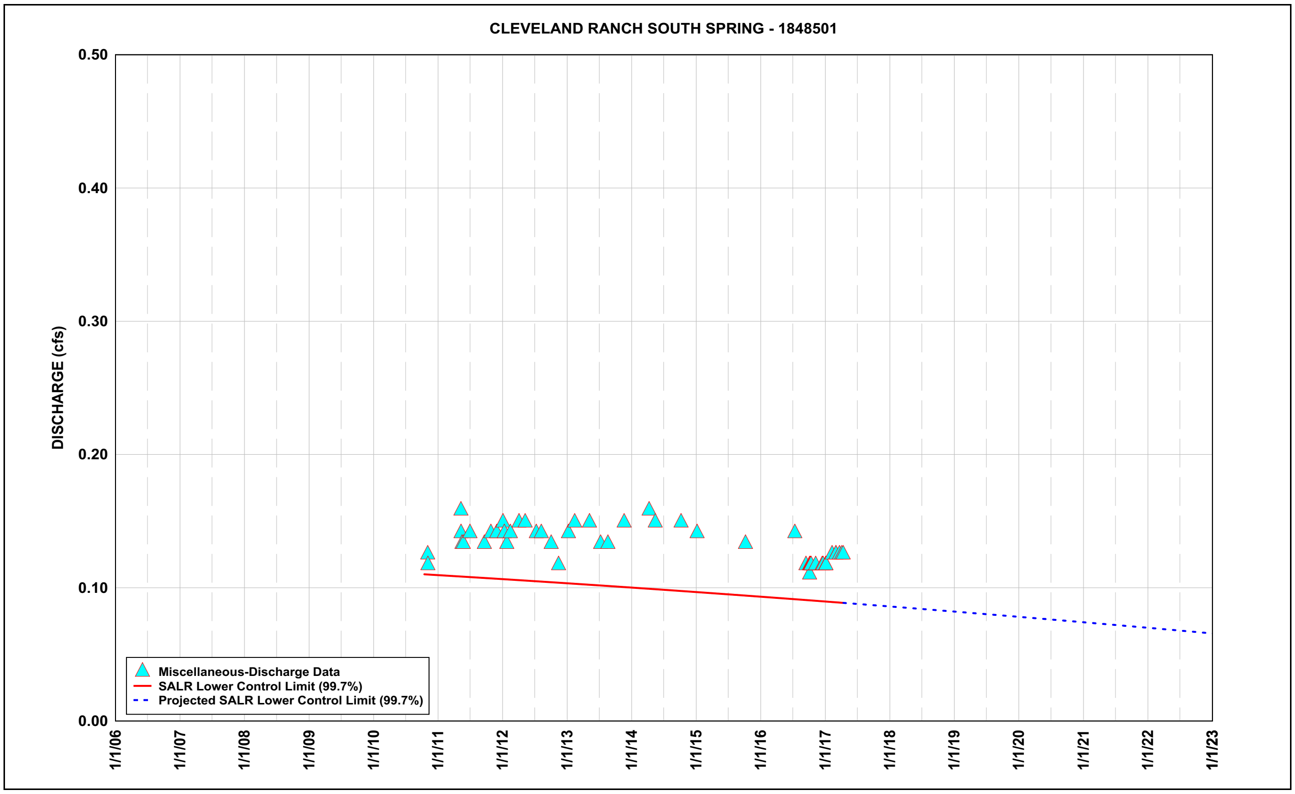


Figure 6-17
Cleveland Ranch South Spring - Trigger

- Prepare mitigation actions for implementation for Management Block 3 senior water rights, including purchasing equipment, establishing contracts, and obtaining any necessary landowner permissions and permits.

- Assess other management actions to avoid activating mitigation triggers in Management Blocks 3, 4 and 5.

- Perform a baseline well and spring assessment (as described in Section 3.2.7) with owner access permission for the 3M Plan underground water rights greater than 10 miles away in Spring Valley from SNWA GDP PODs.

- Increase monitoring frequency of senior spring water right POD locations.

- Continue to observe water levels in the sentinel and other intermediate wells to verify model projections.

- Update and recalibrate the project numerical groundwater flow model and other predictive tools with aquifer response data. The model will be used to predict drawdown with distance and time under different pumping operation scenarios to evaluate if and when a mitigation trigger would be activated at a distant senior water right in Spring Valley.

Mitigation Triggers and Mitigation Actions

The mitigation trigger for all the senior water rights in this management block and is the same as those in Block 1, as described in Section 3.2.6. Mitigation triggers determine when a mitigation action is implemented if the cause of the trigger being activated is SNWA GDP pumping.

If the senior water right mitigation trigger is activated, and is caused by SNWA GDP pumping, mitigation will be implemented. Mitigation actions for Management Block 3 spring and stream senior rights are the same as those listed in Management Block 1.

Mitigation actions available at the Cleveland Ranch area include those presented for Management Block 1 and the following additional specific actions:

- Lining of Cleve Creek diversion ditches or construction of a diversion pipeline to eliminate loss through infiltration of Cleve Creek over the alluvial fan, allowing more water to reach Cleveland Ranch.
- Using SPR7029M2 as a production well to produce mitigation water, SNWA would transfer an appropriate amount of mitigation water to Cleveland ranch.
- Installing additional production wells along the alluvial fan to be used for mitigation.
- Diversion of SNWA surface irrigation water rights from Bastian Creek (permit nos. 81072, 81908, and 81909) and in Management Block 4 including Kalamazoo Creek (permit nos. 4043, V02305, and V02332) and other SNWA water rights as replacement water in Management Block 3 via pipeline or lined ditch.
- Temporary transfer of SNWA grazing allotments.
- Temporary water right transfer.

Additional mitigation actions are presented in Section 3.2.8. Mitigation actions for the senior water rights located within the management block will be effective because suitable replacement water is available. SNWA non-GDP and GDP permitted water rights in this and other Management Blocks are available to be used as mitigation resources if needed. SNWA water rights in Block 3 are presented in Table 6-12. SNWA water rights, in addition the SNWA GDP permitted water rights, are available to be used as mitigation resources. SNWA water rights in Block 3 are presented in Figure 6-18.

Table 6-12
Spring Valley Management Block 3 SNWA Water Rights by Source and Status

Source	Status (Number of Rights/Annual Duty)		
	Certificated (afa)	Permitted (afa)	Vested (afa)
Lake	0 / 0.00	0 / 0.00	0 / 0.00
Spring	0 / 0.00	0 / 0.00	0 / 0.00
Stream	1 / 1,240	0 / 0.00	2 / 12,775.45
Underground	0 / 0.00	0 / 0.00	0 / 0.00

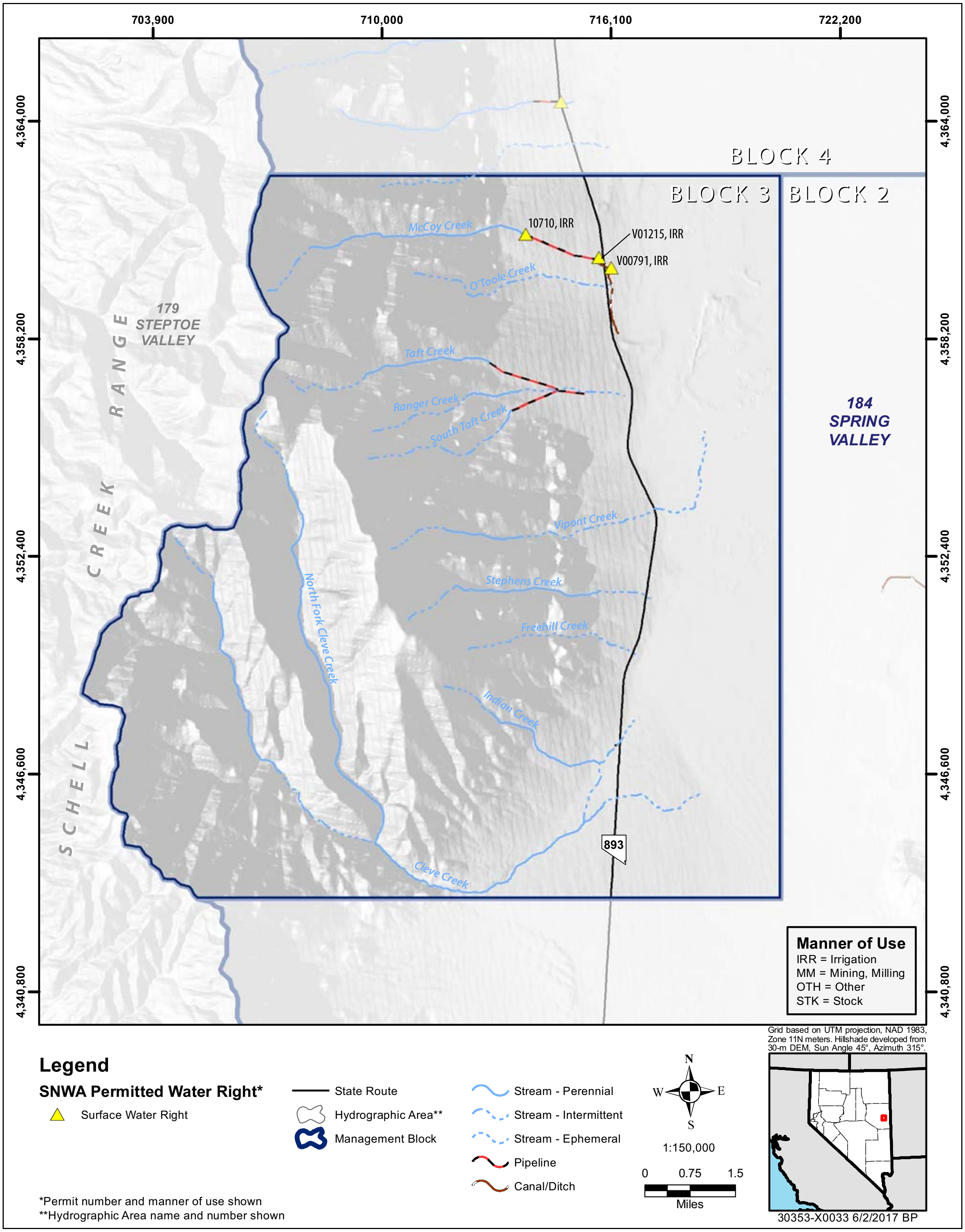


Figure 6-18
SNWA Water Rights in Management Block 3

6.2.4 Senior Water Rights in Management Block 4

Management Block 4 consists of the north central portion of Spring Valley north of McCoy Creek. Water rights senior to SNWA GDP permits and the 3M Plan hydrologic monitoring network in Management Block 4 are shown on Figure 6-19.

A tally of water rights in Management Block 4 senior to SNWA GDP permits by source, status, and hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed, are presented in Table 6-13. Individual senior water rights are listed in Table 6-14, which includes information on water right status, source, manner of use, priority date, diversion rate, annual duty, ownership, distance to the closest SNWA GDP POD, DEM elevation, and management category (as described in Section 3.2.5).

Table 6-13
Spring Valley Management Block 4 Water Rights by Source and Status Senior to SNWA GDP Permits

Source	Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)				Not Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)				
	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)	Certificated (afa)	Decreed (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)
Spring	0 / 0.00	3 / 2,648	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00
Stream	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	5 / 917.8[c]	1 / 1,804.26	4 / 1,358.64[a,c]	0 / 0.00	5 / 3,591.98[b,c]
Underground	7 / 464.55[c]	1 / 1,360	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00

[a]The reported duty includes 1 permitted right with a duty of 0 as reported by the NDWR Hydrographic Abstract and documented in Stanka (2017).
[b]The reported duty includes 1 vested right with a duty of 0 as reported by the NDWR Hydrographic Abstract and documented in Stanka (2017).
[c]The reported duty includes both acre-ft per season and acre-ft per annum.

Within this management block, there are seven certificated underground senior water rights (465 afa), one permitted underground right (1,360 afa), and three permitted spring rights (2,648 afa) for a total duty of 4,473 afa in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed. Ten other senior stream water rights and five stream vested claims with a total duty of 7,673 afa are not in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed due to lack of connection between surface and groundwater at those locations and hydrogeologic setting.

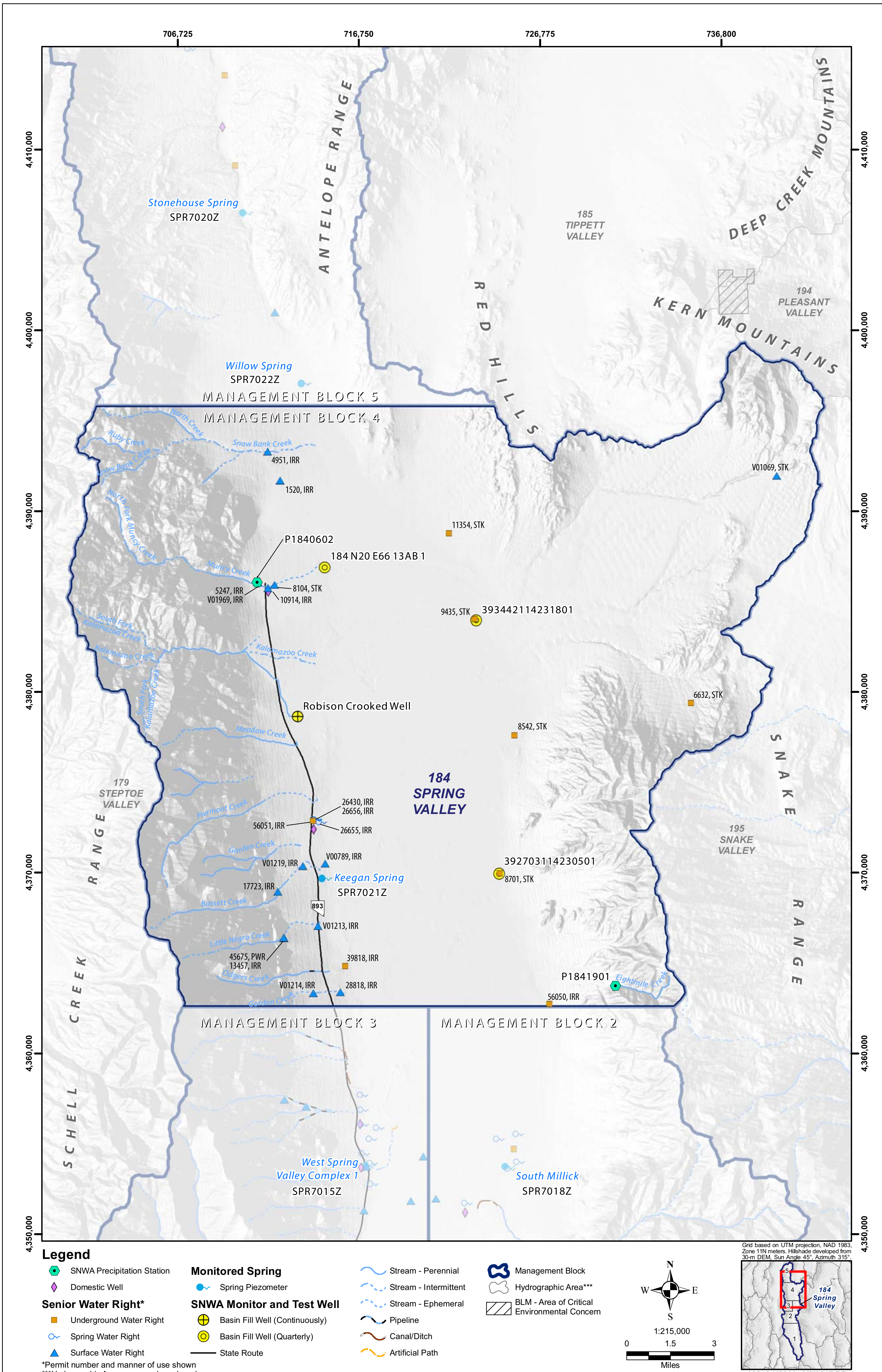


Figure 6-19
Management Block 4 Senior Water Rights and Hydrologic Monitoring Network

Table 6-14
Water Rights within Management Block 4 Senior to SNWA GDP Permits
(Page 1 of 2)

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
1520	CER	STR	IRR	1901	0.08	32.0*,[g]	Olsen, Casten	Alluvial Fan	33.6	5,970	E
4951	CER	STR	IRR	1918	0.083	25.1[g]	Bundy, Clarence A. & Josephine	Alluvial Fan	34.7	6,080	E
5247	PER	STR	IRR	1918	2	201.6*,[g]	George Eldridge & Son, Inc.	Alluvial Fan	30.4	6,010	E
6632	CER	UG	STK	1922	0.024	17.0*	George Eldridge & Son, Inc.	Alluvial Fan	26.6	6,800	C
8104	CER	STR	STK	1927	0.012	3.7*,[g]	Vogler, Henry Conrad IV	Alluvial Fan	30.2	5,930	E
8542	CER	UG	STK	1928	0.025	17.9*	George Eldridge & Son, Inc.	Valley Floor	24.4	5,620	C
8701	CER	UG	STK	1928	0.012	9.0*	George Eldridge & Son, Inc.	Valley Floor	19.6	5,590	C
9435	CER	UG	STK	1931	0.019	10.3*,[g]	George Eldridge & Son, Inc.	Valley Floor	28.3	5,710	C
10914	PER	STR	IRR	1943	1	300.0	George Eldridge & Son, Inc.	Alluvial Fan	30.1	5,960	E
11354	CER	UG	STK	1945	0.04	26.4*	B Enterprises, Limited Partnership UDI and George L. Gardner & Laree Gardner UDI	Alluvial Fan	31.2	5,840	C
13457	CER	STR	IRR	1950	3.44	613.9[g]	George Eldridge & Son, Inc.	Alluvial Fan	18.4	6,310	E
17723	PER	STR	IRR	1958	4	857.0*	George Eldridge & Son, Inc.	Alluvial Fan	19.9	6,170	E
26430	PER	SPR	IRR	1971	2	1,200.0	George Eldridge & Son, Inc.	Valley Floor	22.0	5,650	C
26655	PER	SPR	IRR	1972	1	724.0	George Eldridge & Son, Inc.	Valley Floor	21.9	5,610	C
26656	PER	SPR	IRR	1972	1	724.0	George Eldridge & Son, Inc.	Valley Floor	22.0	5,640	C
28818	CER	STR	IRR	1965	4.8	243.1	George Eldridge & Son, Inc.	Valley Floor / Alluvial Fan	16.0	5,660	E
39818	PER	UG	IRR	1989	2	1,360.0	George Eldridge & Son, Inc.	Valley Floor	16.8	5,590	C
45675	PER	STR	PWR	1982	8	0.0*	George Eldridge & Son, Inc.	Alluvial Fan	18.4	6,320	E
56050	CER	UG	IRR	1979	0.78	240.0	George Eldridge & Son, Inc.	Valley Floor / Alluvial Fan	15.4	5,600	C
56051	CER	UG	IRR	1989	0.34	144.0	George Eldridge & Son, Inc.	Valley Floor / Alluvial Fan	21.9	5,660	C
V00789	VST	STR	IRR	1875	(-)[h]	(-)[h]	McGill, WM.	Valley Floor	20.4	5,610	E
V01069	VST	STR	STK	NA	0.4	12.0*	BLM	Alluvial Fan	34.9	7,240	E

Table 6-14
Water Rights within Management Block 4 Senior to SNWA GDP Permits
(Page 2 of 2)

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
V01213	VST	STR	IRR	1888	0	1,280.0*	George Eldridge & Son, Inc.	Valley Floor / Alluvial Fan	18.4	5,670	E
V01214	VST	STR	IRR	1888	0	2,000.0*	George Eldridge & Son, Inc.	Alluvial Fan	16.3	5,860	E
V01219	DEC	STR	IRR	1878	7.728	1,804.3	George Eldridge & Son, Inc.	Alluvial Fan	20.5	5,750	E
V01969	VST	STR	IRR	1872	1	300.0*[,g]	George Eldridge & Son, Inc.	Alluvial Fan	30.4	6,010	E

[a]DEC - Decreed, CER - Certificated, PER - Permitted, VST - Vested
[b]SPR - Spring, STR - Stream, UG - Underground
[c]IRR - Irrigation, PWR - Power, STK - Stock watering
[d]Rounded to the nearest tenth of a mile.
[e]Rounded to the nearest 10 ft.
[f]See Section 3.2.5 for a detailed explanation of the Management Categories; C - Distant resource > 10 miles, E - Resource not in hydraulic connection with the SNWA GDP POD producing aquifer in which SNWA GDP production wells will be installed.
[g]Acre-ft per season.
[h] No diversion rate or duty as documented in Stanka (2017)
*The reported annual duty is not explicitly documented on the certificate, permit, or vested claim, but reported as such by the NDWR Hydrographic Abstract query.
NA - Not available.

Monitoring Strategy

The distance between the closest SNWA GDP POD and the 11 senior water rights and vested claims within Management Block 4 that are in hydraulic connection with the producing aquifer ranges from 15 to 32 miles and are assigned Management Category C. Significant water level drawdown from SNWA GDP pumping is not expected to occur in Management Block 4.

Five sentinel (Section 3.2.1) monitor wells will provide water level data to avoid activating a mitigation trigger in Management Block 4. The sentinel locations include four SNWA monitor wells (SPR7029M, SPR7029M2, SPR7030M, SPR7030M2) located south of Cleveland Ranch. SPR7044M, a planned monitor well that will be located one mile north of the northern most production well on the east side of the valley is also designated as a sentinel monitor well. These sentinel monitoring locations will be used to detect and measure changes in water level which may indicate propagation of drawdown into Management Block 4. Additional monitoring of aquifer conditions in Management Block 4 includes four monitoring wells and one spring piezometer at Keegan Spring. The four wells are N20 E66 13AB 1, 393442114231801, 39270311430501, and Robison Crooked Well (Table 6-15).

Table 6-15
Spring Valley Management Block 4 Program Monitoring

Senior Water Right	Monitor Well
All Senior Rights in Block 4	Sentinel Monitor wells SPR7029M, SPR7029M2; SPR7030M; SPR7030M2, SPR7044M (planned well)
All Senior Rights in Block4	Four monitor wells and one piezometer providing monitoring of aquifer conditions in Management Block 4 184 N20 E66 13AB 1, 393442114231801, 39270311430501, Robison Crooked Well, Keegan Spring piezometer (SPR7021Z)

Investigation Triggers and Management Actions

The investigation trigger will be activated if the water level in any of the designated sentinel wells decrease below the 99.7 percent lower control limit for six continuous months as described in Appendix A. Activation of an investigation trigger at any of the five sentinel wells will result in an evaluation to determine the cause and significance of the water level change observed using protocols described in Section 3.2.2. Should the cause of the water level change be attributed to SNWA GDP pumping, the following management actions may be taken:

- Measure static water level at least quarterly in the eight underground water right POD wells listed in Table 6-14 beginning at least three years prior to SNWA GDP pumping if physically accessible and permission is granted by the owner.
- Increase monitoring frequency to continuous from quarterly in network monitor wells.
- Measure spring water right permit nos. 26430, 26655, and 26656 directly, if discharge is measurable and owner's permission is obtained. If not measurable, document conditions of the

site and use groundwater level measurements from Keegan Spring piezometer to compare to spring conditions.

- Update the numerical groundwater flow model and other predictive tools with aquifer response data.

- Perform, with owner's permission, a water resource assessment, as described in Section 3.2.7, on the eight wells and three spring water rights located in Management Block 4, listed in Table 6-14, that are in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed.

Mitigation Triggers and Mitigation Actions

The mitigation trigger for all the senior water rights in Management Block 4 is the same as Block 1, as described in Section 3.2.6. Mitigation triggers determine when a mitigation action is implemented if the cause of the trigger being activated is SNWA GDP pumping.

If the senior water right mitigation trigger is activated, and is caused by SNWA GDP pumping, Mitigation actions for Management Block 4 underground, spring, and stream senior rights are the same as those listed in Management Block 1. An additional mitigation action is the diversion of SNWA surface water rights from McCoy (permit nos.10710, V01215, and V00791), Kalamazoo Creeks (permit nos. 4043, V02305, and V02332) and other rights as replacement water for mitigation purposes. The streams have quantity and quality to provide suitable replacement water.

Additional mitigation actions are presented in Section 3.2.8. Mitigation actions for the senior underground water rights located within the management block will be effective because suitable replacement water is available and well modifications or replacements will be designed to produce the amounts required for the senior water rights under conditions that exist during SNWA pumping. SNWA non-GDP and GDP permitted water rights are available to be used as mitigation resources for spring and stream rights if needed. SNWA water rights in Block 4 are presented in Table 6-16 and Figure 6-20.

Table 6-16
Spring Valley Management Block 4 SNWA Water Rights by Source and Status

Source	Status (Number of Rights/Annual Duty)			
	Certificated (afa)	Decreed (afa)	Permitted (afa)	Vested (afa)
Lake	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00
Spring	7 / 377.88[a]	0 / 0.00	1/ 20.00	0 / 0.00
Stream	7 / 3,571.83[b]	3 / 2,411.67	2 / 600.00	0 / 0.00
Underground	1 / 1,266.64	0 / 0.00	0 / 0.00	0 / 0.00

[a]The reported duty includes one or more groups of water rights that have not to exceed total combined duties.
[b]The reported duty includes both acre-ft per season and acre-ft per annum.

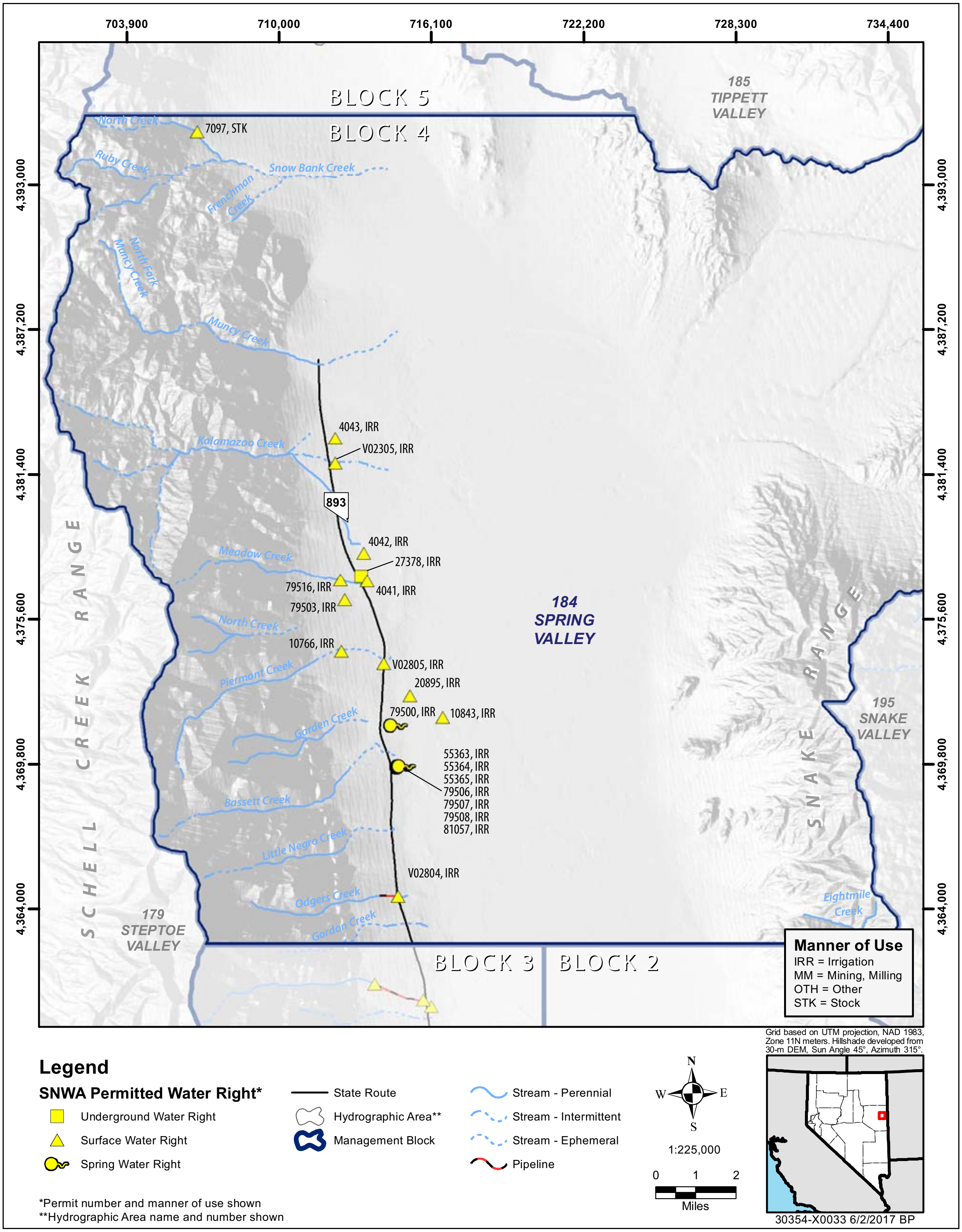


Figure 6-20
SNWA Water Rights in Management Block 4

6.2.5 Senior Water Rights in Management Block 5

Management Block 5 consists of the northern portion of Spring Valley. Water rights senior to SNWA GDP permits and the 3M Plan hydrologic monitoring network in Management Block 5 are shown on Figure 6-21.

A tally of water rights in Management Block 5 senior to the SNWA GDP permits by source, status, and hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed, are presented in Table 6-17. Individual senior water rights are listed in Table 6-18, which includes information on water right status, source, manner of use, priority date, diversion rate, annual duty, ownership, distance to the closest SNWA GDP POD, DEM elevation, and management category (as described in Section 3.2.5).

Table 6-17
Spring Valley Management Block 5 Water Rights by Source and Status Senior to SNWA GDP Permits

Source	Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)				Not Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)			
	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)
Spring	1 / 18.08	0 / 0.00	0 / 0.00	0 / 0.00	1 / 8.6	0 / 0.00	0 / 0.00	1 / 20.9[b]
Stream	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	1 / 261.36[b]	0 / 0.00	0 / 0.00	0 / 0.00
Underground	3 / 16.48[a]	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00

[a]The reported duty includes both acre-ft per season and acre-ft per annum.
[b]Acre-ft per season.

Within this management block, there are three certificated underground (16 afa) and one certificated spring (18 afa) senior water rights for a total duty of 34 afa in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed. One certificated stream (261 afa), one certificated spring (8.6 afa) senior water right and one spring vested claim (21 afa) with a total duty of 291 afa are not in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed due to location and hydrogeologic setting.

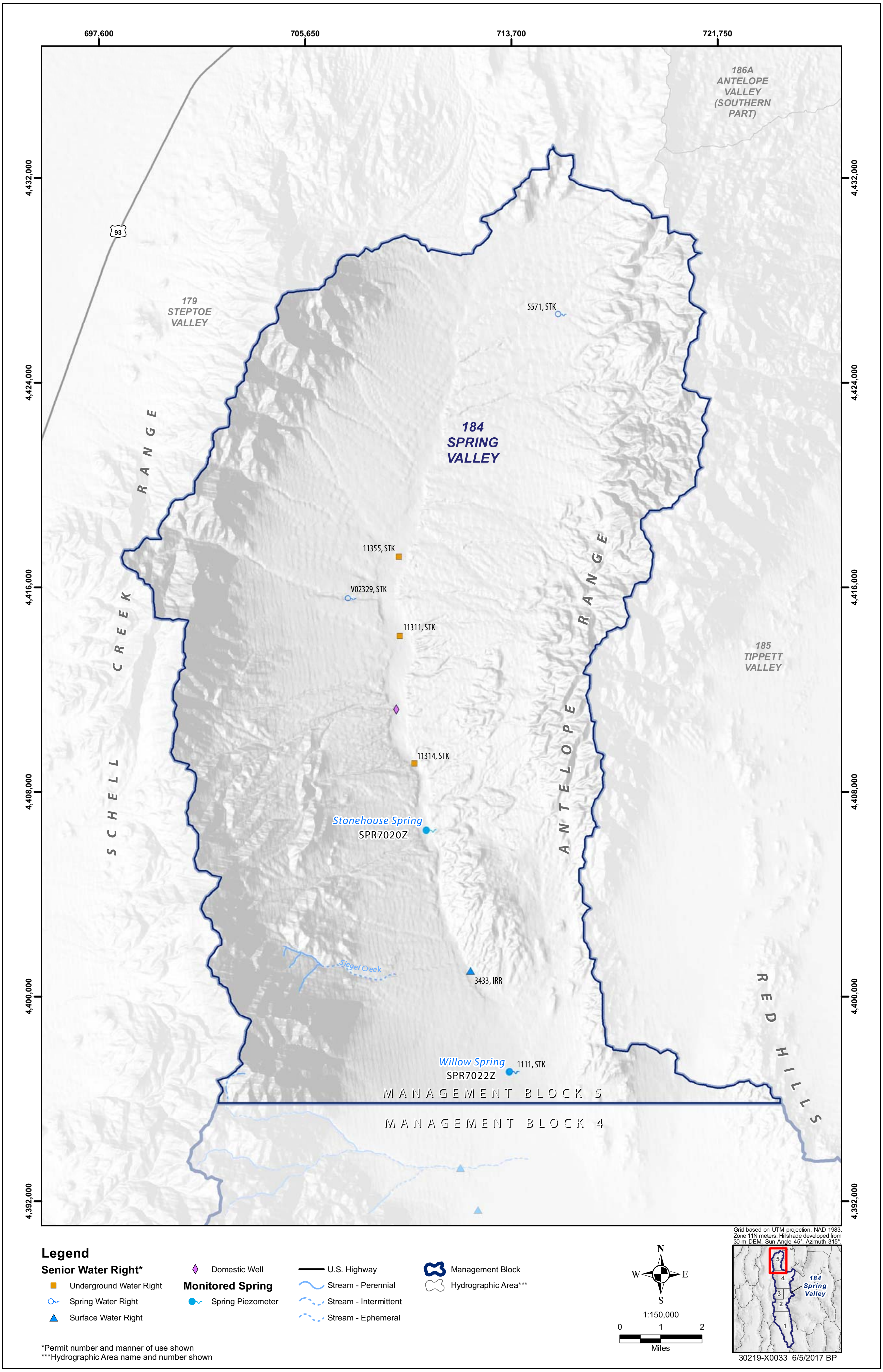


Figure 6-21
Management Block 5 Senior Water Rights and Hydrologic Monitoring Network

Table 6-18
Water Rights within Management Block 5 Senior to SNWA GDP Permits

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
1111	CER	SPR	STK	1908	0.025	18.1*	Olsen, Casten	Valley Floor / Alluvial Fan	36.8	5,990	D
3433	CER	STR	IRR	1915	0.726	261.4[g]	Bundy, Clarence A.	Alluvial Fan / Valley Floor	39.4	6,100	E
5571	CER	SPR	STK	1919	0.012	8.6*	Henry Conrad Vogler IV	Alluvial Fan	55.0	7,080	E
11311	CER	UG	STK	1945	0.017	7.1*	Intermountain Ranches, Ltd	Valley Floor / Alluvial Fan	47.7	6,410	D
11314	CER	UG	STK	1945	0.016	6.5*[,g]	Intermountain Ranches, Ltd	Alluvial Fan	44.6	6,290	D
11355	CER	UG	STK	1945	0.004	2.9*	Henriod, Eugene A.	Valley Floor / Alluvial Fan	49.6	6,490	D
V02329	VST	SPR	STK	1899	0.05	20.9*[,g]	Vogler, Henry Conrad IV	Alluvial Fan	48.8	6,510	E

[a]CER - Certificated, VST - Vested
[b]SPR - Spring, STR - Stream, UG - Underground
[c]IRR - Irrigation, STK - Stock watering
[d]Rounded to the nearest tenth of a mile.
[e]Rounded to the nearest 10 ft.
[f]See Section 3.2.5 for a detailed explanation of the Management Categories; D - Distant resource > 10 miles, E - Resource not in hydraulic connection with producing aquifer in which SNWA GDP production wells will be installed.
[g]acre-ft per season.
*The reported annual duty is not explicitly documented on the certificate or vested claim, but reported as such by the NDWR Hydrographic Abstract query.

Monitoring Strategy

The distance between the SNWA GDP PODs and senior water rights locations that are in hydraulic connection to the producing aquifer ranges from approximately 36 to 50 miles and are assigned Management Category C. Similar to Management Block 4, four sentinel monitor wells, (Section 3.2.1) consisting of SNWA monitor wells (SPR7029M, SPR7029M2, SPR7030M, SPR7030M2) located south of Cleveland Ranch and one future well located one mile north of the northern most production well on the east side of the valley (SPR7044M), are used to detect significant changes in water level which may indicate propagation of drawdown into Management Blocks 3, 4, and 5. The large distance and multiple monitoring wells between Management Block 5 and the SNWA PODs provide a large buffer.

Additional monitoring of aquifer conditions in Management Block 5 includes two shallow piezometers at Willow and Stonehouse springs and spring discharge monitoring at Willow Spring (Table 6-19).

The groundwater discharge area in Management Block 5 is from local recharge at a higher elevation compared the groundwater discharge areas of the other Spring Valley Management Blocks. The sediments also tend to be derived from volcanics and are expected to be of lower hydraulic conductivity. The distance from SNWA GDP PODs, higher elevation, and lower hydraulic conductivity makes it unlikely that effects from SNWA GDP pumping will occur in Management Block 5.

Table 6-19
Spring Valley Management Block 5 Program Monitoring

Senior Water Right	Monitor Well
All Senior Rights in Block 5	Sentinel Monitor wells SPR7029M, SPR7029M2, SPR7030M, SPR7030M2, SPR7044M (planned well)
1111	Willow Spring piezometer (SPR7022Z) and discharge monitoring
Aquifer conditions in Management Block 5	Stonehouse Spring piezometer (SPR7020Z)

Investigation Triggers and Management Actions

An investigation trigger will be activated if the water level in any of the sentinel wells decrease below the 99.7 percent lower control limit for six continuous months, as described in Appendix A. Activation of an investigation trigger at any of the five sentinel wells will result in an evaluation to determine the cause and significance of the water level change observed using protocols described in Section 3.2.2. Should the cause of the water level change be attributed to SNWA GDP pumping, the following management actions may be taken:

- Perform, with owner’s permission, a water resource assessment, as described in Section 3.2.7, on the three wells and one spring water right located in Management Block 5, listed in Table 6-18, that are in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed.

- Update the numerical groundwater flow model and other predictive tools with aquifer response data.

Mitigation Triggers and Mitigation Actions

The mitigation trigger for all the senior water rights in Management Block 5 is the same as for Block 1, as described in Section 3.2.6. Mitigation triggers determine when a mitigation action is implemented if the cause of the trigger being activated is SNWA GDP pumping.

If the senior water right mitigation trigger is activated, and is caused by SNWA GDP pumping, mitigation actions will be implemented. Mitigation actions for Management Block 5 underground, spring, and stream water rights are the same as those listed in Management Block 1.

Additional mitigation actions are presented in Section 3.2.8. Mitigation actions for the senior underground water rights located within the management block will be effective because suitable replacement water is available and well modifications or replacements will be designed to produce the amounts required for the senior water rights under conditions that exist during SNWA pumping. SNWA non-GDP and GDP permitted water rights are available to be used as mitigation resources if needed. SNWA water rights in Management Block 5 are presented in Figure 6-22 and Table 6-20.

Table 6-20
Spring Valley Management Block 5 SNWA Water Rights by Source and Status

Source	Status (Number of Rights/Annual Duty)			
	Certificated (afa)	Decreed (afa)	Permitted (afa)	Vested (afa)
Lake	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00
Spring	1 / 12.03	0 / 0.00	0 / 0.00	2 / 36.18
Stream	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00
Underground	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00

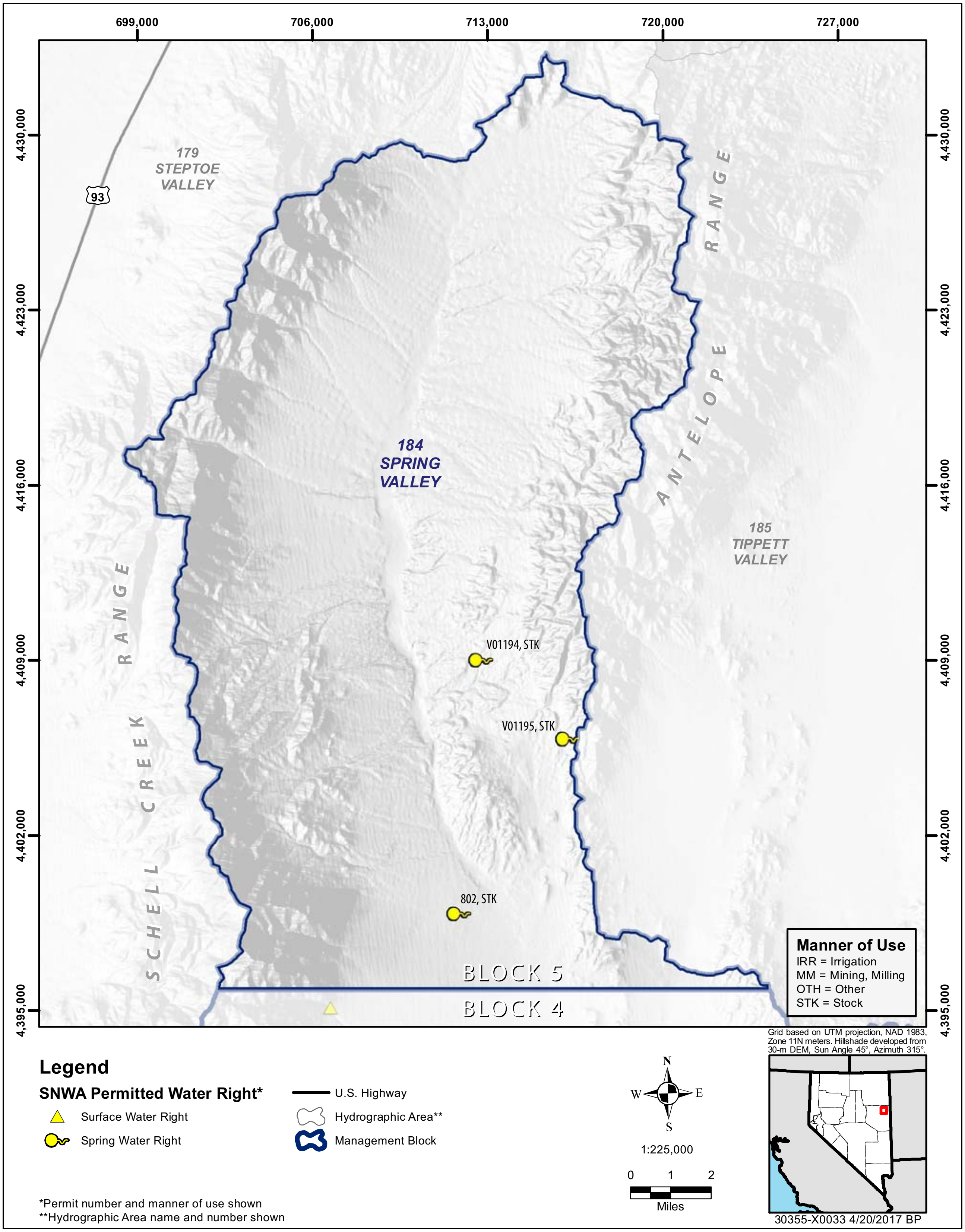


Figure 6-22
SNWA Water Rights in Management Block 5

6.3 Environmental Resources

This sections presents the rationale and analyses for establishment of triggers and management, monitoring, and mitigation actions for environmental resources in Spring Valley. As described in Section 6.1, Spring Valley was divided into Management Blocks to provide a useful structure for developing triggers and monitoring, management, and mitigation actions in the basin. This section refers to those Management Blocks, but is organized by the unreasonable effects to environmental resources defined in Section 2.2 which the SNWA (2017e) Spring Valley 3M Plan is designed to avoid.

The groundwater discharge area in Spring Valley encompasses approximately 170,000 acres (Figure 6-23). This area is largely comprised of shrubland habitat, and also includes mesic habitat, terrestrial woodland habitat, playa, and agriculture [shrubland habitat = 140,000 acres (80%); mesic habitat = 10,000 acres (6%); terrestrial woodland habitat = 4,000 acres (2%); playa = 13,000 acres (8%); and agriculture = 5,000 acres (3%)]. One federally listed species (Pahrump poolfish) and one native aquatic-dependent special status animal species (northern leopard frog) occur in the groundwater discharge area. Habitat descriptions, a summary of wildlife that use the habitats, and details about the special status species occurrences are presented in Section 5.0. The discussion below presents analyses for the federally listed species (Section 6.3.1), the mesic habitat and the native aquatic-dependent special status animal species that uses it (Section 6.3.2), shrubland habitat (Section 6.3.3), and terrestrial woodland habitat (Swamp Cedars) (Section 6.3.4).[1]

The approach to avoid unreasonable effects to environmental resources in Spring Valley relies partly on avoiding unreasonable effects to senior water rights. As described in detail in Section 6.2, this approach includes investigation triggers established at intermediate wells between SNWA GDP PODs and senior water rights; preemptive management actions to avoid or minimize the risk of activating mitigation triggers at senior water right PODs; and mitigation actions to avoid and eliminate conflicts with senior water rights. Given the number and spatial distribution of monitor wells and senior water rights (Figure 6-2), and the general co-location of senior water rights with environmental resources, this approach also helps prevent unreasonable effects to environmental resources.

Additional thresholds, triggers, and monitoring, management, and mitigation actions specific to environmental resources are presented below.

6.3.1 Federally Listed Species

6.3.1.1 Overview

The federally-endangered Pahrump poolfish occurs in Shoshone Ponds in Spring Valley Management Block 1 (Figure 6-24). Extirpated from its only known native site (Manse Spring in Pahrump Valley, southern Nevada), the species now occurs in three previously fishless transplant locations in Nevada: Shoshone Ponds; Lake Harriet (Spring Mountain Ranch State Park, Las Vegas Valley, southern

1. As discussed in Section 5.2, playa is not analyzed in this report because it will not be affected by GDP pumping. The senior water rights that support agriculture are analyzed in Section 6.2.

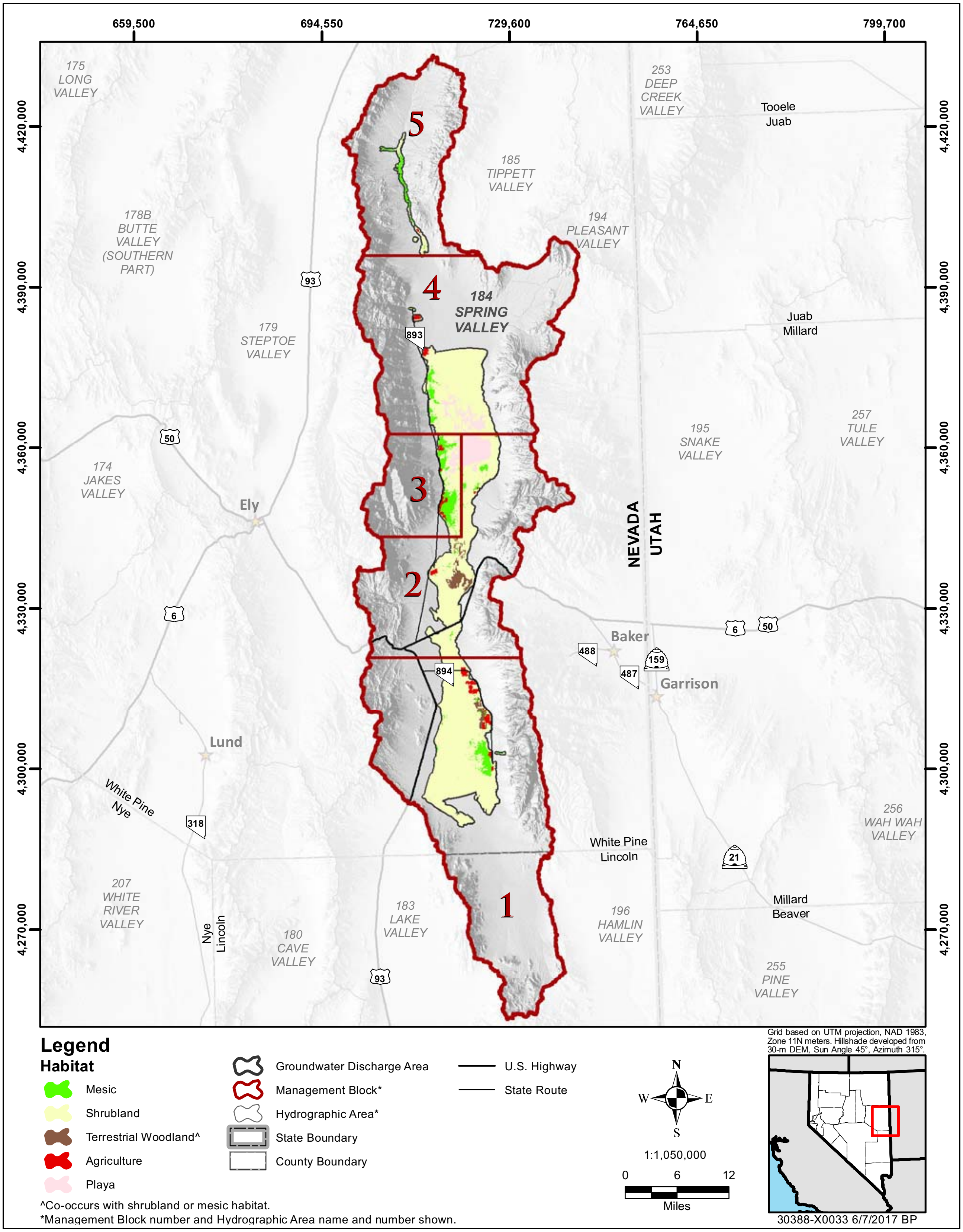


Figure 6-23
Habitats in Spring Valley

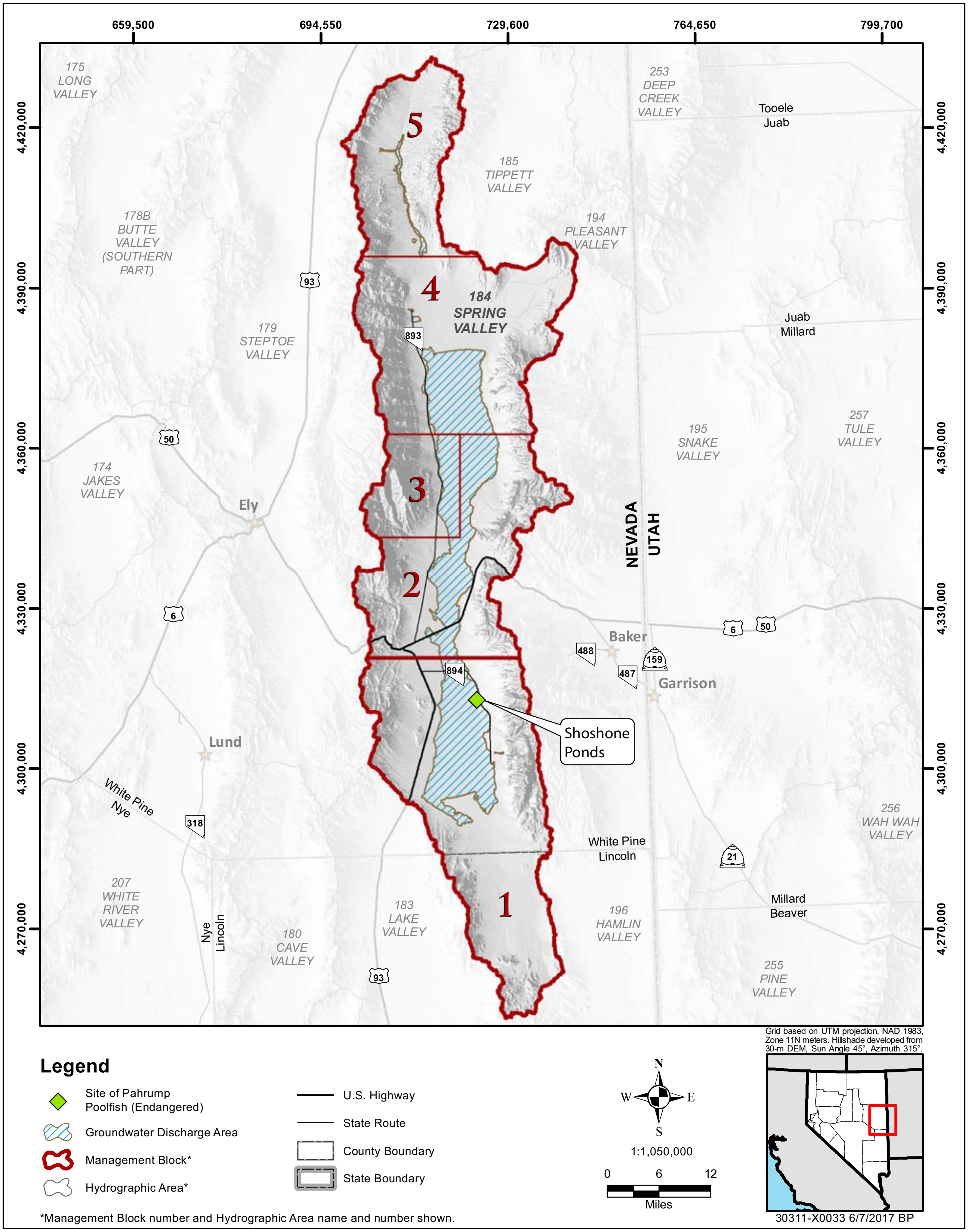


Figure 6-24
Shoshone Ponds, Spring Valley

Nevada); and Corn Creek Springs (Desert National Wildlife Refuge, Las Vegas Valley, southern Nevada).

Because the species no longer exists in its native habitat, recovery efforts are directed toward protecting the transplanted populations and their habitats (USFWS, 1980, at pages 7 and 12). Shoshone Ponds was intended to be only a temporary holding site for the species until other suitable transplant locations were developed (USFWS, 1980, at page 7). However, the species has existed at Shoshone Ponds for 40 years (since 1976), and the need remains to establish additional transplant populations as outlined in the Recovery Plan (USFWS, 1980, at pages 14-15).

For the species to be considered for reclassification to federally threatened status (downlisted), the Recovery Plan states that at least three viable, reproducing populations, each with at least 500 adults, should endure for three years. The habitats would need to be free of immediate and potential threats to permit the change in status (USFWS, 1980, at pages 7 and 12). To be considered for delisting, the Recovery Plan states that these criteria should be met for an additional three years (USFWS, 1980, at page 7). The USFWS once proposed to downlist the species to threatened status (USFWS, 1993), but withdrew the proposal due to existing and potential threats and population instability (USFWS, 2004). In its 2004 determination, the USFWS considered the three refugia locations (Shoshone Ponds, Corn Creek, and Lake Harriet) as three populations. Future downlisting proposals and determinations are expected to again treat Pahrump poolfish at Shoshone Ponds as a single population.

The Pahrump Poolfish habitat at Shoshone Ponds is human-made and sustained by discharge from three wells. The attributes and hydrologic data associated with the wells are described in Section 6.3.1.4. As discussed in Section 6.3.1.4, the lithology underlying Shoshone Ponds consists of clays inter-fingered with sand and gravel layers, which results in confined aquifer conditions in the area. Some of the artesian wells at Shoshone Ponds have been flowing without control valves for over 80 years (since the first wells were installed in 1935), resulting in a decrease in pressure head over time as documented by historical measurements of artesian flow.

Natural springs are not present at Shoshone Ponds. However, local shallow groundwater has accumulated in the area as a result of discharge from the wells. As discussed in Section 6.3.1.4, due to the confining sediments, the shallow groundwater and associated habitats are not in hydraulic connection with the underlying aquifer in which SNWA GDP wells will be installed. Thus, the only way Shoshone Ponds can be affected by SNWA GDP pumping is if the production capacity of the Shoshone Ponds wells is reduced below the amount needed to sustain the habitat. Therefore, the objective of the groundwater management program and associated thresholds and triggers is the protection of the senior water right that provides water to Pahrump poolfish at Shoshone Ponds.

6.3.1.2 Pahrump Poolfish Habitat Needs and Population Dynamics

Data collected on Pahrump poolfish and their habitats show that the species is hardy and adaptable. Pahrump poolfish have survived and reproduced at refuge sites that are distinctly different from their native habitat and vary widely in their environmental characteristics. The habitats have included spring pools and spring brooks, well-fed pools and a shallow outflow brook, a spring-fed irrigation reservoir, and observation tanks. The pools and reservoirs have ranged from small to large

(650 ft^2-3.5 acres). Water quality has ranged from alkaline to neutral pH, and from fairly constant temperatures to seasonally fluctuating temperatures (40-79 °F). Some habitats have had still waters, while others have had measurable water velocities. A number of references are available on these topics (BLM, 2014a; Deacon and Williams, 2010; Goodchild, 2016; NDOW annual survey reports [most recently NDOW, 2015]; Selby, 1977; SNWA, 2012e and 2013e; and USFWS, 1993, 2004, 2008, and 2012).

Pahrump poolfish appear to experience natural population fluctuations. While some fluctuations have been tied to specific effects (e.g., invasive species, water delivery interruptions, habitat destruction), long-term population estimates display consistent fluctuations over time (see discussion below). Management of Pahrump poolfish, and determinations of population success and stability, need to be considered within this context.

Population expansions and rebounds have been documented in all known Pahrump poolfish populations. In its native Manse Spring, periodic population estimates from 1937-1975 fluctuated between less than 50 to more than 1,000, including two population crashes thought to be caused by goldfish eradication efforts and habitat destruction; both times the species fully rebounded (Deacon and Williams, 2010; and Goodchild, 2016). Prior to Manse Spring going dry, 29 poolfish were introduced to the Corn Creek refuge in 1971; just two years later in 1973, the population estimate increased to approximately 1,300 (Selby, 1977). At Lake Harriet, the population estimate reached a low point in 2008 (3,471), and rebounded seven-fold the very next year in 2009 (25,910) (NDOW, 2017).[1] In the Shoshone Ponds stock pond, the subpopulation estimate reached its lowest in 2003 (718), and rebounded seven-fold by 2006 (5,524) (NDOW, 2017). Pahrump poolfish and its habitats continue to be influenced by introduced invasive species and habitat management. However, data clearly show that Pahrump poolfish can become established in a variety of habitats, rebound from population declines, and increase their numbers quickly.

Habitat management is a major external influence on poolfish numbers at Shoshone Ponds. The BLM addressed Shoshone Ponds habitat management in its 2008 Resource Management Plan (BLM, 2008; and USFWS, 2008). In 2016, the BLM was awarded Southern Nevada Public Land Management Act (SNPLMA) funding to enhance Pahrump poolfish habitat in Shoshone Ponds. The goal of the SNPLMA project is to "help ensure that the BLM will be able to better maintain the habitat and ensure a sustainable Pahrump poolfish population" (BLM, 2014a, at page 1). BLM coordinated with the Pahrump Poolfish Recovery Implementation Team (of which SNWA is a member) to generate options to improve the habitat. The SNPLMA project will require at least five years to complete, including planning, environmental compliance, and implementation (BLM, 2014a).

1. Population estimates from mark-recapture surveys. NDOW also reports 95 percent confidence intervals not listed here. See NDOW (2015) for details.

6.3.1.3 Pahrump Poolfish Population and Habitat at Shoshone Ponds

Shoshone Ponds Population

Pahrump poolfish occur in three human-made habitats at Shoshone Ponds: 1) dugout refuge ponds that receive water from the Shoshone NDOW Well; 2) a dugout stock pond that was historically used for livestock watering and receives water from BLM Shoshone Well #4; and 3) a shallow outflow brook created by BLM Shoshone Well #2 (Figure 6-25 and Figure 6-26).

The Pahrump poolfish population started with 66 poolfish that were transplanted from the Corn Creek refuge to the North refuge pond in 1976 (Goodchild, 2016) and later expanded to the various habitats within Shoshone Ponds. The poolfish have been moved among each of the refuge ponds, the stock pond, and the Well #2 outflow over the years (only some of which were clearly documented). Purposeful fish and habitat management have prompted some of the movements, and occasional flooding and actions by the public are also thought to contribute to the movements[1].

Fish and habitat management will continue to be an influential factor for the Pahrump poolfish at Shoshone Ponds. Habitat concerns of vegetation encroachment, siltation and low dissolved oxygen in the refuge ponds have prompted the upcoming habitat management plan that aims to restructure, rehabilitate, and possibly reconfigure some of the habitats (BLM, 2014a).Well conditions may also prompt habitat alterations and fish movements in the future. Some of the wells were constructed by the Civilian Conservation Corps in the mid-1930s, and will likely require BLM maintenance such as redevelopment or re-drilling during the SNWA GDP time frame. Altogether, continued fish movements are likely in this human-made system.

For the Shoshone Ponds population to partially meet the Recovery Plan criteria for species downlisting, enough water must be present to support a viable reproducing population with at least 500 adults. The Shoshone Ponds population has met these criteria for at least the past 20 years (1997-2016 population estimates: range = 922-8,165, mean = 4,393) (NDOW, 2017) (Figure 6-27).[2]

State and federal agencies currently share official responsibility for the listed species and its habitat. USFWS has jurisdiction over the endangered species; NDOW has responsibility for managing the fish and its habitat, as well as maintaining the well that feeds the refuge ponds (Shoshone NDOW Well); and BLM has responsibility for land management, as well as maintaining the wells that feed the stock pond (Shoshone Well #4) and the outflow brook (Shoshone Well #2). Thus, while SNWA will implement management and mitigation to avoid unreasonable effects from SNWA GDP pumping, SNWA does not have control over habitat management or population numbers.

The following sections present detailed information about the Pahrump poolfish subpopulations and habitats at Shoshone Ponds. As defined here, subpopulations are spatially separated groups that are interconnected by periodic fish movements, and thus part of the same population. The information below demonstrates both the differences in subpopulation estimates and habitat characteristics and the similarities in subpopulation fluctuations and rebounds.

1. Shoshone Ponds is used as a camping area by hunters and other visitors.
2. Given the size of fish captured, the population estimates likely represent the adult population.

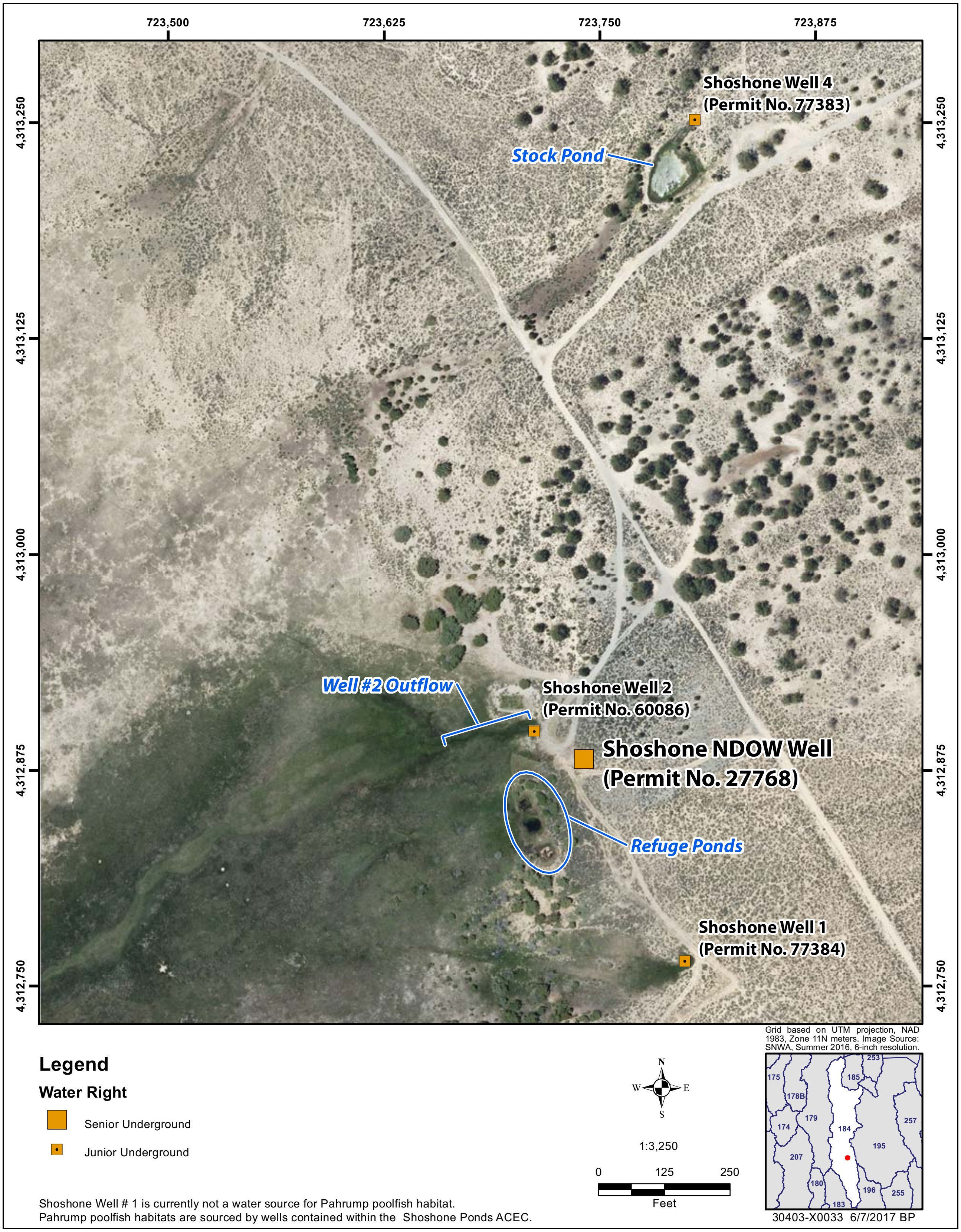


Figure 6-25
Shoshone Ponds Habitats and Wells

Figure 6-26
Shoshone Ponds Pahrump Poolfish Habitat

Left image: Refuge ponds and Well #2 outflow. Right image: Stock pond. Image Source: SNWA June 2012, 6 inch resolution, scale 1:1,125 (1 inch = 0.02 miles).

Refuge Ponds Subpopulation

The refuge ponds (North, Middle, and South) are small dugout ponds with vertical sides, each dug with an approximate 650 ft^2 area (based on measurements from aerial imagery) and 4 ft depth (SNWA, 2012e) (Figure 6-28). The area around the ponds has been fenced since their construction in 1972. The refuge ponds have reduced in size (width and depth) over the years due to siltation and vegetation encroachment, and water delivery appears to have been interrupted at least once; it is thought that these factors led to the recent subpopulation declines (NDOW, 2012 and 2015; and SNWA, 2012e and 2013e). BLM's upcoming SNPLMA habitat enhancement project may include connecting the North and Middle refuge ponds with a channel, connecting all three of the refuge ponds with multiple channels, or creating one large pond from the three existing ponds (BLM, 2014a).

The source water for the three refuge ponds is from artesian flow from the Shoshone NDOW Well. Details on well construction, discharge, and water rights are presented in Section 6.3.1.4 below. Discharge from the well to the refuge ponds is not currently measured; however, the well is estimated to be capable of discharging artesian flow of 15-20 gpm[1]. The well would also be capable of yielding over 20 gpm if a pumping system were installed based upon well construction and hydrogeologic data for the area. The refuge ponds have still waters (the water is piped into the bottom of the ponds, and there is seepage and overflow into the surrounding area). Water temperature at the well is expected to

1. Based on data from Shoshone Well #2 (SNWA database), which is nearby and has a similar completion depth.

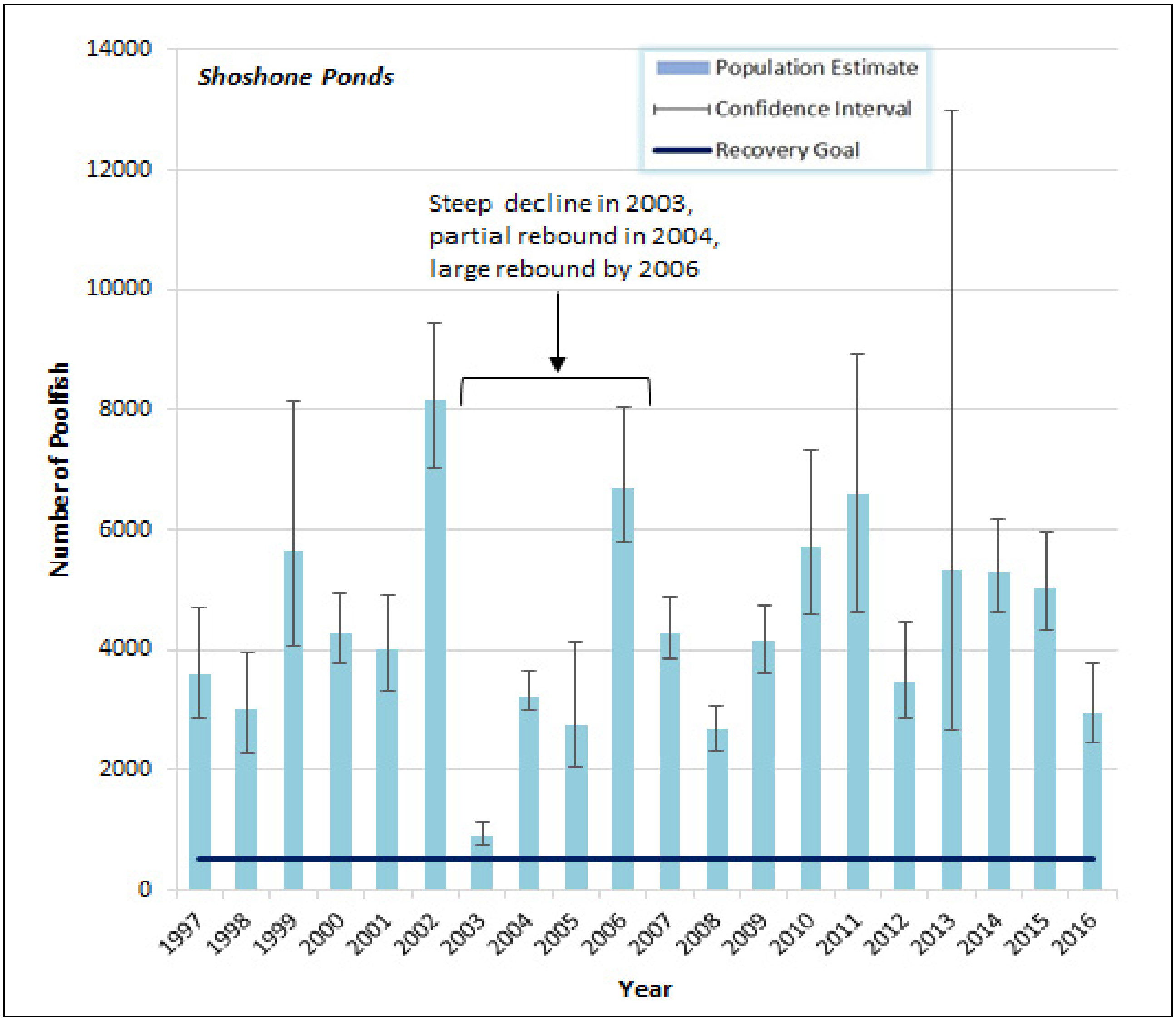


Figure 6-27
Population Estimates for Pahrump Poolfish in Shoshone Ponds

Graph recreated from NDOW (2017) dataset. Bars depict population estimates, brackets 95% confidence intervals.

be around 75-78 °F[1], and in the ponds water temperature fluctuates seasonally from approximately 43-75 °F (NDOW, 2015).

Pahrump poolfish were successfully established in the North refuge pond in 1976, when 66 poolfish were transplanted from the Corn Creek refuge (Goodchild, 2016). The population later expanded to other habitats in Shoshone Ponds. An unknown number of poolfish were introduced to the Middle refuge pond sometime prior to 1997, and approximately 200 poolfish were transplanted from the stock pond to the South refuge pond in 2014 (NDOW, 2015). Since annual surveys began in 1997, subpopulation estimates have fluctuated from: 0-794 in the North pond (1997-2016 mean: 215);

1. Based on data from Shoshone Well #2 (SNWA database), which is nearby and has a similar completion depth.

Figure 6-28
Shoshone Ponds Refuge Ponds

Top image: North pond. Middle image: Middle pond. Bottom image: South pond. July 2016 (SNWA photos)

44-1,714 in the Middle pond (1997-2016 mean: 691); and 65-277 in the South pond (2014-2016 mean: 163). Altogether, the three refuge ponds are estimated to have supported 44-2,017 poolfish in any given year (1997-2016 mean: 931) (NDOW, 2017) (Figure 6-29).

Stock Pond Subpopulation

The stock pond is a dugout pond that is considerably larger than the refuge ponds, with an approximate 6,700 ft^2 area (based on measurements from aerial imagery), 5 ft depth (Goodchild, 2016), and a more gradual slope with banks (Figure 6-30). The stock pond was historically used for livestock watering, but was fenced in 2014 to prevent livestock access. Since the fence was installed, SNWA biologists have observed an increase in vegetation around the pond.

The source water for the stock pond is from Shoshone Well #4, which was constructed to a depth of 262 ft bgs in 1935. Details on well discharge and water rights are presented below in Section 6.3.1.4. The stock pond has still waters (the water flows into the pond, and there is seepage into the surrounding area; at very high water levels limited outflow occurs through a pipe). Water temperature at the well is approximately 71 °F (2008 measurement, SNWA database), and in the pond water temperature fluctuates seasonally from approximately 40-77 °F (Goodchild, 2016).

Early measurements of artesian flow in the Shoshone Pond area, beginning in 1935, with documented flow of over 40 gpm in 1950 (Rush and Kazmi, 1965). However, flow decreased with time, likely due to continued uncontrolled artesian flow from the well and drought conditions. Over the last decade artesian flow measurements collected by SNWA at Shoshone Well #4 ranged from 0.5 to 3.5 gpm. In 2014, Shoshone Well #4 no longer produced artesian flow, and a pump was installed in the well to provide consistent discharge. The discharge rate after installation of the pump was measured at approximately 3.3 gpm, which has maintained the pond at full capacity.

When artesian flow at Shoshone Well #4 decreased to less than 0.5 gpm in 2014 and the stock pond receded, approximately 52,000 gallons of water were hauled in as a temporary measure until a pump could be installed. This water came from two irrigation wells located north of Shoshone Ponds, and the Shingle Creek diversion which brings surface water down from the Snake Range mountain block. The fluctuating water elevations and any different water chemistry and temperature during this time did not appear to have any appreciable effect on the poolfish, as the subpopulation estimates were steady from 2013-2015 (Figure 6-31).

An unknown number of fish were introduced to the stock pond sometime prior to 1989 as part of the population expansion into the various habitats in Shoshone Ponds (NDOW, 2015). Since annual surveys began at the stock pond in 1997, subpopulation estimates have fluctuated from 718-6,588 (1997-2016 mean: 3,347) (NDOW, 2017) (Figure 6-31).

The stock pond subpopulation demonstrates that a stable Pahrump poolfish population of sufficient size to help downlist the species can be maintained on a discharge of 3.3 gpm. The senior water right at the Shoshone NDOW Well (12.39 gpm) is over three times that flow.

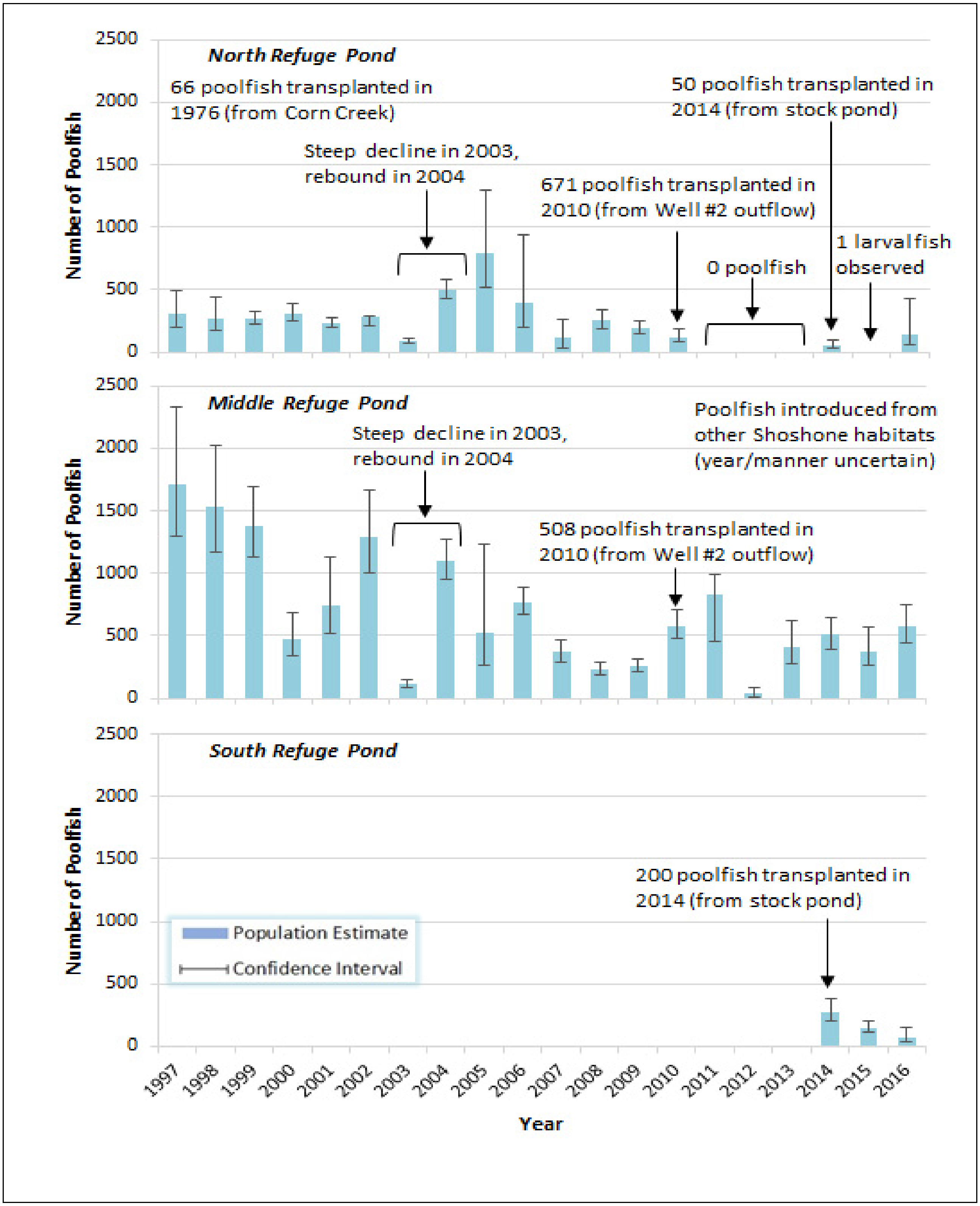


Figure 6-29
Subpopulation Estimates for Pahrump Poolfish in Shoshone Ponds: Refuge Ponds

Graph recreated from NDOW (2017) dataset. Bars depict subpopulation estimates, brackets 95% confidence intervals.

Figure 6-30
Shoshone Ponds Stock Pond

Top image: September 2009. Bottom image: July 2016. (SNWA photographs).

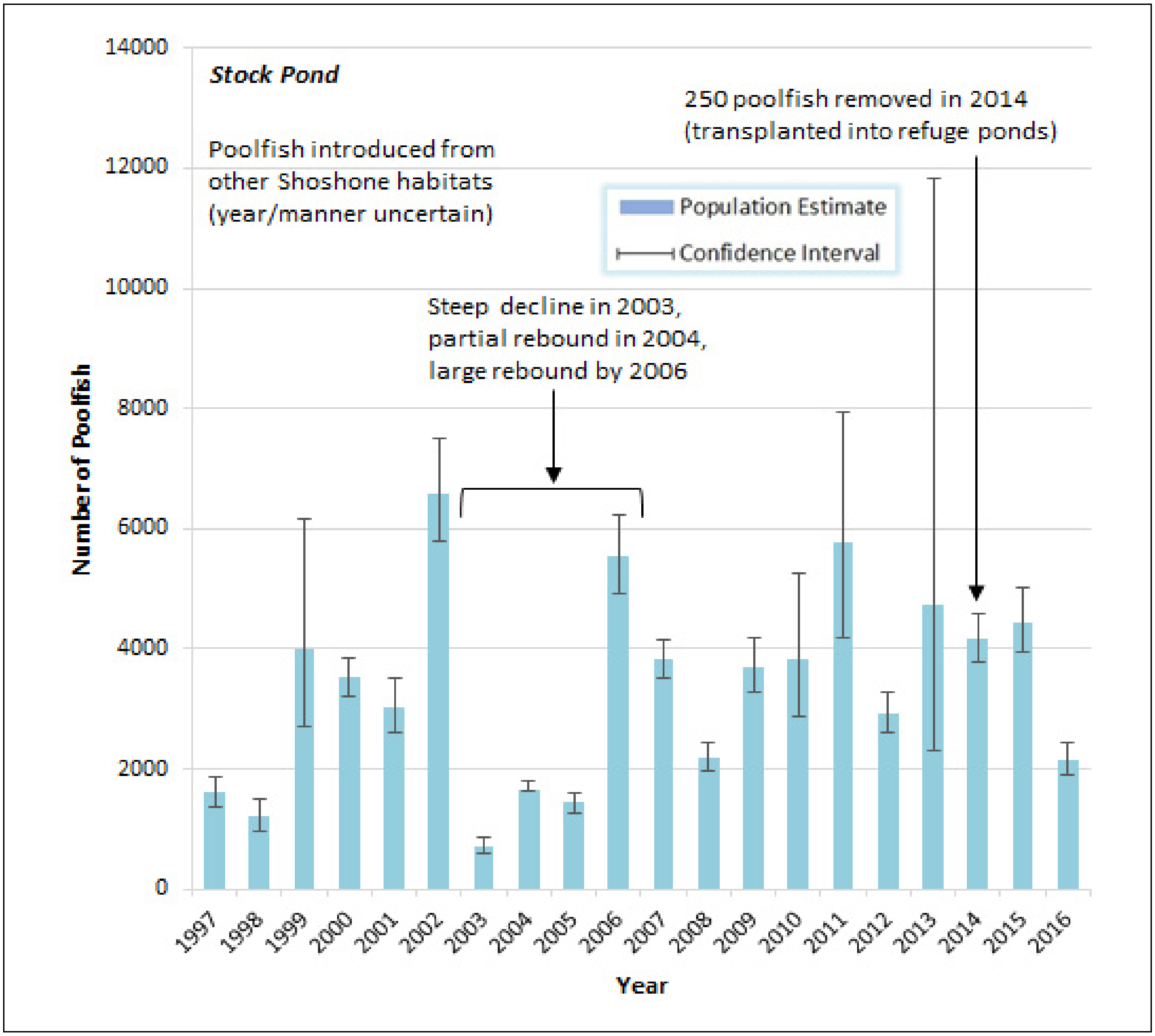


Figure 6-31
Subpopulation Estimates for Pahrump Poolfish in Shoshone Ponds: Stock Pond

Graph recreated from NDOW (2017) dataset. Bars depict subpopulation estimates, brackets 95% confidence intervals.

Shoshone Well #2 Outflow Subpopulation

Well #2 outflow is a very shallow, narrow, braided brook that extends approximately 160 ft from Shoshone Well #2 and then diffuses into a marshy/wet meadow area (Figure 6-32). Pahrump poolfish has occurred along the entire extent of the brook (BLM, 2010b). The brook and surrounding vegetation was historically grazed, but the area was fenced in 2014 to prevent livestock access. Since 2014, extensive vegetation encroachment has occurred (Figure 6-32). BLM's upcoming SNPLMA habitat enhancement project may include developing a pond along the extent of the brook (BLM, 2014a).

The source water for the outflow brook is from Shoshone Well #2. Details on the well, its discharge, and water rights are described in Section 6.3.1.4. Along the brook, water velocity in April 2013 ranged from 0.04-0.7 feet per second (mean: 0.3) (SNWA, 2013e). Water temperature at the well is approximately 75-78 °F (SNWA database). The water is slightly warmer in the brooks than the ponds due to its shallowness; at noon on April 2013, the brook was 78 °F, while the surface water of the refuge ponds was 76 °F and stock pond was 69 °F (SNWA, 2013e).

Pahrump poolfish were first observed in the Well #2 outflow in 1999, but annual surveys in the brook did not begin until 2012. Because the habitat did not appear very suitable for reproduction and growth, it was assumed that poolfish occurrence was occasional and the conservation value was limited (USFWS, 2008, at page 90; and USFWS, 2012, at page 279). In 2010, a salvage effort accompanied BLM's Shoshone Well #2 discharge flow valve installation, and 1,179 poolfish were trapped from the outflow and transplanted to the refuge ponds (BLM, 2010b; and NDOW, 2012). The subpopulation endured for a number of years after the salvage, but survey numbers declined in 2015-2016. The reason for the decline has not been verified, but based on observations it may be due to vegetation encroachment, difficulties in trapping due to the increased vegetation density, and/or intensive avian predation. From 2012-2016, subpopulation estimates fluctuated from 12-518 (mean: 224) (NDOW, 2017) (Figure 6-33).

6.3.1.4 Hydrogeology and Water Rights

As discussed in Section 6.3.1.3, Pahrump poolfish habitat at Shoshone Ponds consists of three refuge ponds, the stock pond, and the Well #2 outflow. The refuge ponds are supplied entirely from the Shoshone NDOW Well, and the Well #2 outflow brook is supplied by Shoshone Well #2. Both of these wells have artesian flow. The stock pond is supplied by Shoshone #4 Well, which was flowing until 2014 when a pumping system was installed. Drilling data from the construction of Shoshone Well # 1 (an additional flowing artesian well located south of the ponds that does not supply water for Pahrump poolfish habitat) provides lithologic and hydrogeologic information on the area. The locations of all four wells are identified in Figure 6-25 (above). Water right information, well construction attributes, and well performance for these wells are presented in Table 6-21.

Shoshone Ponds is located in the transition zone between coarse alluvial fan sediments originating from the Snake Range mountain block to the east and lacustrine (lake) clay deposits to the west. Well completion logs for the Shoshone NDOW Well and Shoshone Well #1, presented in Appendix B, provide information on hydrogeologic conditions of the area. The area is underlain by clay with inter-fingered confined sand and gravel layers which are the production zones for the four wells.

The Shoshone Well #1 log reported flowing artesian conditions first encountered at a depth of 56 ft bgs. The Shoshone NDOW Well log contains a more general lithologic description and reports that the uppermost saturated sand and gravel was encountered between 27 and 162 ft bgs and the well is completed in a deeper sand producing zone encountered between 385 and 441 ft bgs. The lithology to the east of the area is expected to transition to more extensive sand and gravels associated with the

Figure 6-32
Shoshone Ponds Well #2 Outflow

Top image: August 2012 (photograph from NDOW, 2012). Bottom image: July 2016 (SNWA photograph).

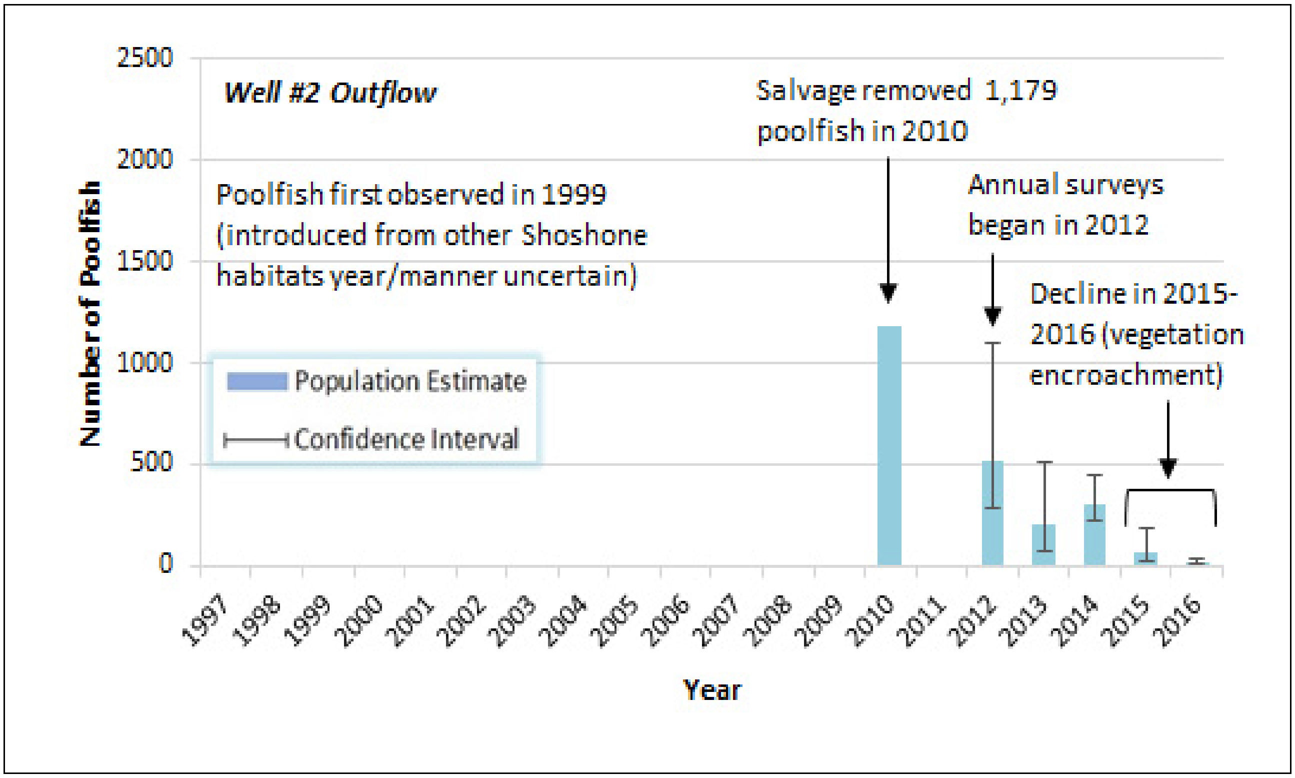


Figure 6-33
Subpopulation Estimates for Pahrump Poolfish in Shoshone Ponds: Well #2 Outflow

Graph recreated from NDOW (2017) dataset. Bars depict subpopulation estimates, brackets 95% confidence intervals. 2010 salvage included fish of all sizes; 2012-2013 estimates from standard mesh traps (fish ≥30 mm); 2014-2016 estimates from smaller mesh traps (fish ≥20 mm) (NDOW, 2015; and Pahrump Poolfish Recovery Implementation Team, 2016, pers. comm.).

alluvial fan sediments where unconfined aquifer conditions occur as supported from well logs from Well SPR7007M completed in the upper alluvial fan.

Some of the artesian wells at Shoshone Ponds have been flowing without control valves for over 80 years since the wells were constructed. This has resulted in a significant reduction of pressure head and artesian flow for the wells over time, as shown by comparing current flow rates to those documented in 1935 and 1950 by Rush and Kazmi (1965). Local shallow groundwater has accumulated in the area as a result of the discharge at Shoshone Well #2, and from the seepage and overflow from the refuge and stock water ponds sourced by the Shoshone NDOW Well and Shoshone Well #4, respectively. Due to presence of the confining clays and lack of natural springs, the shallow groundwater and habitat that relies on it are not directly connected to the producing aquifer in which SNWA GDP production wells will be installed. Thus, the only way the Shoshone Ponds habitat could be affected by SNWA GDP pumping is if the existing wells ceased to have artesian flow, and pumps placed in the wells are unable to produce the volume required to sustain the habitat. The well construction and hydraulic performance of the wells indicate the wells equipped with proper pumps can produce far greater volumes than the current water rights.

Table 6-21
Shoshone Ponds Water Rights and Well Attributes

Well Name	Water Right Permit No.	Water Right Certificate No.	Well Log No.	Drill Date	Well Depth (ft)	Specific Capacity Range (gpm/ft)	Priority Date	Annual Duty (afa)	Diversion Rate (gpm)	Pending Water Rights (af)	Current Flow Rate (gpm)
Shoshone NDOW Well	27768	8979	15172	1971	441	---	1973	20.00	12.39	---	Unknown
Shoshone Well 2	60086	18457	---	1935	407	2.12 - 3.89	1992	7.27	4.50	42.00 af (26.02 gpm)	17 (flowing)
Shoshone Well 4	77383	18464	---	1935	262	0.47 - 4.00	2008	10.86	6.73	---	3.3 (pumping)
Shoshone Well 1	77384	18465	1039	1949	194	---	2008	19.55	12.11	---	<5 (flowing)

Shoshone NDOW Well

The Shoshone NDOW Well is the POD for the senior water right (permit number 27768 and certificate number 8979), which has a 20.0 afa annual duty and a 0.0278 cfs diversion rate (calculated 12.39 gpm continuous flow rate). A photograph of the Shoshone NDOW well house is presented in Figure 6-34.

The well currently has artesian flow with discharge directly piped to the North, Middle, and South refuge ponds (Figure 6-25 above). The well completion log indicates a completion depth of 441 ft bgs, with perforations from 421 to 441 ft bgs within the deepest of three identified confined aquifer zones (Appendix B). The well was reported to be flowing at 25 gpm at the time of completion in 1971.

Shoshone Well # 1

Shoshone Well #1 is the POD for a junior water right with a 19.55 AF annual duty and a diversion rate of 0.027 cfs (calculated 12.11 gpm continuous flow rate) (permit number 77384, certificate number 18465, and priority date 9/12/2008). A photograph of the well is presented in Figure 6-35.

Well Log #1039 indicates that the Shoshone Well #1 was drilled in 1949, completed at a depth of 194 ft bgs with perforations from 55 to 194 ft bgs, and with flowing artesian conditions first encountered at a depth of 56 ft bgs (Appendix B). The well log also provides lithologic information of the Shoshone Ponds area.

The Shoshone Well #1 has flowed uncontrolled since 1949. Historical artesian flow has decreased significantly from 40 gpm observed in 1950 (Rush and Kazmi, 1965) to between 2 and 5 gpm measured by SNWA over the past several years.

Figure 6-34
Shoshone NDOW Well

Looking northwest. Shoshone Well # 2 visible in background. (SNWA photograph)

Shoshone Well #2

Shoshone Well #2 is the POD for a junior water right with a 7.27 AF annual duty and a permitted diversion rate of 0.035 cfs (calculated 4.50 gpm continuous flow rate) (permit number 60086, certificate number 18457, and priority date 9/28/1992). A protested pending junior application (number 78767) with a diversion rate of 0.0657 cfs (26 gpm continuous flow) is also associated with Shoshone Well #2. A photograph of Shoshone Well #2, with the Shoshone NDOW Well in the background, is presented in Figure 6-36.

The Shoshone Well #2 was reported in the Spring Valley Reconnaissance Report #33 to be completed in 1935 at a depth of 407 ft bgs (Rush and Kazmi, 1965). However, no well completion log is available. The well is equipped and measured by BLM with SNWA assistance. The well is equipped with a pressure transducer to record pressure head and a flow meter. The existing head measurements and discharge data are presented on Figure 6-37. Specific capacity estimates range from 2.12 to 3.89

Figure 6-35
Shoshone Well #1

Also known as the Fish and Game Well. (SNWA photograph)

gpm/ft of drawdown. Measurements of recent pressure head at Shoshone Well #2 indicates a shut in (zero flow rate) artesian water level of approximately 16 feet above ground surface (-16ft), and an artesian water level of approximately 8 feet above ground surface (-8ft) at a flow rate of 17 gpm.

The Shoshone Well #2 flowed uncontrolled since 1935 until the installation of a flow control valve in 2014. Flow decreased significantly with time, likely due to continued uncontrolled artesian flow from the well and drought conditions. Artesian flow was documented at 90 gpm in 1935 and 50 gpm in 1950 and 1964 (Rush and Kazmi, 1965). Prior to the installation of the flow valve in May 2014, the artesian flow was measured at approximately 25 gpm. Since installation and setting of the flow control valve, measured well discharge with the discharge valve fully open has varied between 16 gpm and 20 gpm.

If the artesian flow decreases further over time, the Shoshone Well #2 has the depth and capacity to provide the water right using a pump based upon the observed specific capacity of the well.

Figure 6-36
Shoshone Well #2

Looking southeast. Shoshone NDOW well house in background. (SNWA photograph)

Shoshone Well #4

Shoshone Well #4 is the POD for a junior right (permit number 77383, certificate number 18464, and priority date 9/15/2008) with a 10.86 AF annual duty and a diversion rate of 0.015 cfs (calculated 6.81 gpm continuous flow rate). The well was reported to be drilled in 1935. A photograph of the well is presented in Figure 6-38.

The USGS conducted specific capacity testing of the well on 12/12/15 and performed a video log in 2016. The video indicates a completion depth of 262 ft bgs. The specific capacity testing determined that the well could produce up to and probably greater than 20 gpm with installation of a pump. The well has the depth and capacity to provide the water right.

6.3.1.5 Monitoring, Management, and Mitigation

Overview

The approach to avoid jeopardizing the continued existence of the federally endangered Pahrump poolfish relies on avoiding unreasonable effects to the senior water right at Shoshone Ponds. As

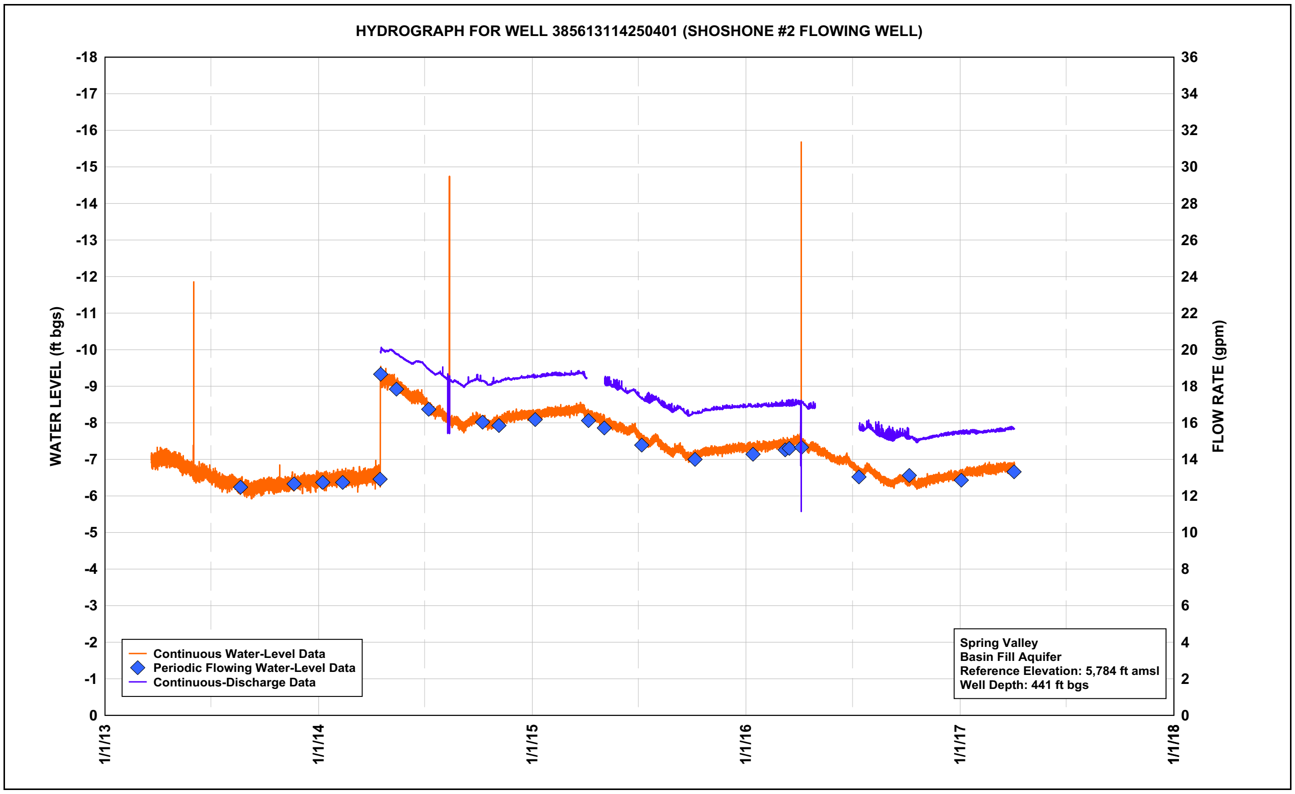


Figure 6-37
Shoshone Well #2 Water Level and Controlled Discharge Rate

described in Section 6.3.1.3, a stable Pahrump poolfish population of sufficient size to help downlist the species can be maintained on a discharge of 3.3 gpm. The senior water right at Shoshone Ponds (12.39 gpm) is over three times that flow.

The senior water right POD is the Shoshone NDOW Well (see description in Section 6.3.1.4). The Shoshone NDOW Well has no access port to measure flow from the well or water levels. However, Shoshone Well #2, located 100 ft to the northwest, has a completion depth of 407 ft bgs and is being monitored for discharge rate and water level. Shoshone Well #2 can be used as a proxy well for hydrologic conditions at the Shoshone NDOW Well because of the similar completion depth and proximity. The Shoshone NDOW Well is expected to have a higher water level under similar discharge rates as Shoshone Well #2, due to the deeper well completion depth and expected upward vertical hydraulic gradient in the area.

Based on the measured production rate data from Shoshone Well #2, the Shoshone NDOW Well is estimated to yield 15 to 20 gpm under current conditions. This is higher than its permitted water right, if flow is not controlled by the discharge line valve. The well construction and associated water level information for the Shoshone NDOW Well are illustrated on Figure 6-39. Based on the well completion details, the well can accommodate a lowering of the water table and, if needed, has the capacity to accommodate a pumping system to produce water greater than the senior water right.

Figure 6-38
Shoshone Well #4

Looking west. Stock Pond to the left. (SNWA photograph)

SNWA will pay for the pump and pumping costs as part of the mitigation commitment for the Shoshone NDOW Well.

To avoid jeopardizing the continued existence of Pahrump poolfish and avoid and eliminate conflict with the senior water right, the threshold is established as the ability to deliver the senior water right of 12.39 gpm without interruption. Preemptive management and mitigation actions will be taken to avoid crossing the threshold. As discussed below, the primary mitigation action is installing a pump. With a pumping system installed, the well has the specific capacity to produce the 12.39 gpm senior water right up until a decrease in static groundwater level of 350 ft. This is far below the projected drawdown at the site of 50 feet after 75 years of continuous SNWA GDP pumping using model results presented in Watrus and Drici, 2011.

Monitoring

Permission will be requested from NDOW to install a flow meter and pressure transducer or pressure gauge on the Shoshone NDOW Well. Monitoring will begin at least five years prior to initiation of SNWA GDP pumping to coincide with Pahrump poolfish monitoring (below). Hydraulic testing of the well will be performed to determine the specific capacity of the well. If permission to install instrumentation in the Shoshone NDOW Well is denied, Shoshone Well #2 will be used as a proxy

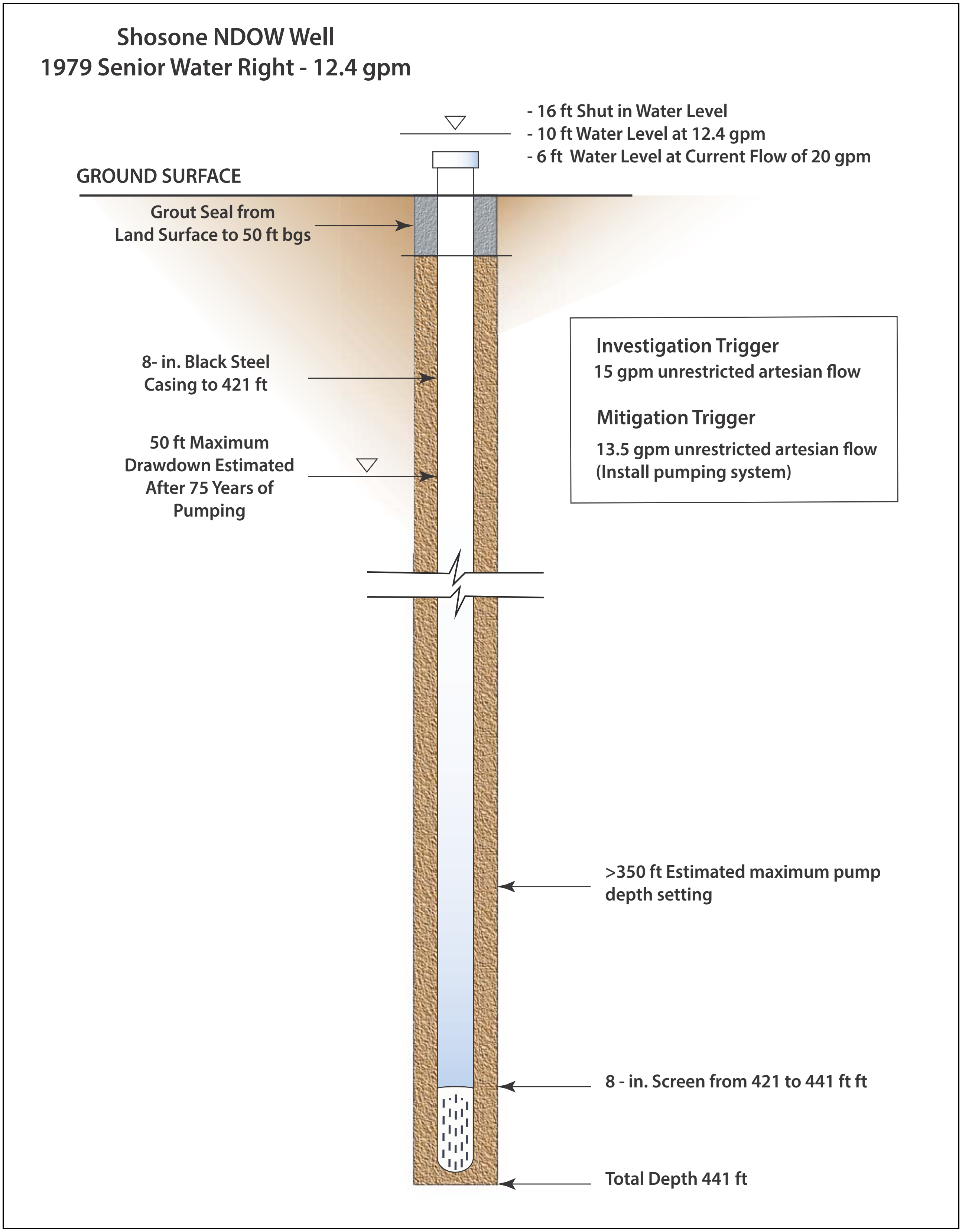


Figure 6-39
Shoshone NDOW Well Construction Schematic and Management Plan

monitor well. The Shoshone Well #2 is located 100 feet away and completed similarly to the Shoshone NDOW Well, and is equipped with a pressure transducer and flow meter that provide head measurements and discharge data. (Section 6.3.1.4).

The closest SNWA GDP POD to Shoshone Ponds is permit number 54019, located 6.5 miles southeast (Figure 6-40). Monitor wells SPR7024M and SPR7024M2, completed in two different confined zones at depths of 250 and 699 ft bgs, respectively, are located approximately 1.5 miles south-southeast of the Shoshone Pond ACEC (Figure 6-40). Water levels in these wells are currently being monitored continuously by SNWA.

SPR7024M and SPR7024M2 will be used as intermediate monitoring locations between Shoshone Ponds and the SNWA GDP POD to detect and measure the relative change in water level between the future production areas to the south and the Shoshone Ponds wells. The wells also provide information on vertical hydraulic gradient between confined zones of different depths. In Ruling 6164, the NSE found that the positioning of these monitor wells in proximity to Shoshone Ponds and the SNWA GDP POD for permit number 54019 is appropriate, and will provide the data necessary to assure that development of the SNWA GDP permits will not conflict with existing water rights at Shoshone Ponds (NDWR, 2012a, at page 114).

Monitor well 385636114265501 is a shallow basin fill well located 1.5 miles west of the Shoshone Ponds area that provides an intermediate monitoring location between SNWA GDP PODs located on the west side of the Spring Valley and the Shoshone Ponds area (Figure 6-40). As part of the hydrologic monitoring network, groundwater levels in this well are to be measured quarterly.

SNWA will also support NDOW with its annual Pahrump poolfish survey at Shoshone Ponds. SNWA's support will ensure that the survey efforts are conducted on an annual basis for at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley, and will continue as long as SNWA pumps groundwater under the Spring Valley GDP permits. The time frame of five years was selected because it provides a range of variation across years. SNWA will also continue to participate on the Pahrump Poolfish Recovery Implementation Team.

Investigation Trigger and Management Actions

An investigation trigger is established for the Shoshone NDOW Well (or the Shoshone Well #2 if permission to install instrumentation is denied) using a specific uncontrolled flow rate. Use of a statically derived lower control limit, as is used at other sites in the 3M Plan, is not as effective at the Shoshone NDOW Well due to less accurate water level measurements caused by flowing artesian conditions and a control valve that is used to regulate flow. Therefore, the investigation trigger is established as a decrease in artesian flow below 15 gpm with no flow valve restrictions for a continuous period of six months. The 15 gpm discharge rate is approximately 20 percent above the senior water right of 12.4 gpm. The six month time frame allows for physical quarterly measurements to confirm any temporary variation in water level or measurement error.

Activation of the investigation trigger will result in an evaluation to determine the cause and significance of the change using the protocols described in Section 3.2.2. Should the cause of the

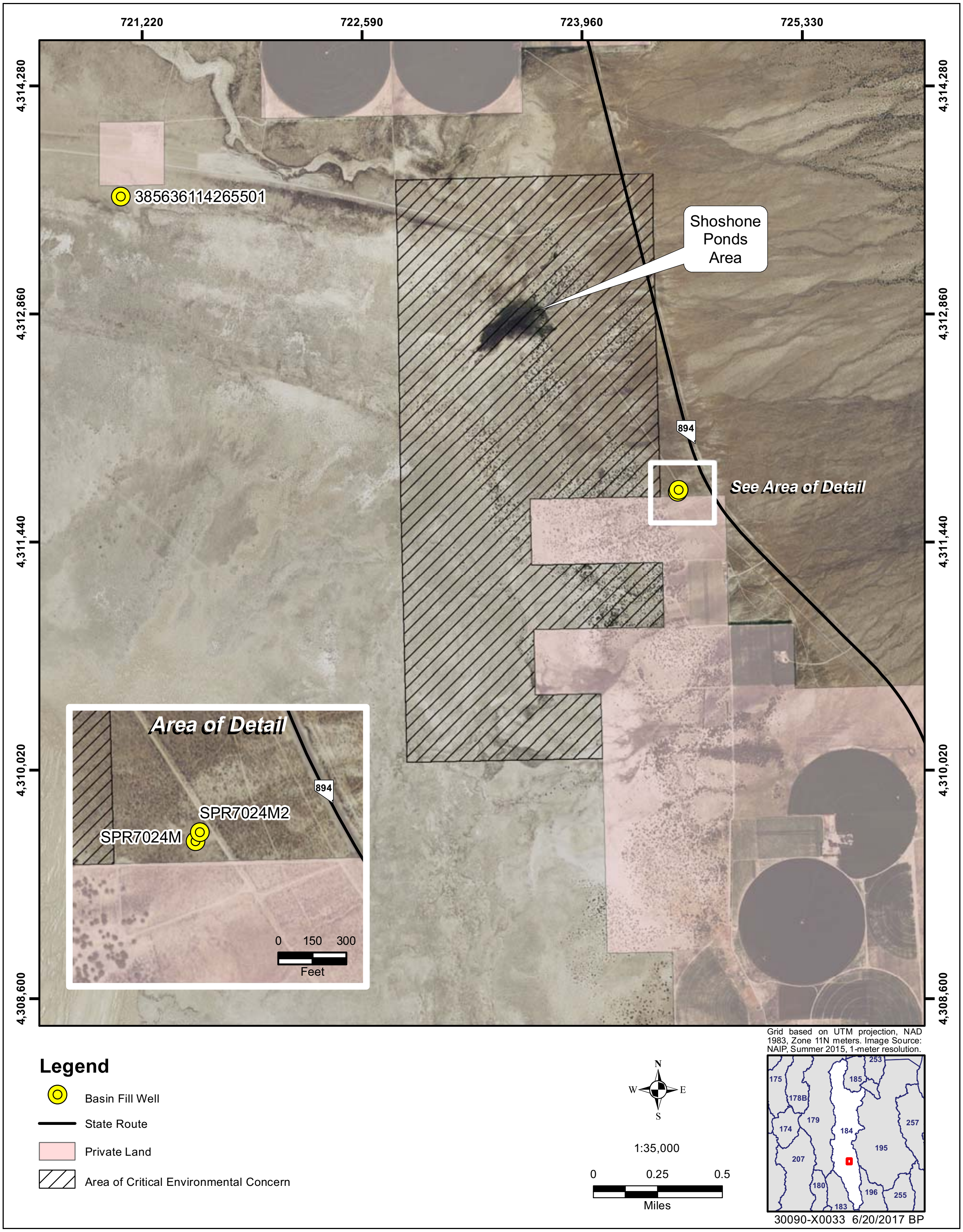


Figure 6-40
Monitor Wells in the Vicinity of Shoshone Ponds

water level change be attributed to SNWA GDP pumping, the following management actions may be taken:

- Prepare the identified mitigation action for implementation, including purchasing equipment, establishing contracts, and obtaining permissions and permits.
- Assist BLM and NDOW and fund habitat management activities at Shoshone Ponds to improve Pahrump poolfish habitat, such as removing encroaching vegetation physically or by targeted grazing. As discussed in Section 6.3.1.3, habitat management is an influential factor on Pahrump poolfish at Shoshone Ponds.
- Assist BLM and NDOW and fund measures to control invasive species in Pahrump poolfish habitat at Shoshone Ponds.While invasive species have not been a major issue at the site, they could become an issue in the future as has occurred in other locations.
- Preemptively implement mitigation actions.

Mitigation Trigger and Mitigation Actions

The mitigation trigger is established as a decrease in artesian flow below 13.5 gpm with no flow valve restrictions for a continuous period of six months. The 13.5 gpm trigger provides a 10 percent buffer above the senior water right of 12.39 gpm and allows time to implement mitigation actions to avoid an unreasonable effect.

Mitigation actions for the senior water right will include at least one of the following:

- Install a pump in the Shoshone NDOW Well to ensure the senior water right can continue to be delivered. The pump will be solar powered to avoid constructing power infrastructure, and the pump setting will be adjusted as needed to maintain the senior right.
- Temporary water can be provided by a water truck, on-site storage or other alternative method until another mitigation action is implemented.
- Rehabilitate the Shoshone NDOW Well to increase well performance.
- Install a new well.
- Convey water from an SNWA water right.
- Modify SNWA GDP pumping duration, rate, or distribution.

In addition to senior water right mitigation, environmental mitigation will be implemented. The environmental mitigation actions will include at least one of the following:

- Collaborate with BLM and NDOW and fund implementation of a habitat enhancement project suitable for Pahrump poolfish reproduction and growth using the senior water right.

- Collaborate with the USFWS and NDOW and fund the establishment of a new Pahrump poolfish refuge population.

As discussed in Section 6.3.1.3, the Pahrump poolfish refuge ponds that are sourced from the senior water right are currently in need of rehabilitation. BLM's SNPLMA habitat enhancement project aims to restructure, rehabilitate, and possibly reconfigure some of the Pahrump poolfish habitats at Shoshone Ponds, including the refuge ponds (BLM, 2014a). As discussed in Section 6.3.1.3, NDOW has responsibility for managing the fish and its habitat and maintaining the Shoshone NDOW Well (the POD for the senior water right); and BLM has responsibility for land management at Shoshone Ponds. This management and other factors external to the SNWA GDP may affect the Pahrump poolfish population and habitat. SNWA's commitment is to avoid a conflict with the senior water right, ensure sufficient water supply is available to support a population of sufficient size to help recover the species, and assist NDOW and BLM with their management efforts.

This mitigation will be effective because (1) it ensures that at least 12.39 gpm of flow will be maintained at Shoshone Ponds; (2) 12.39 gpm is over three times the flow needed to maintain a stable Pahrump poolfish population of sufficient size to help downlist the species; and (3) it enhances the habitat, which has supported a stable Pahrump poolfish population for 20 years.

6.3.2 Mesic Habitat and Native Aquatic-Dependent Special Status Animal Species

6.3.2.1 Overview

Mesic habitat in the Spring Valley groundwater discharge area is composed of spring, seep, pond, wetland/meadow, marsh, and stream components that are often intermixed to form complexes. Mesic habitat is displayed in Figure 6-23 (Section 6.3.1.1) and discussed in Section 5.2. The native aquatic-dependent special status animal species in the Spring Valley groundwater discharge area is the northern leopard frog[1]. Because northern leopard frogs rely on mesic habitat, the habitat and the frogs are considered together in the analysis below.

Approximately half of the mesic habitat in the Spring Valley groundwater discharge area is located in Management Block 3 (4,500 acres, or 7 square miles) (Figure 6-23 in Section 6.3.1.1). As shown in the figures below, the mesic habitat in Management Block 3 is configured in large contiguous areas, with smaller mesic stepping stones in between. The various habitat components mentioned above are present. The concentration of mesic habitat, the extensive north-to-south distribution, and the variety of mesic habitat components support northern leopard frog and a variety of wildlife and provides for dispersion opportunities and seasonal needs. Thus, the strategy to avoid the unreasonable effect of elimination of mesic habitat from the Spring Valley groundwater discharge area focuses on supporting the mesic habitat in Management Block 3.

The mesic habitat in the groundwater discharge area of Management Block 3 is used extensively by northern leopard frogs. Additional wildlife that use this habitat include birds, bats, springsnails, and big game. An SNWA 2008-2010 telemetry study documented widespread sage-grouse use of

1. Northern leopard frog is a Nevada state-protected and Nevada BLM sensitive species (see status designations in Section 5.3).

Management Block 3, including consistent use of ranch lands to meet summer seasonal needs (SNWA, 2013d). SNWA biologists have also observed migratory water fowl and other breeding birds in Management Block 3, including greater sandhill cranes nesting in two of the four land holdings. Furthermore, SNWA biologists have observed that Management Block 3 is a high use area for mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis nelsoni*), and pronghorn antelope (*Antilocapra americana*), and a pronghorn movement corridor passes through it (NDOW, 2007).

Field surveys indicate that Management Block 3 supports multiple northern leopard frog sub-populations, including a large sub-population at the SNWA Robison Ranch McCoy Creek Property (hereafter referred to as McCoy Creek Property). Northern leopard frog observations in Management Block 3 are displayed in Figure 6-41. Documented occurrences span from 2001-2016 (Albrecht et al., 2009; Golden et al., 2007; Hitchcock, 2001; NDOW, 2004; and SNWA, 2009a, 2016c, and 2016g). Of the 4 land holdings in Management Block 3, the McCoy Creek Property has been the most extensively surveyed. Less data are available for the private properties, but the mesic habitat is extensive and suitable for northern leopard frogs, and the species observations are distributed across the Block. Observations of widespread use and breeding activity that span 15 years, and extensive suitable habitat for eggs, tadpoles, juveniles and adults, demonstrate that Management Block 3 supports multiple sub-populations, large numbers, and all life stages of northern leopard frogs. Thus, the strategy to avoid the unreasonable effect of extirpation of native aquatic-dependent special status animal species in the Spring Valley groundwater discharge area focuses on supporting the conservation of mesic habitat that the northern leopard frogs use in Management Block 3.

The mesic habitat in Management Block 3 is maintained by a variety of natural and human-made factors, including stream inflow, spring discharge, surface water runoff, and subsurface inflow from the mountains, shallow groundwater, precipitation, water diversions, well outflow, and irrigation. Various stream systems and springs support the habitat, as shown in Figure 6-42. The streams originate in the Schell Creek Range mountain block and become intermittent or are diverted at the alluvial fan, with the diverted water carried down to the valley floor. The springs daylight at the alluvial fan/valley floor interface (see additional hydrogeologic information in Section 6.2.3). Stream and spring diversions include modified channels (e.g., irrigation canals) and pipelines that distribute the water to irrigate the wetland/meadow areas. The distribution of water for ranching purposes enhances and expands the natural extent of mesic habitat. As shown in Figures 6-1 and 6-42, the majority of existing water rights and land holdings on the valley floor and alluvial fan are privately owned, with the McCoy Creek property and existing water rights in the north owned by SNWA.

Most of the Block 3 mesic habitat (90%) was mapped to the vegetation community level in 2008-2009, as shown in Figure 6-43. This detailed vegetation map was produced by identifying plant communities in the field based on the three most dominant plant species in order of dominance, and mapping them on SNWA 2007 high resolution imagery (McLendon et al., 2011). Each vegetation community was categorized into biomes (wetland, meadow, aquatic, shrubland, woodland, and early seral) based on the two most dominant species and environmental conditions required by the recorded species (McLendon et al., 2011).[1] The majority of the mapped communities in Management Block 3 were categorized as wetland and meadow (60% and 24%, respectively), with aquatic communities (<1%) mixed in (SNWA et al., 2011). A smaller number of communities were categorized as shrubland (15%) or woodland or early seral (<1%), which were also intermixed with the wetland and meadow communities. This digital map provides extensive information about the wildlife habitat in Management Block 3.

The northernmost SNWA GDP POD is approximately three and a half miles south of Management Block 3. As described in Section 6.2.3, in Ruling 6164 the NSE denied the 4 SNWA GDP PODs within and south of Management Block 3 (application numbers 54016, 54017, 54018 and 54021) (NDWR, 2012a, at page 216). The four denied PODs are shown in Figure 6-1 (Section 6.1). Thus, there is a geographic buffer from SNWA GDP PODs and Management Block 3.

The McCoy Creek Property and associated SNWA surface water rights offer substantial integrated resource management opportunities. Approximately 40 percent of the 2,300-acre McCoy Creek Property (930 acres, or 1.5 square miles) is mesic habitat, and an additional 200 acres is irrigated land that is also used by wildlife. The mesic habitat on McCoy Creek Property is characterized by a series of seeps and springs that feed into wet meadows and form pools, ponds, and channels. The property also receives water from McCoy Creek (perennial water conveyed in a pipe from the mountain block) and O'Toole Creek (intermittent water that originates in the mountain block). SNWA has water rights that support the property (permit number 10710, and vested claims V00791 and V01215). As shown in Figure 6-41, the McCoy Creek Property mesic habitat is used extensively by northern leopard frog. Other wildlife that use the property's mesic habitat include greater sage-grouse (SNWA, 2013d), bats, birds, and big game. SNWA biologists have observed that the property is a high use area for mule deer, and a pronghorn movement corridor passes through nearly the entire property (NDOW, 2007).

Northern leopard frogs have been widely documented on the McCoy Creek Property, with all of the life stages (egg, tadpole, juvenile, and adult) represented (SNWA, 2016c and g) (Figure 6-41 above). The various mesic habitat components support the different life stages, with permanent ponds and pools providing egg and tadpole habitat and frog overwintering habitat. Breeding has been documented in most wet areas of the property, including pools, ponds, open marsh, and even calm areas along flowing channels. In 2012, a total of 2,578 egg masses were documented in just two one-day visits to different portions of the property, which may represent the largest concentration of leopard frog egg masses ever reported in Nevada (SNWA, 2016c).

6.3.2.2 Monitoring, Management, and Mitigation

Overview

The approach to avoid elimination of mesic habitat and extirpation of native aquatic-dependent special status animal species from the Spring Valley groundwater discharge area relies on: (1) avoiding unreasonable effects to senior water rights, which support mesic habitat and northern

1. A biome is a large, naturally occurring community of plants and animals occupying a major habitat. Vegetation communities were categorized into biomes. Wetland: area where the soil is saturated for most of the year, but not perennially covered by water, and not dominated by grasses. Meadow (i.e., grassland): area dominated by grasses and not perennially covered by water. Aquatic: area perennially covered by water and often supporting plants. Shrubland: area where shrubs are the dominant species.Woodland: area where trees are the dominant or sub-dominant species. Early seral: area devoid of plant cover or supporting only plants characteristic of early stages of succession. Definitions as in McLendon et al., 2011.

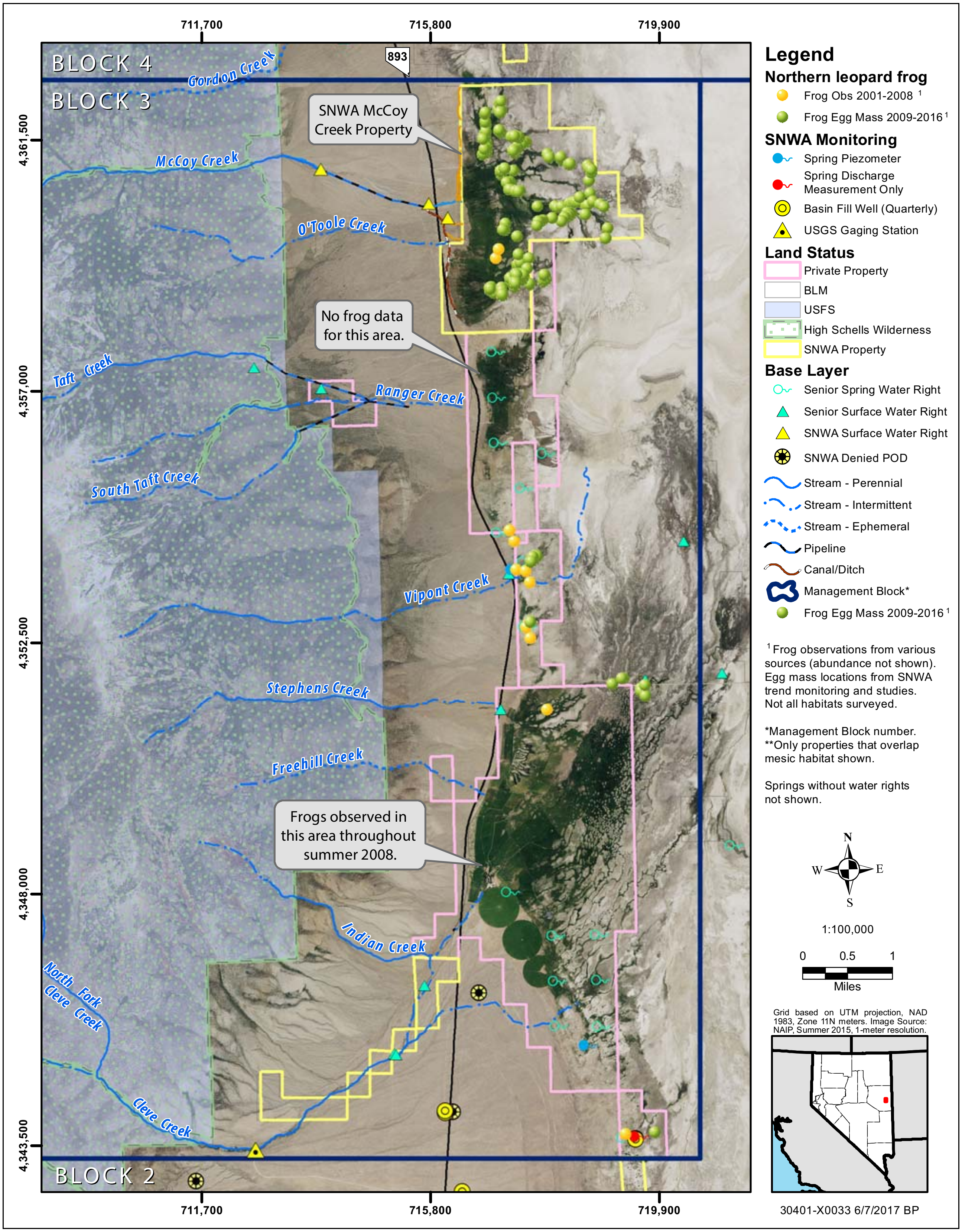


Figure 6-41
Northern Leopard Frog Observations in Management Block 3

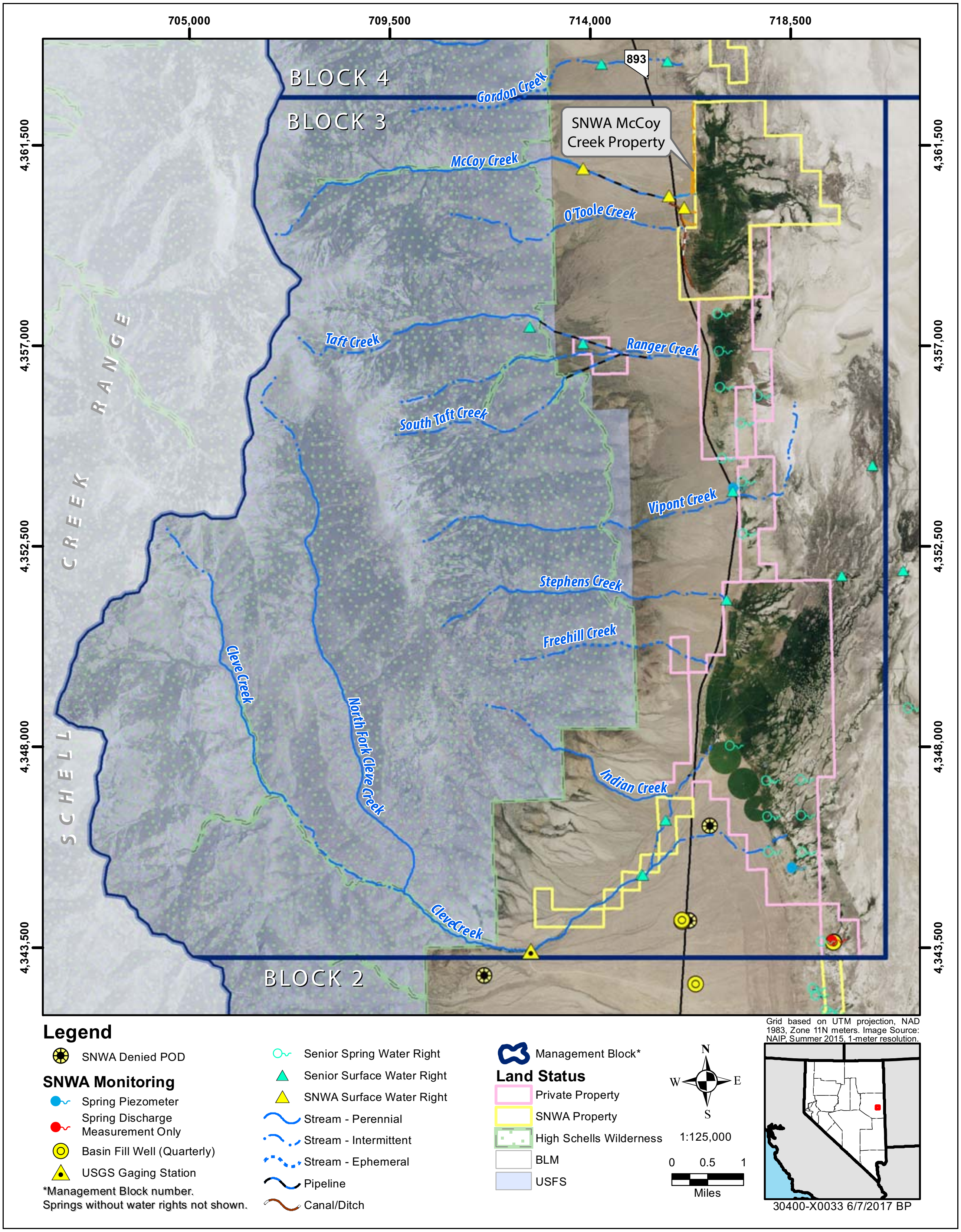


Figure 6-42
Water Sources and Water Rights in Management Block 3

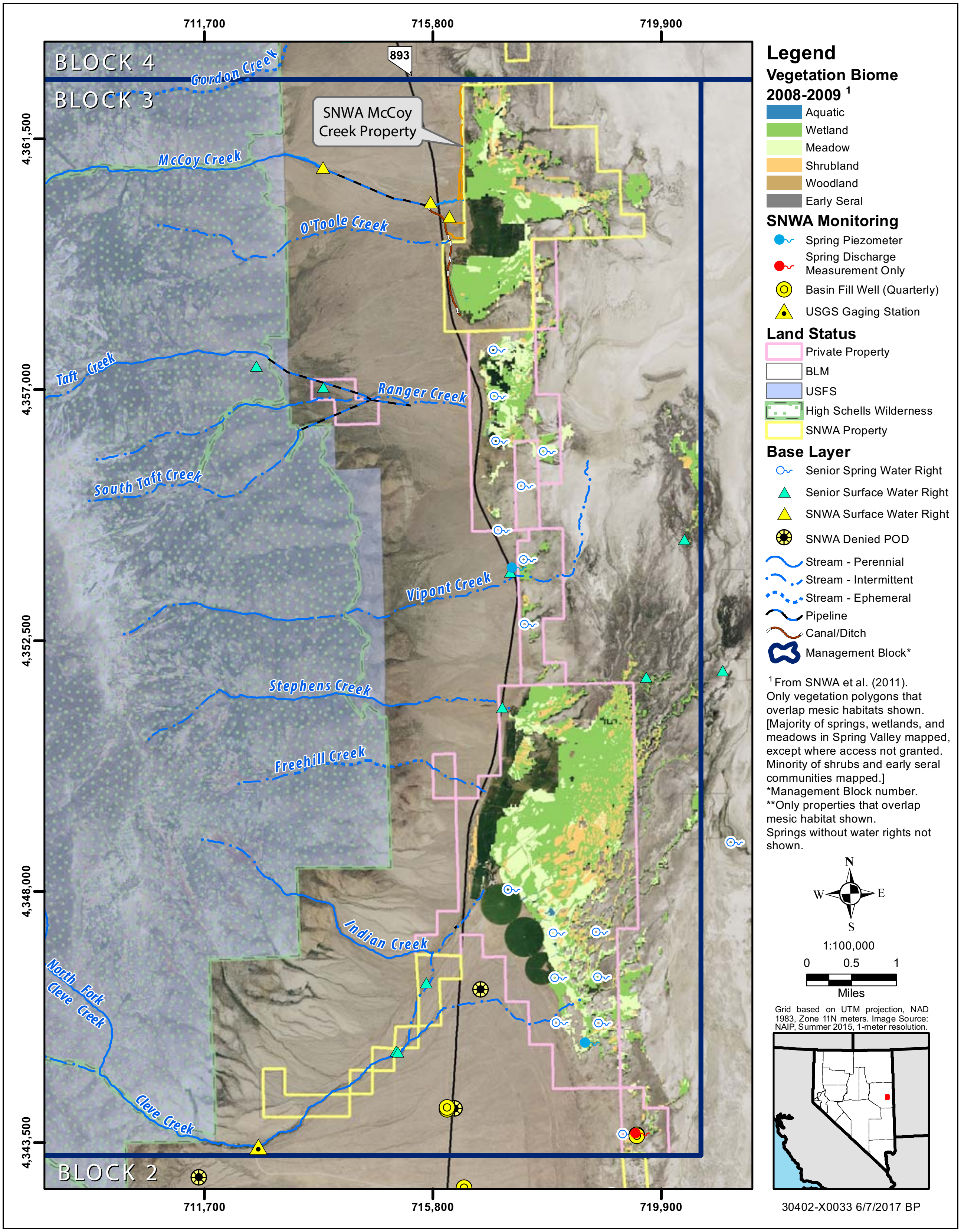


Figure 6-43
Vegetation Biomes and Water Rights in Management Block 3

leopard frogs, and (2) ensuring sufficient mesic habitat is preserved to support a viable, reproducing population of northern leopard frog.

As discussed in 6.3.2.1, the approach focuses on Management Block 3. Senior water rights and SNWA water rights in Management Block 3 support extensive mesic habitat and multiple northern leopard frog subpopulations. As part of this approach, SNWA will also manage the McCoy Creek Property to maintain and/or enhance the mesic habitat for the benefit of northern leopard frog and other wildlife species. These monitoring, management and mitigation actions are discussed below.

As described in detail in Section 6.2, an extensive hydrologic monitoring network, investigation triggers, preemptive management actions, mitigation triggers, and mitigation actions are established to avoid and eliminate conflicts with senior water rights. Given the number and spatial distribution of monitor wells and senior water rights, and the general co-location of senior water rights with environmental resources, protecting senior water rights also helps prevent unreasonable effects to mesic habitat and northern leopard frogs in Spring Valley, including Management Block 3.

Monitoring

Environmental monitoring will be conducted to verify the continued status of mesic habitat and northern leopard frogs on the McCoy Creek Property. The extent of mesic habitat on McCoy Creek Property will be monitored each year using satellite or aerial imagery (see example of imagery in Figure 6-42 above). Springtime images will be used to coincide with the northern leopard frog egg mass surveys. Northern leopard frog egg mass surveys will also be conducted on McCoy Creek Property during the breeding season. Egg mass surveys are a useful method because (1) egg masses are stationary and relatively conspicuous compared to other life stages, making detection easier; and (2) they provide information about frog presence, relative abundance, and reproduction.

Data will be collected for at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley and will continue as long as SNWA pumps groundwater under the Spring Valley GDP permits. Based on northern leopard frog egg mass surveys conducted in Spring Valley between 2009 and 2014, substantial annual variation is expected in northern leopard frog egg masses (SNWA, 2014d and 2016c). The extent of mesic habitat also varies as a result of annual precipitation. The time frame of five years was selected because it provides a range of variation across years.

Northern leopard frog egg mass surveys conducted on the McCoy Creek Property between 2009 and 2013 identified general breeding areas on the property. As stated in SNWA (2016c), extensive surveys conducted in 2011 and 2012 documented breeding in most wet areas of the property, including pools, ponds, open marsh, and even calm areas along flowing channels. However, the largest concentrations of egg masses and most reliable breeding habitat appeared to be at the pools and ponds in the northern and southern portions of the property. These surveys demonstrate that northern leopard frog egg mass surveys can be used to effectively find and document the species on the property. A field reconnaissance prior to monitoring will inform an effective sample design based on ground conditions at that time.

Hydrologic monitoring for senior water rights that support mesic habitat and northern leopard frogs in Management Block 3 is presented in Section 6.2.3. This monitoring includes five sentinel wells to detect and measure propagation of drawdown, which is a key component of the monitoring and management strategy to avoid activating mitigation triggers at the senior water rights listed in Table 6-10. The hydrologic monitoring also includes other monitor wells, spring discharge, and stream flow. Details are presented in Section 6.2.3.

Investigation Triggers and Management Actions

If an investigation trigger at one of the Management Block 3 sentinel wells (SPR7029M, SPR7029M2, SPR7030M, SPR7030M2, or SPR7044; Figure 6-7) is activated due to SNWA GDP pumping as described in Section 6.2.3, the following management actions may be taken:

- Manage the McCoy Creek Property to maintain mesic habitat. Use SNWA water rights to continue to support the mesic habitat on the property (permit number 10710 and vested claims V00791 and V01215). Manage water diversions and grazing operations on the property to reduce stress on the mesic habitat and the northern leopard frog population.

- Preemptively implement the mitigation actions for mesic habitat and northern leopard frog conservation at the McCoy Creek Property.

Additional potential management actions for senior water rights in Management Block 3 are presented in Section 6.2.3. These actions include but are not limited to mitigation preparation and modification of SNWA pumping rates, durations, and/or distribution to avoid activating senior water right mitigation triggers.

Mitigation Triggers and Mitigation Actions

If a mitigation trigger at one of the Management Block 3 senior water rights (Figure 6-7) is activated due to SNWA GDP pumping as described in Section 6.2.3, mitigation actions will be implemented. The mitigation actions will include at least one of the following:

- Enhance mesic habitat on the McCoy Creek Property to improve the quality of the mesic habitat for the benefit of northern leopard frog and other wildlife species. This includes modifying water diversions to enhance habitat composition and distribution, and create a more complex wetland/meadow system for northern leopard frogs.

- Use livestock on the property as a tool focused on management and enhancement of mesic habitat, including northern leopard frog breeding habitat.

- Collaborate with other landowners in Management Block 3 and fund modification of land use or water use to enhance or create mesic and northern leopard frog habitat in other areas.

Additional mitigation actions for senior water rights in Management Block 3 are presented in Section 6.2.3. These actions include but are not limited to lining of Cleve Creek diversion ditches or construction of a diversion pipeline to eliminate loss and allow more water to reach Cleveland Ranch; modification of SNWA pumping rates, durations, and/or distribution; and provision of water.

This mitigation will be effective because (1) it ensures that SNWA GDP pumping will not cause conflicts with the many senior water rights that support mesic habitat and northern leopard frogs in Management Block 3; (2) it ensures that a large, heterogeneous, contiguous block of mesic habitat is preserved within Spring Valley; (3) the habitat is suitable for the various life stages and seasonal needs of northern leopard frogs, and (4) it enhances the habitat, which has supported a viable and successful population of northern leopard frogs for at least the past 15 years. The use of progressive stewardship of working ranchlands as a conservation strategy to benefit ecosystems and species has been studied and successfully implemented (Brunson and Huntsinger, 2008; McMillan, 2015). This mitigation will also ensure habitat is protected for other wildlife species, including greater sage-grouse, other birds, bats, and big game, including mule deer, elk, and pronghorn antelope.

6.3.3 Shrubland Habitat

6.3.3.1 Overview

Approximately 80 percent of the Spring Valley groundwater discharge area is shrubland habitat (140,000 acres) (Figure 6-44). These shrublands include facultative phreatophytic shrub species as well as shrub species that rely solely on precipitation. Facultative phreatophytic shrub species typically use groundwater as a secondary water source after precipitation, but may also exist on sites where groundwater is not available (McLendon, 2011a; and Smith et al., 1997). As stated in McLendon (2011a), the productivity of facultative phreatophytes is increased by access to groundwater, but lack of groundwater within their rooting zones does not, in and of itself, cause widespread plant loss. For this reason, they can be considered groundwater-sensitive species rather than groundwater-dependent species.

Should depth to water increase below the main rooting zone of a phreatophytic shrub, the cover of that shrub may decrease (McLendon, 2011a). Over time, the plant community would likely shift to more drought-tolerant, deeper rooted, and/or non-phreatophytic species (Patten et al., 2008; and McLendon, 2011a). As depth to water increases due to SNWA GDP pumping, shrubland vegetation cover may thus decrease in the short-term, but is expected to stabilize over time.

The exact nature and rate of plant transition will depend on a number of inter-relating factors, such as plant species composition and health, hydrology (including groundwater level), soil types and conditions, topography, animal use, disturbance (e.g., fire/lack of fire, drought, unusually wet periods, insects, and disease), and management actions in the area (Maron and Crone, 2006; Haferkamp, 1987; and Euler, 2009). A declining water table over a long time period can reduce the amount of salt brought to the surface via plant capillary action, causing a transition from salt-tolerant halophytes (such as greasewood (*Sarcobatus vermiculatus*)) to salt-intolerant species (e.g., big sagebrush (*Artemisia tridentata*)) that previously were unable to live under such saline conditions (Patten et al., 2008). If greasewood-dominated shrublands are ultimately replaced by big sagebrush shrublands, an ecological benefit may be realized (e.g., increased vertebrate diversity (Germano and Lawhead, 1986); expanded greater sage-grouse habitat).

However, if groundwater drawdown occurs too rapidly to accommodate a gradual plant transition, excessive loss of shrub cover can result in extensive bare ground, which can lead to soil erosion and

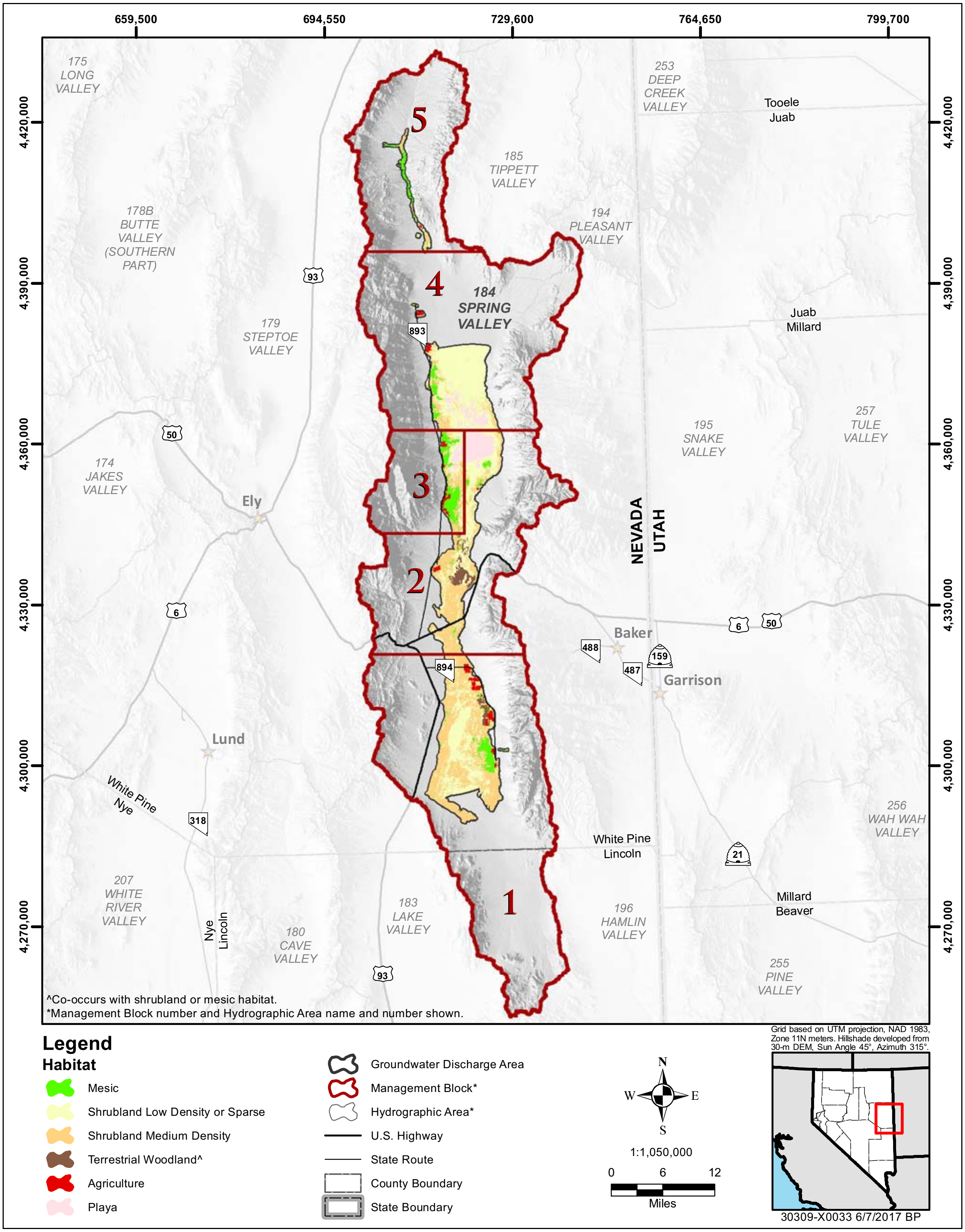


Figure 6-44
Shrublands and Other Habitat Types, Spring Valley

weed expansion[1]. Thus, the purpose of the triggers and management and mitigation actions that are established in this section are to allow for transition in shrubland plant communities while avoiding this unreasonable effect. Management and mitigation actions to avoid and eliminate conflicts with senior water rights (Section 6.2) also helps protect shrublands by attenuating groundwater drawdown and propagation.

The approach to avoid unreasonable effects to shrubland habitat (elimination of shrubland habitat from the Spring Valley groundwater discharge area, and excessive loss of shrub cover that results in extensive bare ground) focuses on Management Blocks 1 and 2 (Figure 6-44). Management Blocks 1 and 2 encompass the permitted SNWA GDP PODs (Figure 6-1 in Section 6.1), so effects would be seen in these blocks first. The threshold triggers, and management and mitigation actions described below identify how the shrubland habitat type will be maintained, and how excessive loss of shrub cover will be avoided.

As discussed in Section 6.3.2, Management Block 3 (shown in Figure 6-44) will be managed for avoiding conflicts with senior water rights and preserving mesic habitat. The senior water rights on the surface waters of Management Block 3 are protected by triggers and management and mitigation actions to avoid senior water conflicts. The SNWA water rights will be used for mitigation on the mesic habitat on the McCoy Creek property. The surface water from stream flow and mountain runoff from the Schell Creek Range infiltrates into the alluvial fan to recharge the groundwater flowing east in Management Block 3. Given the triggers and management and mitigation actions that are already established and the hydrogeology of the area, unreasonable effects to the shrubland habitat in Management Block 3 are unlikely. Thus, Management Block 3 is not included in the shrubland analysis below.

The shrubland habitat in Management Block 4 is over 15 miles from the northernmost permitted Spring Valley GDP POD (Figures 6-1 and 6-44). This distance and the triggers and management and mitigation actions associated with the senior water rights and environmental resources in Management Blocks 1-3 provide a buffer against effects to environmental resources in Management Block 4. Because it is unlikely for SNWA GDP pumping to cause excessive loss of shrub cover in Management Block 4, this Block was not included in the analysis below. Nonetheless, to ensure that unreasonable effects to shrubland habitat are avoided, if an investigation trigger at the West Spring Valley Complex piezometer or South Millick Spring piezometer (Figure 6-19) is activated due to SNWA GDP pumping as described in Section 6.2.4, shrubland monitoring, management, and mitigation will be implemented in Management Block 4 (see discussion in Section 6.3.3.4).

Management Block 5 is over 35 miles from the northernmost permitted Spring Valley GDP POD and contains limited shrubland habitat (Figures 6-1 and 6-44). The triggers, management and mitigation actions associated with the senior water rights and environmental resources in Management Blocks 1-4 provide a large buffer for shrubland habitat in Management Block 5. Furthermore, as discussed in Section 6.2.5, the distance from SNWA GDP PODs, local recharge, and higher elevation and lower basin fill sediment hydraulic conductivity compared the other Management Blocks makes it unlikely that effects from SNWA GDP pumping will occur in Management Block 5. Therefore, no shrubland triggers or management or mitigation actions are established in Management Block 5.

1. The proliferation of weeds is common in the analysis area and may occur regardless of SNWA GWD pumping.

6.3.3.2 Remote Sensing Analysis

Overview and Methods

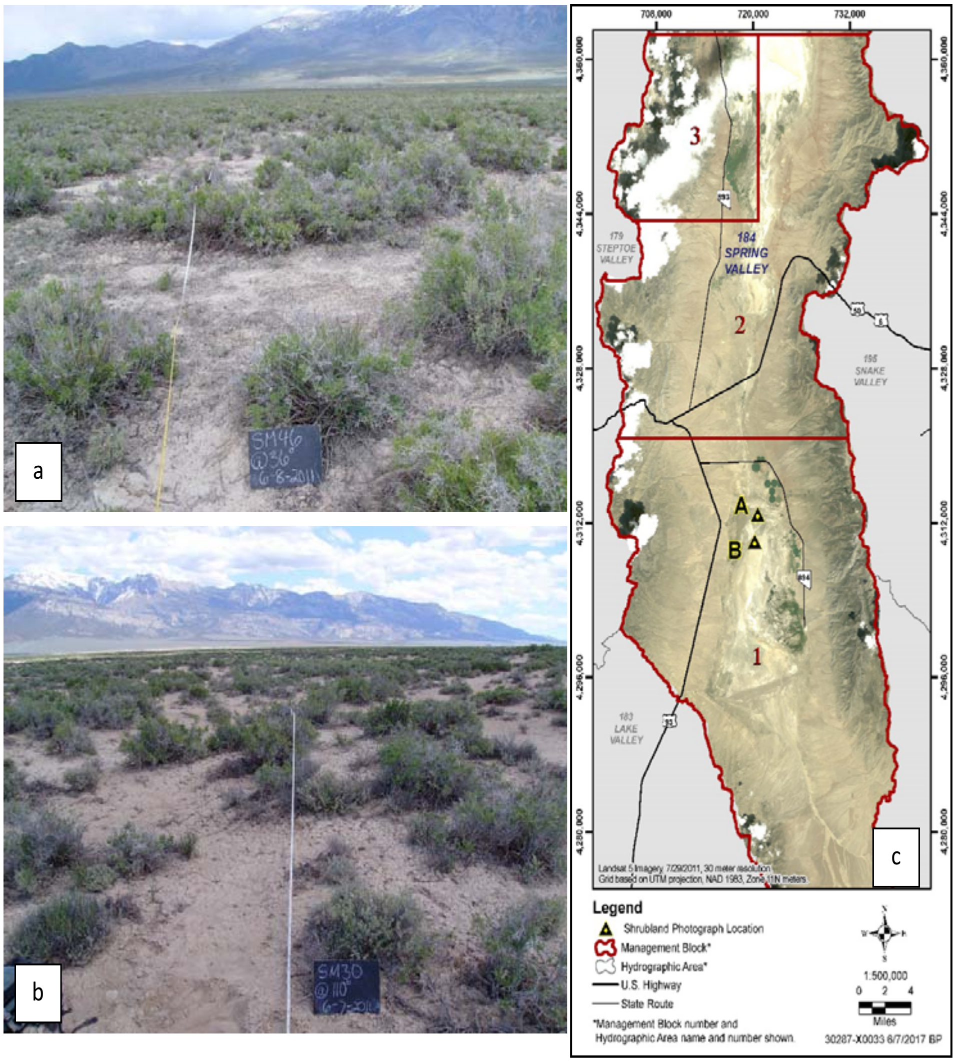
Remote sensing was used to analyze shrubland habitat and quantify investigation and mitigation triggers in Management Blocks 1 and 2. The groundwater discharge area in Management Blocks 1 and 2 encompasses approximately 90,000 acres of shrubland habitat. Approximately 55,000 acres (60%) of that habitat is medium-density shrubland (defined as greater than 20% plant cover), and 35,000 acres (40%) is low-density or sparse shrubland (less than or equal to 20% plant cover) (see land cover classification discussion in Appendix D, D.1.1.1) (Figure 6-44 above). The major advantage of using remote sensing is its landscape scale, which is effective for analyzing and managing these expansive shrublands.

The purpose of the shrubland analysis was to establish triggers and management and mitigation actions to avoid the unreasonable effect of eliminating shrubland habitat from the groundwater discharge area and causing excessive loss of shrub cover that results in extensive bare ground. As discussed below, the analysis focused on medium-density and low-density shrubland habitat. Photographs of medium-density and low-density shrubland are displayed in Figure 6-45.

Thirty-one years of Landsat satellite image data were analyzed (1985-2015). Landsat is a U.S. government satellite program currently run by NASA[1], and it provides the longest continuous record of satellite imagery of Earth's surface. Since 1972, at least one satellite has crossed every point on Earth once every 16-18 days, producing images with every pass. The image data used for the analysis were limited to Landsat 5, 7 and 8 satellites, as the satellite sensors were able to be calibrated to allow reliable comparison over time (Huntington et al., 2016) (Appendix D, D.1.2.2).[2] From 1985-2015, one to two satellites have been active at any time, together acquiring images at a 30-meter resolution every 8-16 days. Landsat data are multi-layered, with each layer representing a different wavelength range on the electromagnetic (light energy) spectrum. Within each of those layers, each image pixel quantifies the wavelengths reflected from features on the Earth's surface, such as plants[3].

Normalized Difference Vegetation Index (NDVI) was used to examine changes in vegetation cover over time. NDVI is a standard remote sensing index derived from satellite or aerial imagery that provides a measure of "greenness" and is a proxy for cover. As discussed in Appendix D, D.1.2.1, NDVI has been shown to outperform other indices in quantifying vegetation cover in arid environments (McGwire et al., 2000; Pettorelli, 2013; and Wu, 2014). NDVI values were computed from the Landsat image data, which had undergone atmospheric correction and been converted to at-surface reflectance (see NDVI computation in Appendix D, D.1.2.2 and NDVI zonal statistics in Appendix D, D.1.2.3). Figure 6-46 below displays Landsat and NDVI images in Management Blocks 1 and 2.

1. Landsat imagery is available on-line at https://landsat.usgs.gov/index.php. U.S. Geological Survey (USGS), Earth Resources and Observation Science Center.
2. Cross-sensor calibration is not as effective prior to Landsat 5. Landsat 5 was active 1984-2013; Landsat 6 failed to reach orbit; Landsat 7 was active from 1999-current; Landsat 8 from 2013-current; Landsat 9 is planned for launch in 2020.
3. Each pixel in the Landsat raster datasets was 30 m x 30 m. A pixel is the smallest unit of information in a raster image (a cell in an array of data values).



a) Medium-density shrubland on the valley floor of south Spring Valley. June 8, 2011. Dominant species: rubber rabbitbrush and black greasewood.
b) Low-density shrubland on the valley floor of south Spring Valley. June 7, 2011. Dominant species: black greasewood.
c) Photograph locations overlaid on July 29, 2011 Landsat imagery.

Clouds and cloud shadows can be seen on the western portion of the map. NDVI data influenced by clouds or cloud shadows were filtered out of the datasets. Annual precipitation was above average in 2011 (Ely, Nevada precipitation gauge, http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nv2631).

Figure 6-45
Medium-Density and Low-Density Shrublands, Spring Valley

The analysis focused on NDVI from July-September of each year. This period is ideal to track groundwater availability to plants across years, as soil water from winter and spring precipitation is reduced and spectral variability tends to be lower (Huntington et al., 2016). Phreatophytic shrubs primarily rely on precipitation-derived soil moisture, and typically only use harder-to-access groundwater when soil moisture declines (usually during summer and early fall) (Huntington et al., 2016; and McLendon, 2011a). Interannual NDVI variability during mid to late summer is primarily a function of interannual precipitation, soil moisture, and shallow groundwater levels (Huntington et al., 2016). Thus, this period minimizes the signal from vegetation that can be highly variable due to seasonal precipitation, and maximizes the relevant signal for tracking annual changes in vegetation in relation to groundwater availability.

Spatially-explicit precipitation data were used in the analysis (see gridMET precipitation extraction in Appendix D, D.1.2.2 and precipitation zonal statistics in Appendix D, D.1.2.3). Annual precipitation was totaled over the water year (October-September), as precipitation in late fall and winter supports plant germination and growth the following spring and summer.

NDVI derived from Landsat data has been shown to be a useful index for jointly analyzing vegetative, climatic, and hydrologic variables at large spatial and temporal scales. Generalized relationships between NDVI and vegetation characteristics (e.g., cover) are well established, as are relationships between NDVI and climatic variables (e.g., precipitation and evapotranspiration) (McGwire et al., 2000; Pettorelli et al., 2005; Devitt et al., 2011; Pettorelli, 2013; Wu, 2014; and Huntington et al., 2016). The Spring Valley hydrologic monitoring network (Section 10.2) provides extensive data to analyze with NDVI. Recent studies have also demonstrated how these variables can be jointly analyzed in the context of groundwater availability and resource management (Huntington et al., 2016). Therefore, analyzing July-September NDVI in conjunction with water-year precipitation (October-September) and hydrologic data (e.g., groundwater level) is an effective way to track change in shrubland habitat over time on a landscape level.

Analyzing NDVI and precipitation has also been shown to be a useful way to assess success of ecological restoration efforts in arid environments (Hausner et al., 2016; and Huntington et al., 2016). For example, in Huntington et al. (2016), an examination of NDVI at two creeks in Nevada showed increased NDVI in relation to restoration efforts that could not be explained by precipitation alone. A similar finding was reported in Hausner et al. (2016), where examination of NDVI at a creek in Oregon showed post-restoration NDVI values above a pre-restoration prediction interval. Therefore, analyzing NDVI in conjunction with precipitation and management and mitigation actions (e.g., SNWA GDP pumping modification, vegetation treatment for mitigation purposes; see Sections 6.3.3.4) will be useful for assessing efficacy of those actions and implementing adaptive management.

The remote sensing analysis was conducted on shrubland polygons (areas) that were digitized in ArcGIS (Figure 6-46). Two groups of polygons were delineated for the main analysis: medium-density shrubland polygons (totaling approximately 28,000 acres) and low-density shrubland polygons (totaling approximately 12,000 acres). As discussed in Appendix D, D.1.1.1, the purpose of using the polygons was two-fold: (1) to provide sample groups that characterized and sampled the shrubland habitat on a landscape scale, and (2) to enable a data-rich remote sensing analysis. The polygons were delineated based on an SNWA (2007) land cover map presented in the

2011 water rights hearing (Burns and Drici, 2011, at Figure 5-1) that was converted to a habitat map for the purposes of this report. A few sparse shrubland and bare ground polygons were also delineated to provide context for the NDVI values. The methods used to delineate the polygons are described in Appendix D, D.1.1.1.

Remote-sensing plots were delineated within the medium-density and low-density shrubland polygons (Figure 6-46). As described in Appendix D, D.1.1.2, the plots were located in the polygons using a proportionate stratified random design. These plots provide additional opportunities for statistical analysis and a framework for the ground vegetation transect design (Sections 6.3.3.3).

The analysis focused on the relationship between NDVI and precipitation from 1985-2015. Mean annual NDVI and precipitation was calculated for each shrubland habitat group using the methods in Appendix D, D.1.3. Statistical differences in NDVI among the habitat groups were examined. Computations and significance tests are described in Appendix D, D.1.3.

Prediction intervals were calculated for medium-density and low-density shrubland polygons and plots. The upper and lower control limits were calculated by performing a least squares linear regression on mean annual NDVI and precipitation values for each habitat group using a 95 percent confidence level (see methods in Appendix D, D.1.3). A prediction interval is a statistical estimate of an interval in which future observations will fall, with a certain probability, given what has already been observed (Meeker et al., 2017; and Hyndman and Athanasopoulos, 2014). In this case, prediction intervals provided ranges of mean NDVI values expected for medium- and low-density shrubland habitat across a range of precipitation levels if no significant changes occur from baseline. The prediction intervals for the shrubland polygons were used to establish investigation and mitigation triggers (Section 6.3.3.4).

Results and Discussion

Medium-density shrubland, low-density shrubland, sparse shrubland, and bare ground each exhibited significantly different mean NDVI (Figure 6-47).

Mean NDVI values for medium-density shrubland polygons were significantly greater than those for low-density shrubland polygons (mean NDVI across 1985-2015: medium-density shrubland = 0.177 [SE = 0.003], low-density shrubland = 0.120 [SE = 0.002]; p-value <0.001)[1]. The low-density shrubland polygons averaged approximately 25 percent lower mean NDVI than the medium-density shrubland polygons on a consistent basis across the 31-year baseline period (see Figure 6-48 time series line graph below). This consistent difference demonstrates the accuracy of the SNWA (2007) land cover map and the utility of splitting the shrubland polygons into the two habitat groups, and provides a reliable baseline for detecting change over time. The 31-year baseline also encompassed a range of variation across wet and dry periods, providing a good predictor of future conditions. The relationship between NDVI and precipitation was statistically significant for both medium-density

1. 1.Mean NDVI calculated using values weighted by polygon size (Appendix D, D.1.3). SE = standard error of the sample mean. P-value reflects statistical difference calculated with linear mixed model Type III test of fixed effects and Tukey's honest significant difference test (Appendix D, D.1.3). Shapiro-Wilks tests confirmed normality.

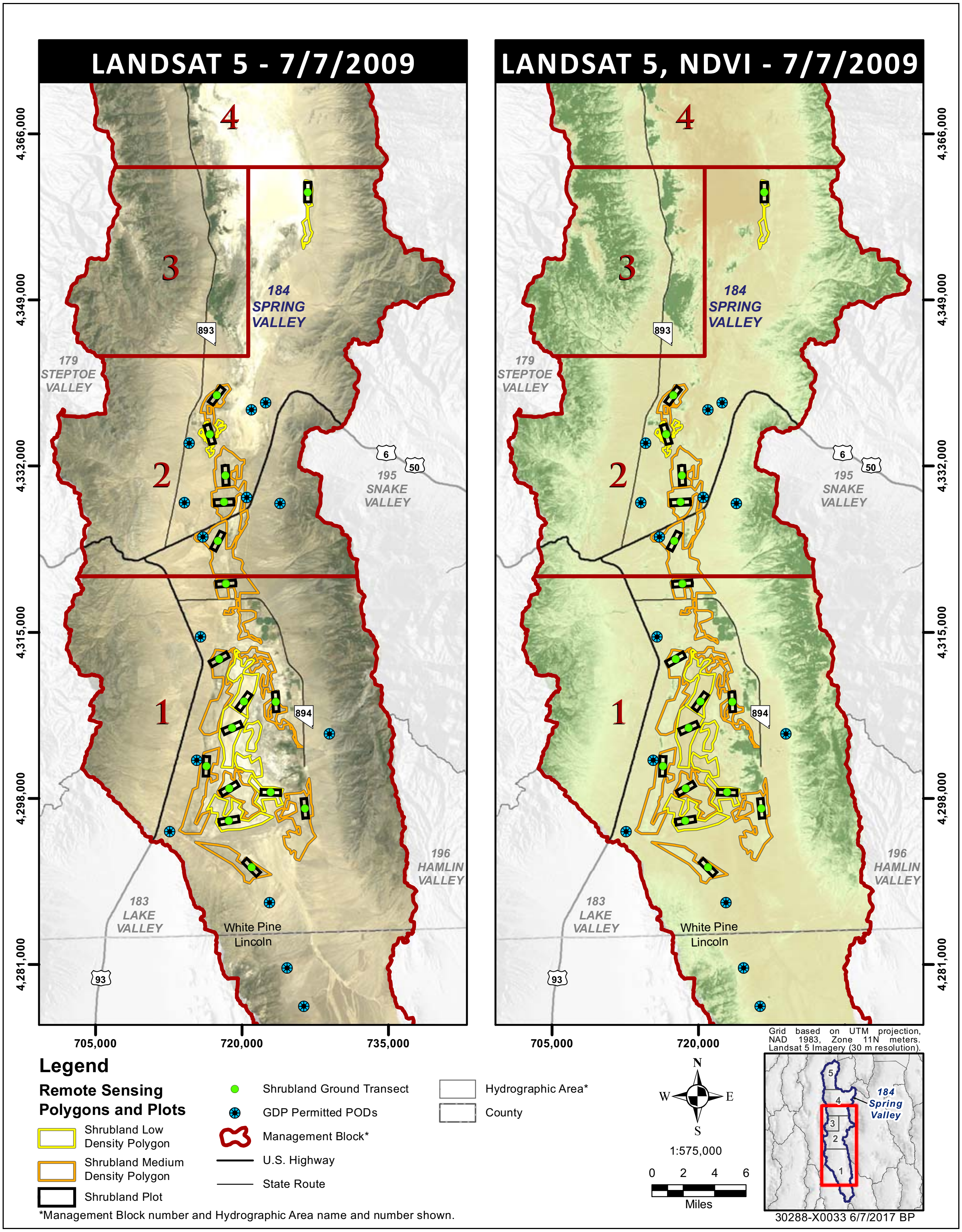
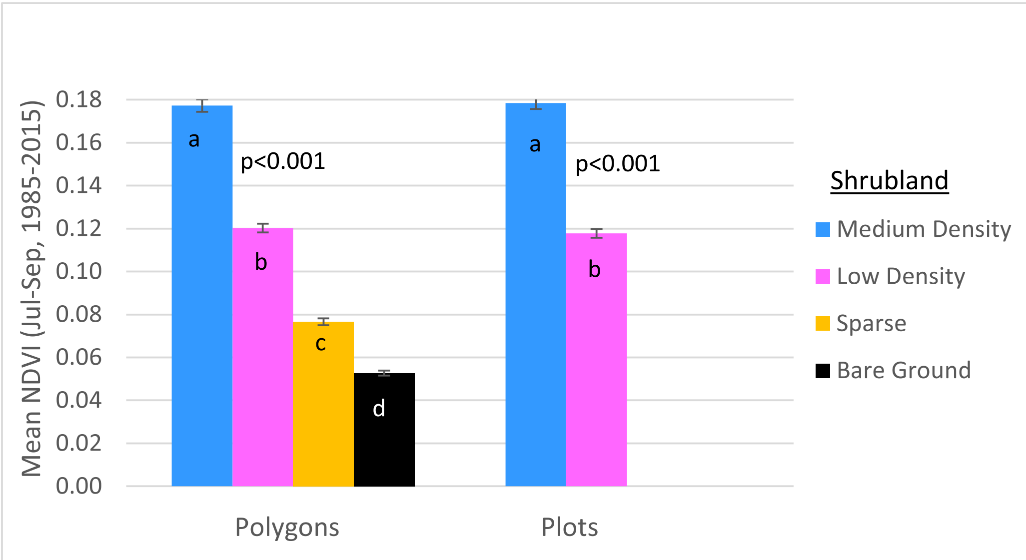


Figure 6-46
Landsat and NDVI Images with Shrubland Sampling Design, Blocks 1 and 2



Bar graph of mean NDVI (July-September, 1985-2015) for medium-density shrubland, low-density shrubland, sparse shrubland, and bare ground. Brackets depict standard error. P-values denote significant overall difference among habitats (linear mixed model Type III test for fixed effects). Letters denote significant difference between habitats (Tukey's HSD test, polygons and plots analyzed separately).

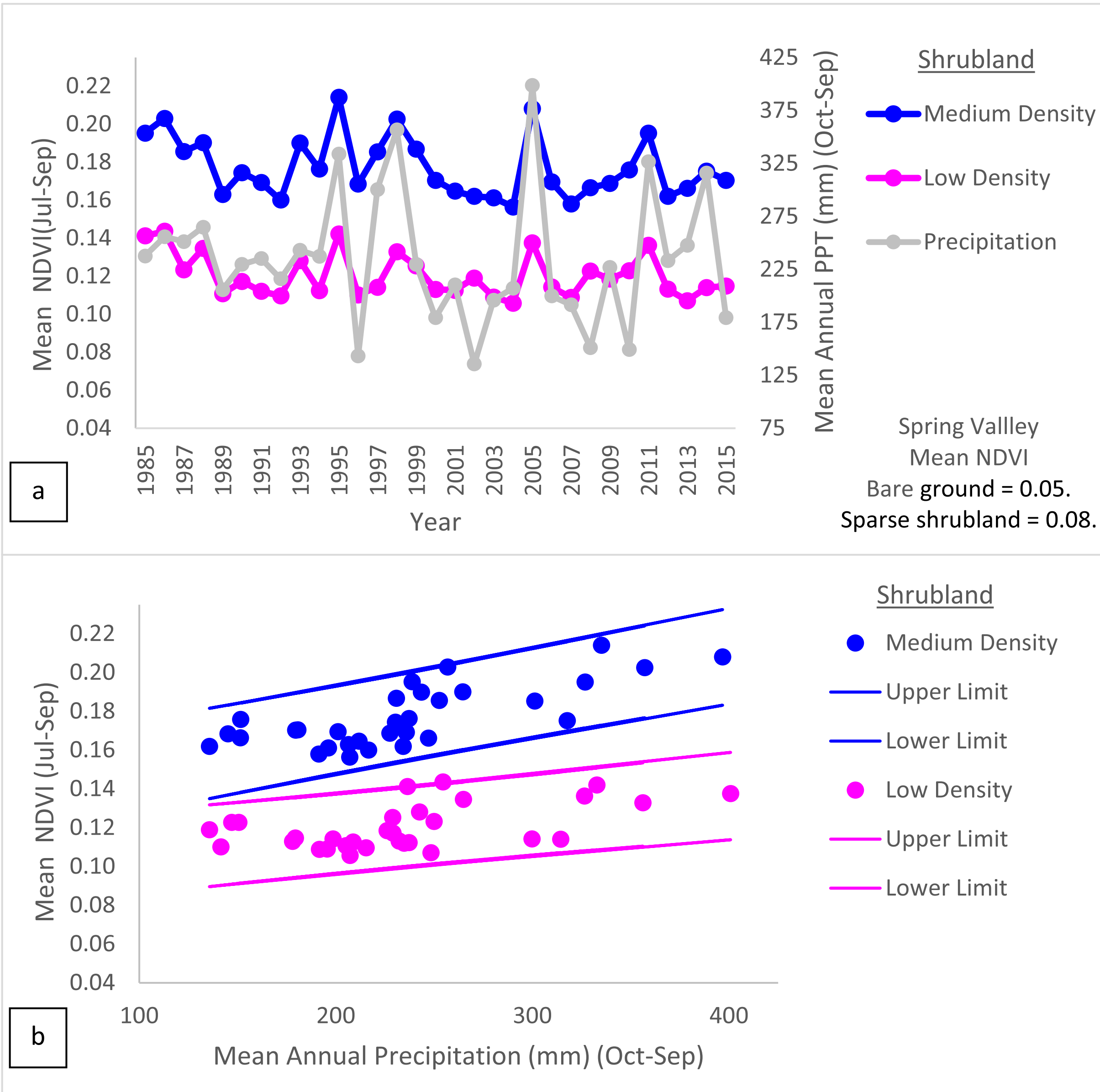
Figure 6-47
NDVI Comparisons Among Shrubland Habitats, Management Blocks 1 and 2

and low-density shrubland polygon groups (p-values < 0.005). The prediction intervals for the polygon groups are presented in Figure 6-48.

Results from the remote sensing plot data were similar to the polygon data, demonstrating that the plots were representative of the polygons and of the region (see Figure 6-47 above and Figure 6-49 below). Mean NDVI values for medium-density shrubland plots were significantly greater than those for low-density shrubland plots (mean NDVI across 1985-2015: medium-density shrubland = 0.178 [SE = 0.003], low-density shrubland = 0.118 [SE = 0.002]; p-value <0.001).[1] As with the polygons, the low-density shrubland plots averaged approximately 25 percent lower mean NDVI than the medium-density shrubland plots on a consistent basis across the 31-year baseline period (Figure 6-49 time series line graph). The relationship between NDVI and precipitation was statistically significant for both medium-density and low-density shrubland plot groups (p-values < 0.001). The prediction intervals for the plots were similar to those of the polygons (Figure 6-49).

These results demonstrated that the polygons (which sample the habitat on a landscape scale) and the plots (which subsample the habitat in a structured statistical design) both provide effective ways of tracking change in NDVI over time, and that they can be analyzed separately and in conjunction with one another. As described in Section 6.3.3.4, the polygon data are used to establish triggers and signal

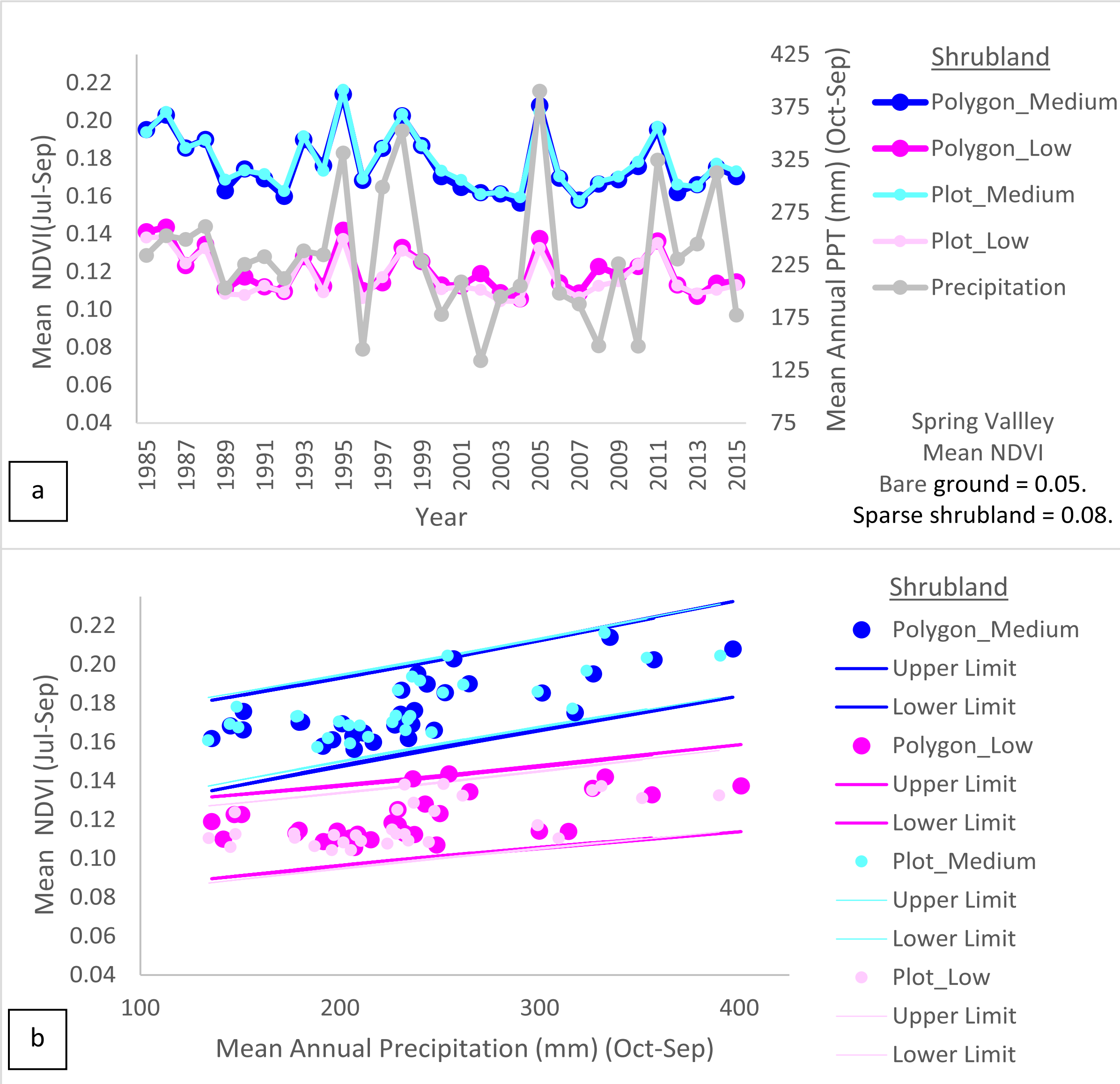
1. P-value reflects statistical difference calculated with linear mixed model Type III test of fixed effects and Tukey's honest significant difference test (Appendix D, D.1.3). Shapiro-Wilks tests confirmed normality.



a) Time-series line graph of mean annual NDVI and precipitation for medium-density and low-density shrubland polygons, 1985-2015.

b) Prediction interval for mean annual NDVI and precipitation for medium-density and low-density shrubland polygons. Data points are the same as those shown in graph (a). Lines display upper and lower control limits of the prediction intervals (95% confidence level).

Figure 6-48
Time Series and Prediction Intervals for NDVI and Precipitation in Shrubland Polygons, Management Blocks 1 and 2



a) Time-series line graph of mean annual NDVI and precipitation for medium-density and low-density shrubland plots, 1985-2015. Overlaid on polygon data.

b) Prediction interval for mean annual NDVI and precipitation for medium-density and low-density shrubland plots. Data points are the same as those shown in graph (a). Lines display upper and lower control limits of the prediction intervals (95% confidence level). Overlaid on polygon data.

Figure 6-49
Time Series and Prediction Intervals for NDVI and Precipitation in Shrubland Plots, Management Blocks 1 and 2

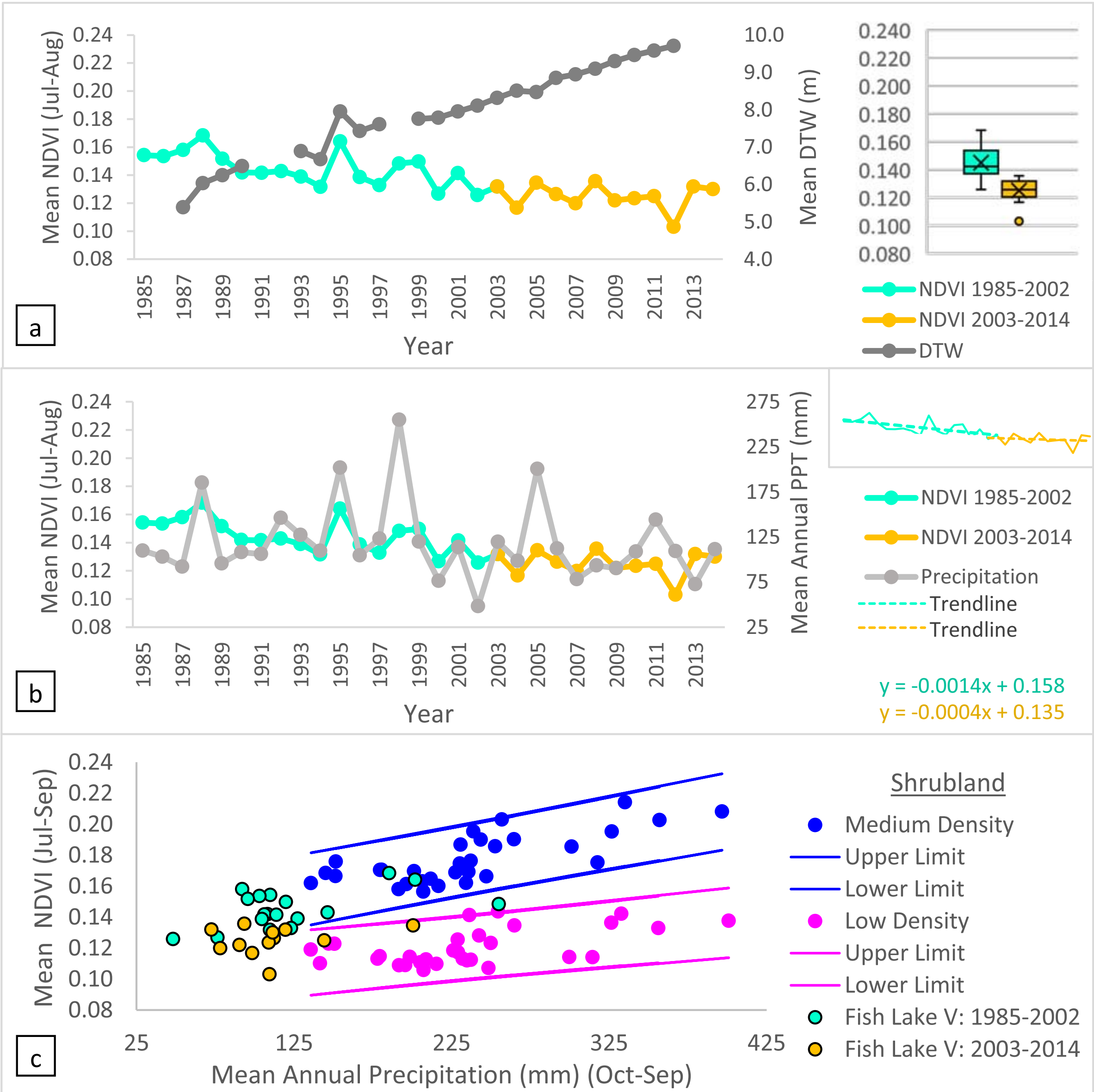
trigger activation, and the plots provide additional opportunities for statistical analysis during investigations.

Application of data from recent case studies demonstrate how prediction intervals will be effective in identifying and tracking changes in shrubland habitat. In Huntington et al. (2016), summer mean NDVI was derived from 30 years of Landsat data (1985-2014) at a shrubland site in Fish Lake Valley (southwest Nevada) that originally had a shallow groundwater level. According to Huntington et al. (2016), groundwater levels have steadily decreased at this site since 1979, presumably due to nearby groundwater pumping for irrigation. Figure 6-50 (a) depicts the increase in depth to groundwater from 1985-2014, with a corresponding decrease in NDVI from 1985-2002 followed by NDVI stabilization from 2003-2014. The box plots in inset (a) depict the greater spread of data during the transition period from 1985-2002. Figure 6-50 (b) places NDVI in the context of precipitation, which had a slight negative trend from 1985-2014; this is compared to the statistically significant negative slope of NDVI from 1985-2002, followed by a slight negative trend from 2003-2014, as shown in inset (b). Together, this evidence indicates that declining groundwater level was likely a causal factor for the reduction in NDVI, but that shrub cover stabilized over time. Figure 6-50 (c) overlays the Fish Lake Valley data on the Spring Valley medium-density and low-density shrubland polygon 95 percent prediction intervals from Figure 6-48 (above)[1]. Most of the 1985-2002 Fish Lake Valley data fall within the Spring Vally medium-density shrubland prediction interval, with values declining as time progresses. Once NDVI stabilizes (2003-2014), the Fish Lake Valley data largely fall within the upper portion of the Spring Vally low-density shrubland prediction interval. In another example, Hausner et al. (2016), post-restoration vegetation differences were evident when overlaying post-restoration NDVI and precipitation data on pre-restoration prediction intervals. These case studies demonstrate the utility of using prediction intervals to establish triggers and track changes in shrubland habitat over time.

6.3.3.3 Ground Vegetation Transects

Ground vegetation transect data will also be used to analyze shrubland habitat and quantify investigation and mitigation triggers. As stated in Section 6.3.3.2, the major advantage of using remote sensing is its landscape scale, which is effective for analyzing and managing the expansive shrublands in Spring Valley. However, current remote sensing technologies are limited in their ability to provide detailed information (e.g., plant composition). The major advantage of using ground vegetation data is the level of detail that the data provide. However, ground vegetation data are limited in the amount of area that can be reasonably sampled, and the data have to be extrapolated to the larger landscape scale. Therefore, both remotely sensed data and ground vegetation data will be used in a complimentary manner to provide information about both landscape-scale shrubland habitat changes and the nature of those changes.

1. Baseline data were not available to develop prediction intervals for Fish Lake Valley (groundwater declines began prior to 1985); thus, Spring Valley prediction intervals were used as a proxy. Although Fish Lake Valley is different than Spring Valley, the shrubland habitat at the case study site is reasonably comparable for demonstration purposes. Huntington et al.[2016] classified the site as alkali shrub with greasewood and saltgrass, and the NDVI and precipitation data fell largely within the extrapolated Spring Valley prediction intervals as would be expected for a drier climate.



a) Time-series line graph of mean annual NDVI and depth to water (DTW), Fish Lake Valley shrubland/meadow, 1985-2014. Inset shows NDVI box plots (brackets = max/min, box = upper-lower quartile (middle 50% of data), line = median, X = mean, point = outlier).

b) Time-series line graph of mean annual NDVI and precipitation (PPT, Oct-Sep), Fish Lake Valley shrubland/meadow. Inset shows NDVI trendlines.

c) Fish Lake Valley mean annual NDVI vs precipitation overlaid on prediction intervals for Spring Valley medium-density and low-density shrubland polygons.

Figures (a) and (b) adapted from Huntington et al. (2016).

Figure 6-50
NDVI and Precipitation, Fish Lake Valley, Nevada

Ground transect data will help distinguish the reason for reduced NDVI (e.g., excessive herbivory, smaller plant stature, plant succession, or mortality). It will also help distinguish whether stabilized or increased NDVI is due to a successful transition of acceptable species or propagation of noxious or invasive weeds over large areas. Furthermore, it will help identify in-coming or germinating plants that may have lower contributions to NDVI due to plant size or physiology, but signify a shift in species composition and a successful transition process.

As with the NDVI data, ground vegetation transect data collection and analysis will focus on the summer season. As discussed in Section 6.3.3.2, this timing minimizes the signal from vegetation that can be highly variable due to seasonal precipitation, and maximizes the relevant signal for tracking annual changes in vegetation in relation to groundwater availability. This timing also best enables joint analysis of the NDVI and ground vegetation data, as it won't complicate the interpretation with seasonal differences.

The transects are located in the center of the remote sensing plots, as shown in Figure 6-46 (above). The remote sensing plots, which were randomly stratified within the medium- and low-density shrubland polygons (Appendix D, D.1.1.2), provided a statistical framework for the ground transect design. Data collection will include cover and composition and gap intercept data, as summarized in 6.3.3.4 and detailed in the Spring Valley 3M Plan (SNWA, 2017e).

6.3.3.4 Monitoring, Management, and Mitigation

The triggers and management and mitigation actions described below allow for successful transition in shrubland plant communities (as discussed in Section 6.3.3.1), including shrub transition from medium- to low-density shrubland. Low-density shrubland is expansive in Spring Valley and common in the Great Basin Desert, as indicated in Figure 6-44 (in Section 6.3.3.1) and the SNWA (2007) land cover map (SNWA, 2009b, at Figure 7-1). The remote sensing analysis presented in Section 6.3.3.2 showed that low-density shrubland in Management Blocks 1 and 2 maintained itself for the past 31 years, indicating that it is not a landscape on the verge of changing to extensive bare ground. As shown in the photographs in Figure 6-45 (above), "low density" is a relative term, and shrub cover remains present and regular in these areas.

Monitoring

NDVI data will be derived from Landsat satellite image data every year. Data analysis will be limited to the July-September time frame to minimize the signal from vegetation that can be highly variable due to seasonal precipitation, and maximize the relevant signal for tracking annual changes in vegetation in relation to groundwater availability. Landsat data will be cross-calibrated, NDVI and precipitation data will be computed, and NDVI and precipitation zonal statistics will be calculated using the methods described in Appendix D, D.1.2. Mean annual NDVI and precipitation will be calculated for each habitat group (medium-density shrubland, low-density shrubland) using the methods described in Appendix D, D.1.3.

Ground vegetation transect data will also be collected every year. The surveys will be conducted during summer (August) to coincide with the remotely sensed NDVI data. Data will be collected for at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley and will continue as long as SNWA pumps groundwater under the Spring Valley GDP permits. The time frame of five years was selected because it provides a range of variation across years with varying precipitation levels.

One vegetation transect is located in the center of each remote sensing plot, as shown in Figure 6-46 above. As described in Section 6.3.3.2 and Appendix D, D.1.1.2, remote sensing plots were randomly stratified within the medium- and low-density shrubland polygons, providing a statistical framework for the ground transect design. A ground-truthing exercise and updated remote-sensing analysis will be conducted prior to initiating monitoring in order to confirm remote sensing polygon and plot and ground vegetation transect configurations. For annual monitoring, cover and composition and gap-intercept data will be collected along the transects, and a photograph will be taken. Mean annual percent live shrub cover will be calculated for each habitat group (medium-density and low-density shrubland).

Prior to SNWA GDP groundwater withdrawal from Spring Valley, mean annual NDVI, percent live shrub cover, and precipitation will calculated using the entire baseline dataset to derive prediction intervals for each habitat group (medium-density and low-density shrubland). The prediction intervals will be calculated by performing a least squares linear regression with a 95 percent confidence level, as shown in Figure 6-48 and described in Appendix D, D.1.3. Prediction intervals for NDVI will be calculated using the NDVI and precipitation data from the remote sensing polygons. Prediction intervals for percent live shrub cover will be calculated using the live shrub cover data from the ground vegetation transects, and precipitation data from the remote sensing polygons where the transects are located. Once SNWA GDP pumping begins, the mean annual NDVI and precipitation values for each habitat group will be overlaid on the baseline prediction intervals. The data points will be compared to the lower control limits of the prediction intervals to signal trigger activation, as described below.

To expand the hydrologic monitoring network in shrubland habitat six additional piezometers were located in the monitored shrubland areas (four in Management Block 1 and two in Management Block 2) (Figure 6-52 below). The piezometers were spatially distributed across the medium-density and low-density shrubland plots, taking the hydrologic monitoring network into consideration. These locations will be confirmed along with the polygons, plots, and transects after conducting the ground-truthing exercise and updated remote-sensing analysis discussed above. The piezometers will be installed to a depth of up to 50 ft, depending on hydrogeologic conditions encountered, to provide information about the depth to water within the rooting zones of the phreatophytic shrubs.[1] Data will be collected from the piezometers for at least five years prior to SNWA groundwater withdrawal from Spring Valley and will continue as long as SNWA pumps groundwater under the Spring Valley GDP permits, to coincide with the ground vegetation transect monitoring. These data will be collected on at least a quarterly basis, on the same schedule as other GDP monitoring wells in the basin.

As discussed in Section 6.3.3.1, due to distance from the permitted SNWA GDP PODs and the triggers and management and mitigation actions associated with the senior water rights and environmental resources in Management Blocks 1-3, it is unlikely that SNWA GDP pumping would

1. Maximum rooting depth of facultative phreatophytes in the region is approximately 50 ft (BLM, 2012a, at page 3.5-13; McLendon, 2011a).

cause excessive loss of shrub cover in Management Block 4. Nonetheless, to ensure that unreasonable effects to shrubland habitat are avoided, if an investigation trigger at the West Spring Valley Complex piezometer or South Millick Spring piezometer (Figure 6-19) is activated due to SNWA GDP pumping as described in Section 6.2.4, shrubland monitoring will be initiated in the groundwater discharge area of Management Block 4.

To initiate shrubland monitoring in Management Block 4, a ground-truthing exercise and remote-sensing analysis would be conducted to establish remote sensing polygons and plots, ground vegetation transects, and piezometers using the same methods as for Management Blocks 1 and 2. Data collection methods would be the same as in Management Blocks 1 and 2. Mean annual NDVI and percent live shrub cover would also be calculated and plotted against the mean annual precipitation using the methods as described for Management Blocks 1 and 2. These data points would be overlaid on the baseline prediction intervals calculated for Management Blocks 1 and 2 prior to SNWA GDP groundwater withdrawal. Alternatively, if the data demonstrate that drawdown propagation to the monitored areas has not occurred and the NSE approves, the data points may be overlaid on baseline prediction intervals calculated specifically for Management Block 4 using monitoring data acquired during the years prior to drawdown propagation reaching Management Block 4. The data points would be compared to the 95 percent lower control limit of the prediction interval to signal trigger activation, as described for Management Blocks 1 and 2.

Investigation Triggers and Management Actions

The threshold for shrubland habitat is established as the low-density shrubland baseline vegetation cover. Trigger parameters include remotely-sensed and ground vegetation parameters: NDVI (derived from Landsat imagery), and percent live shrub cover (recorded on ground vegetation transects). As discussed in Section 6.3.3.3, these data types together provide information about landscape-scale shrubland habitat changes and the nature of those changes.

Quantitative trigger levels are the lower control limits of prediction intervals (Figure 6-51). The prediction intervals are calculated using baseline data from remote sensing polygons and ground vegetation transects in medium-density and low-density shrubland habitat in Management Blocks 1 and 2. The upper and lower control limits are calculated by performing a least squares linear regression on mean annual NDVI v. mean annual precipitation for each polygon habitat group (as shown in Figure 6-48 above), and on mean annual percent live shrub cover v. mean annual precipitation values for each transect/plot habitat group, using a 95 percent confidence level (see methods in Appendix D, D.1.3). The prediction intervals will be re-calculated using the entire baseline period (from 1985 to the initiation of SNWA GDP groundwater withdrawal from Spring Valley) following the methods in Appendix D, D.1.2 and D.1.3.

An investigation trigger is activated if:

- mean annual NDVI for either habitat group (medium-density shrubland, low-density shrubland) falls below the medium-density or low-density shrubland 95 percent lower control limit for NDVI, or

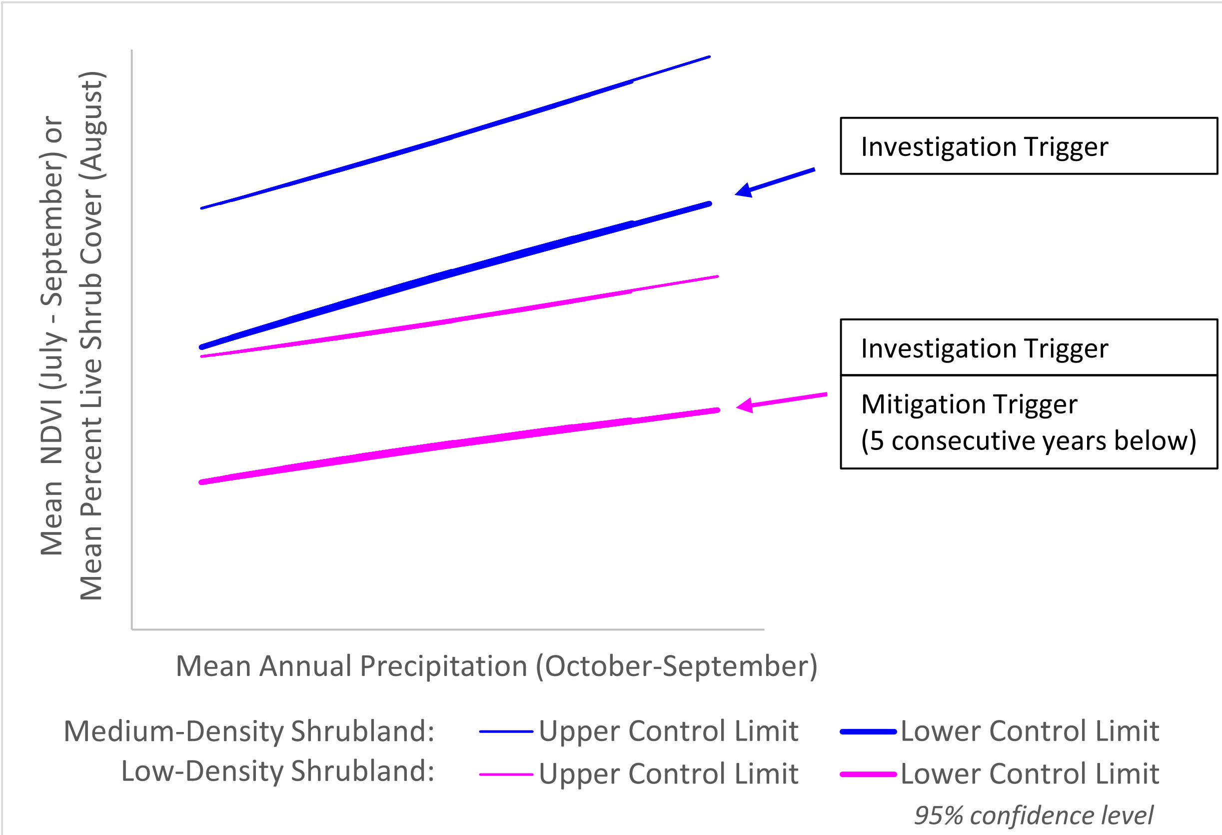


Figure 6-51
Diagram of Shrubland Prediction Intervals and Triggers

- mean percent live shrub cover for either habitat group falls below the medium-density or low-density shrubland 95 percent lower control limit for percent live shrub cover.

Activation of an investigation trigger will result in investigation actions using the protocols described in Section 3.2.2 to determine cause, condition, and significance of observed changes, and to inform management and mitigation actions. Investigation actions will include but are not limited to: analyses of remotely-sensed vegetation data and ground vegetation data to understand the nature of the vegetation changes; analyses of hydrologic data (e.g., groundwater level) and SNWA pumping data to understand the groundwater drawdown propagation; analyses regarding the effects of precipitation and other climatic factors on the vegetation; and analyses of vegetation and hydrologic data to determine if vegetation changes may be due to changes in groundwater availability. Figure 6-52 shows the shrubland sampling design overlaid with the hydrologic monitoring network, indicating the comprehensive nature of the data that will be analyzed in the event an investigation trigger is activated.

If the investigation trigger is activated, in addition to the management actions identified for senior water rights in Sections 6.2.1 and 6.2.2, the following management actions may be taken:

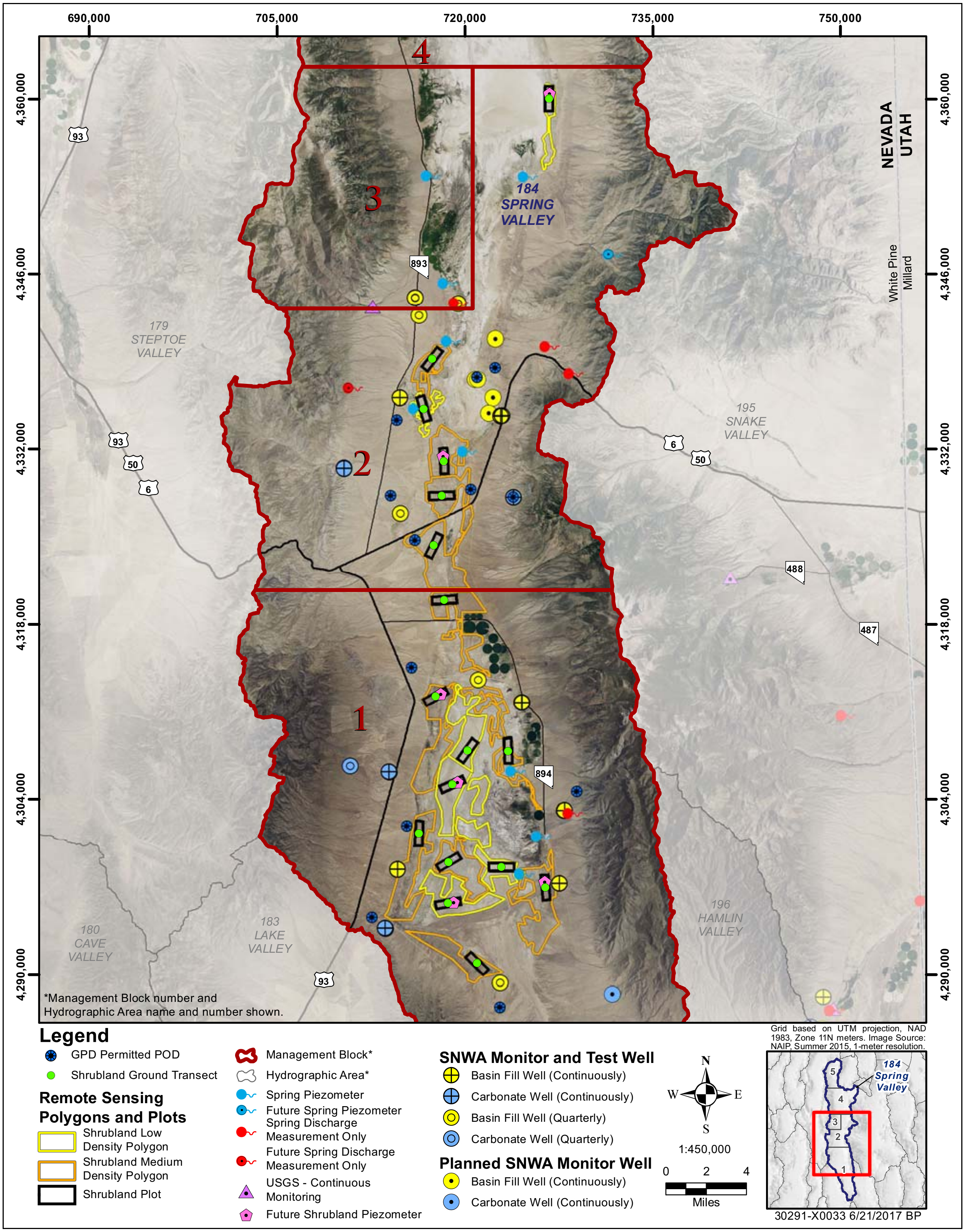


Figure 6-52
Shrubland Sampling Design and Hydrologic Monitoring, Management Blocks 1 and 2

- Conduct detailed statistical tests to inform management and mitigation actions. For example, correlations can be run and graphs constructed to examine the relationship of NDVI to live shrub cover. The remote sensing plot data can be used to analyze the NDVI data in various statistical configurations, such as grouping plots by pumping locations and groundwater levels. Change in NDVI and live shrub cover over time can be analyzed with time series analyses (as shown in Figure 6-48), and differences between medium-density and low-density shrubland can be analyzed using significant difference tests (as shown in Figure 6-47). Analyses of other data collected on the transects (grass, forb, dead shrub, dead tree, and ground cover; photographs; and qualitative observations) will also help elucidate change factors and condition.

- Prepare mitigation actions for implementation, including purchasing equipment, establishing contracts, and obtaining any necessary landowner permissions and permits.

- Preemptively implement mitigation actions for shrubland habitat to avoid activating a mitigation trigger. The decision to preemptively implement mitigation actions will be dependent upon the results of the investigations.

Mitigation Triggers

A mitigation trigger is activated if, as a result of SNWA GDP pumping:

- mean annual NDVI for either habitat group (medium-density shrubland, low-density shrubland) falls below the low-density shrubland 95 percent lower control limit for NDVI for five consecutive years, or

- mean percent live shrub cover for either habitat group falls below the low-density shrubland 95 percent lower control limit for percent live shrub cover for five consecutive years.

The five-year time frame for the mitigation trigger is necessary to observe whether the natural transition from medium to low-density shrubland is successful, or if mitigation actions need to be taken. There is natural variability in shrub reproduction, germination, establishment, and growth rates. Shrubs may not reproduce every year, and seeds can germinate in their first year or remain dormant in the soil for many years (Hansen, 1989; and Jacobs et al., 2011). Extrinsic factors such as soil condition, herbivory, and disturbance also affect shrub cover. Unpredictable weather patterns and variable local climatic conditions of the southwest in general further contribute to natural variability in shrub characteristics. For example, precipitation in Spring Valley can be highly variable and influence shrub cover, as depicted in Figure 6-48. Because of this natural variability, NDVI and percent live shrub cover may fall below the lower control limit of the low-density shrubland prediction interval in one year and be within the prediction interval the next year.

The five-year time frame allows the time necessary for natural plant growth. As discussed in Section 6.3.3.1, if shrub cover decreases as a result of increasing depth to water, over time the plant community would likely shift to more drought-tolerant, deeper rooted, and/or non-phreatophytic species (Patten et al., 2008; and McLendon, 2011a). Implementing mitigation actions five years after data indicate a variance from the prediction intervals allows natural plant transition to occur and provides a reasonable time frame to determine whether shrubland conditions are out of the ordinary.

Vegetation restoration provides a suitable example of the time frame necessary for new plant growth. Federal land managers consider it takes at least five years for restored construction projects to establish vegetation and achieve cover, density, and species richness standards (BLM, 2001a; BLM, 2001b). Five to seven years is the standard minimum time frame in southwest shrubland habitat (Kern River, 2002; SWIP, 2008; Ruby Pipeline, 2009; SNWA, 2010c; SWCA, 2010; USFWS, 2011b; and AECOM 2004), and is typically achieved within this time frame (Smith, 2014; and Kern River, 2007, at pages 44-45). Thus, five years is used in this analysis as the appropriate time frame for the shrub community to shift to more drought-tolerant, deeper rooted, and/or non-phreatophytic species.

Mitigation Actions

If the mitigation trigger is activated, mitigation actions will be taken to reverse the trend until the shrublands are above the threshold level. A variety of mitigation actions are available, and will be used in situations where they are most practical or effective. The investigation findings (discussed above) will inform the mitigation actions based on ground conditions. These mitigation actions may also be preemptively implemented to avoid activating the mitigation triggers. In addition to the mitigation actions identified for senior water right mitigation in Sections 6.2.1 and 6.2.2, shrubland habitat mitigation will include at least one of the following:

- Vegetation treatments, using standard Great Basin Desert shrubland revegetation and restoration practices. All vegetation treatments on BLM-managed land will be approved by BLM. SNWA has a proven track record in environmental restoration, as demonstrated by its activities and success in 15 years of ecosystem restoration on the Las Vegas Wash (Eckberg, 2016). The following treatments can be implemented on their own or in combination with one another.

    - Direct seeding and seedling transplanting using native, non-phreatophytic or drought-tolerant shrubs, including shrub/grass/forb mixes. Seeding and transplanting increase plant abundance and can change plant composition to include more desired species. Seeding can be accomplished by seed drilling and/or broadcast/aerial seeding.

    - Plant protection (e.g., tree shelters, rock mulch, plastic mesh, wire cages, temporary fencing, and brush). This has been shown to increase establishment success of seeded and transplanted species (Bainbridge, 2007).

    - Transplanting nursery stock. This may be done with supplemental irrigation and/or protection from herbivory and other environmental elements.

    - Grazing management. Reduction in livestock grazing in seeded and transplanted areas during the growing season reduces grazing pressure and supports plant establishment and growth.

- Supplemental watering in key restoration areas using SNWA water rights. Water is often the limiting factor of plant establishment and growth (Bainbridge, 2007). Methods will be site-specific and may include soil modification and surface shaping (e.g., decompaction, pitting, imprinting, microcatchments, and mulch) to improve water capture, storage, and infiltration, and/or direct irrigation (e.g., water truck, by hand, and drip irrigation).

- Weed control. Weed treatments are useful when noxious or invasive weeds are out-competing desired species. With responsible weed treatment, native species are better able to become established and compete successfully, resulting in a more desired and robust plant community. Weed control options include cultural control (e.g., avoiding overgrazing, using well-adapted competitive forage species, and maintaining good soil fertility), chemical control (e.g., herbicides), mechanical control (physical removal), and biological control (e.g., insects, fungi, and pathogens). However, cheatgrass invasion may occur regardless of SNWA GDP pumping, as its proliferation is common in the region.

- Integrated resource management using SNWA Great Basin Ranch assets. As described in more detail below, SNWA's resources provide the ability and flexibility to implement integrated resource management to enhance shrubland habitats. Options include:

  - Modified use of SNWA Great Basin Ranch irrigation and stock water rights.

  - Modified grazing practices.

- Modification of SNWA GDP pumping rates, durations and/or distribution. Such operational changes can protect shrublands by attenuating groundwater drawdown and propagation. Operational changes can also be targeted to reduce pumping stresses and increase recharge to areas in need of mitigation.

The success rate of seeding and seedling transplanting is dependent on factors such as the specific method, species, quality of plant/seed materials, existing soil conditions, timing, precipitation, and subsequent land use. Seed drilling has been shown to be more successful than broadcast/aerial seeding in semi-arid shrublands, especially in times of low precipitation (Bainbridge, 2007). With broadcast/aerial seeding, lightly tilling seeds into the soil increases success. Tilling can be done mechanically, or by driving sheep across seeded areas to allow the sheep hoofs to till the seeds into the soil. Efficacy of both seed drilling and aerial seeding is increased when seeding is timed in relation to optimal seasonal and precipitation conditions, and when grazing pressure is reduced during germination and early growth (Bainbridge, 2007).

Plant species can be chosen that increase the value of the wildlife habitat compared to the existing habitat. For example, seeding with a mix of sagebrush, grasses, and forbs in some areas would help increase winter and nesting habitat for greater sage-grouse. Multi-stemmed shrubs act as excellent pioneer species, creating a microhabitat around themselves and supporting the establishment of other desirable species (Bainbridge, 2007). Supplemental watering needs are assessed based on plant species and area of re-vegetation.

Mycorrhizal fungi inoculation of seeds and seedlings can improve nutrient availability and uptake, improve water uptake, reduce disease by improving overall plant health, increase soil aggregation (to help bind soil particles together and allow for better exchange of air/water), and increase overall competitive success of the species (Pendleton et al., 1999; and Bainbridge, 2007). Seeds can be inoculated by tumbling inoculum with seeds, sand, and a binding agent. Seedlings can be inoculated while in the nursery or during transplanting. The inoculum would be layered in the nursery container as it is filled or layered in the planting hole during transplanting.

An integrated weed management approach (using several techniques) often produces the best long-term results (BLM, 2010a). Factors to consider when selecting weed treatments include site conditions, the biology of the weed species, the species physical location, and the size of the infestation. Control activities can be timed before and after seeding/transplanting treatments to provide the non-targeted plants a greater competitive edge and opportunity to establish and grow (BLM, 2010a).

As presented in the 2011 water rights hearing, SNWA Northern Resources include approximately 23,500 acres (37 square miles) of SNWA land holdings; 930,000 acres (1,400 square miles) of SNWA-permitted grazing allotments managed by federal and state agencies; and 64,000 afa of associated water rights across eight hydrographic areas (Marshall and Luptowitz, 2011, at Section 6.3). Thus, SNWA has the capability to coordinate the management of water, land, ecosystems, special status species, and other related natural resources to ensure their long-term sustainability.

SNWA has approximately 42,000 afa of non-GDP permitted water rights in Management Blocks 1 and 2 (Tables 6-4 and 6-8) and approximately 8,200 afa in Management Block 4 (Table 6-16). SNWA GDP permitted water rights are also available for shrubland mitigation. This water can be conveyed or transferred to key restoration sites to support plant germination and growth.

SNWA-permitted grazing allotments and deeded land holdings provide flexibility for effective land management. Approximately 40,000 acres (45%) of the shrubland habitat in Management Blocks 1 and 2 are on BLM allotments where SNWA holds grazing permits, and approximately 6,500 acres (7%) are on SNWA land holdings (Figure 6-53). SNWA is permitted to graze a total of 9,682 cattle and sheep AUMs on these three allotments in Management Blocks 1 and 2 (Table 6-22).

Numerous studies are available that discuss how grazing practices can be modified to improve land condition (e.g., Hendershot, 2004; and Launchbaugh et al., 2006). A recent case study at Ucross Ranch in Wyoming demonstrated the power of grazing management to improve conditions even in times of disturbance (Graham, 2014). In 2002, Ucross Ranch was assessed as having abundant bare soil, erosion, low plant productivity and invasive and noxious weeds. After instituting grazing management changes, the ranch increased pasture productivity and reduced bare ground. These improvements occurred even though multiple disturbances (fire, grasshopper outbreaks, and several dry years) transpired. It was determined that modified grazing practices improved ecosystem processes, which in turn reduced the intensity and duration of negative effects created by the disturbances. Rate of improvement slowed during times of disturbance, but improvements nevertheless continued. Years with positive growing conditions brought more rapid reductions in bare ground, strong plant productivity, and more rapid and desired shifts in plant species composition (Graham, 2014).

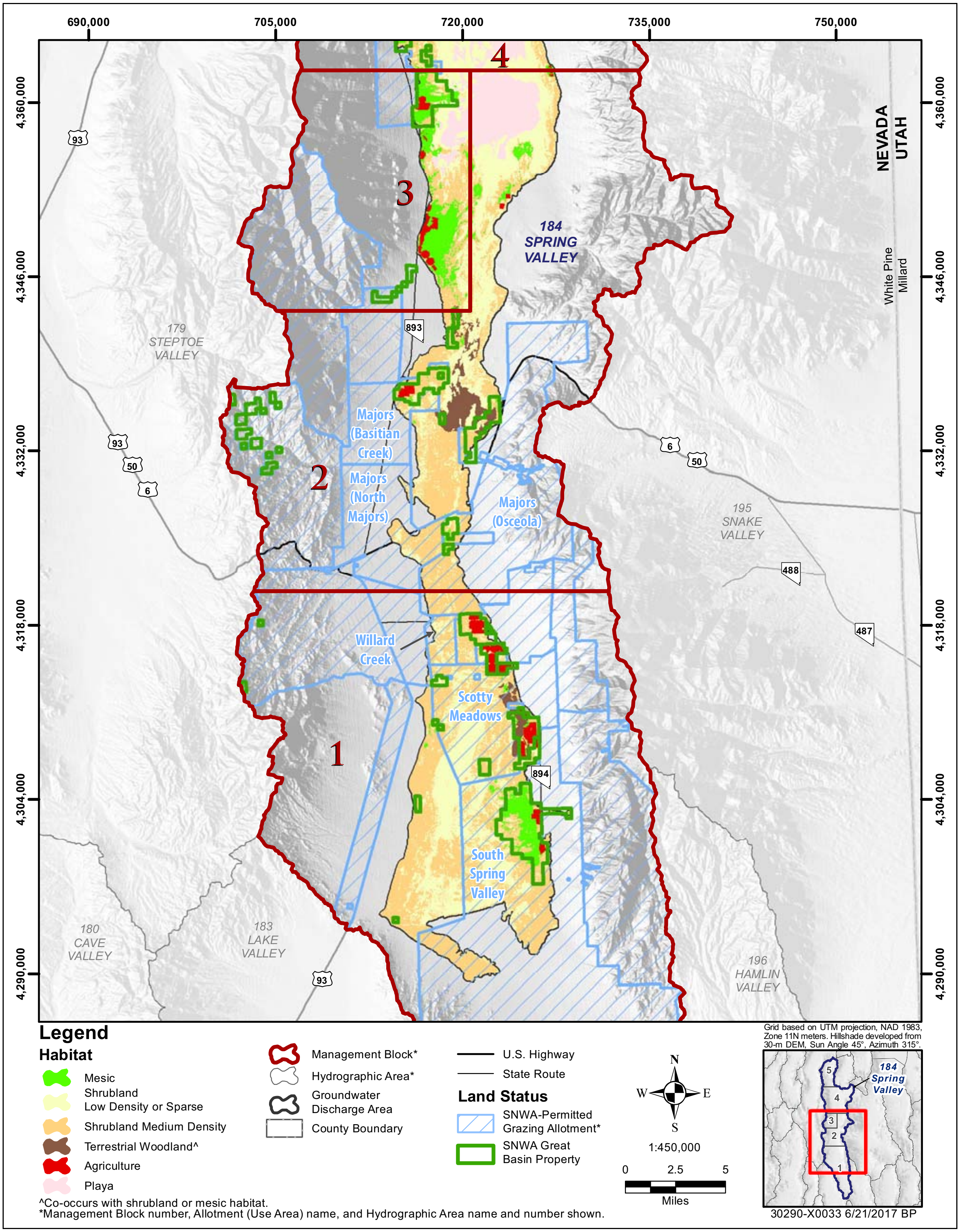


Figure 6-53
SNWA Permitted Allotments and Land Holdings Overlaid on Shrubland Habitat

Table 6-22
SNWA-Permitted AUMs on Use Areas Intersecting Block 1 and 2 Shrublands

BLM Allotment[a]	Use Area	Livestock	AUMs[b]
Majors	North Majors	Cattle	635
Majors	Osceola	Cattle	391
Majors	Bastian Creek	Cattle	300
Scotty Meadows		Cattle	1,227
South Spring Valley		Cattle	1,700
		Sheep	4,626[c]
Willard Creek		Cattle	803[d]
Total		Cattle	5,056
Total		Sheep	4,626
Total		Total	9,682

a. Allotments with minor overlap with Management Block 1 and 2 shrublands not included.
b. AUM = amount of forage necessary for sustenance of one cow or its equivalent (e.g., five sheep) for one month (43 CFR 4100.0-5). When calculating grazing fees, a cow-calf pair = 1 AUM as long as the calf is < 6 months when it enters BLM-managed land, and does not turn 12 months during its use of the land (43 CFR 4130.8-1 (c)).
c. 4,226 of the 4,626 AUMs are currently held in voluntary non-use for the conservation and protection of natural resources.
d. 492 of the 803 AUMs are currently held in voluntary non-use for the conservation and protection of natural resources.

SNWA has successfully employed modified grazing practices that can continue to be effective for shrubland habitat mitigation. These practices include but are not limited to: implementing and modifying grazing rotations (altering place, time and frequency of use); reducing grazing intensity (animal unit months [AUM]) and duration (reducing utilization); engaging in dormant-season grazing (to improve plant vigor and growth); and changing water haul and livestock distribution (to correct disproportionate use and better manage the land). Such practices can be targeted to relieve stressed areas, support vegetation treatment efforts, and allow greater shrub growth and vitality.

SNWA has a proven track record in using grazing to sustainably manage the land. When grazing cattle and sheep on federal allotments, SNWA adheres to federal grazing permit terms and conditions and employs an adaptive management approach. SNWA responds to actual conditions on the range to graze in a more sustainable manner. For example, in response to historical overgrazing and drought conditions in 2013-2015, SNWA reduced grazing pressure and allowed vegetation re-growth. Measures taken on the range included modifying grazing plans and practices as a result of ground conditions, incorporating rotations into grazing plans, collecting real-time telemetry location data to better manage sheep movements and resource utilization, voluntarily placing AUMs in conservation non-use, temporarily shortening seasons of use and reducing AUMs when needed, altering timing of use (e.g., engaging in dormant-season grazing) to improve plant vigor, adjusting grazing duration and speed to reduce utilization levels, herding sheep to avoid or target areas for grazing, and changing water haul and livestock distribution to better manage the land (SNWA, 2016e and f).

6.3.4 Terrestrial Woodland Habitat

6.3.4.1 Overview

Terrestrial woodland habitat encompasses approximately 4,000 acres in the Spring Valley groundwater discharge area (Figure 6-23 in Section 6.3). This low-elevation woodland habitat is referred to as Swamp Cedars, a name with historical and cultural significance. Biologically speaking, however, the habitat is not a true swamp and the trees are not cedars. The ground surface in most areas is usually dry, although in springtime soils in some areas are moist under the surface making it difficult to traverse. The trees are Rocky Mountain juniper (*Juniperus scopulorum*), with Utah juniper (*Juniperus osteosperma*) mixed in at places (SNWA, 2012c). The terrestrial woodland habitat in Spring Valley co-occurs with shrubland habitat (where trees are intermixed with shrubs, as shown in Figure 6-54) and mesic habitat.

Figure 6-54
Swamp Cedar ACEC, Spring Valley

April 2017 (SNWA Photo)

Approximately 40 percent (1,500 acres) of the terrestrial woodland habitat in the Spring Valley groundwater discharge area is within the BLM-designated Swamp Cedar ACEC in Management Block 2 (Figure 6-55). This area was designated as an ACEC by the BLM for its cultural resources and its unique plant community (Rocky Mountain juniper in alkali valley soils) (BLM, 2007; and BLM, 2012a, at page 3.14-19). As presented in the 2011 water rights hearing by the Confederated Tribes of the Goshute Reservation (CTGR), this swamp cedar area is also an area of special cultural significance (Lahren, 2010; referred to under its former designation of "Swamp Cedar Natural

Area"). Thus, the approach to avoid the unreasonable effect of elimination of terrestrial woodland habitat from the Spring Valley groundwater discharge area is focused on the Swamp Cedar ACEC.

The trees in the Swamp Cedar ACEC are entirely or predominantly Rocky Mountain juniper[1]. Rocky Mountain junipers are widely distributed across North America and are not of biological conservation concern (McLendon, 2011a; and Noble, 1990). In Spring Valley, Rocky Mountain junipers occur on the valley floor and alluvial fan/valley floor interface as well as in the mountain block. In North America, the species occurs and is native to 16 U.S. states and three Canadian provinces (USDA, 2017). As a species, Rocky Mountain juniper has a broad ecological range, is not groundwater dependent, and is adapted to relatively dry and wet conditions within its range. The species is known to exploit additional moisture when available, however, which can result in higher productivity (McLendon, 2011a).

The hydrologic monitoring network in the vicinity of the Swamp Cedar ACEC is presented on Figure 6-56. Based on the hydrogeologic setting, the Swamp Cedar ACEC area is expected to be underlain by clayey lake deposits. In June 2016, SNWA hydrologists advanced a shallow hand auger within a grove of juniper trees on the adjacent SNWA El Tejón Ranch Osceola Property (hereafter referred to as Osceola Property) to a depth of 15 ft. The lithology of the boring consisted of clay and silty clay sediments. The sediments were observed to be saturated at approximately 8 ft.

6.3.4.2 Remote Sensing Analysis

The remote sensing analysis for trees in the Swamp Cedar ACEC utilizes two calculations: 1) tree cover area, and 2) baseline percent range in cover, using NDVI as a proxy for cover.

Tree Cover Area

Tree cover area within the Swamp Cedar ACEC was quantified using 2015 National Agricultural Imagery Program (NAIP) high-resolution digital aerial imagery.[2] NAIP is a U.S. government program that is administered by the USDA Farm Service Agency. The NAIP image data used in the analysis was of one-meter resolution and acquired in June 2015. Natural color (red, green, and blue) and near infrared image data was collected, which allowed for derivation of an NDVI for vegetation analysis.

NDVI values derived from the NAIP imagery were used to distinguish trees so that tree cover area could be calculated. Through examination of the NDVI and image data in the Swamp Cedar ACEC, a range of NDVI values were determined to indicate juniper trees (see methods in Appendix D, D.2.2.1). The data within this range were converted into tree polygons, with each polygon encircling a tree or a cluster of trees. The data were quality checked to ensure that juniper trees were captured by

1. Utah junipers may be mixed in with the Rocky Mountain junipers, as they occur on the alluvial fan and have been documented on the valley floor. Utah juniper is a wide-spread species, and its occurrence on the valley floor is typically perceived as encroachment.
2. NAIP imagery is available on-line at https://gdg.sc.egov.usda.gov/GDGHome_DirectDownLoad.aspx. USDA Farm Service Agency, Aerial Photography Field Office.

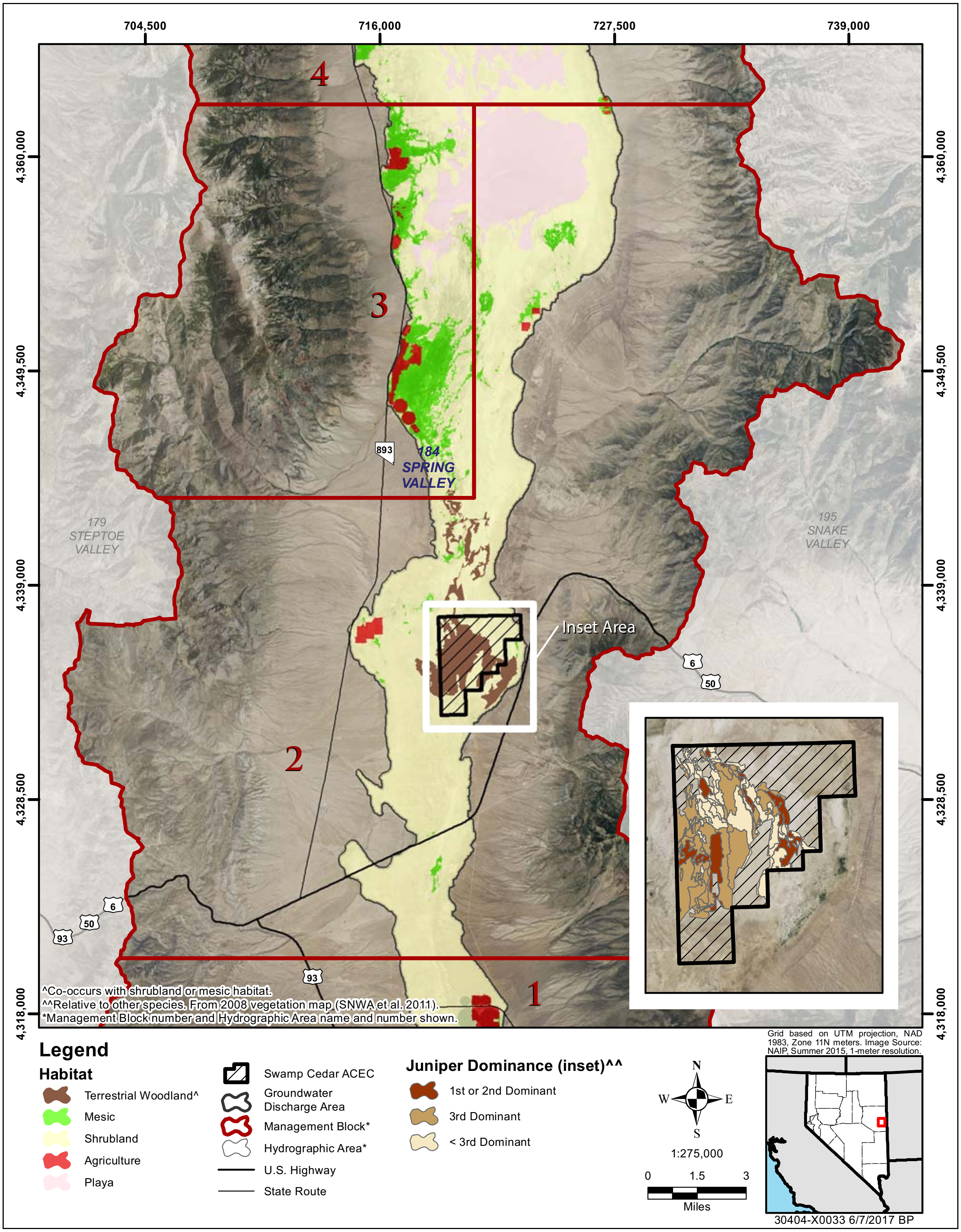


Figure 6-55
Woodland Habitat and the Swamp Cedar ACEC in Management Block 2

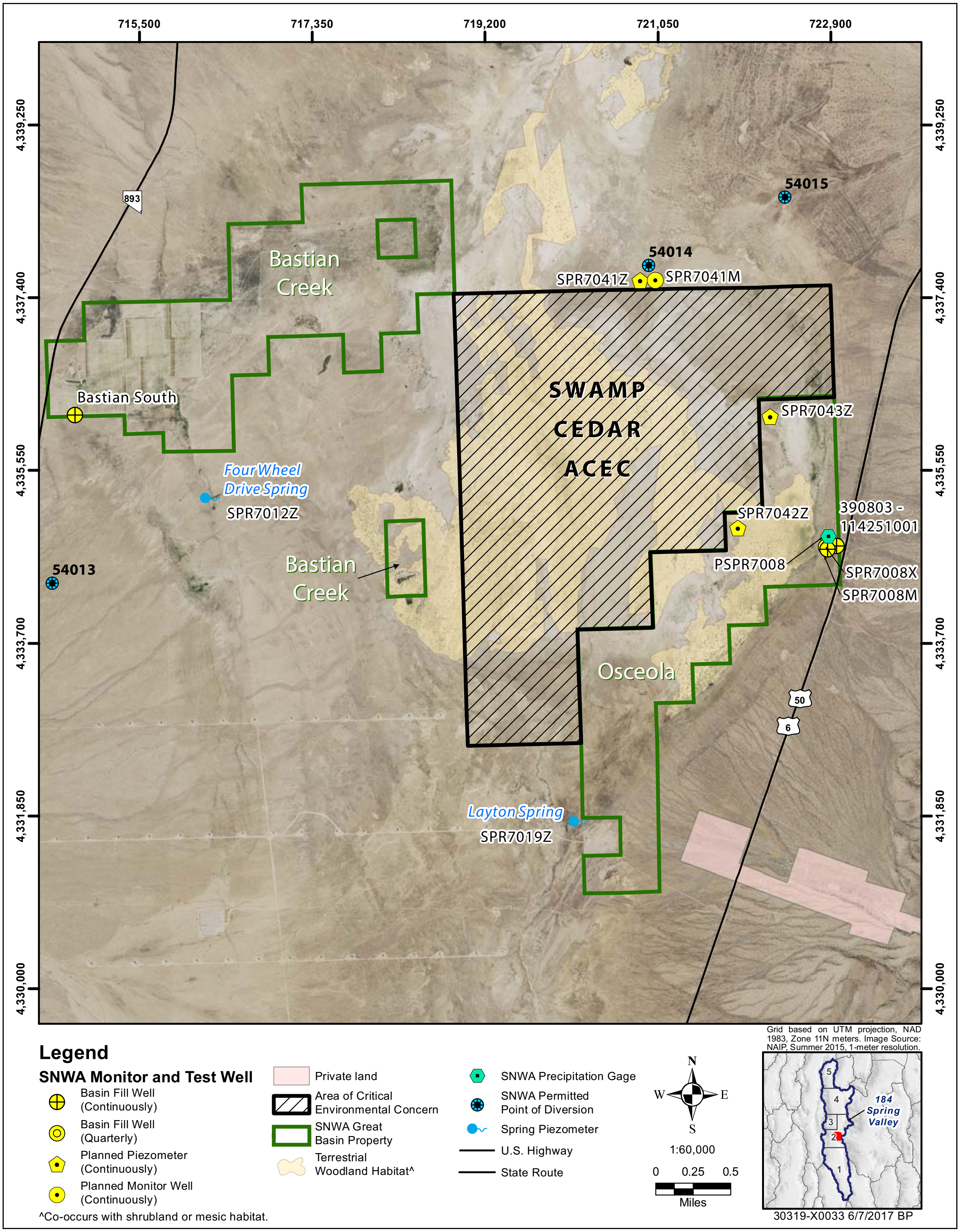


Figure 6-56
Hydrologic Monitoring in Vicinity of Swamp Cedar ACEC Woodland

the process, and that other vegetation were not included. The total tree cover area within the ACEC (the sum of the tree polygon areas) in 2015 was approximately 44 acres (Figure 6-57).

This analysis demonstrated that tree cover area in the Swamp Cedar ACEC can be reliably quantified. As discussed in Appendix D, D.2.2.1, while NAIP imagery was sufficient for this analysis, the utility of this imagery in comparing tree cover area over time is limited given that the collection dates and frequency are inconsistent, and NDVI values derived from different cameras or sensors are not necessarily consistent. In addition, because the imagery resolution is 1 meter, trees less than 1-1.5m in diameter were not as discernible from noise or background, especially in areas of dense shrubs. Therefore, imagery of at least 0.5 m resolution that provides standardized measurements of spectral radiance will be collected and used to calculate tree cover area for the SNWA (2017e) Spring Valley 3M Plan.[1] Tree cover area within the Swamp Cedar ACEC will be calculated every year for the Spring Valley 3M Plan (SNWA, 2017e). This information will be used to ensure that tree cover area remains at or above a threshold, as described in Section 6.3.4.3 below.

Baseline Percent Range in Cover

To determine the baseline percent range in cover within the Swamp Cedar ACEC, an analysis was conducted using NDVI derived from 1985-2015 Landsat satellite imagery. The NAIP imagery used to quantify tree cover area could not be used for this analysis due to the limitations in comparing NAIP data over time, as discussed above. Therefore, NDVI was derived from Landsat imagery data to examine changes in cover over time. As discussed in Section 6.3.3.2, NDVI is a proxy for cover, and Landsat imagery provides a long continuous record of satellite imagery. Given the long life span, slow growth rate and variable recruitment of the Rocky Mountain juniper species, the long record of data provided by Landsat imagery is optimal for this analysis.

To ensure that the NDVI data would reflect changes in tree cover and not simply changes in shrub or grass cover, small sample areas (60 m x 60 m, or 2 x 2 Landsat pixels) were located where tree cover area was relatively high (Appendix D, Figure D-3). To avoid sampling bias, the sample areas included areas with large trees or clumps of trees, as well as areas with a variety of tree sizes, which were visible on the NAIP 2015 imagery (see methods in Appendix D, D.2.2.2).

The NDVI analysis was conducted using the same methods as used for shrubland habitat (summarized in Section 6.3.3.2 and described in Appendix D, D.1.2.2 and D.1.2.3). In short, NDVI was derived from July-September Landsat image data to maximize the relevant signal for tracking annual changes in vegetation in relation to groundwater availability (see discussion in Section 6.3.3.2). Mean NDVI was computed using zonal statistics for each sample area in each NDVI raster image. Any NDVI data influenced by clouds were filtered out of the dataset. The NDVI values were then averaged across sample areas by year to derive mean annual NDVI values from 1985-2015.[2]

1. High-resolution satellite imagery products by the Airbus Defence and Space Pleiades Constellation (http://www.intelligence-airbusds.com/en/3027-pleiades-50-cm-resolution-products) and Digital Globe Worldview 2 (https://www.digitalglobe.com/about/our-constellation) are examples of this type of imagery.

The mean annual NDVI values were examined for the range of values between 1985-2015. Minimum mean annual NDVI (0.150) was 75% of the maximum mean annual NDVI (0.199). Thus, the baseline percent range ((maximum - minimum) / maximum * 100) equaled 25%. Prior to SNWA GDP groundwater withdrawal from Spring Valley, the baseline percent range in cover will be re-calculated using the entire baseline period.

6.3.4.3 Monitoring, Management, and Mitigation

The goal of the terrestrial woodland habitat management and mitigation is to maintain a viable tree population within the Swamp Cedar ACEC.

Monitoring

Tree cover area within the Swamp Cedar ACEC will be monitored using high-resolution imagery. To ensure accuracy, precision, and comparable data over time, the imagery will be of at least 0.5 m resolution and provide standardized measurements of spectral radiance. The data will be acquired in the summertime (primarily August)[1] to maximize the relevant signal for tracking annual changes in tree cover area in relation to groundwater availability. The data will be collected on an annual basis for at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley, and will continue as long as SNWA pumps groundwater under the Spring Valley GDP permits. The time frame of five years was selected because it provides a range of variation across years with varying precipitation levels.

Total tree cover area within the Swamp Cedar ACEC will be calculated using the methods described in Section 6.3.4.2 and Appendix D, D.2.2.1. In case the terrestrial woodland habitat extends into different parts of the ACEC in the future, tree cover area will be calculated annually across the entire ACEC. Prior to SNWA GDP groundwater withdrawal from Spring Valley, the annual tree cover area values will be used to calculate the baseline maximum tree cover area.

Baseline percent range in cover within the Swamp Cedar ACEC will be calculated using the methods described in Section 6.3.4.2 and Appendix D, D.2.2.2. This value will be calculated for the remote sensing sample areas with relatively high tree cover area using mean annual NDVI values derived from July-September Landsat imagery data. As discussed in Sections 6.3.4.2, the current calculation for baseline percent range in cover within the Swamp Cedar ACEC is 25 percent. This value will be re-calculated prior to SNWA GDP pumping withdrawal from Spring Valley using the entire baseline period following the methods in Appendix D, D.2.2.2.

To enhance understanding and tracking of tree population dynamics, five tree ground monitoring plots (100 m x 100 m) are designed within the Swamp Cedar ACEC. Ground tree data will be

2. This calculation was first made by dividing the sample areas into two groups, medium-density and low-density vegetation, as described in Appendix D, D.2.2.2. Because the percent range for the two groups was similar, the sample areas were combined to produce the final results. Medium-density group: minimum mean annual NDVI = 0.169, 73% of the maximum mean annual NDVI (0.232); percent range = 27%. Low-density vegetation group: minimum mean annual NDVI =0.128, 79% of the maximum mean annual NDVI (0.162); percent range = 21%. All sample areas followed similar trends across the years, regardless of habitat group, tree cover area, or whether they included areas with large trees or a variety of tree sizes.
1. Weather conditions in August may delay imagery capture to September.

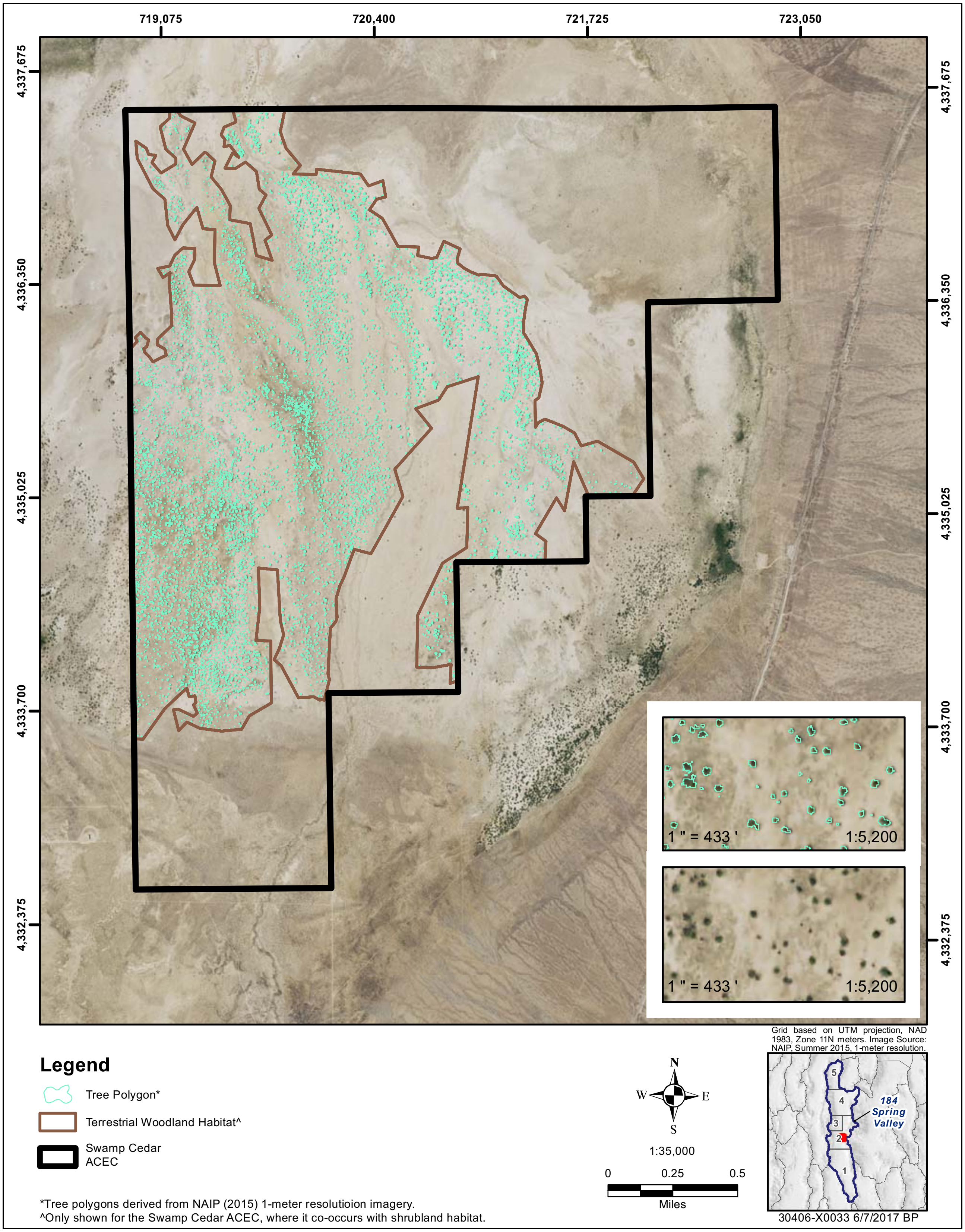


Figure 6-57
Tree Polygons in the Swamp Cedar ACEC Woodland

collected from the monitoring plots during summer (primarily August) to coincide with the remotely sensed tree cover area data. Using the habitat map, the plots shown in Figure 6-58 were located in medium-density and low-density vegetation habitat using a proportionate stratified random design (Appendix D, D.2.2.3).

Data collection in the ground monitoring plots will include presence of seedlings (< 0.1 m), number of saplings (0.1 m-1 m), and number of mature trees (>1 m) within each plot, and a photograph. Every five years, sapling height will also be measured. The age classes are based on information about growth and reproduction for the species. In the southwestern U.S., average annual growth rate for Rocky Mountain juniper during the first 40 years is 0.1 m per year, and seed production begins under favorable conditions when plants are approximately 10 years old (approximately 1.0 m tall) (Noble, 1990). These variables will aid in understanding and tracking survivorship and recruitment over time, and will be compared to tree cover area calculated for each plot to provide explanatory power to the tree cover area data. To coincide with the tree cover area monitoring, the ground tree plot data will be collected on an annual basis for at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley, and will continue as long as SNWA pumps groundwater under the Spring Valley GDP permits.

To enhance the hydrologic monitoring network in proximity to the Swamp Cedar ACEC, three shallow piezometers and one nested deeper well will be installed adjacent to the ACEC (Figure 6-58). The piezometers will be installed to provide information on shallow groundwater conditions in the area. As discussed in Section 6.2.2, the nested wells will evaluate the vertical hydraulic conductivity, leakage across the clays, and changes in shallow groundwater level. A precipitation station was installed adjacent to the ACEC by SNWA in 2017 (Figure 6-58). Monitoring will begin at least five years prior to initiating SNWA GDP pumping to coincide with the tree cover area monitoring. The water level will be measured at least on a quarterly basis, and precipitation will be recorded continuously. The local hydrologic data will be analyzed in context with the regional hydrologic network, and water levels will be compared to precipitation and Rocky Mountain juniper data.

Investigation Triggers and Management Actions

The remote sensing analyses described in Section 6.3.4.2 showed that the tree population within the ACEC has maintained itself over the past 31 years, indicating that it is not a landscape on the verge of losing its woodland habitat. This baseline encompassed a range of variation across wet and dry periods, providing for a good predictor of future conditions. The threshold for terrestrial woodland habitat is thus established at the lower limit of the baseline percent range of cover within the Swamp Cedar ACEC.

The investigation trigger is activated if annual tree cover area for the Swamp Cedar ACEC, compared to the baseline maximum tree cover area, falls within 5% of the lower limit of the baseline percent range in cover. Using the current baseline as an example, where the percent range in cover is 25%, the investigation trigger would be activated when annual tree cover area within the Swamp Cedar ACEC falls 20% below the maximum baseline tree cover area. In this example, if the baseline maximum tree cover area were 44 acres, the investigation trigger level would be 35 acres (44 acres - (20% of 44)).

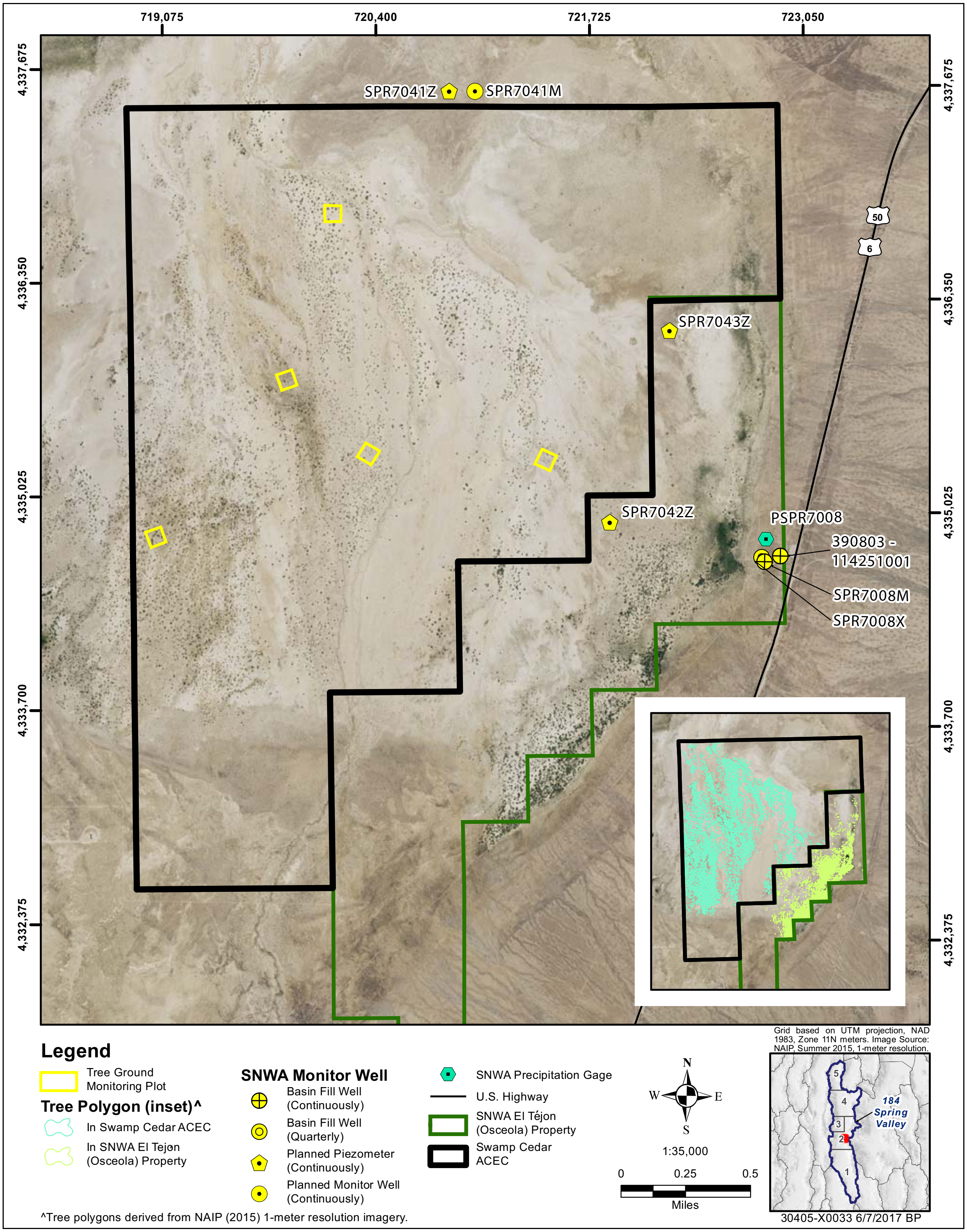


Figure 6-58
Woodland in Swamp Cedar ACEC and Adjacent SNWA Property

Activation of the investigation trigger will result in investigation actions using the protocols described in Section 3.2.2 to determine cause, condition, and significance of observed changes, and to inform management and mitigation actions. Investigation actions will include but are not limited to: analyses of tree cover area data and ground tree data to understand the nature of the vegetation changes; analyses of hydrologic data (e.g., groundwater level) and SNWA pumping data to understand the groundwater drawdown propagation; analyses regarding the effects of precipitation and other climatic factors on the vegetation; analysis of the interrelationship between the shallow and deeper monitor wells adjacent to the Swamp Cedar ACEC; and analyses of tree and hydrologic data to determine if tree changes are due to changes in groundwater availability. Multiple lines of evidence will be used to determine the nature of the vegetation changes.

If the investigation trigger is activated, in addition to the management actions identified for senior water rights in Section 6.2.2, the following management actions may be taken:

- Conduct detailed analyses of tree population dynamics using the tree ground monitoring plot data and inform management and mitigation actions.
- Preemptively implement mitigation actions for terrestrial woodland habitat.

Mitigation Trigger and Mitigation Actions

The mitigation trigger is activated if annual tree cover area for the Swamp Cedar ACEC, compared to the baseline maximum tree cover area, falls below the lower limit of the baseline percent range in cover for a period of five consecutive years as a result of SNWA GDP pumping. Using the current baseline as an example, where the percent range in cover is 25%, the mitigation trigger would be activated when annual tree cover area within the Swamp Cedar ACEC falls 25% below the maximum baseline tree cover area for five consecutive years. In this example, if the baseline maximum tree cover area were 44 acres, the mitigation trigger level would be 33 acres (44 acres - (25% of 44)).

The five year time frame allows for the natural variability in tree reproduction, germination, establishment, and growth rates. As stated above, in the southwestern U.S., average annual growth rate for Rocky Mountain juniper during the first 40 years is 0.1 m per year, and seed production begins under favorable conditions when plants are approximately 10 years old (approximately 1.0 m tall) (Noble, 1990).The interval when Rocky Mountain juniper trees produce heavy seed crops varies from 2 to 5 years, and seeds normally germinate after an 14-16 month ripening period; however, delayed germination of more than 2 years is not unusual (Noble, 1990). Extrinsic factors such as seed distribution by bird and animal populations, soil temperature and herbivory also affect tree cover area. Unpredictable weather patterns and variable local climatic conditions of the southwest in general further contribute to natural variability in shrub characteristics. For example, precipitation in Spring Valley can be highly variable and influence tree cover. Because of this natural variability, tree cover area may fall below the baseline range in one year and be within the range the next year.

If the mitigation trigger is activated, mitigation actions will be taken to reverse the trend until the tree cover area is above the threshold level. A variety of mitigation actions are available, and will be used in situations where they are most practical or effective. The investigation findings (discussed above) will inform the mitigation actions based on ground conditions. These actions may also be preemptively implemented to avoid activating the mitigation trigger. Actions that affect the Swamp Cedar ACEC will be coordinated with and approved by BLM. In addition to the mitigation actions identified for senior water rights in Section 6.2.2, terrestrial woodland habitat mitigation will include at least one of the following. More detailed discussion on many of these mitigation actions is presented in Section 6.3.3.4.

- Terrestrial woodland habitat enhancement within the Swamp Cedar ACEC, subject to BLM approval of activities within the ACEC.
    - Seeding and/or planting. In consultation with botanists, SNWA would develop and implement a planting plan identifying the most effective methods to expand and enhance the woodland habitat. The plan would utilize the most current research and science. Methods may include but are not limited to seed drilling, planting, and mycorrhizal fungi inoculation.
    - Temporary irrigation. SNWA would run temporary, above-ground irrigation lines from its adjacent Osceola Property, to enhance tree germination and growth. The lines would be laid above-ground, to avoid ground-disturbance within the ACEC.
    - Shallow aquifer recharge. SNWA would apply water along the western edge of its Osceola Property so that it infiltrates and recharges the shallow aquifer underneath the downgradient ACEC.
- Terrestrial woodland habitat enhancement on the SNWA Osceola Property. The Osceola Property is immediately adjacent to the Swamp Cedar ACEC, and the trees on the property are a natural continuation of the trees in the ACEC (Figure 6-58 inset). The total tree cover area on the Osceola Property in 2015, derived using the methods in Appendix D, D.2.2.1, was approximately 35 acres. SNWA would maintain and establish Rocky Mountain juniper trees on its property commensurate with the acreage necessary to offset the loss below the mitigation trigger. Mitigation monitoring, including aerial photography and ground monitoring plots, would be established as described in the monitoring section above.
    - Seeding and/or planting. As described above, a planting plan would be developed and implemented using the most effective methods to expand and enhance the woodland habitat on the property.
    - Application of water to enhance tree germination and growth. SNWA would use its water rights to increase the acreage of woodland habitat on the property.
    - Modified grazing practices. SNWA has successfully employed grazing practices on various rangeland areas that can be effective for woodland mitigation, including but not limited to: resting an area for one or more years; reducing grazing intensity and duration (reducing utilization); and engaging in dormant-season grazing (to improve plant vigor and growth). Such practices can be targeted to relieve stressed areas, support seeding and planting efforts, and support greater growth of young tender trees.

- Modified use of SNWA water rights.
  - SNWA's non-GDP permitted water rights (Section 6.2) and GDP permitted water rights are available for terrestrial woodland habitat mitigation. This water can be conveyed or transferred to key restoration sites to support plant germination and growth.
- Modification of SNWA GDP pumping rates, durations and/or distribution.
  - Operational changes can protect the terrestrial woodland habitat by attenuating groundwater drawdown and propagation. Operational changes can also be targeted to reduce pumping stresses and increase recharge to areas in need of mitigation.

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7.0 TRIGGERS, MANAGEMENT AND MITIGATION: NORTHERN HAMLIN AND SOUTHERN SNAKE VALLEYS (HYDROGRAPHIC AREAS 196 AND 195)

7.1 Introduction

This section provides technical background and rationale for the Spring Valley 3M Plan associated with SNWA GDP permits in Spring Valley (permit numbers 54003-54015 and 54019-54020) in regard to resources in northern Hamlin and southern Snake valleys. Analyses are presented for the thresholds, triggers, and monitoring, management, and mitigation actions established to avoid unreasonable effects to senior water rights and environmental resources in Hamlin and Snake valleys. The area of focus is the inter-basin groundwater flow path that occurs across the Limestone Hills from southern Spring Valley to northern Hamlin Valley and into Snake Valley. The analyses were conducted in accordance with the conceptual approach described in Section 3.0. The analysis area, SNWA GDP PODs in southern Spring Valley, senior water rights in northern Hamlin and southern Snake valleys, and the 3M Plan hydrologic monitoring network in the area are shown on Figure 7-1.

SNWA GDP pumping in Spring Valley is planned in three stages as authorized in NSE Ruling 6164 and described in Section 6.1. The staged development approach limits SNWA GDP pumping while aquifer response data is monitored.

7.2 Hydrologic Monitoring and Senior Water Rights

Numerous studies have been completed that characterize the hydrogeologic framework and hydrologic baseline conditions associated with southern Spring, northern Hamlin and southern Snake valleys. These studies are summarized by Burns and Drici (2011) with subsequent recent studies and ongoing monitoring included below:

- "*Evaluating Connection of Aquifers to Springs and Streams, Great Basin National Park and vicinity, Nevada*" (Prudic et al., 2015), which is the USGS study of inter-basin flow from Spring to Hamlin and Snake valleys and the source of Big Springs;
- *Hydrogeologic Studies and Groundwater Monitoring in Snake Valley and Adjacent Hydrographic Areas, West-central Utah and East-central Nevada* (Hurlow, 2014), which describes Utah Geological Survey (UGS) ongoing monitoring of groundwater levels and surface water discharge along the Nevada-Utah state line in Snake Valley.

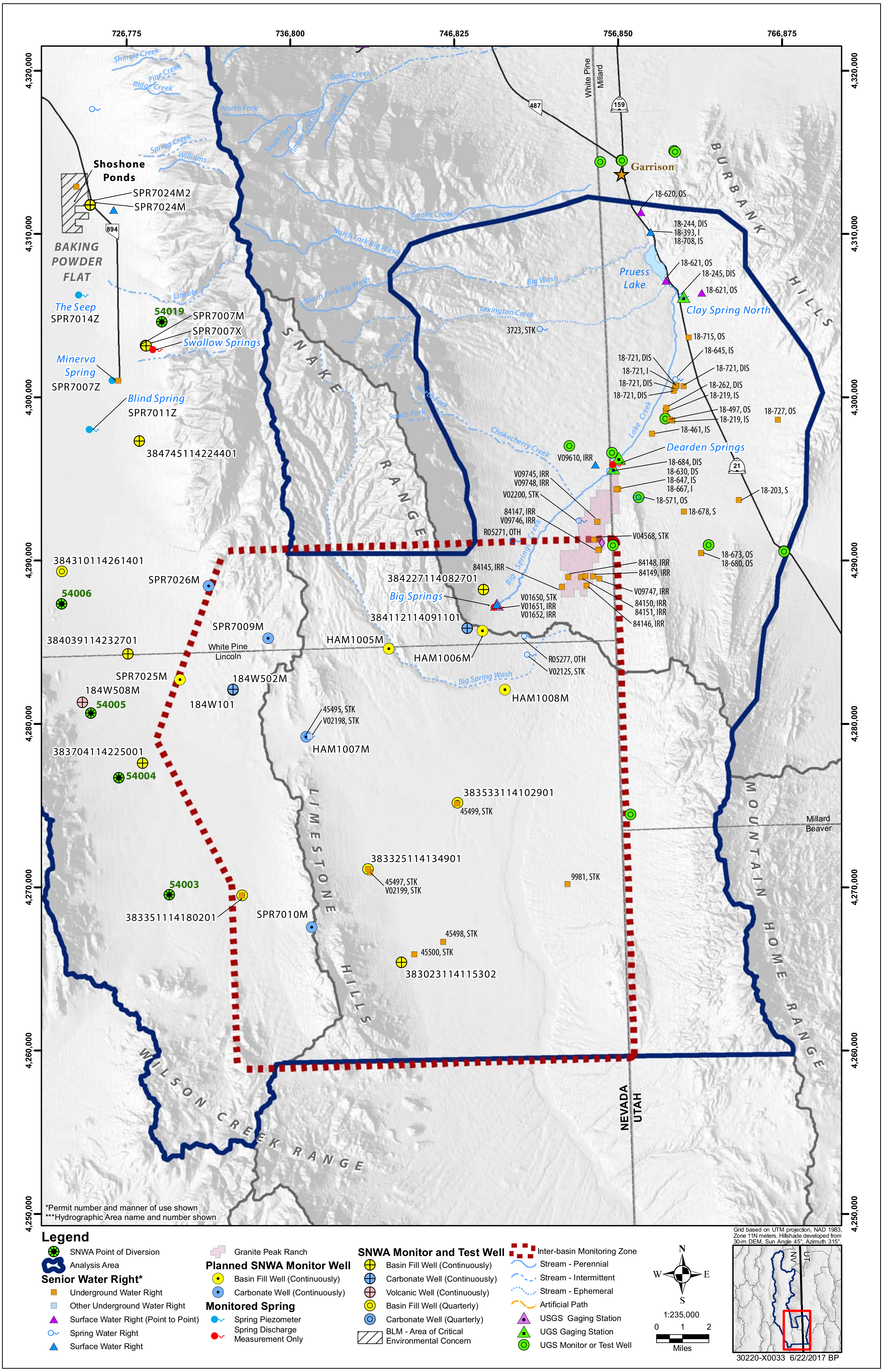


Figure 7-1
SNWA GDP PODs, Senior Water Rights, and Hydrologic Monitoring Network

- "*Synoptic Discharge Study Big Springs and Lake Creeks Snake Valley, Nevada and Utah - March 5, 2014 and September 17, 2014*" (SNWA, 2015e), which provides data on Big Springs and Lake Creeks;

- *2016 Spring Valley Hydrologic Monitoring, Management, and Mitigation Plan Status and Data Report* (SNWA, 2017b) which documents ongoing SNWA Spring Valley 3M Plan baseline hydrologic monitoring; and

- *Regional Potentiometric-Surface Map of the Great Basin Carbonate and Alluvial Aquifer System in Snake Valley and Surrounding Areas* (Gardner et al., 2011).

The recent USGS study conducted by Dr. David Prudic and others included an evaluation of the source of Big Springs located in Snake Valley and an assessment of groundwater flow from southern Spring Valley into northern Hamlin Valley and on to southern Snake Valley. The results of the study counter claims that Big Springs is sourced by groundwater from Spring Valley. The findings of the study associated with inter-basin flow for this portion of the analysis area are summarized below:

> "A groundwater divide in southern Spring Valley south of Baking Powder Flat separates groundwater flow to the flat from southeastward flow into northern Hamlin Valley. Groundwater flow from southern Spring Valley south of the groundwater divide into northern Hamlin Valley was estimated to range from 6,000 to 11,000 acre-feet per year. This groundwater does not flow to Big Springs in southern Snake Valley; rather, the source of water to Big Springs is groundwater recharge in the Big Spring Wash drainage basin and in nearby smaller drainage basins at the south end of the Snake Range." (Prudic et al., 2015).

The UGS installed monitor wells in the vicinity of the Nevada-Utah state line in Snake Valley as part of the West Desert Groundwater Monitoring Network. The period of record for the piezometers range from 2006 or 2009 to present. UGS also operates three surface water gaging stations on Lake Creek and one at Clay Springs North as presented on Figure 7-1. A description of the UGS network and monitoring data are presented on the UGS project web site (UGS, 2017).

SNWA conducted a synoptic discharge study of the Big Springs Creek/Lake Creek complex, located in Snake Valley Nevada-Utah to meet the requirements of the Spring Valley 3M Plan (SNWA, 2015e). Study participants included representatives of SNWA, NSE, DOI, and UGS. The study utilized six existing continuous gaging stations coupled with ten miscellaneous discharge measurement locations to characterize surface water-groundwater interaction through measurement of the gain and loss of stream flow over the entire system from Big Springs to Pruess Lake. The study included two field events performed on March 5, 2014 during non-irrigation season and September 17, 2014 during the irrigation season. The study will be repeated every five years after SNWA GDP pumping operations begin. The synoptic discharge study report includes a description of the study area, work plan, methodology, and results (SNWA, 2015e).

Results of the studies conducted in the area indicate that inter-basin flow from southern Spring Valley joins groundwater flowing north from southern Hamlin Valley toward the area of Granite Peak Ranch and Dearden Springs. More details on groundwater flow in the area is presented by Prudic et al. (2015) and SNWA (2015e).

7.2.1 Hydrologic Monitoring

SNWA established a hydrologic monitoring program associated with the Spring Valley 3M Plan in Spring, northern Hamlin, and southern Snake valleys. Baseline hydrologic data have been collected for this monitoring network since 2006. The NSE approved the original monitoring plan in February 2009 and a revised version in 2011 (SNWA 2009e and 2011d). The Spring Valley 3M Plan has been revised again as described in this report to address concerns stated in the Remand Order.

The monitoring element of the Spring Valley 3M Plan associated with Hamlin and Snake valleys provides the ability to effectively detect and measure propagation of drawdown in order to implement appropriate management and mitigation actions to avoid unreasonable effects in both Nevada and Utah. The Spring Valley 3M Plan monitoring network is presented in Section 10.2.2 and shown for this area in Figure 7-1 and summarized below:

- A special inter-basin monitoring zone (IBMZ) was established in previous Spring Valley 3M Plans and included in the current plan to focus on the hydrologic relationship between Spring, Hamlin, and Snake valleys. The boundary of the IBMZ is highlighted on Figure 7-1.

- Sixteen monitor wells that are either existing or planned to be constructed are associated with the IBMZ. Eight of the monitor wells are planned for construction by SNWA at least three years prior to SNWA GDP pumping, including two monitor wells (SPR7025M and SPR7026M) to be constructed between the two closest SNWA GDP production wells and the IBMZ. Sites for these two monitor wells will be identified after the SNWA GDP production well configuration is determined. Right-of-way grants have been approved from BLM for the other five planned monitor wells.

- One downgradient monitor well (HAM1008M), located in Hamlin Valley south of the Snake Valley Hydrographic Basin boundary between monitor well 383533114102901 (Monument Well) and Granite Peak Ranch (Figure 7-1), is proposed to be installed at least three years prior to SNWA GDP pumping to provide a mitigation trigger point for Snake Valley senior water rights.

- Continuous gaging stations at two spring orifices at Big Springs are currently monitored by USGS through a joint funding agreement with SNWA and NDWR.

- Four gaging stations are maintained and operated by UGS. One gage is located upstream of Dearden Springs, two are located downstream of Dearden Springs at the West and East Middle Ditches on Lake Creek and one gage is located at Clay Spring North.

- Perform a synoptic discharge study of Big Springs-Lake Creek complex during irritation and non-irrigation season prior to SNWA GDP pumping (completed). The study will be repeated every five years after SNWA GDP pumping in Spring Valley begins unless schedule is modified by the NSE.

- A groundwater monitoring network along the Nevada-Utah state line in Snake Valley was installed and is maintained by UGS (UGS, 2017).

SNWA hydrologic monitoring data is provided to the NSE electronically on a quarterly basis. Annual data reports have been provided since 2008. Historical data for each element of the monitoring program are presented in *2016 Spring Valley Hydrologic Monitoring, Management, and Mitigation Plan Status and Data Report* (SNWA, 2017b).

7.2.2 Senior Water Rights

A query of the NDWR Water Rights Database for all active water rights and domestic wells in Hamlin and Snake valleys was performed. Active water rights are those that are not in application status, but it includes vested claims. Based on this query, as of November, 2016 there are 66 active water rights in Hamlin Valley, Nevada that have a status of certificated, decreed, permitted, reserved, or vested. The resulting data set was further reduced to include 12 water rights that are within the analysis area in Hamlin Valley (Section 4.1). The data set was further reduced to exclude water rights that are in the mountain block of the basin, have priority dates junior to the SNWA GDP permits, or are owned by SNWA. In Hamlin Valley, Nevada two of the 12 active water rights were excluded from further consideration based upon those criteria. The resulting data set includes 10 active water rights in Hamlin Valley that meet the analysis criteria.

The query of the NDWR Water Rights Database in Snake Valley, Nevada indicated that there are 160 active water rights as of November, 2016 that have a status of certificated, decreed, permitted, reserved, or vested. The resulting data set was further reduced to include 52 water rights that are within the analysis area in Snake Valley (Section 4.1). The data set was further reduced to exclude water rights that are in the mountain block of the basin, have priority dates junior to the SNWA GDP permits, or are owned by SNWA. In Snake Valley, Nevada 33 of the 52 active water rights were excluded from further consideration based upon those criteria. The resulting data set includes 19 active water rights in Snake Valley, Nevada.

The locations of water rights senior to the SNWA GDP permits within the analysis area in northern Hamlin and southern Snake valleys are presented in Figure 7-1. Tallies of water rights senior to SNWA GDP permits by source and status in Hamlin and southern Snake Valley, Nevada are presented in Tables 7-1 and 7-2. Individual Nevada senior water rights within the analysis area are listed in Table 7-3, which includes information on water right status, source, manner of use, priority date, diversion rate, annual duty, ownership, distance to the closest SNWA GDP POD, DEM elevation, and management category (as described in Section 3.2.5).

Within the analysis area in Hamlin Valley, there are five underground and one spring certificated senior water rights; one reserved senior spring water right; and three senior vested claims as listed in Table 7-4. The BLM reserved right is for stock and wildlife uses and the nine other senior water rights in Hamlin Valley are for stock watering.

There are ten permitted underground rights, one certificated spring right, one reserved water right, and seven vested claims that are senior to the SNWA GDP permits within the analysis area in south

Table 7-1
Water Rights in Northern Hamlin Valley, Nevada by Source and Status Senior to SNWA GDP Permits

Source	Senior Water Right Status (Number of Rights/Annual Duty)			
	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)
Other Groundwater	0 / 0.00	0 / 0.00	0 / 0.00	1 / 10.16[a]
Spring	1 / 86.85	0 / 0.00	1 / 26.32	1 / 13.33
Underground	5 / 353.41[b]	0 / 0.00	0 / 0.00	1 / 10.16[a]

[a]Acre-ft per season.
[b]The reported duty includes both acre-ft per season and acre-ft per annum.

Table 7-2
Water Rights in Southern Snake Valley, Nevada by Source and Status Senior to SNWA GDP Permits

Source	Senior Water Right Status (Number of Rights/Annual Duty)			
	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)
Other Groundwater	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00
Spring	1 / 24.24[a]	0 / 0.00	1 / 26.05	1 / 9.33[a]
Stream	0 / 0.00	0 / 0.00	0 / 0.00	4 / 3,414.09[b]
Underground	0 / 0.00	10 / 3,983.04[c]	0 / 0.00	2 / 3,983.04[c]

[a] Acre-ft per season.
[b] The reported duty includes both acre-ft per season and acre-ft per annum.
[c]The reported duty represents a not to exceed total combined duty of 3,983.04 afa. It consists of 10 permitted rights and 1 vested right.

Snake Valley, Nevada (Table 7-4). The BLM reserved water right is for stock and wildlife uses, and the other senior water rights are for irrigation or stock watering.

A query of the Utah Division of Water Rights (UDWRi) water right point of diversion database for all active water rights in Snake Valley, Utah was performed in November, 2016. Based on this query, there are 693 approved and perfected water rights in the Utah portion of Snake Valley. The resulting data set was reduced to 66 water rights are within the project analysis area. These water rights were

Table 7-3
Water Rights in Northern Hamlin and Southern Snake Valleys, Nevada Senior to SNWA GDP Permits
(Page 1 of 2)

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
Northern Hamlin Valley											
9981	CER	UG	STK	1936	0.017	6.7*[,h]	Ashdown, Sidney	Alluvial Fan	15.1	5,950	D
45495	CER	SPR	STK	1982	0.12	86.8*	Okelberry, Ray	Alluvial Fan	8.1	6,060	D
45497	CER	UG	STK	1982	0.12	86.8*	Okelberry, Ray	Alluvial Fan	7.7	5,730	D
45498	CER	UG	STK	1982	0.12	86.8*	Okelberry, Ray	Valley Floor	10.6	5,760	D
45499	CER	UG	STK	1982	0.12	86.8*	Okelberry, Ray	Alluvial Fan	11.5	5,670	D
45500	CER	UG	STK	1982	0.119	86.1*	Okelberry, Ray	Valley Floor	9.6	5,780	D
R05277	RES	SPR	OTH	1926	0.036[i]	26.32[i]	BLM	Valley Floor	16.8	5,570	D
V02125	VST	SPR	STK	1900	0.025	13.33[i]	Swallow, A.M.	Valley Floor	16.5	5,610	D
V02198	VST	OGW	STK	1899	0.025	10.2*[,h]	Swallow, A.M.	Alluvial Fan	8.1	6,060	D
V02199	VST	UG	STK	1899	0.025	10.2*[,h]	Swallow, A.M.	Alluvial Fan	7.6	5,730	D
Southern Snake Valley, Nevada											
3723	CER	SPR	STK	1915	0.05	24.2*[,h]	Production Credit Corp. of Berkeley	Alluvial Fan	25.8	6,090	D
84145	PER	UG	IRR	1972	1	263.0	Granite Peak Properties LC	Valley Floor	19.0	5,510	D
84146	PER	UG	IRR	1986	1.003	180.0	Granite Peak Properties LC	Valley Floor	19.7	5,510	D
84147	PER	UG	IRR	1986	0.886	159.0	Granite Peak Properties LC	Valley Floor	21.0	5,480	D
84148	PER	UG	IRR	1986	0.55	99.0	Granite Peak Properties LC	Valley Floor	19.4	5,510	D
84149	PER	UG	IRR	1986	0.45	81.0	Granite Peak Properties LC	Valley Floor	20.2	5,500	D
84150	PER	UG	IRR	1986	0.78	141.0	Granite Peak Properties LC	Valley Floor	19.8	5,500	D
84151	PER	UG	IRR	1986	1.67	300.0	Granite Peak Properties LC	Valley Floor	19.9	5,500	D
R05271	RES	SPR	OTH	1926	0.036	26.1*	BLM	Alluvial Fan	18.9	5,560	D
V01650	VST	STR	STK	1919[g]	0	6.7*[,h]	Murray Sheep Company	Valley Floor / Alluvial Fan	16.6	5,580	D

Table 7-3
Water Rights in Northern Hamlin and Southern Snake Valleys, Nevada Senior to SNWA GDP Permits
(Page 2 of 2)

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
V01651	VST	STR	IRR	1919[g]	1.555	534.8*,[h]	Smith, Charles	Valley Floor / Alluvial Fan	16.6	5,580	D
V01652	VST	STR	IRR	1919[g]	2.6	251.2*,[h]	Winder, Leo C.	Valley Floor / Alluvial Fan	16.6	5,580	D
V02200	VST	SPR	STK	1900	0.025	9.3*,[h]	Granite Peak Properties, L.C.	Valley Floor	21.2	5,470	D
V04568	VST	UG	STK	1970	0[i]	0[i]	Granite Peak Properties LC or NV LC	Valley Floor	21.1	5,480	D
V09610	VST	STR	IRR	1895	7.6[i]	2,621.4[i]	Baker Ranches, Inc.	Alluvial Fan	23.0	5,470	D
V09745	VST	UG	IRR	1934	0.89	82.0[i]	Granite Peak Properties, L.C.	Valley Floor	21.6	5,470	D
V09746	PER	UG	IRR	1934	1.12	80.0	Granite Peak Properties, L.C.	Valley Floor	20.9	5,480	D
V09747	PER	UG	IRR	1934	0.55	80.0	Granite Peak Properties, L.C.	Valley Floor	20.3	5,540	D
V09748	PER	UG	IRR	1934	2.22	80.0	Granite Peak Properties, L.C.	Valley Floor	21.6	5,470	D

[a]CER - Certificated, PER - Permitted, RES- Reserved, VST - Vested
[b]OGW - Other Groundwater, SPR - Spring, STR - Stream, UG - Underground
[c]IRR - Irrigation, OTH - Other, STK - Stock watering
[d]Rounded to the nearest tenth of a mile. Distance measured from the listed resource to SNWA POD No.54003.
[e]Rounded to the nearest 10ft.
[f]See Section 3.2.5 for a detailed explanation of the Management Categories; D - Senior water right in an adjacent hydrographic area.
[g]Filing date, not priority date.
[h]Acre-ft per season.
[i]Reported number was derived from an analysis documented in Stanka (2017).
*The reported annual duty is not explicitly documented on the certificate, reserved right, or vested claim, but reported as such by the NDWR Hydrographic Abstract query.

further reduced by those water rights that are in the mountain block of the basin, abandoned wells, or non-production wells. Thirty-five water rights were excluded from further consideration based upon those criteria. There are two water rights that were in the mountain block, two water rights that corresponded to abandoned wells and 31 water rights that corresponded to non-production wells. The resulting data set includes 31 approved and perfected water rights within the Snake Valley, Utah project analysis area which are listed in Table 7-4 and presented in Figure Figure 7-1.

A query was also made of water rights in the Utah portion of Hamlin Valley. There are no senior water rights outside the mountain block in the analysis area.

Table 7-4
Water Rights in Southern Snake Valley, Utah Senior to SNWA GDP Permits
(Page 1 of 2)

App No.	Chexnum[a]	Status[b]	Source[c]	Manner of Use[d]	Priority Date	Diversion Rate (cfs)	Duty (af)	Owner of Record	Geographic Location	Distance to Nearest POD[e] (mi)	DEM Elevation[f] (ft amsl)	Management Category[g]
18-203		P	UG	S	1958	0.015	0.0	USA Bureau of Land Management	Alluvial Fan	26.4	5,580	D
18-219		P	UG	IS	1961	0	742.8	Davies Ranch Incorporated	Alluvial Fan	26.3	5,420	D
18-219	a33632	A	UG	IS	2007	0	742.8	Davies Ranch Incorporated	Valley Floor	26.3	5,420	D
18-219	a33632	A	UG	IS	2007	0	742.8	Davies Ranch Incorporated	Alluvial Fan	26.4	5,420	D
18-244		P	Surface	DIS	1895	0	2,588.0	Baker Ranches Inc.	Alluvial Fan	31.2	5,380	D
18-245		P	Spring	DIS	1881	0.562	0.0	Baker Ranches, Inc.	Alluvial Fan	30.0	5,440	D
18-262		P	UG	DIS	1930	0.011	0.0	Davies Ranch Inc.	Valley Floor	26.5	5,410	D
18-393		P	Surface	I	1895	0	12.9	B & E Ranches Incorporated	Alluvial Fan	31.2	5,380	D
18-461		P	UG	IS	1981	3	0.0	Carl J. Dearden	Valley Floor	25.4	5,430	D
18-497		P	UG	OS	1983	0.025	11.8	USA Bureau of Land Management	Alluvial Fan	26.2	5,420	D
18-497	a17864	A	UG	OS	2016	0.025	11.8	USA Bureau of Land Management	Alluvial Fan	26.2	5,420	D
18-571		P	Spring	OS	1903	0.013	0.0	Richfield District USA BLM	Alluvial Fan	23.4	5,450	D
18-620		P	Point to Point	OS	1903	0.02	0.0	USA Bureau of Land Management	Valley Floor	31.6	5,310	D
18-621		P	Point to Point	OS	1903	0.02	0.0	USA Bureau of Land Management	Valley Floor	30.6	5,580	D
18-621		P	Point to Point	OS	1903	0.02	0.0	USA Bureau of Land Management	Valley Floor	30.0	5,370	D
18-630		P	UG	DS	1992	0	1.4	Kenneth C. Knudson	Valley Floor	23.0	5,460	D
18-645		A	Spring	IS	1995	2	0.0	Dearden Land and Livestock	Valley Floor	27.6	5,400	D
18-647		P	UG	I	2004	0	641.4	Kenneth C. Knudson	Valley Floor	23.0	5,450	D
18-667		P	UG	I	2001	2	400.0	Kenneth C. Knudson	Valley Floor	23.0	5,450	D

Table 7-4
Water Rights in Southern Snake Valley, Utah Senior to SNWA GDP Permits
(Page 2 of 2)

App No.	Chexnum[a]	Status[b]	Source[c]	Manner of Use[d]	Priority Date	Diversion Rate (cfs)	Duty (af)	Owner of Record	Geographic Location	Distance to Nearest POD[e] (mi)	DEM Elevation[f] (ft amsl)	Management Category[g]
18-673		A	UG	OS	2002	0.026	19.1	USA Bureau of Land Management	Alluvial Fan	24.0	5,710	D
18-678		P	UG	S	2002	0.018	13.0	USA Bureau of Land Management	Alluvial Fan	24.4	5,500	D
18-680		P	UG	S	2003	0.004	0.0	State of Utah School & Institutional Trust Land Admin	Alluvial Fan	24.0	5,710	D
18-684		P	Spring	DIS	1881	30	0.0	Second Big Springs Irrigation Company	Valley Floor	23.3	5,440	D
18-708		P	Surface	IS	1895	0	1,710.7	Baker Ranches Inc.	Alluvial Fan	31.2	5,380	D
18-715		A	UG	OS	2007	0.018	6.9	USA Bureau of Land Management	Alluvial Fan	29.0	5,410	D
18-721		A	UG	I	2008	0	400.0	Carter’s Cattle	Valley Floor	27.3	5,400	D
18-721	a40465	A	UG	DIS	2015	0	400.0	Carter’s Cattle	Valley Floor	27.5	5,410	D
18-721	a40465	A	UG	DIS	2015	0	400.0	Carter’s Cattle	Valley Floor	27.1	5,410	D
18-721	a40465	A	UG	DIS	2015	0	400.0	Carter’s Cattle	Valley Floor	27.3	5,400	D
18-721	a40465	A	UG	DIS	2015	0	400.0	Carter’s Cattle	Valley Floor	27.3	5,400	D
18-727		A	UG	OS	2009	0.044	23.5	Department of Interior Bureau of Land Management	Alluvial Fan	29.4	5,790	D

[a]Change or Exchange Number
[b]P - Perfected: proof filed, right certificated; A - Approved
[c]UG - Underground, Point to Point - Point to point diversions are not developed points of diversion. The reference is to a stream segment from which stock may drink. See https://www.waterrights.utah.gov/gisinfo/wrpod.htm for more detail.
[d]D - Domestic, I - Irrigation, O - Other, S - Stock watering
[e]Rounded to the nearest tenth of a mile. Distances measured from listed resource to SNWA POD No. 54003.
[f]Rounded to the nearest 10 ft.
[g]See Section 3.2.5 for a detailed explanation of the Management Categories; D - Senior water right in adjacent hydrographic area.

7.2.3 Monitoring, Management, and Mitigation

Senior water rights meeting the analysis criteria are assigned a management category which defines the monitoring strategy and establishes appropriate investigation triggers to evaluate the cause and significance of variation from baseline conditions. Appropriate management actions may be implemented based upon the results of the investigation to avoid or minimize the likelihood of activating a mitigation trigger. The monitoring and management strategy, investigation and management actions, and mitigation triggers and actions for Hamlin and Snake valleys are presented in this section.

Monitoring Strategy

The senior water rights meeting the analysis criteria in Hamlin and Snake valleys are assigned Management Category D, as described in Table 3-1, because they are located in an adjacent basin to SNWA GDP pumping. The monitoring and management strategy for this category consists of using sentinel monitor wells, as explained in Section 3.2.1, located between the SNWA GDP PODs and the more distant senior water rights to detect and measure propagation of drawdown. The sentinel wells are a key component of the monitoring and management strategy to avoid unreasonable effects to senior water rights in Hamlin and Snake valleys.

Inter-basin groundwater flow between Spring and Hamlin valleys is limited to the carbonate aquifer below the Limestone Hills due to the low hydraulic conductivity of the Snake Range to the north and the Indian Peak Caldera Complex to the south as described in Rowley et al. (2011). Three planned wells SPR7009M, HAM1007M, and SPR7010M, are designated as sentinel monitor wells, and will be installed at least three years prior to SNWA GDP pumping along the Limestone Hills in the carbonate aquifer near the Spring and Hamlin Valley hydrographic boundary as shown on Figure 7-1. These sentinel monitor wells will be effective at detecting and measuring propagation of drawdown because they are located in the groundwater flow path between the SNWA GDP PODs and Hamlin Valley.

There are seven senior water rights or vested claims in Hamlin Valley located approximately 7.75 to 11.5 miles from the closest SNWA GDP POD. These senior water rights will be monitored at four assigned wells, as listed in Table 7-5, which are located at the senior water right POD or in close proximity to the senior water right POD. The remaining three senior water rights in Hamlin Valley are located greater than 15 miles from the closest SNWA GDP POD and are managed similar to the distant senior water rights located in Snake Valley.

Table 7-5
Hamlin Valley Senior Water Rights Closest to SNWA GDP PODs and Associated Monitor Wells

Senior Water Right	Associated Monitor Well
45495 (Spring), V02198 (OGW)	HAM1007M
45497 (UG), V02199 (UG)	383325114134901
45498 (UG), 45500 (UG)	383023114115302
45499 (UG)	383533114102901

The sentinel monitor wells and groundwater monitoring associated with the seven senior water rights in Hamlin Valley located closest to SNWA GDP PODs will provide a substantial distance buffer and early warning of potential effects at senior water rights located in Snake Valley. Cross sectional profile locations which illustrate the hydrogeology and monitor well distribution between the SNWA GDP PODs in Spring Valley across Hamlin Valley to Dearden Springs in Snake Valley, are presented on Figure 7-2. The east-west regional geologic profile, A-A', at the south end of the Snake Range across the Limestone Hills and the north-south hydrogeologic profile, B-B', along the Limestone Hills are presented on Figure 7-3. The profiles show that inter-basin flow between Spring and Hamlin valleys occurs through the carbonate aquifer across the Limestone Hills where the sentinel monitor wells will be completed.

The two profiles C-C' and D-D' across the northern and southern portions of the Limestone Hills, presented on Figure 7-4, illustrate the SNWA GDP PODs for permit numbers 54003 to 54005, sentinel monitor wells, other intermediate monitor wells, and the distance to Dearden Springs. The figure shows the large distance and multiple monitor wells located between the SNWA GDP PODs and senior water rights in Snake Valley.

Investigation Triggers and Management Actions

An investigation trigger will be activated if the water level in any of the sentinel monitor wells or monitor wells associated with the senior water rights listed in Table 7-5 are below the 99.7 percent lower control limit for a continuous period of six months, as described in Appendix A. Baseline water level hydrographs for the monitor wells 383325114134901, 383023114115302, and 383533114102901 showing the current 99.7 lower control limit, are presented on Figures 7-5 through 7-7, respectively.

The three sentinel monitor wells, SPR7009M, HAM1007M, and SPR7010M, will be installed at least three years prior to SNWA GDP pumping. The 99.7 percent lower control limit used for the investigation trigger will be derived for the new wells prior to SNWA GDP pumping using the baseline data collected. An expanded synthetic historical record will be developed for the new wells if the baseline data collected are consistent with observations at other monitor wells in the area. If they are not consistent with other wells in the area, only the baseline period of record will be used to determine the 99.7 percent lower control limit.

Activation of an investigation trigger at the sentinel wells or monitor wells listed in Table 7-5 will result in an evaluation to determine the cause and significance of the water level change observed using protocols described in Section 3.2.2. Should the cause of the water level change be attributed to SNWA GDP pumping, the following management actions may be taken:

- Prepare to implement mitigation actions for the seven Hamlin Valley senior water rights listed on Table 7-6, including purchasing equipment, establishing contracts, and obtaining any necessary landowner permissions and permits.

- Update and recalibrate the numerical groundwater flow model and other predictive tools with aquifer response data. The model will be used to predict drawdown with distance and time

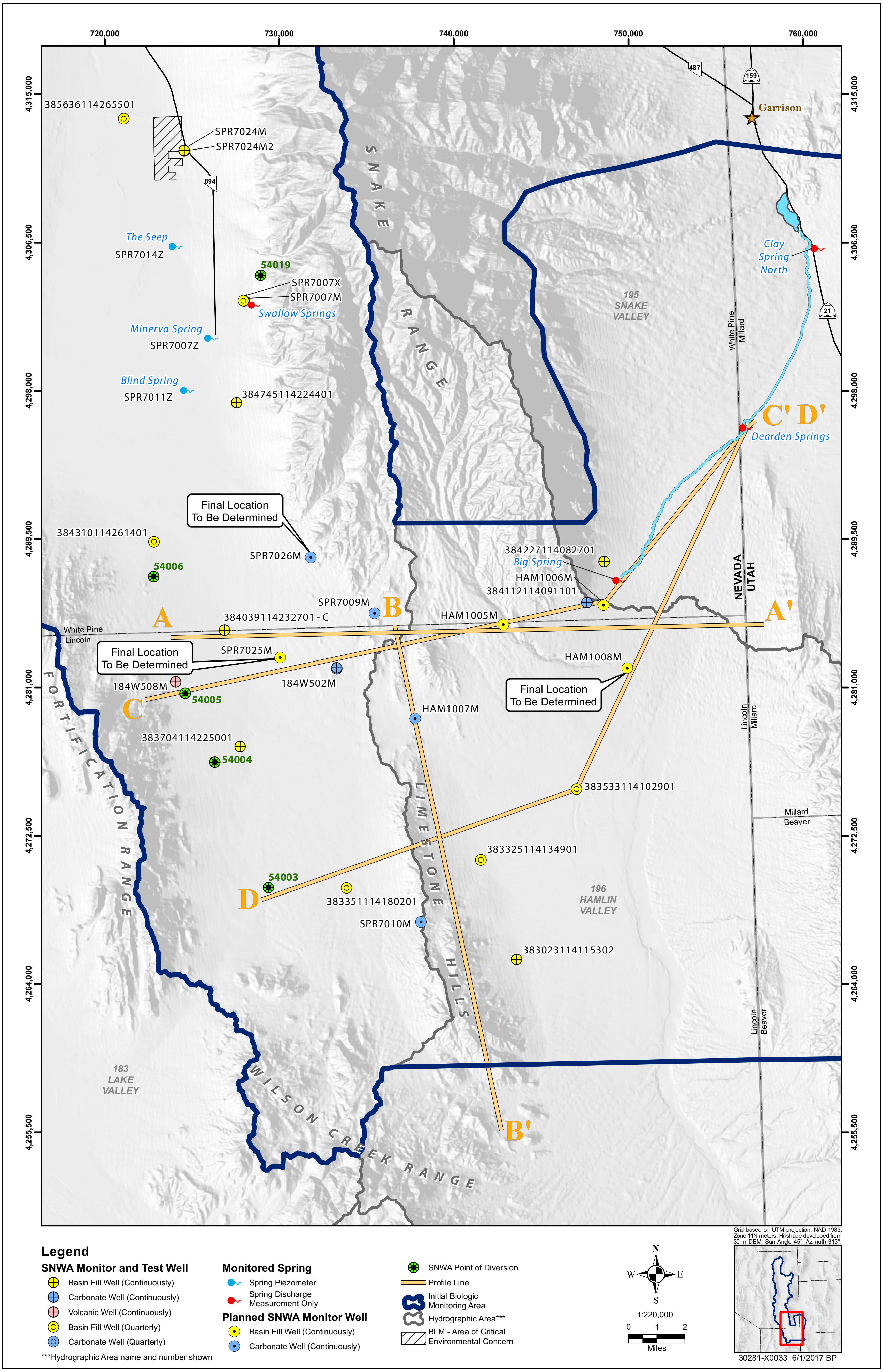
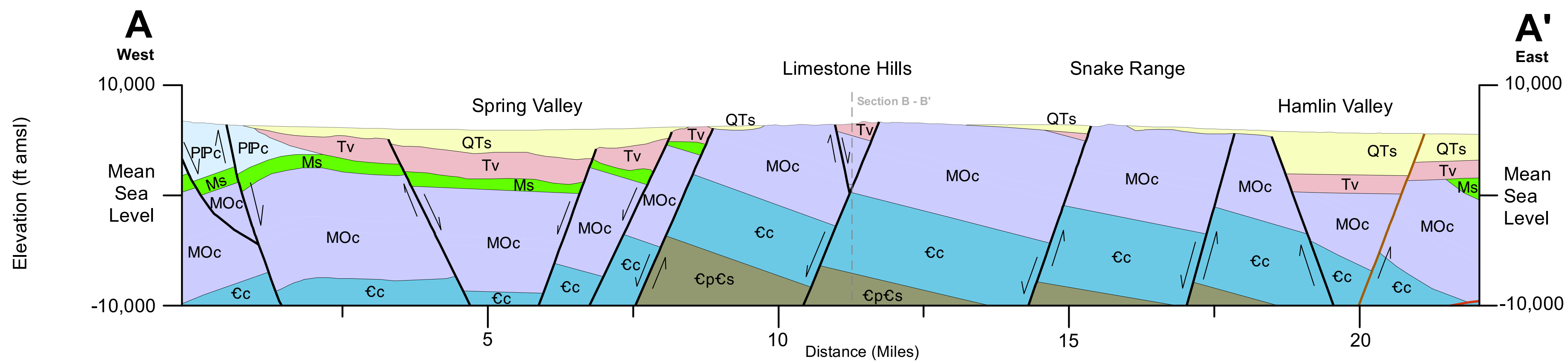


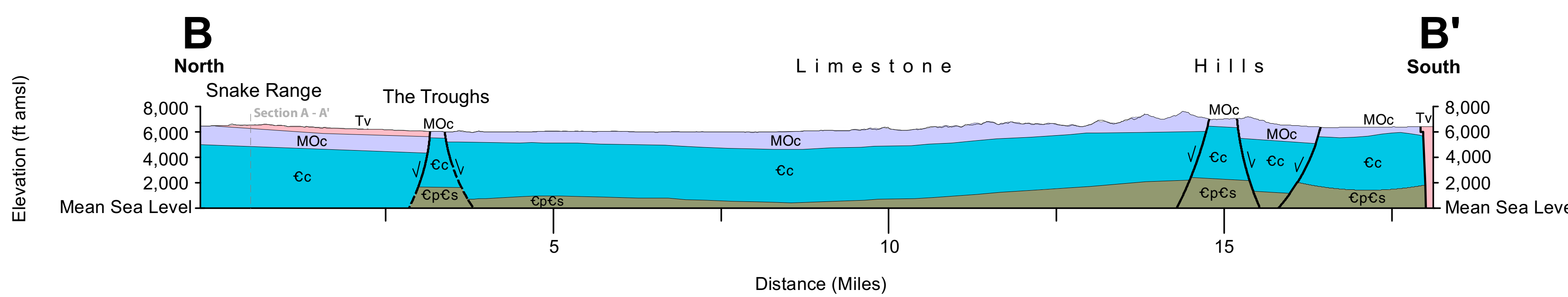
Figure 7-2
Geologic and Monitor Well Profile Locations



Source: SNWA, 2011c

Hydrogeologic Profile A - A'

1:150,000



Vertical Exaggeration = 0

Hydrogeologic Profile B - B'

1:150,000

Legend

Hydrogeology

Map Unit - Description

Map Unit	Description
QTs	Quaternary-Tertiary sediments
Tv	Tertiary volcanic rocks
PIPc	Permian-Pennsylvanian carbonate rocks
Ms	Mississippi siliciclastic rocks
MOc	Mississippian-Ordovician carbonate rocks
€c	Cambrian carbonate rocks
€p€s	Cambrian-pre-Cambrian clastic rocks

Regional Faults

- Normal Fault
- Thrust Fault
- Quaternary Normal Fault

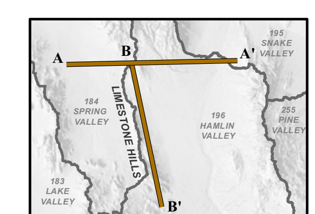


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Figure 7-3
Geologic Profile for Limestone Hills Area

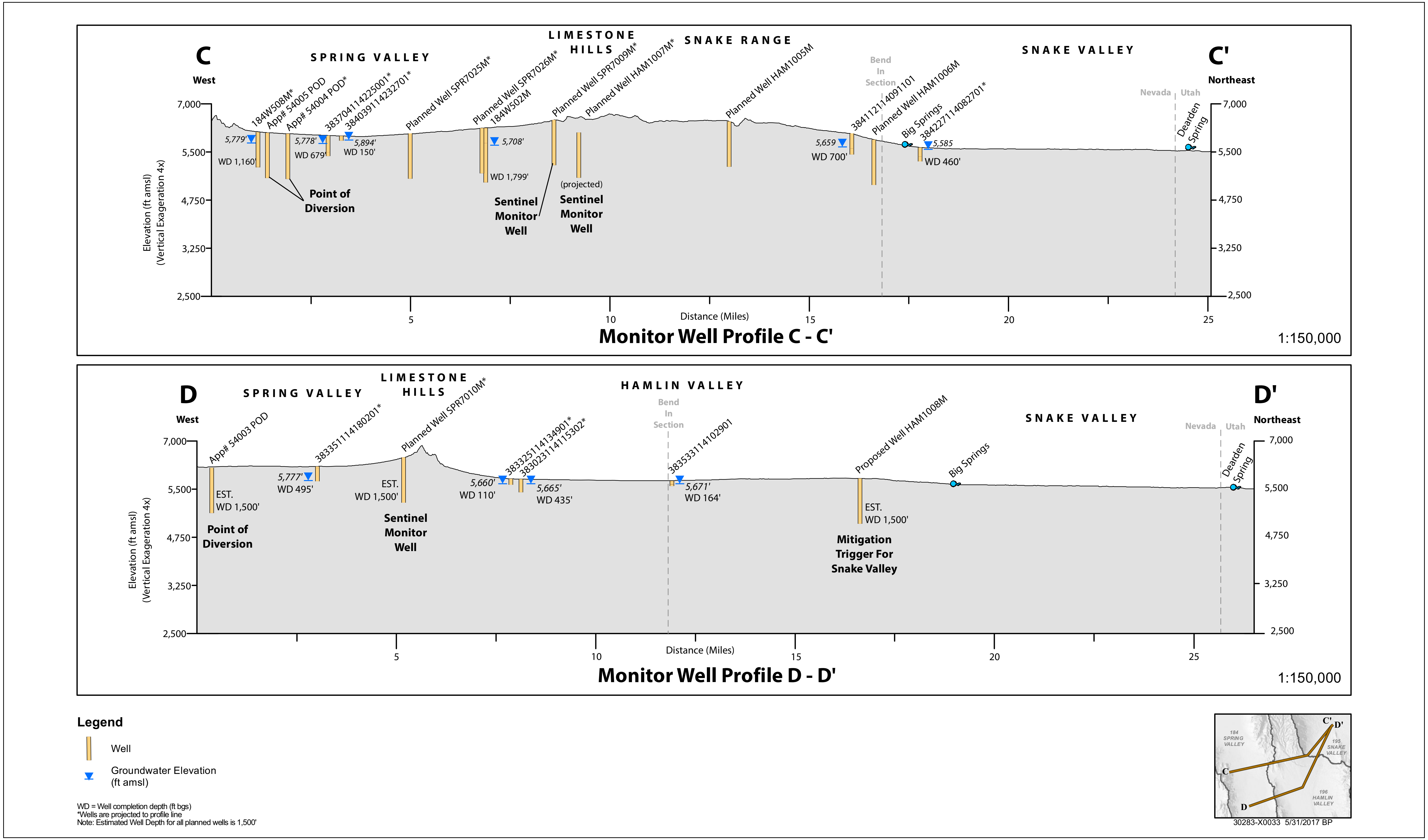

Figure 7-4
Profile of Monitor Well Locations

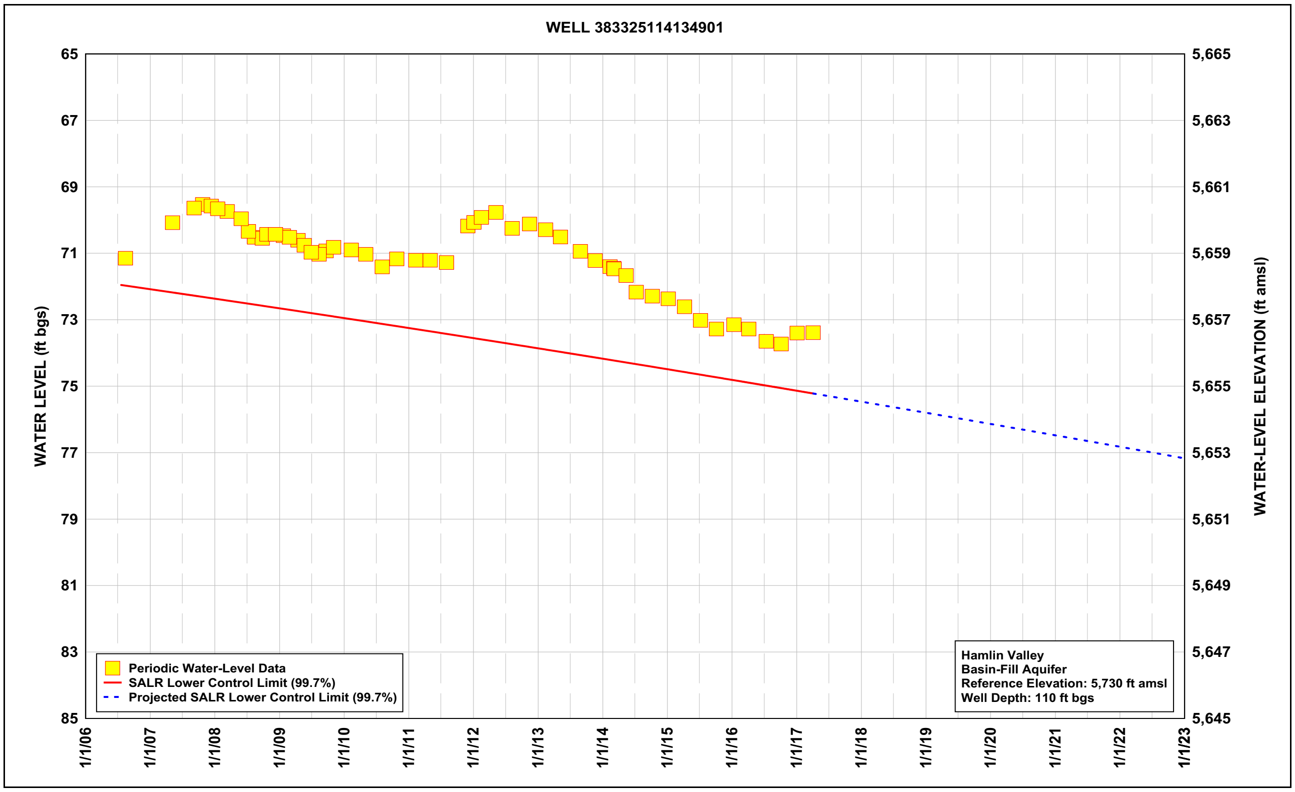

Figure 7-5
Well 383325114134901 (Hyde Well) - Trigger

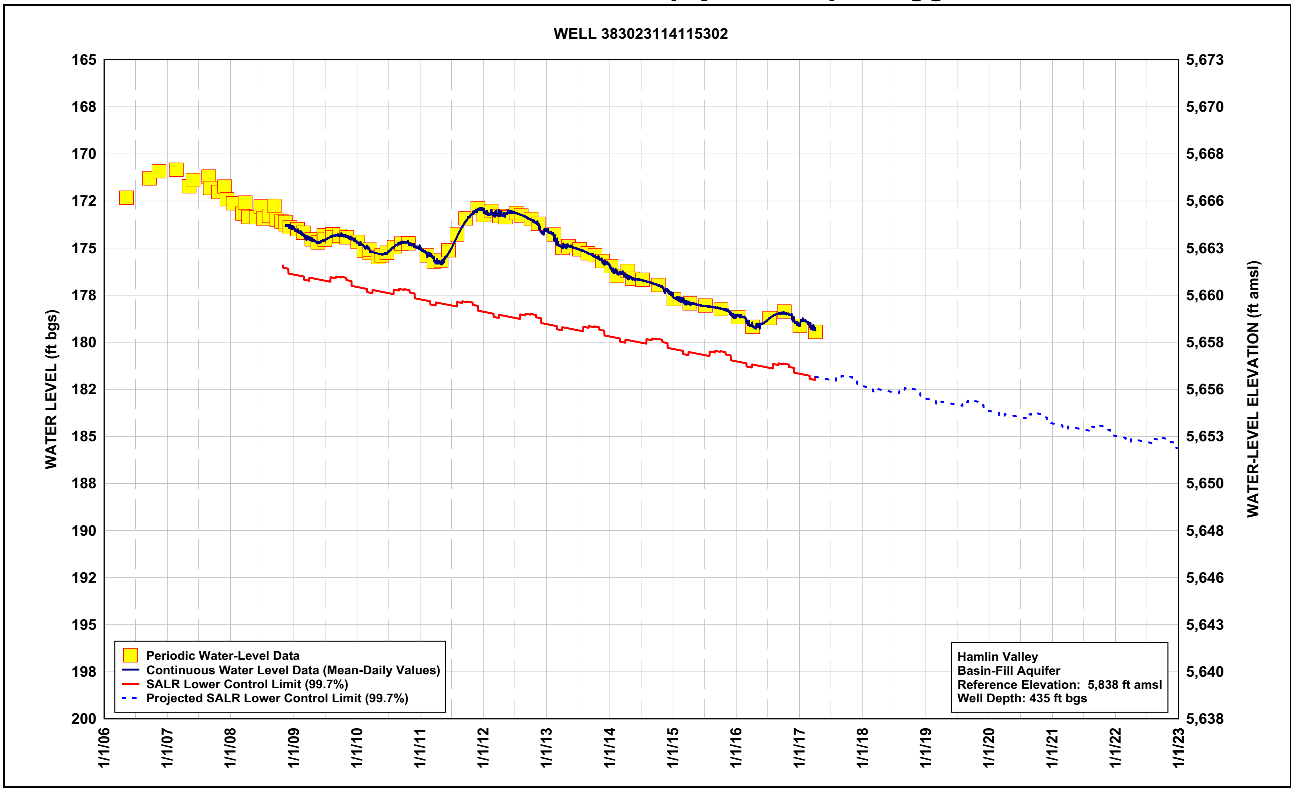

Figure 7-6
Well 383023114115302 - Trigger

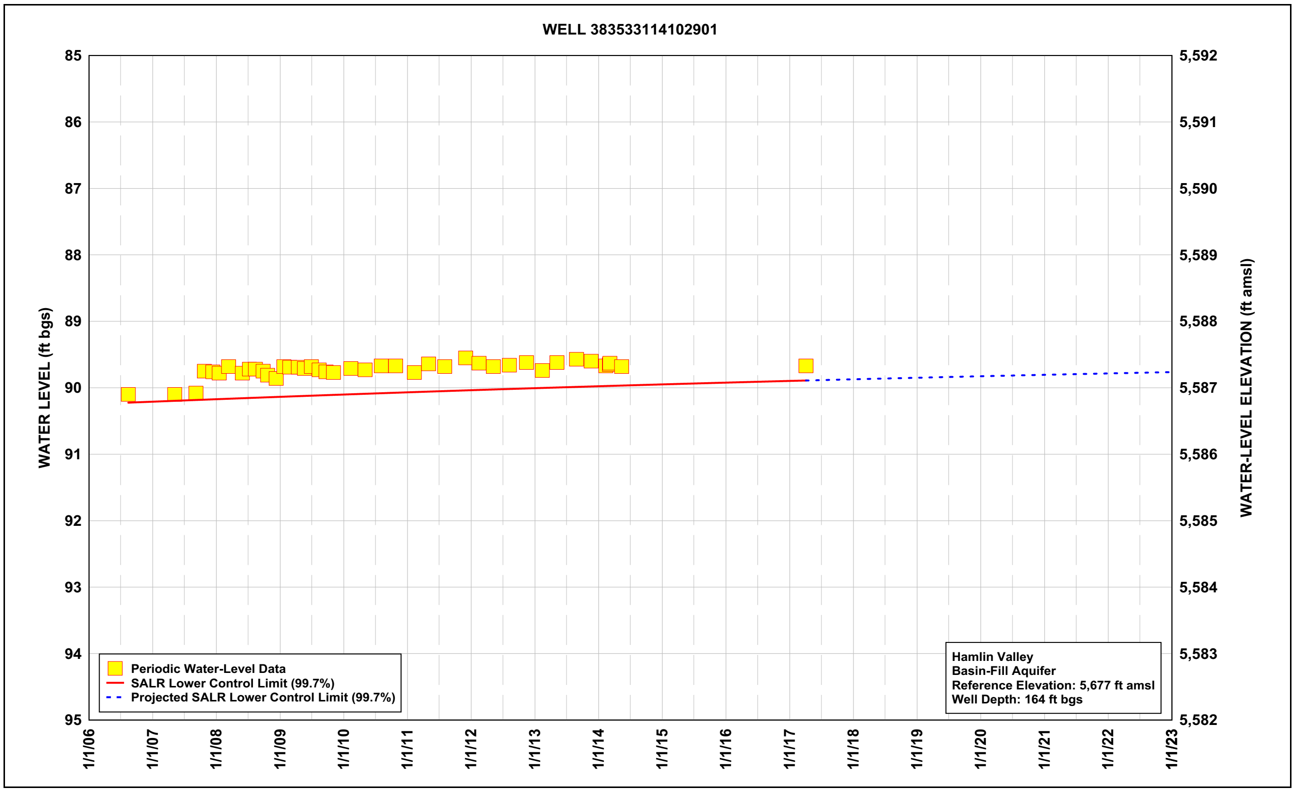

Figure 7-7
Well 383533114102901 (Monument Well) - Trigger

under different pumping scenarios to evaluate if and when a mitigation trigger would be activated at a distant senior water right in Snake Valley.

- Continue to monitor water levels in the sentinel and other intermediate wells to verify model projections.
- Increase monitoring frequency in well being monitored quarterly.
- Evaluate the addition of other existing production wells downgradient of the sentinel wells including Granite Peak Ranch wells, for inclusion into the monitoring network.
- Request adjudication of selected vested claims within the analysis area of Snake Valley.
- Perform a baseline well assessment (as described in Section 3.2.7) with owner access permission for the underground water rights at Granite Peak Ranch and permit number 9981 in eastern Hamlin Valley,
- Adjust SNWA GDP pumping rates, durations, and/or distribution to avoid activating a mitigation trigger at monitor well HAM1008M or distant senior water right locations further downgradient in Hamlin and Snake valleys.

Monitoring at the three sentinel wells and the closest seven Hamlin Valley senior water rights described above will provide early warning of changes in groundwater levels. Early warning will allow time for implementation of appropriate management actions to avoid activating mitigation triggers at monitor well HAM1008M, the three distant senior water rights in Hamlin Valley (permit numbers 9981, R05277, and V02125) and all the senior water rights in Snake Valley.

Any management actions implemented will provide additional data which can be used by SNWA to adjust groundwater pumping to avoid impacts from occurring at more distant senior water rights and environmental resource sites in Snake Valley. The SNWA monitoring network provides over 15 miles of buffer between the sentinel monitor wells located along the Limestone Hills and Dearden Springs and other senior water rights located in Nevada and Utah. The SNWA hydrologic monitoring network will provide data on changes in water levels between the SNWA PODs and the Utah state line to effectively detect and measure propagation of drawdown, if it occurs. The UGS monitoring network in Utah provides additional hydrologic data and would detect propagation of drawdown associated with the SNWA GDP.

The source water for Big Springs is derived from local recharge from the southern Snake Range (and not inter-basin flow from Spring Valley) as described by Prudic et al. (2015) (see discussion in Section 7.1). This fact and hydrogeologic conditions in the area make it unlikely that Big Springs would be affected by SNWA GDP pumping in Spring Valley. The unnamed springs north of Big Springs and groundwater along the Snake Range front in Nevada are also sourced from the Snake Range. Clay Spring North located east of Lake Creek in Utah is located on the western flank of the northern Burbank Hills (Hurlow, 2014). Groundwater recharge from the Burbank Hills area likely contributes to the discharge of Clay Springs North.

Granite Peak Ranch irrigation wells are located upgradient of Dearden Springs and within the groundwater flow path for water originating in southern Hamlin and Spring Valley. The effect of local irrigation practices in the area and operations of Granite Peak Ranch irrigation wells on water rights, especially on Dearden and Big springs, were presented in NSE Ruling 6311, (NDWR, 2015), and by Prudic et al. (2015). The influence of Granite Peak Ranch irrigation operations would be considered in evaluating causation of impacts on other senior water rights in Snake Valley.

Mitigation Triggers

The mitigation trigger applies to all the senior water rights in this section, as described in Section 3.2.6. Mitigation triggers determine when a mitigation action is implemented, if the cause of the trigger being activated is SNWA GDP pumping.

A mitigation trigger is set at proposed monitor well HAM1008M, located upgradient of Snake Valley, which would be activated prior to effects occurring in Snake Valley. The mitigation trigger at HAM1008M is the continuous departure of water levels outside the 99.7 percent lower control limit for six months, as described in Appendix A. The mitigation triggers and mitigation actions described below also apply to senior water rights located in Utah.

Underground Senior Water Rights

The mitigation trigger for underground senior water rights are defined for two categories where: (1) The well and current production capacity is capable of producing more water than the water right diversion rate allows; and (2) the well and current production capacity is capable of producing water only equal to or less than the water right diversion rate allows.

The mitigation triggers are based upon specific capacity and change in static groundwater levels as described in Section 3.2.6.1. The mitigation triggers are summarized below:

Underground Senior Water Rights

The mitigation trigger for underground senior water rights are defined for two categories where: (1) the well and current pump production capacity is capable of producing more water than the water right's diversion rate allows; and (2) the well and current pump production capacity is capable of producing water only equal to or less than what the water right's diversion rate allows.

The mitigation triggers are based upon change in static groundwater level and specific capacity as described in Section 3.2.6.1. The mitigation triggers are detailed below:

- Well production > permitted diversion rate prior to SNWA GDP pumping: A decrease in groundwater level that reduces the column of water in the well needed to produce the permitted diversion rate based on the well's specific capacity range plus either a 10 percent or 10 foot buffer, which ever is greater. The buffer provides time to implement the mitigation action prior to reaching a conflict. An example of a mitigation trigger for this case is presented in Section 3.2.6.1. An alternative fixed mitigation trigger for the well is activated if the maximum production capacity from the well decreases to less than 10 percent above the permitted diversion rate and the static groundwater level has decreased as a result of SNWA GDP pumping. An evaluation would be made to determine if the changes were a result of SNWA GDP pumping or were due to a deterioration in the well or pump conditions and efficiency.

- Well production < permitted diversion rate prior to SNWA GDP pumping: The mitigation trigger is activated if the evaluation associated with the investigation trigger determines the cause of the change in water level to be SNWA GDP pumping.

- Increase of more than 25 percent in power usage to pump the same amount of water as a result of decreased water levels from SNWA GDP pumping.

Spring and Stream Senior Water Rights

The mitigation trigger for spring and stream rights is based upon change in flow rate in relation to the permitted diversion rate or historical baseline flow rate as described in Section 3.2.6.2. The mitigation trigger for a senior spring or stream water-right is presented under two cases: (1) spring or stream flow at the POD which has been measured consistently above the permitted diversion rate, or (2) spring or stream flow at the POD which has been measured consistently at or below the permitted diversion rate. The mitigation triggers are detailed below:

- If measured baseline spring or stream flow has been consistently above the permitted diversion rate, the mitigation trigger is 10 percent above the permitted diversion rate to provide a buffer and is activated if spring or stream discharge decreases below this mitigation trigger level as a result of SNWA GDP pumping.

- If measured baseline spring or stream flow has been consistently at or less than the permitted diversion rate, the mitigation trigger is activated if the evaluation associated with the investigation trigger determines the cause of the change to be SNWA GDP pumping.

A third case consist of springs which have intermittent flow or are consistently dry. A spring which has non-measurable intermittent flow or that is dry over extended periods of time will be studied as a special case using nearby shallow piezometers, if present, or visual observations. The spring conditions will be compared to water levels and regional precipitation conditions to determine the conditions under which the spring flows. After SNWA GDP pumping begins, the spring will be monitored to determine if there is a change in the observed spring flow compared what has been observed under similar baseline regional hydrologic conditions.

Mitigation Actions

If a senior water right mitigation trigger is activated, and is caused by SNWA GDP pumping, mitigation actions will be implemented. The mitigation actions for the senior water rights in Hamlin and Snake valleys are presented in two groups. The first group is for the seven senior water rights located within 11.5 miles of the closest SNWA permit POD. The second group is for the more distant senior water rights. The mitigation actions for the distant senior water rights are further divided into actions for senior water rights associated with wells and those for senior water rights on springs or streams. A comprehensive list of mitigation actions for the SNWA GDP are presented in Section 3.2.8.

Mitigation actions for the seven closest senior water rights located within 11.5 miles to SNWA GDP permit PODs are identified in Table 7-6. Four of the rights (permit numbers 45497 - 45500) and one vested claim (V02199) are used for stock water and are associated with three water supply wells (383023114115302, 383325114134901, and 383533114102901). A water resource assessment will be performed on the three supply wells as described in Section 3.2.7 to determine the water column in the well to meet the permitted diversion rate. The primary mitigation actions include lowering the pumps, redeveloping the well, and the deepening or replacing wells should a mitigation trigger be activated by SNWA GDP pumping.

Spring water right permit number 45495 and vested claim V02198 are located near monitor well HAM1007M and can be mitigated with a shallow well if a mitigation trigger is activated. These mitigation actions will be effective because the well modifications or replacements will be designed to produce the amount of water required for the senior water rights. Additional mitigation actions are included below.

Table 7-6
Mitigation Actions for Senior Water Rights in Northern Hamlin, Nevada

App No.	Status[a]	Source[b]	Manner of Use	Diversion Rate (cfs)	Annual Duty (afa)	Distance to Nearest POD[c] (mi)	Site Name and Attributes Primary Mitigation Actions
Closest Northern Hamlin Valley Senior Water Rights to SNWA GDP POD							
45497	CER	UG	STK	0.12	86.8*	7.7	383325114134901 (Hyde Well) Depth of well 110' water level at 73'; 37 ft of saturated column Temporary water tank; lower pump; deepen or replace well
V02199	VST	UG	STK	0.025	10.2*,[d]	7.6	383325114134901 (Hyde Well) Depth of well 110' water level at 73'; 37 ft of saturated column Temporary water tank; lower pump; deepen or replace well
45495	CER	SPR	STK	0.12	86.8*	8.1	Near location of monitor well HAM1007M (Troughs Area) Temporary water tank; drill well; exchange water right
V02198	VST	OGW	STK	0.025	10.2*,[d]	8.1	Near location of monitor well HAM1007M (Troughs Area) Temporary water tank; drill well; exchange water right
45500	CER	UG	STK	0.119	86.1*	9.6	Well 383023114115302 Well depth 435' water level 178' 257' of saturated column Temporary water tank; lower pump; deepen or replace well
45498	CER	UG	STK	0.12	86.8*	10.6	Well 383023114115302 Well depth 435' water level 178' 257' of saturated column Temporary water tank; lower pump; deepen or replace well
45499	CER	UG	STK	0.12	86.8*	11.5	383533114102901 (Monument Well) Well depth 164' water level at 92 72 ft of saturated column Temporary water tank; lower pump; deepen or replace well

[a]CER - Certificated, VST - Vested
[b]OGW - Other Groundwater, SPR - Spring, UG - Underground
[c]Rounded to the nearest 0.1 mile. Distance measured from the listed resource to SNWA POD No. 54003.
[d]Acre-feet per season
*The reported annual duty is not explicitly documented on the certificate, reserved right, or vested claim, but reported as such by the NDWR Hydrographic Abstract query.

The three sentinel monitor wells (SPR7009M, HAM1007M, and SPR7010M) and the monitoring seven closest water rights provide a substantial early warning buffer to implement management actions to avoid activating mitigation triggers at the senior water rights located at a farther distance in Hamlin and Snake valleys. The sentinel monitor well HAM1007M will provide early warning of potential effects to Dearden Springs and provide data to evaluate capture of flow to Dearden Springs.

The water level at HAM1007M and HAM1008M will decrease below the 99.7 percent lower control limit prior to propagation of drawdown to Dearden Springs**.** Using the data from the sentinel wells and monitoring of the seven closest senior water rights in Hamlin Valley will provide time for management actions to be implemented as described in this section to avoid unreasonable effects in Snake Valley.

Mitigation triggers, as described in above, also apply to senior water rights located in Utah. Mitigation actions in Snake Valley, Nevada and Utah, if caused by SNWA GDP pumping will be implemented. The mitigation actions for the distant (>11.5 miles from the closest SNWA GDP POD) senior water rights in Hamlin and Snake valleys are presented for wells and springs/streams. Mitigation in Snake Valley is unlikely due to the mitigation trigger at Monitor HAM1008M and distance from SNWA PODs. The mitigation actions including the following:

Additional mitigation actions for wells include:

- Modification of SNWA GDP pumping duration, rate, or distribution
- Lowering of the pump if the well has the depth and capacity to produce the water right.
- Rehabilitate the well to increase well efficiency.
- Deepen the well if the aquifer has the ability to yield the water right.
- Drilling and equipping a replacement well.
- Compensate well owners for the incremental increase in power usage if power usage increase greater than 25 percent to produce a similar volume of water.
- Temporary storage tank to supplement the well’s production while other mitigation actions are implemented. Water supplying the tank can be sourced by pumping the well for a longer period of time at a lower pumping rate or by a water truck delivering water.

Additional mitigation actions for springs or streams include:

- Constructing a well and piping to convey the replacement water to the POD or place of beneficial use.
- Drilling a supply well to offset decrease in spring flow.
- Modify the springhead or construct a reservoir at the spring.
- Temporary storage tank to supplement the spring or stream flow while other mitigation actions are implemented. Water supplying the tank can be sourced by temporary piping from another source provided by SNWA or by deliveries from a water truck.

Another option to offset effects on a specific senior water right is irrigation improvements provided by SNWA for the senior water right holder facilities to increase effectiveness of irrigation for the impacted water right or other water rights. Irrigation improvements include:

- Lining of irrigation ditches over losing reaches.
- Providing aqueducts to reduce losses between the POD and point of beneficial use.
- Improving sprinkler efficiency.
- Other improvements in irrigation.

Additional mitigation actions for stock water right uses include:

- Providing alternative ranch grazing land for stock.
- Temporary trucking of stock water.
- Providing stock water improvements to offset impacts to a senior water right.

7.3 Environmental Resources

Overview

This section establishes triggers and monitoring, management, and mitigation actions to avoid unreasonable effects to environmental resources in northern Hamlin and southern Snake valleys from SNWA GDP pumping in Spring Valley.

The groundwater discharge area in northern Hamlin Valley encompasses approximately 3,400 acres (Figure 7-8). This area is largely comprised of shrubland habitat, with the remainder comprised of mesic habitat [shrubland habitat = 3,250 acres (95%); mesic habitat = 150 acres (5%)]. No federally listed species or native aquatic-dependent special status animal species occur in this area. Habitat descriptions and a summary of wildlife that use the habitats are presented in Section 5.2.

The groundwater discharge area in southern Snake Valley encompasses approximately 28,500 acres (Figure 7-8).This area is largely comprised of shrubland habitat, and also includes mesic habitat, lake (reservoir) habitat, and agriculture [shrubland habitat = 23,000 acres (80%); mesic habitat = 1,800 acres (6%); lake (reservoir) habitat = 300 acres (1%); agriculture = 3,600 acres (13%)]. Big Springs Creek / Lake Creek and associated springs span 16 miles south-to-north. The creek has been highly modified by surface water diversions, and in most years it becomes ephemeral before reaching its terminus at Pruess Lake. No federally listed species occur in the area. Three native aquatic-dependent special status animal species occur in southern Snake Valley (longitudinal gland pyrg, bifid duct pyrg, and California floater), as well as an assemblage of native Bonneville Basin fish species that is of conservation interest.[1] Habitat descriptions, a summary of wildlife that use the habitats, and details about the special status species occurrences are presented in Sections 5.2 and 5.3.

The longitudinal gland pyrg (a springsnail) may be endemic to southern Snake Valley, and is only known to occur at Dearden (Stateline) Springs, Big Springs, and Clay Spring North (Figure 7-8). Surveys in 2009 and 2010 showed the species to be abundant at Big Springs and Clay Spring North (SNWA, 2011e). As discussed in Section 7.2.3, Big Springs and Clay Spring North are sourced from local recharge, and are not located along the groundwater flow path from southern Spring Valley into Hamlin and Snake valleys. Given the improbability of effects from SNWA GDP pumping, no triggers or mitigation actions are necessary to protect the species or their habitat at these sites. At Dearden Springs, surveys have shown springsnail counts in individual springs to be lower, but the species has been documented at 13 different springs in the spring complex (Albrecht et al.,2009; Sada, 2017a.; SNWA, 2011e). As discussed in Section 7.1, inter-basin flow from southern Spring Valley joins groundwater flowing north from southern Hamlin Valley toward the area of Dearden Springs. Given the inter-basin groundwater flow path and the limited range of the species, triggers and management and mitigation actions are established below for longitudinal gland pyrg.

The approach to avoid unreasonable effects to environmental resources in northern Hamlin and southern Snake valleys primarily relies on avoiding unreasonable effects to senior water rights. As described in detail in Section 7.2.3, this approach includes hydrologic monitoring, investigation triggers at intermediate wells, preemptive management actions, mitigation triggers, and mitigation actions to avoid conflicts with senior water rights. Given the number and spatial distribution of monitor wells and senior water rights (Figure 7-1) and the general co-location of senior water rights with environmental resources, this approach also helps prevent unreasonable effects to environmental resources. Additional environmental triggers and management and mitigation actions are established below.

Native aquatic-dependent special status animal species

The approach to avoid extirpation of native aquatic-dependent special status animal species from the Snake Valley groundwater discharge area includes habitat protection for the longitudinal gland pyrg. The approach is as follows:

1. The native fish assemblage consists of mottled sculpin (*Cottus bairdi*), redside shiner (*Richardsonius balteatus*), speckled dace (*Rhinichthys osculus*) Utah chub (*Gila atraria*), Utah sucker (*Catostomus ardens*). Redside shiner, Utah chub, and Utah sucker were previously designated as Utah state protected species (as stated in Marshall and Luptowitz, 2011), but are no longer on the Utah Sensitive Species List (UDWR, 2015).

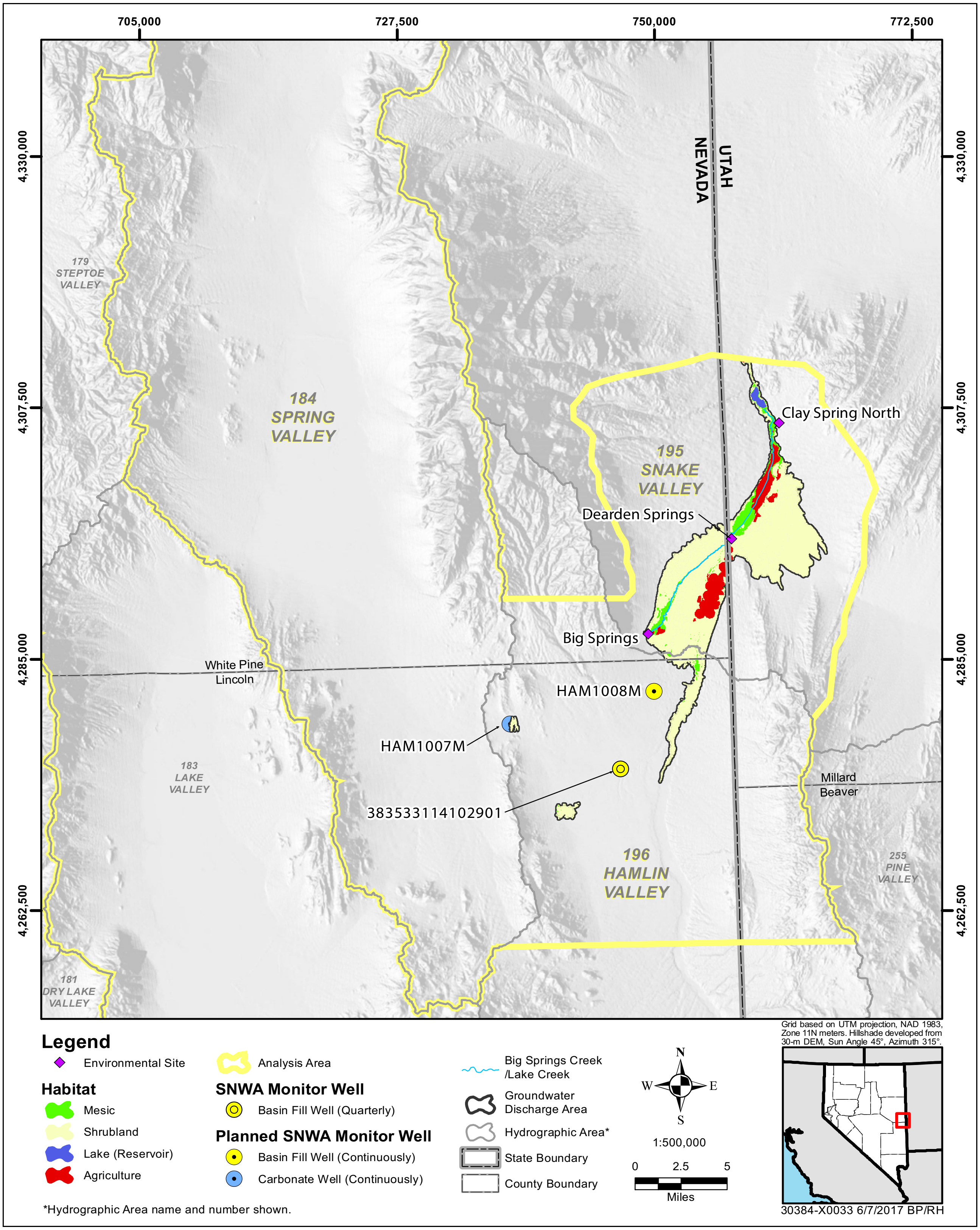

Figure 7-8
Habitats in Northern Hamlin and Southern Snake Valleys Groundwater Discharge Areas

- Implement management and mitigation actions to avoid conflicts with senior water rights as described in Section 7.2.3.

- If the investigation trigger at the monitor well 383533114102901 is activated as a result of SNWA GDP pumping as discussed in Section 7.2.3, conduct annual presence/absence monitoring of the longitudinal gland pyrg at Dearden Springs, Big Springs, and Clay Spring North (Figure 7-8). The purpose of the monitoring is to verify the continued existence of the species at the sites.

  - This monitoring data will be collected on an annual basis as long as the investigation trigger is activated at monitor well 383533114102901, the hydrologic mitigation trigger is activated at monitor well HAM1008M, or as long as mitigation actions for the longitudinal gland pyrg are being conducted for the SNWA GDP.

- If the mitigation trigger at the monitor well HAM1008M is activated as a result of SNWA GDP pumping as described in Section 7.2.3, implement mitigation actions focused primarily on Dearden Springs (Figure 7-8). The purpose of the mitigation is to reduce the risk of losing longitudinal gland pyrg from Dearden Springs and avoid extirpation of the species from the Snake Valley groundwater discharge area.

- In addition to the mitigation actions identified for senior water rights (Section 7.2.3), environmental mitigation actions for the longitudinal gland pyrg will include at least one of the following:

  - Collaborate with private landowners and/or water right holders and fund measures to ensure water is available to support the species and its habitat;

  - Collaborate with private landowners and NDOW and/or Utah Division of Wildlife Resources (UDWR) and fund improvements to existing habitat; and

  - Collaborate with NDOW and/or UDWR and fund expansion of habitat, creation of suitable habitat, and/or establishment of additional populations of the longitudinal gland pyrg.

These mitigation actions also help protect the needs of other wildlife at Dearden Springs, as well as downstream habitat and wildlife in Big Springs Creek/Lake Creek that are supported by the Dearden Springs discharge. Given the number of senior water rights up-gradient of Dearden Springs (Figure 7-1), and the management and mitigation actions to avoid conflicts with those rights (Section 7.2.3), effects to longitudinal pyrg and other wildlife and habitat at these sites are unlikely. Nonetheless, this plan will help ensure that unreasonable effects are avoided.

Triggers and mitigation actions are not required for the special status bifid duct pyrg (which occurs in Unnamed 1 Spring North of Big) or California floater (which occurs in Pruess Lake) (Section 5.0). Unnamed 1 Spring North of Big is sourced from local recharge and is not located along the primary groundwater flow path from Spring Valley into Hamlin and Snake valleys; thus, effects from SNWA GDP pumping at the site are improbable (Section 7.2.3). Pruess Lake is highly managed and experiences large baseline water level fluctuations as a result of reservoir irrigation management and upstream water right management. While SNWA cannot control reservoir management practices, avoiding conflicts with the senior water rights on Big Springs Creek/Lake Creek ensures that SNWA GDP pumping does not limit the creek inflows that support lake habitat and the California floater.

Habitat Types

Mesic and shrubland habitat occur in northern Hamlin Valley, and mesic, shrubland and lake habitat occur in southern Snake Valley. The approach to avoid conflicts with senior water rights (Section 7.2.3), extirpation of native aquatic-dependent special status animal species (above), and excessive loss of shrub cover that results in extensive bare ground (below) will also avoid elimination of these habitat types from each basin's groundwater discharge area.

Shrub Cover

Shrublands within the northern Hamlin and southern Snake valleys groundwater discharge areas include facultative phreatophytic shrub species as well as shrub species that rely solely on precipitation. Facultative phreatophytic shrub species typically use groundwater as a secondary water source after precipitation, but may also exist on sites where groundwater is not available (Smith et al., 1997; and McLendon, 2011a). As stated in McLendon (2011a), the productivity of facultative phreatophytes is increased by access to groundwater, but lack of groundwater within their rooting zones does not, in of itself, cause widespread plant loss. For this reason, they can be considered groundwater-sensitive species rather than groundwater-dependent species.

As discussed in Section 6.3.3.1, should depth to water increase below the main rooting zone of a phreatophytic shrub, the cover of that shrub may decrease (McLendon, 2011a). Over time, the shrub community would likely shift to more drought-tolerant, deeper rooted, and/or non-phreatophytic species (Patten et al., 2008; and McLendon, 2011a). As depth to water increases due to SNWA GDP pumping, shrubland vegetation cover may thus decrease in the short-term, but is expected to stabilize over time. However, if groundwater drawdown occurs too rapidly to accommodate a gradual plant transition, excessive loss of shrub cover can result in extensive bare ground, which can lead to soil erosion and weed expansion[1]. Thus, the purpose of the triggers and management and mitigation actions that are established in this section are to allow for transition in shrubland plant communities while avoiding this unreasonable effect.

The approach to avoid excessive loss of shrub cover that results in extensive bare ground is to maintain shrub cover at or above the threshold level of low density shrubland. Low-density shrubland is common in the Great Basin Desert, as indicated in the SNWA (2007) land cover map (SNWA 2009b, at Figure 7-1). As discussed in Section 6.3.3.2, data collected in the past 31 years in Spring Valley shows that low-density shrubland maintains itself, indicating that it is not a landscape on the verge of changing to extensive bare ground. As shown in the photographs in Figure 6-45 (Section 6.3.3.2), "low density" is a relative term, and shrub cover remains present and regular in these areas. The approach is as follows:

1. The proliferation of weeds is common in the analysis area and may occur regardless of SNWA GWD pumping.

- Implement management and mitigation actions to avoid conflicts with senior water rights as described in Section 7.2.3. These actions help protect shrublands by attenuating groundwater drawdown and propagation.

- Initiate shrubland monitoring as follows:

  - If the investigation trigger at the sentinel well HAM1007M is activated as result of SNWA GDP pumping as discussed in Section 7.2.3, initiate shrubland monitoring in the northern Hamlin Valley groundwater discharge area (Figure 7-8).

  - If the investigation trigger at the monitor well HAM1008M is activated as result of SNWA GDP pumping as discussed in Section 7.2.3, initiate shrubland monitoring in the groundwater discharge area in southern Snake Valley, Nevada. All evidence indicates that the shrublands west of Big Springs Creek/Lake Creek in Nevada and east of Big Springs Creek/Lake Creek in Utah are supported by local recharge and not inflow from Spring Valley, making effects improbable (Section 7.2.3). Therefore, monitoring will focus on the shrublands east of Big Springs Creek (Figure 7-8).

  - For each basin, collect monitoring data on an annual basis as long as the investigation trigger is activated at the aforementioned monitor well or as long as mitigation actions for the basin's shrublands are being conducted for the SNWA GDP.

- If initiated, conduct shrubland monitoring in the basin as follows:

  - Conduct a remote-sensing and ground-truthing exercise to establish remote sensing polygons and plots, ground vegetation transects, and a piezometer using the same methods as in Spring Valley (Section 6.3.3 and Appendix D, D.1.1). Delineate polygons within medium-density and low-density shrubland habitat (if both are present in adequate acreages). Locate the remote sensing plots in the polygons using a proportionate stratified random design. Locate one ground vegetation transect in the center of each remote sensing plot. Based on the polygon, plot, and transect configurations, install a piezometer in the monitored shrubland habitat.

  - Conduct annual monitoring using the same methods as in Spring Valley. Monitoring methods include: remote sensing analyses (deriving July-September NDVI data from Landsat satellite image data and precipitation data from GridMET data, starting in 1985, as summarized in Section 6.3.3.2 and described in Appendix D, D.1.2); ground vegetation surveys (collecting vegetation cover and composition data and photographs on transects every August, as discussed in Section 6.3.3.3); and piezometer measurements (taking water levels at least quarterly) (Section 6.3.3.4). As discussed in Section 6.3.3.2, the timing of the remote sensing analyses and ground vegetation surveys is designed to minimize the signal from shallow rooted grasses and forbs and wet soil that can be highly variable due to precipitation, and maximizes the relevant signal from phreatophytic shrubs.

  - For each basin, calculate mean annual NDVI, percent live shrub cover, and precipitation using the methods described in Appendix D, D.1.3. Plot the mean annual NDVI and percent live shrub cover values against the mean annual precipitation values. Overlay these data points on the shrubland baseline prediction intervals calculated for Spring Valley Management Blocks 1 and 2 prior to SNWA GDP groundwater withdrawal. Alternatively, if the data demonstrate that drawdown propagation to the monitored areas has not occurred and the NSE approves, the data may be overlaid on baseline prediction intervals calculated specifically for northern Hamlin or southern Snake valley using monitoring data acquired during the years prior to drawdown propagation reaching the basins.

- An investigation trigger is activated if:
  - mean annual NDVI for either habitat group (medium-density shrubland, low-density shrubland) falls below the medium-density or low-density shrubland 95 percent lower control limit for NDVI, or
  - mean percent live shrub cover for either habitat group falls below the medium-density or low-density shrubland 95 percent lower control limit for percent live shrub cover.
- Activation of an investigation triggers will result in investigation actions using the protocols described in Section 3.2.2 to determine cause, conditions, and significance of observed changes, and to inform management and mitigation actions. Investigation actions related to vegetation data are discussed further in Section 6.3.3.4.
- If the investigation trigger is activated, in addition to the management actions identified for senior water rights in Section 7.2.3, the following management actions may be taken:
  - Conduct additional detailed statistical tests to analyze the vegetation monitoring data and inform management and mitigation actions (see discussion in Section 6.3.3.4).
  - Preemptively implement mitigation actions for shrubland habitat.
- A mitigation trigger is activated if, as a result of SNWA GDP pumping:
  - mean annual NDVI for either habitat group (medium-density shrubland, low-density shrubland) falls below the low-density shrubland 95 percent lower control limit for NDVI for five consecutive years, or
  - mean percent live shrub cover for either habitat group falls below the low-density shrubland 95 percent lower control limit for percent live shrub cover for five consecutive years. The five-year time frame allows the time for natural plant growth, and is necessary to observe whether the natural transition from medium to low-density shrubland is successful or if mitigation actions need to be taken (see discussion in Section 6.3.3.4).
- If the mitigation trigger is activated, mitigation actions will be taken to reverse the trend until the shrublands are above the threshold level. A variety of mitigation actions are available, and will be used in situations where they are most practical or effective. The investigation findings will inform the mitigation actions based on ground conditions. These actions may also be

preemptively implemented to avoid activating the mitigation trigger. In addition to the mitigation actions identified for senior water rights in Section 7.2.3, shrubland mitigation actions (described in detail in Section 6.3.3.4) will include at least one of the following:

- Collaborate with BLM and/or private landowners and fund vegetation treatments (e.g., direct seeding and seedling transplanting; plant protection; transplanting nursery stock; weed control).

- Collaborate with private landowners and/or water right holders and fund measures to increase water availability to the shrublands.

- Collaborate with BLM, private landowners, and/or federal grazing permittees and fund measures to reduce other stressors (e.g., reduce livestock grazing during the growing season to support plant establishment and growth).

These mitigation actions listed will also help protect wildlife that use the shrublands.

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8.0 TRIGGERS, MANAGEMENT AND MITIGATION: CAVE AND SOUTHERN WHITE RIVER VALLEYS (HYDROGRAPHIC AREAS 180 AND 207)

8.1 Introduction

This section provides technical background and rationale for the DDC 3M Plan associated with the SNWA GDP permits in Cave Valley. Analyses are presented for the thresholds, triggers, and monitoring, management, and mitigation actions that are established to avoid unreasonable effects to senior water rights and environmental resources in Cave and southern White River valleys. The analyses were conducted in accordance with the conceptual approach described in Section 3.0. The analysis area, SNWA GDP PODs in Cave Valley (permit numbers 53987 and 53988), senior water rights, and the 3M Plan hydrologic monitoring network within Cave and southern White River valleys are shown on Figures 8-1 and 8-2.

A primary area of focus of the DDC 3M Plan is the groundwater flow path from Cave Valley to White River Valley via Shingle Pass and the southeastern portion of White River Valley south of Shingle Pass. The emphasis is on senior water rights and environmental resources at Flag and Butterfield springs and the downstream Sunnyside Creek, which are partially sourced from groundwater outflow from Cave Valley. As described in Section 8.2.3, given the staged development, reserved groundwater, and management plan to protect spring flows at Flag and Butterfield springs, effects in White River Valley from SNWA GDP pumping are unlikely. Nonetheless, triggers and management and mitigation actions are established to ensure unreasonable effects in White River Valley are avoided.

In Ruling 6165, the NSE reserved 7,300 afa of Cave Valley groundwater for the purpose of protecting White River Valley spring flows (NDWR, 2012b, at page 80). The NSE determined the perennial yield of Cave Valley to be equal to the basin recharge of 12,900 afa minus the reserved amount of 7,300 afa. The NSE re-established the perennial yield of Cave Valley to be 5,600 acre-feet, of which 5,235 afa was granted to SNWA for appropriation.

SNWA requests that the NSE reconsider the volume of 7,300 afa reserved in Cave Valley, due to the following facts which emerged subsequent to Ruling 6165:

1. SNWA committed to following a staged groundwater development schedule in Cave Valley during the process of acquiring federal rights-of-way for the main SNWA GDP pipeline and associated facilities (SNWA, 2012d).

2. An additional monitor well at the base of Shingle Pass in White River Valley (WRV1013M) is incorporated into the SNWA 2017 DDC 3M Plan (SNWA, 2017d). This well will expand the

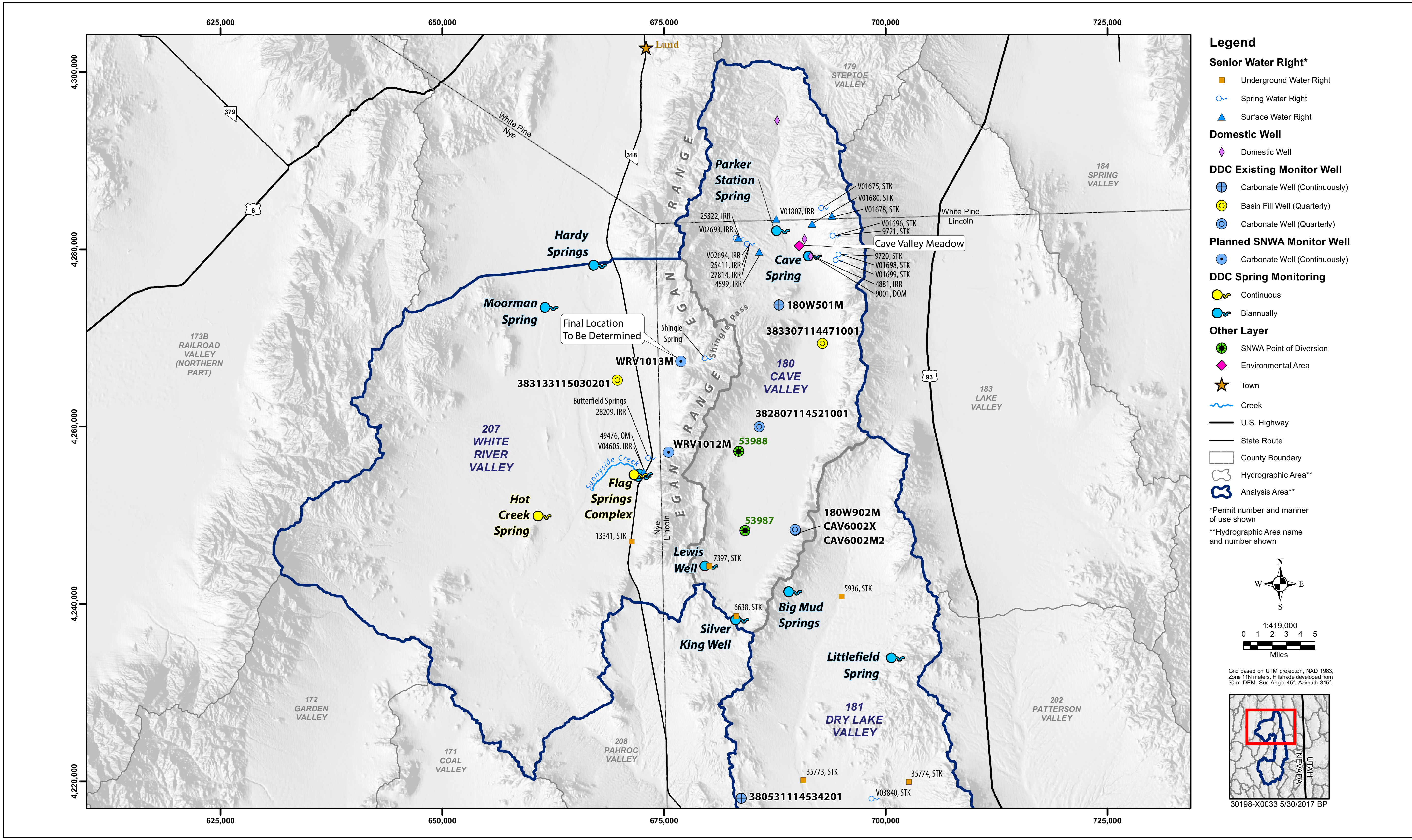

Figure 8-1
Cave Valley GDP PODs, Senior Water Rights, and Hydrologic Monitoring Network

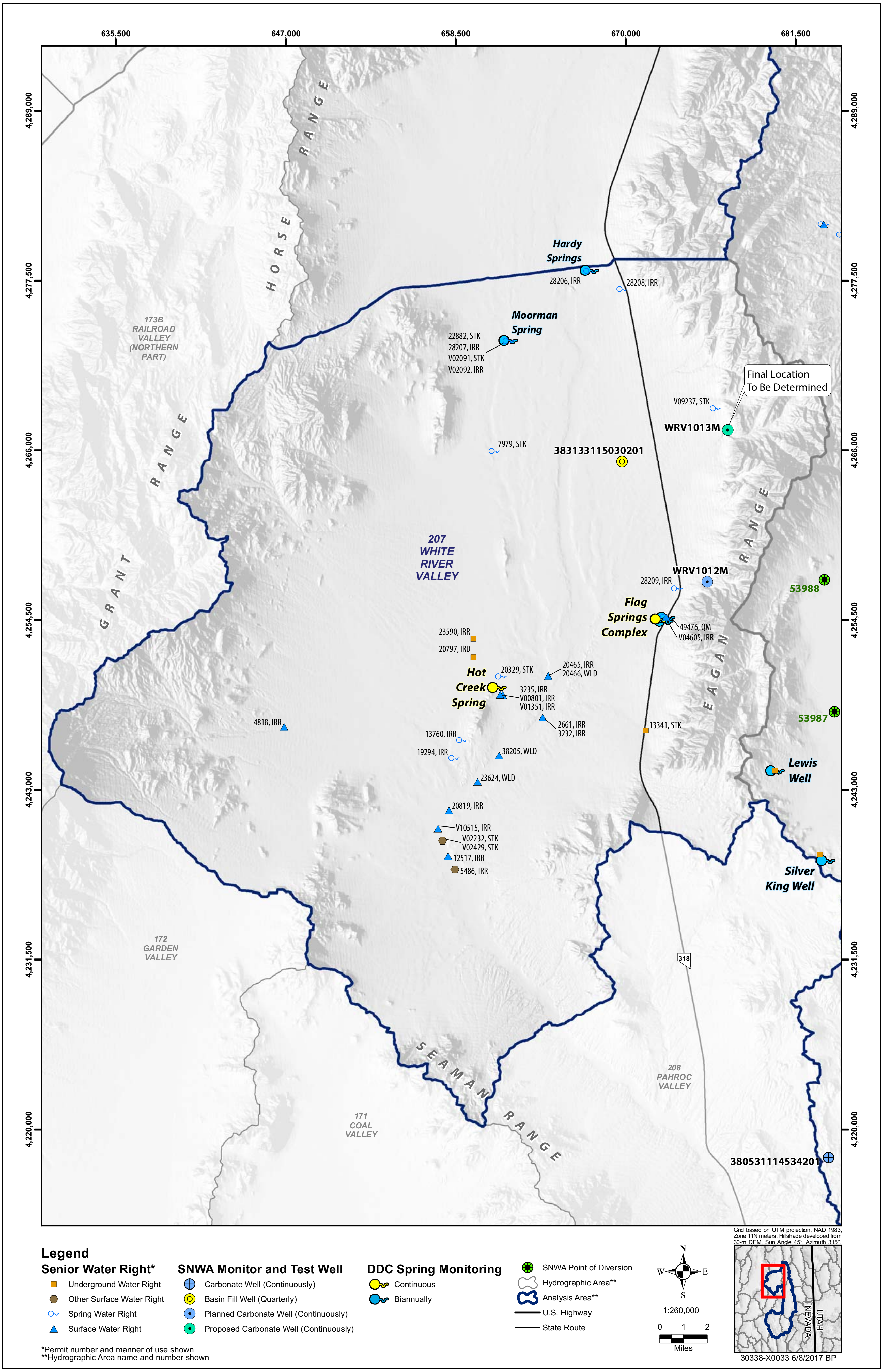

Figure 8-2
Southern White River Valley Senior Water Rights and Hydrologic Monitoring Network

groundwater monitoring network to gain a better understanding of the relationship between Cave Valley outflow through Shingle Pass and spring discharge at Butterflied and Flag springs. This well will also reduce the uncertainty of the numerical groundwater flow model and other predictive tools used to analyze and manage potential effects from SNWA GDP pumping.

3. Specific investigation and mitigation triggers associated with Cave Valley outflow are incorporated into the 2017 DDC 3M Plan (SNWA, 2017d) (see discussion in Section 8.2.3). This provides for detection and measurement of propagation of drawdown from SNWA GDP pumping into southern White River Valley.

SNWA requests that 3,500 afa of the reserved water under Ruling 6165 be incorporated into the staged groundwater development schedule shown in Table 8-1. The first three stages incrementally increase pumping up to 5,235 afa in Cave Valley over a span of 15 years, which is consistent with the staged development schedule in the federal right-of-way grant issued by the BLM for the first tier of the SNWA GDP (BLM, 2013, at pages 65-66). Pumping the additional 3,500 afa would not occur until the fourth stage.

While Ruling 6165 reserved 7,300 afa, the estimated outflow from Cave Valley to White River Valley was only 3,800 afa (Burns and Drici, 2011). The Stage 4 pumping volume of 3,500 afa is the difference between the amount reserved for outflow and the estimated outflow. Including the additional 3,500 afa as the fourth stage provides the same level of protection as reserving 7,300 afa during the first 15 years of SNWA GDP pumping. NSE authorization would be required to advance from Stage 3 to pump this additional water.

Table 8-1
Cave Valley Staged Development Schedule

Stage	Incremental Volume (afa)	Total Volume (afa)	Time Period (Years)
1[a]	2,600	2,600	0 - 5
2[a]	1,300	3,900	5 - 10
3[a]	1,335	5,235	10-15
4	**3,500**	**8,735**	>15

[a] To advance to the next stage, SNWA will be required to pump at least 85 percent but not more than 100 percent of the total afa for a minimum of five years. Data from those five years of pumping and updated numerical groundwater flow modeling results will be submitted to the NSE as part of the DDC 3M Plan annual report. The NSE will then make a determination as to whether SNWA can proceed to the next development stage.

The staged-development approach limits GDP pumping while aquifer response data is collected. Data collected during these stages will provide additional information on aquifer properties, which will be used to calibrate the transient-state numerical flow model and refine other predictive analytical tools. The revised model or other predictive tools will provide estimates of future drawdown with distance and time under various pumping scenarios with greater certainty. Results of the model projections will be evaluated by the NSE for approval to advance to the next stage of development. The model and tools will continue to be refined in an iterative manner as data are collected through the life of the SNWA GDP.

8.2 Hydrologic Monitoring and Senior Water Rights

SNWA completed numerous hydrologic study reports to define basin characteristics and hydrologic baseline conditions associated with Cave and southern White River valleys. These and other non-SNWA studies related to Cave Valley and adjacent basins are summarized by Burns and Drici (2011). The hydrologic monitoring program for this area is summarized in this section.

A query of the NDWR Water Rights Database for all active water rights and domestic wells in Cave and White River valleys was performed in November, 2016. Active water rights are those that are not in application status, but it includes vested claims. The data set was reduced by removing water rights that are located in the mountain block, have priority dates junior to the SNWA GDP permits, reservoir rights, and those owned by SNWA.

The resulting data set of senior water rights are assigned a management category which defines the monitoring strategy and establishes appropriate investigation triggers to evaluate the cause and significance of variations from baseline conditions. Appropriate management actions are implemented based upon the results of the investigation to avoid or minimize the likelihood of activating a mitigation trigger. The monitoring and management strategy, investigation triggers and management actions, and mitigation triggers and actions for Cave and southern White River valleys are presented in this section.

8.2.1 Hydrologic Monitoring

SNWA established a hydrologic monitoring program associated with the DDC 3M Plan in Cave and White River valleys. Baseline hydrologic data have been collected for this monitoring network since 2006. The NSE approved the original monitoring plan in December 2009 and a revised version in 2011 (SNWA, 2009d and 2011c). The DDC 3M Plan is being revised again as described in this report to address concerns stated in the Remand Order.

The monitoring element of the DDC 3M Plan associated with Cave and White River valleys provides the ability to effectively detect and measure propagation of drawdown in order to implement appropriate management and mitigation actions to avoid unreasonable effects. The DDC 3M Plan monitoring network is presented in Section 10.3 and summarized for this area below:

- A spring monitoring network consisting of four springs in Cave Valley and five springs within White River Valley, including two gaging stations at Flag Springs and Hot Creek Spring.
- Spring monitoring at Butterfield Springs currently by USGS through a USGS/SNWA joint funding agreement.
- Seven existing monitor wells consisting of six in Cave Valley and one in White River valley are currently being monitored.

- One carbonate monitor well (WRV1012M) located northeast of Flag Springs is planned to be constructed prior to SNWA GDP pumping. BLM right-of way access has been granted for the sites.

- One additional monitor well (WRV1013M) is proposed to be constructed at the base of Shingle Pass to further evaluate the hydrologic relationship between Cave Valley outflow and spring discharge at Flag and Butterfield springs.

- Assemble and report data from existing regional precipitation stations in the vicinity of the DDC analysis area.

- Collect two rounds of water-chemistry data from up to 12 locations six months apart within the DDC analysis area prior to SNWA GDP pumping and every five years after pumping begins.

- Aquifer tests were performed on two wells located in the southeastern portion of Cave valley in 2007 and 2008 (180W902M and CAV6002X) to collect aquifer property data.

Hydrologic monitoring data is provided to the NSE electronically on a quarterly basis. Annual data reports have been provided since 2008. Historical data for each element of the monitoring program are presented in *2016 DDC Hydrologic Monitoring, Management, and Mitigation Plan Status and Data Report* (SNWA, 2017a).

8.2.2 Cave Valley

Cave Valley Senior Water Rights

A query of the NDWR Water Rights Database for all active water rights and domestic wells in Cave Valley was performed. Active water rights are those that are not in application status, but it includes vested claims. Based on this query, there are 78 active water rights in Cave Valley as of November, 2016 that have an application status of certificated, decreed, permitted, reserved, or vested. The data set was reduced by excluding 59 water rights that are in the mountain block of the basin, have priority dates junior to the SNWA GDP permits, reservoir rights, or that are owned by SNWA. The water rights located in the basin mountain block were removed because they are not hydraulically connected to the producing aquifer in which SNWA GDP production wells will be installed, and are therefore not likely to be impacted by SNWA GDP permits. The resulting data set includes 19 active senior water rights in Cave Valley. In addition, there are three domestic wells in Cave Valley which are listed in Appendix B Table B-1.

The POD location of water rights senior to the SNWA GDP permits within Cave Valley are presented on Figure 8-1. Tallies of senior water rights by source, status, and hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed are presented in Table 8-2. Individual senior water rights are listed in Table 8-3 including information on water right status, source, manner of use, priority date, diversion rate, annual duty, ownership, distance to the closest SNWA POD, DEM elevation, and management category (as described in Section 3.2.5).

Table 8-2
Cave Valley Water Rights by Source and Status Senior to SNWA GDP Permits

Source	Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)				Not Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)			
	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)
Spring	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	6 / 498.46[a]	0 / 0.00	0 / 0.00	6 / 18.77[b]
Stream	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	2 / 276[a]	0 / 0.00	0 / 0.00	3 /344.38[c]
Underground	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	2 / 4.02[a]	0 / 0.00	0 / 0.00	0 / 0.00

[a]The reported duty includes both acre-ft per season and acre-ft per annum.
[b]Reported duty takes into account a total combined duty of 11.31 afa as documented in Stanka (2017).
[c]Reported duty takes into account a total combined duty of 7.56 afa as documented in Stanka (2017).

Cave Valley Monitoring Strategy

Senior water rights in Cave Valley within the analysis criteria are listed in Table 8-3. There are ten certificated senior water rights (two underground, six spring and two stream) and nine vested claims (six spring and three stream) located 3 to 18 miles from the closest SNWA GDP permit POD. All of the senior water rights are assigned Management Category E, as described in Table 3-1, because they are not in hydraulic connection with the producing aquifer in which SNWA production wells in southern Cave Valley will be installed.

Seventeen of the senior water rights are located in the northern portion of Cave Valley. These senior water rights are not in hydraulic connection with the producing aquifer in southern Cave Valley in which SNWA GDP production wells will be installed. This is due to the hydrogeologic setting and elevation differences between the senior water rights (6,480-7,690 ft amsl) and the estimated water levels at the SNWA PODs (5,800-5,850 ft amsl). Well logs in the northern portion of Cave Valley (well log numbers 71199 and 92077) indicate shallow groundwater and the presence of deeper, low hydraulic conductivity sediments. In recognition of this, the NSE in Ruling 6165 determined that impacts to senior water rights were not expected (NDWR, 2012b, at page 113). However, even though Cave and Parker Station springs are in this northern area, they are included in the 3M Plan monitoring network to provide data on hydrologic conditions in this area.

Cave Spring exhibits intermittent discharge as shown in Figures 8-3 and 8-4, with no flow observed during fall and winter during the period of record (2006 to present). The Parker Station site monitors spring discharge along the northwest portion of the valley and is shown on Figure 8-5. Three monitor wells (382807114521001, 383307114471001, and 180W501M) are located between the SNWA permit PODs and northern Cave Valley and Shingle Pass to monitor groundwater levels and detect propagation of drawdown.

Table 8-3
Water Rights within Cave Valley and Downgradient of Shingle Pass in White River Valley Senior to SNWA GDP Permits
(Page 1 of 2)

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
4599	CER	STR	IRR	1917	0.12	36.0[h]	Adams, Myron	Alluvial Fan	14.1	6,710	E
4881	CE.	SPR	IRR	1918	0.751	225.6[h]	Cave Valley Ranch, LLC	Alluvial Fan / Mountain Block	14.6	6,490	E
6638	CER	UG	STK	1922	0.003	2.1*	Jensen, Bruce A.	Alluvial Fan	6.0	6,230	E
7397	CER	UG	STK	1925	0.015	1.9*[,h]	Jensen, Bruce A.	Alluvial Fan	3.5	6,260	E
9001	CER	SPR	DOM	1929	0.044	31.85[i]	Great Western Mining & Development Co	Alluvial Fan / Mountain Block	14.6	6,490	E
9720	CER	SPR	STK	1934	0.025	17.9*	Cave Valley Ranches	Alluvial Fan / Mountain Block	15.5	7,460	E
9721	CER	SPR	STK	1934	0.025	17.9*	Cave Valley Ranches	Alluvial Fan / Mountain Block	16.6	7,660	E
25322	CER	STR	IRR	1969	0.89	240.0	Leavitt, Paul and Chad 50% UDI; Leavitt, Dianne and Gary 50% UDI	Mountain Block / Alluvial Fan	15.0	6,930	E
25411	CER	SPR	IRR	1970	0.564	79.2	Leavitt, Paul and Chad 50% UDI; Leavitt, Dianne and Gary 50% UDI	Alluvial Fan	14.6	6,780	E
27814	CER	SPR	IRR	1973	0.67	126.0	Leavitt, Paul and Chad 50% UDI; Leavitt, Dianne and Gary 50% UDI	Alluvial Fan	14.6	6,780	E
V01675	VST	SPR	STK	1903	0.025	7.5*	Cave Valley Ranch, LLC	Alluvial Fan	18.1	7,570	E
V01678	VST	STR	STK	1903	0.016[i]	7.56[i]	Cave Valley Ranch, LLC	Alluvial Fan	17.7	7,840	E
V01680	VST	STR	STK	1903	0.016[i]	7.56[i]	Cave Valley Ranch, LLC	Alluvial Fan	16.8	6,950	E
V01696	VST	SPR	STK	1890	0.025	11.31[i]	Geyser Land & Cattle Co.	Alluvial Fan / Mountain Block	16.6	7,660	E
V01698	VST	SPR	STK	1890	0.025	11.31[i]	Geyser Land & Cattle Co.	Alluvial Fan / Mountain Block	15.5	7,460	E
V01699	VST	SPR	STK	1890	0.025	11.31[i]	Cave Valley Ranches Inc.	Alluvial Fan	15.1	7,190	E

Table 8-3
Water Rights within Cave Valley and Downgradient of Shingle Pass in White River Valley Senior to SNWA GDP Permits
(Page 2 of 2)

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
V01807	VST	STR	IRR	1880	1.12[i]	336.82[i]	Cave Valley Ranch, LLC	Valley Floor	16.5	6,550	E
V02693	VST	SPR	IRR	1885	(-)[i]	0[i]	Leavitt, Paul and Chad 50% UDI; Leavitt, Dianne and Gary 50% UDI	Mountain Block / Alluvial Fan	15.0	6,930	E
V02694	VST	SPR	IRR	1890	(-)[i]	0[i]	Leavitt, Paul and Chad 50% UDI; Leavitt, Dianne and Gary 50% UDI	Alluvial Fan	14.6	6,780	E
White River Valley Water Rights Downgradient of Shingle Pass											
13341	CER	UG	STK	1950	0.008	4.0*,[h]	Jensen, Pamela G.	Alluvial Fan	19.5 / 8.0[g]	5,340	D
28209	CER	SPR (Butterfield Springs)	IRR	1974	2.15	1,556.5	Jensen, Bruce A.	Valley Floor / Alluvial Fan	14.0 / 6.2[g]	5,310	D
49476	CER	SPR (Flag Springs)	QM	1985	0.022	1.8	Nevada-Department of Wildlife	Valley Floor / Alluvial Fan	15.2 / 6.8[g]	5,300	D
V04605	VST	STR (Sunnyside Creek)	IRR	1880	7.69	2,206.4	Nevada-Department of Wildlife	Valley Floor	15.2 / 6.8[g]	5,300	D

[a]CER - Certified, VST - Vested
[b]SPR - Spring, STR - Stream, UG - Underground
[c]DOM - Domestic, IRR - Irrigation, QM - Quasi-municipal, STK - Stock watering
[d]Rounded to the nearest tenth of a mile.
[e]Rounded to the nearest ten feet.
[f]See Section 3.2.5 for a detailed explanation of the Management Categories; D - Resource in adjacent hydrographic area, E - Resource not in hydraulic connection with producing aquifer in which SNWA GDP production wells will be installed.
[g]First distance measured from White River Valley senior permits to existing monitor well 180W501M. Second distance measured from White River Valley senior permits to nearest SNWA POD.
[h]Acre-ft per season.
[i]Reported number was derived from an analysis documented in Stanka (2017).
*The reported annual duty is not explicitly documented on the certificate or vested claim, but reported as such by the NDWR Hydrographic Abstract query.

Figure 8-3
Cave Spring, May 2016

Figure 8-4
Cave Spring, October 2016

Figure 8-5
Parker Station, October 2013

Two certificated underground water right PODs, Lewis Well and Silver King well are located in the southern portion of Cave Valley and are low-yielding modified springs with shallow collectors used for stock watering. The sites are not hydraulically connected with the producing aquifer in which SNWA GDP production wells will be installed due to: (1) the low hydraulic conductivity of the sediments underlying the sites as shown by the limited yield of the discharge; and (2) the elevation difference between the estimated water level at the SNWA permit PODs.

The Lewis Well (permit number 7397), shown in Figure 8-6 originally had a spring collection catch basin which drained into a 26-ft deep collector well. Silver King Well (permit number 6638) is a six foot diameter 13-ft deep collector well, originally with a drain pipe to a trough as shown in Figure 8-7. Both sites are included in the DDC 3M Plan monitoring program to provide hydrologic data in the area. The Silver King Well has not been used since mid-2016, as the stock trough was removed and stock water is being trucked in as shown in Figure 8-8.

Cave Valley Investigation Triggers and Management Actions

Even though no effects to senior water rights in Cave Valley are expected, the monitoring network includes six wells and four springs in Cave Valley that are monitored to observe hydrologic conditions and verify that no impact occurs. An investigation trigger at monitor well 383307811447 1001 located in central Cave Valley, described in Section 8.2.3 below, will be activated

Figure 8-6
Lewis Well, May 2015 (looking west)

Figure 8-7
Silver King Well, May 2011 (looking east)

Figure 8-8
Silver King Well, October 2016 with water tuck in background (looking west)

prior to any potential changes in northern Cave Valley. Investigation triggers and management actions associated with the Cave Valley monitor wells are described in Section 8.2.3.

Cave Valley Mitigation Triggers

No specific mitigation triggers have been set in Cave Valley because effects to senior water rights and environmental resources are improbable due to the hydrologic setting and the elevation difference between the resources and the groundwater level in the producing aquifer which the SNWA GDP production well will be installed.

8.2.3 Southern White River Valley

White River Valley Senior Water Rights

A query of the NDWR Water Rights Database for all active water rights in White River Valley was performed. Active water rights are those that are not in application status, but it includes vested claims. Based on this query, there are 383 active water rights in White River Valley as of March, 2017 that have an application status of certificated, decreed, permitted, reserved, or vested. The data set was further reduced to only those water rights that are within the analysis area. There are 72 active water rights within the analysis area. This data set was further reduced by excluding 39 water rights whose PODs are located in the mountain block, have priority dates junior to the SNWA GDP permits, reservoir rights, or that are owned by SNWA. The water rights located in the basin mountain block were removed because they are not hydraulically connected to the producing aquifer in which SNWA GDP production wells will be installed, and are therefore not likely to be impacted by SNWA GDP permits. The resulting data set includes 33 active water rights in White River Valley.

The 3M Plan for senior water rights located in southern White River Valley focuses on the area south of Shingle Pass along the Egan Range in the southeastern portion of the valley which receives groundwater outflow from Cave Valley. Senior water rights in this area are highlighted on Figure 8-1 and listed on Table 8-3. The additional senior water rights located within the analysis area in southern White River Valley are presented on Figure 8-2 and listed in Appendix B. These include senior water rights in the central and western portion of southern White River Valley which are unlikely to be influenced by the SNWA GDP pumping because they are located outside of the effects of Cave Valley outflow from Shingle Pass and are sourced from northern or western White River Valley.

The primary contribution of groundwater outflow from Cave Valley to White River Valley is through Shingle Pass located north of Butterfield and Flag springs (Figure 8-1). Groundwater flow through White River Valley from north of Shingle Pass and local recharge from the western slope of the Egan Range also contribute to the discharge at Butterfield and Flag springs. Dr. Jim Thomas provided testimony at the 2011 NSE hearing that “the isotopic data show that little if any groundwater from Cave Valley flows to the warm springs in White River Valley. He also testified, however, that some Cave Valley recharge flows to the cool, range-front springs in White River Valley that includes Butterfield and Flag springs” (NDWR, 2012b, at page 77 Ruling 6165). This supports the limited influence of Cave Valley outflow outside the southeastern portion of White River Valley.

Staged development of SNWA GDP permits in Cave Valley allow assessment of aquifer response under limited production. The aquifer response is expected to be observed first in monitor well 382807114521001. Propagation of drawdown within Cave Valley and from Cave Valley into White River Valley will be tracked using data collected from the monitoring network. Transient water-level data collected during Stage 1 of development will be used to refine the numerical groundwater flow model and other analytical predictive tools to estimate drawdown with time, distance, and POD pumping rate and duration.

No unreasonable effects are expected to occur at Flag, Butterfield, or Shingle springs because: (1) the development will be limited to volume-specified stages that are only approved if no unreasonable effects are observed; (2) distance from the SNWA GDP PODs, 3) hydrogeologic setting; and 4) the ability to implement early management actions based upon observations at the sentinel monitor wells.

Southern White River Valley Monitoring and Management Strategy

Senior water rights in southern White River Valley are assigned Management Category D, as described in Table 3-1, because they are located in an adjacent basin. The monitoring and management strategy for this category consists of using sentinel monitor wells, as explained in Section 3.2.2. These monitor wells are located between the SNWA GDP PODs and the more distant senior water rights to detect and measure propagation of drawdown. The sentinel wells are a key component of the monitoring and management strategy to avoid activating mitigation triggers at senior water rights and to protect environmental resources in White River Valley.

Senior water rights and vested claims in the vicinity of Shingle Pass in southern White River Valley are believed to be supported to some degree by groundwater outflow from Cave Valley. These are the Flag Springs complex (Flag Springs nos. 1, 2, and 3) and Butterfield Springs. A vested claim (V04605) of 7.626 cfs is held by NDOW on Sunnyside Creek downstream of the Flag Springs discharge. Butterfield Springs is located one mile north of Flag Springs along the Egan Range front. A certificated water right of 2.150 cfs on Butterfield Springs (permit number 28209) is held by Bruce Jensen. The aerial imagery which show the discharge area for Flag and Butterfield springs are presented in Figures 8-9 and 8-10. Underground stock water right (permit number 13341) with 3.96 afa annual duty is located south of Flag Springs along the western front of the Egan Range.

Other senior water rights in southern White River Valley are presented in Appendix B. These senior water rights are unlikely to be effected by SNWA GDP pumping because they do not rely on outflow from Cave Valley.

Four wells located in Cave and White River valleys are designated as sentinel monitor wells with investigation triggers (Figure 8-1). They are located in central Cave Valley (existing well 383307114471001), within Shingle Pass (existing well 180W501M), at the base of Shingle Pass in White River Valley (WRV1013M proposed, not sited), and on the western front of the Egan Range (WRV1012M planned and sited) between Flag and Butterfield springs. These sentinel monitor wells will be used to detect changes in water level which may indicate propagation of drawdown from Cave Valley into White River Valley. The stratigraphy and structural orientation of the Egan Range makes it very unlikely for groundwater in Cave Valley to flow directly through the range, west to the Flag Springs Complex. However, the installation of a new monitor well, WRV1012M, is planned for the west slope of the Egan Range in the vicinity of Flag and Butterfield springs to detect drawdown propagation should it occur through the Egan Range.

Three springs (Emigrant, Moorman, and Hardy springs) and one monitoring well (383133115030201) located upgradient of Flag and Butterfield springs are not likely to be affected by SNWA GDP pumping, but Moorman, and Hardy springs are included in the monitoring network to detect influences from northern White River Valley and monitor hydrologic conditions upgradient of Shingle Pass in White River Valley. Hot Creek, Moon River, and Camp springs, located in west White River Valley, are outside the area of influence of SNWA GDP pumping. However, Hot Creek Spring is monitored continuously to document hydrologic conditions in southwest White River Valley.

The DDC 3M Plan also includes a continuous gaging station installed and operated at Flag Spring No. 2 by SNWA. Flag Spring No. 2 is the center and highest producing spring orifice in the Flag Springs Complex and has favorable channel conditions without diversions or excessive vegetation. Periodic measurements are also performed at Flag Spring Nos. 1, 2, and 3 and Butterfield Springs. Variations in the baseline discharge at Flag Spring No. 2 is consistent with changes at the other two Flag Spring orifices and is representative of spring conditions at Flag Springs Complex and Butterfield Springs. A photo of the Flag Spring No. 2 gage is presented in Figure 8-11. The combined discharge of the three Flag Spring orifices as compared to the vested-right claim is presented on Figure 8-12. The historical hydrograph for Butterfield Springs is presented in Figure 8-13.

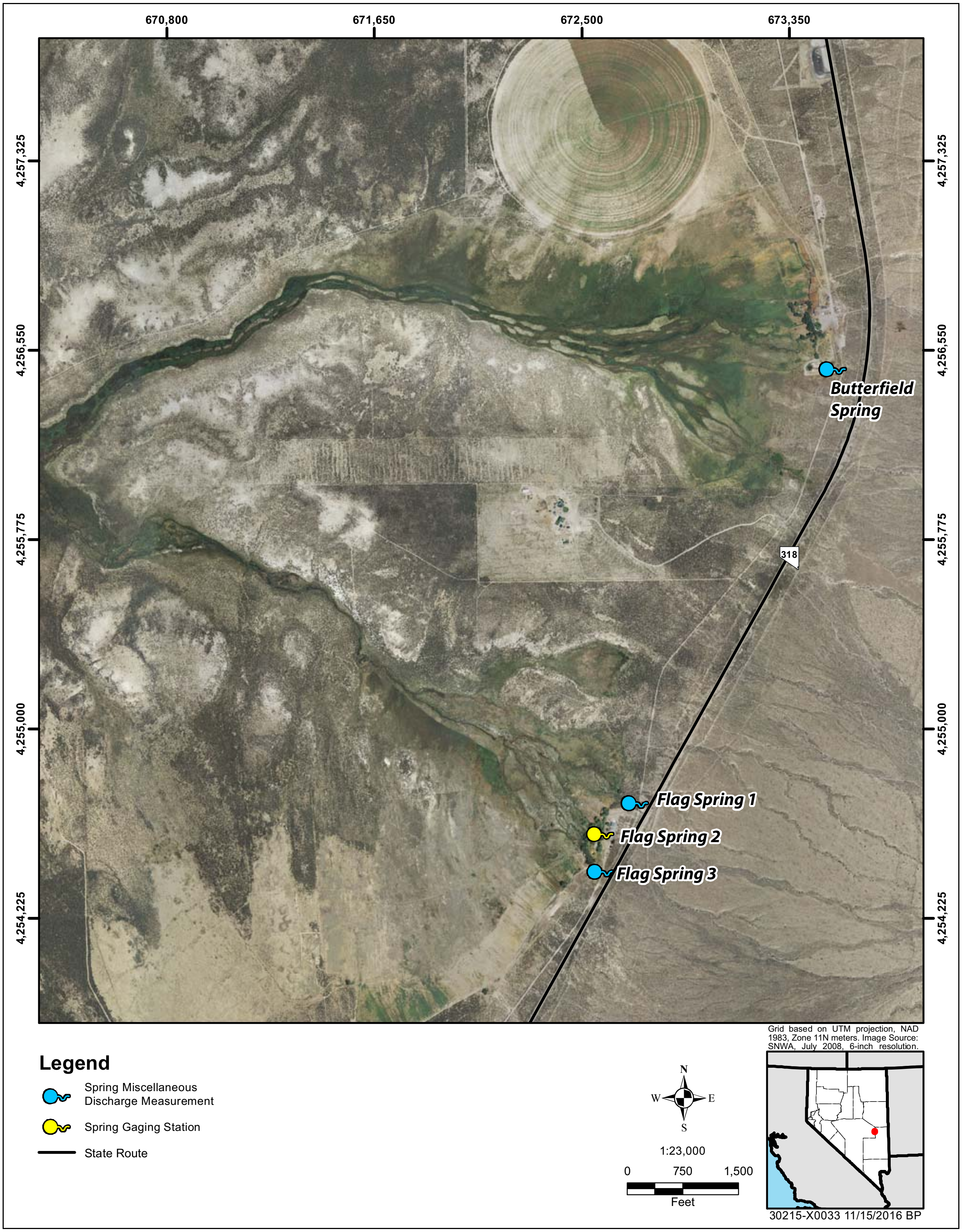

Figure 8-9
Butterfield Springs and Flag Springs Complex

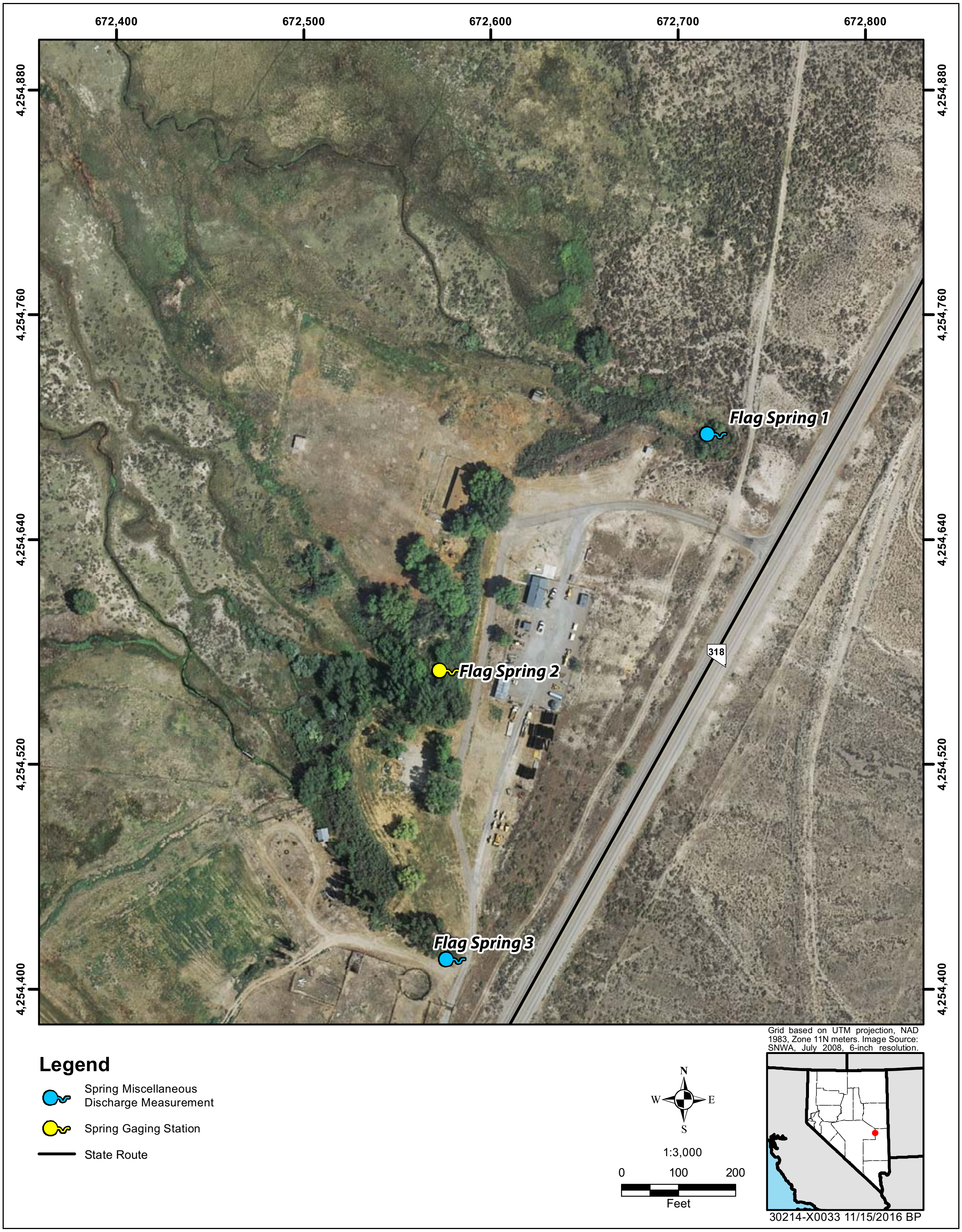

Figure 8-10
Flag Springs Complex

Figure 8-11
Flag Spring No. 2, March 2014 (looking toward the flume and spring orifice)

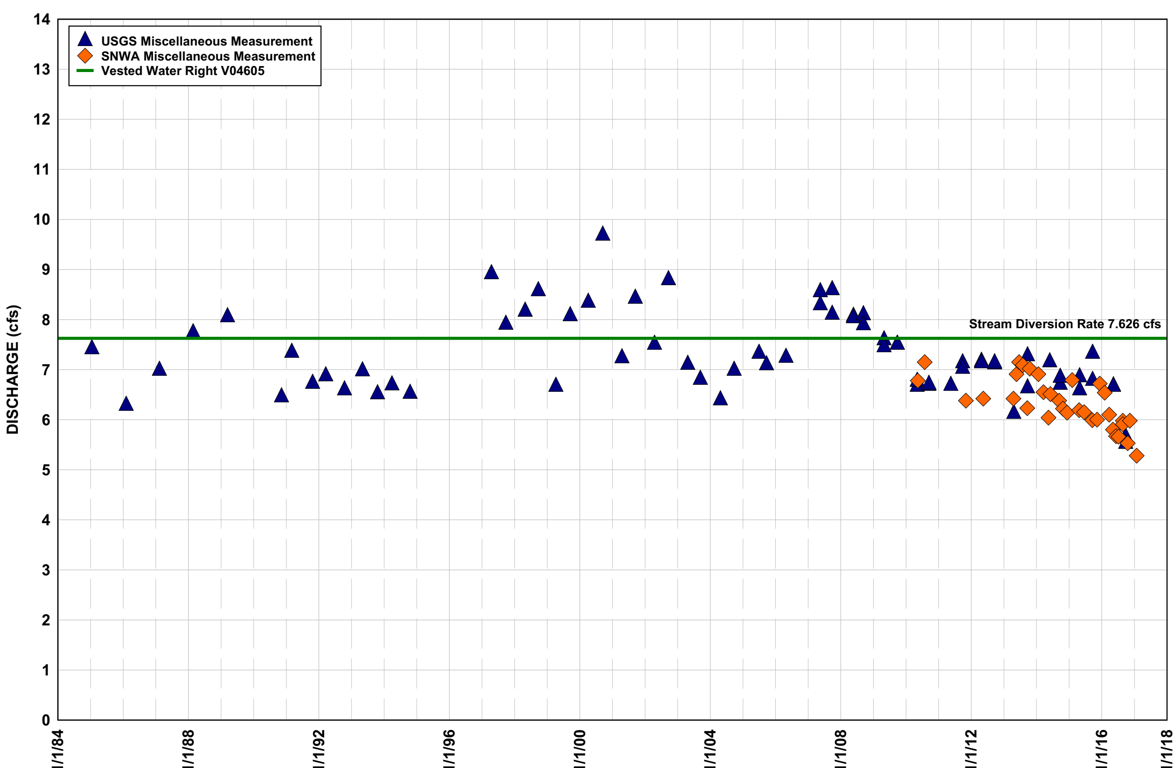

Figure 8-12
Combined Discharge of the Flag Springs Complex

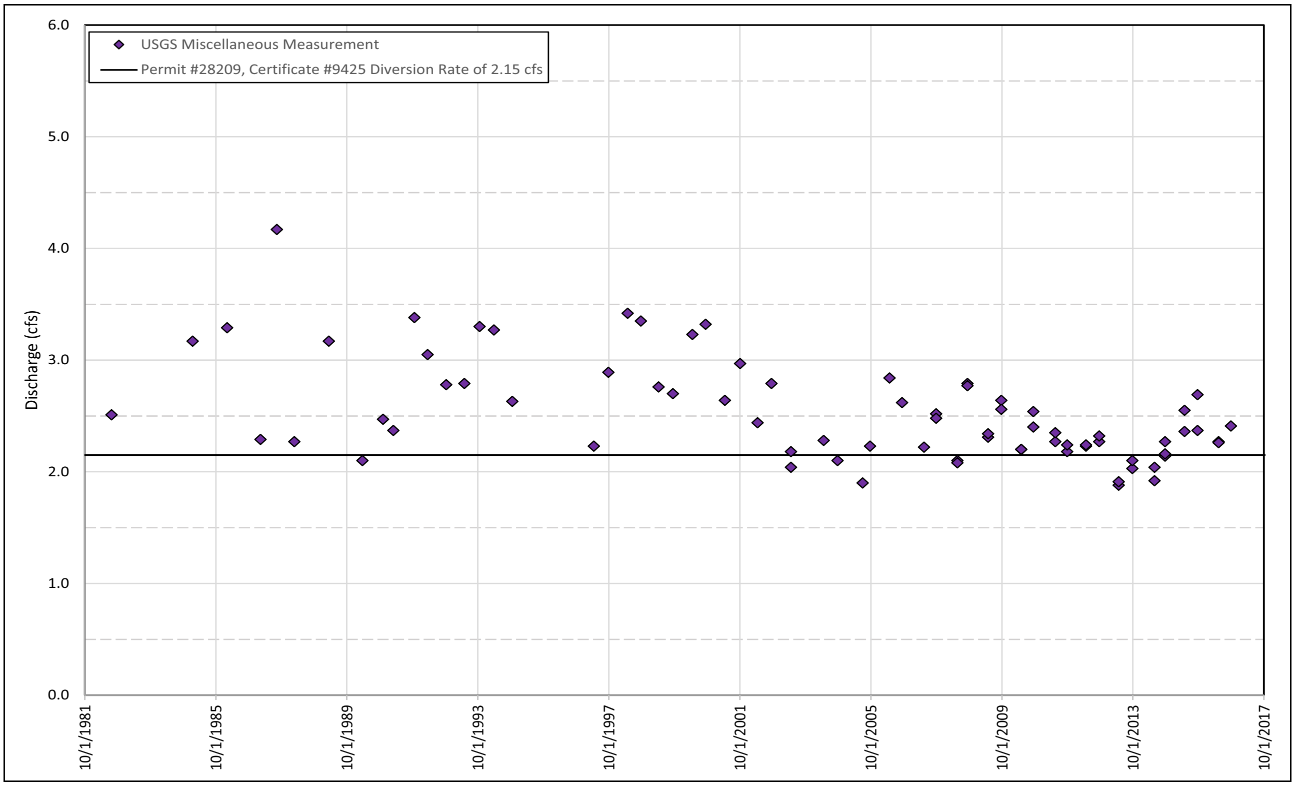

Figure 8-13
Discharge Measurements at Butterfield Springs with Diversion Rate

Southern White River Valley Investigation Triggers and Management Actions

An investigation trigger will be activated if the water level in any of the sentinel wells decrease below the 99.7 percent control limit for a continuous period of six months, as described in Appendix A.

Although effects are not anticipated, the staged-development approach and monitoring of sentinel wells between SNWA GDP POD locations and senior rights located in White River Valley provide additional protection so that potential effects will be identified early to implement management actions prior to a mitigation trigger being activated. The monitoring and management strategy for Butterfield and Flag springs and other senior rights in White River Valley consists of the following:

- The sentinel monitor wells 383307114471001, 180W501M, WRV1012M, and WRV1013M located between the SNWA GDP PODs and senior water right PODs in White River Valley will be monitored for water-level trends deviating from the baseline record.

- Monitoring in Cave and White River valleys will include wells and springs identified in Section 10.3.1, including the gaging station at Flag Spring No. 2, and collecting miscellaneous discharge measurements at Flag Spring No. 1, Flag Spring No. 3, and Butterfield Springs. A baseline record for the sites currently monitored already exists.

Monitoring will be initiated at the new sites prior to the required two year baseline period prior to Stage 1 development. Monitoring will continue during SNWA GDP operations.

- An investigation trigger would be activated at any of the sentinel wells when ground water level decreases below the 99.7 percent lower control limit for a continuous period of six months, as described in Appendix A. The baseline hydrograph for wells 383307114471001 and 180W501M and current 99.7 percent level lower control limit are presented on Figures 8-14 and 8-15, respectively.

- The numerical groundwater flow model and other predictive tools will be updated and calibrated as part of the evaluation initiated as a result of activating the investigation trigger. Aquifer response data will be incorporated to reduce the uncertainty of simulation results predicting the potential for impacts on Flag and Butterfield springs. The evaluation includes an estimate of drawdown propagation with time and evaluates the influence of changing the rate and distribution of pumping on the propagation of drawdown with distance and time. The model will be updated every five years after GDP initiation or when an investigation trigger is activated. Model results will be verified by future monitoring data.

- Should projections of drawdown using the data from the sentinel wells indicate a mitigation trigger may be activated in the future, modification of the temporal and spatial distribution of SNWA GDP Cave Valley pumping to avoid activating a mitigation trigger level will be evaluated.

- An investigation trigger is also set directly at the continuous gaging station at Flag Spring No. 2. The gaging station is also a proxy for Butterfield Spring. An investigation trigger at Flag Spring No. 2 is activated if the spring discharge decreases below the 99.7 percent lower control limit for a continuous period of six months, as described in Appendix A. The period of record hydrograph and current lower control limit for Flag Springs No. 2 is presented in Figure 8-16.

- An investigation of a monitoring location or area can be requested at any time by the NSE.

- The activation of an investigation trigger will result in an evaluation of causation and significance of the change, as described in Section 3.2.2, and will include analysis of regional hydrologic conditions and other monitor wells in the project area. Spring discharge will be compared to historical regional hydrologic conditions, spring discharge at locations upgradient of Shingle Pass (e.g. Hardy Spring), water levels in monitor wells, and the magnitude and spatial distribution of drawdown throughout the analysis area.

Southern White River Valley Mitigation Triggers and Mitigation Actions

The mitigation trigger at the Flag Springs Complex will be activated if: (1) the evaluation associated with the investigation trigger determines the cause of the change to be SNWA GDP pumping; and (2) the combined discharge at Flag Springs Complex is less than 10 percent above the permitted diversion if adjudicated, or the vested claim if not adjudicated.

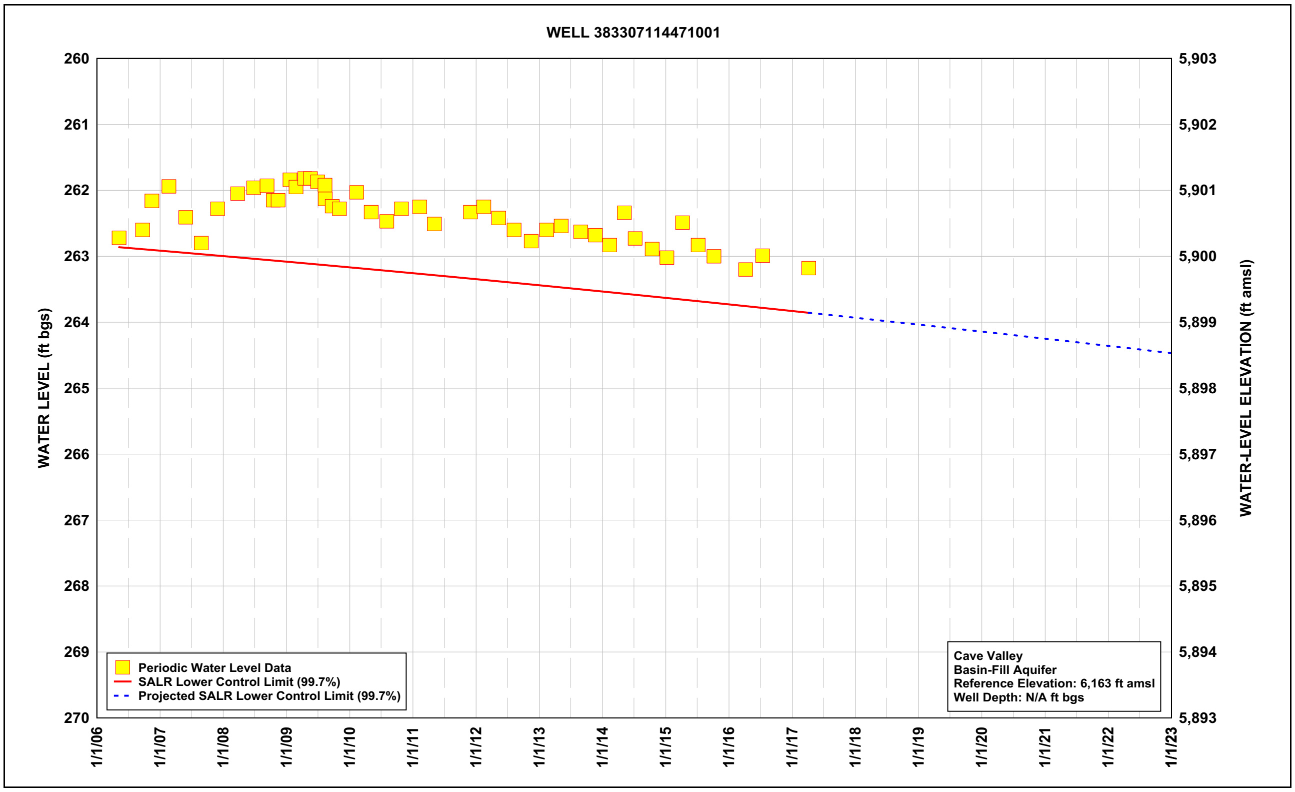

Figure 8-14
Well 383307114471001 - Trigger

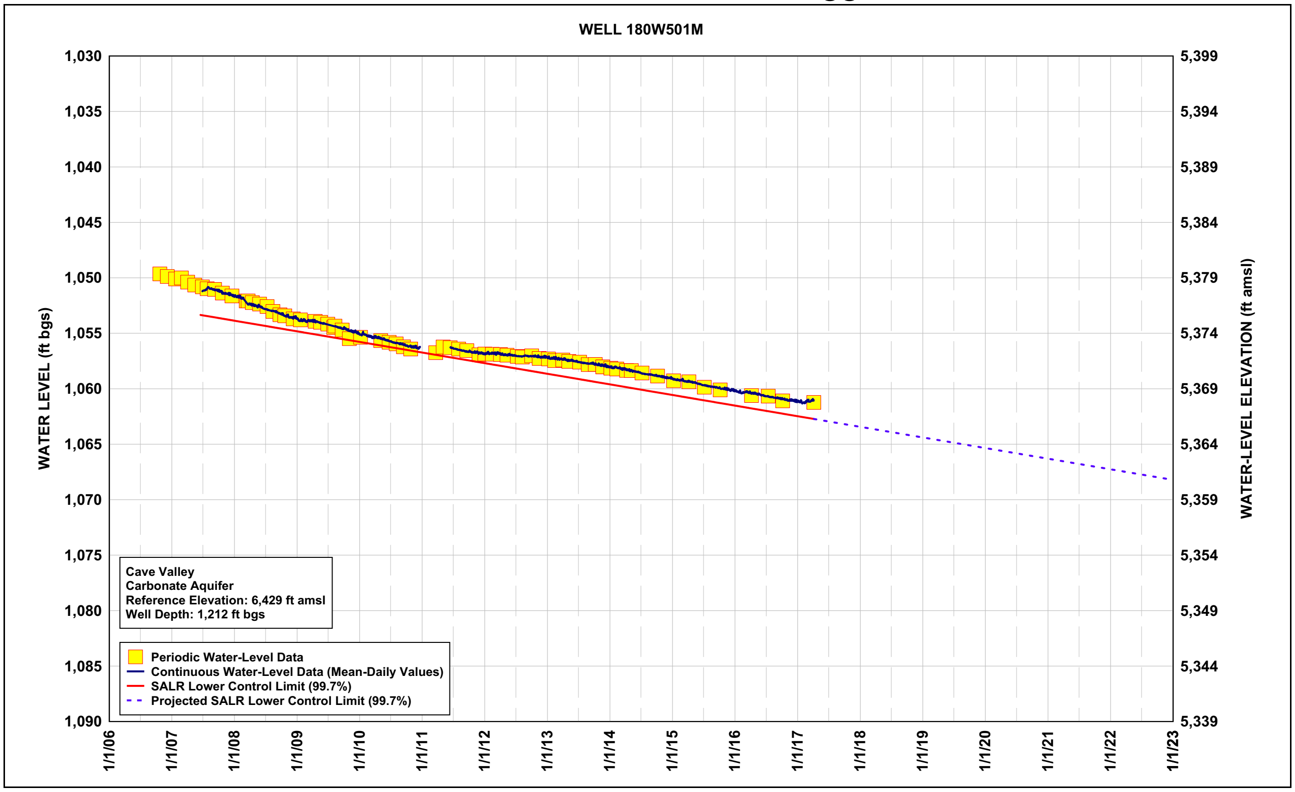

Figure 8-15
Monitor Well 180W501M - Trigger

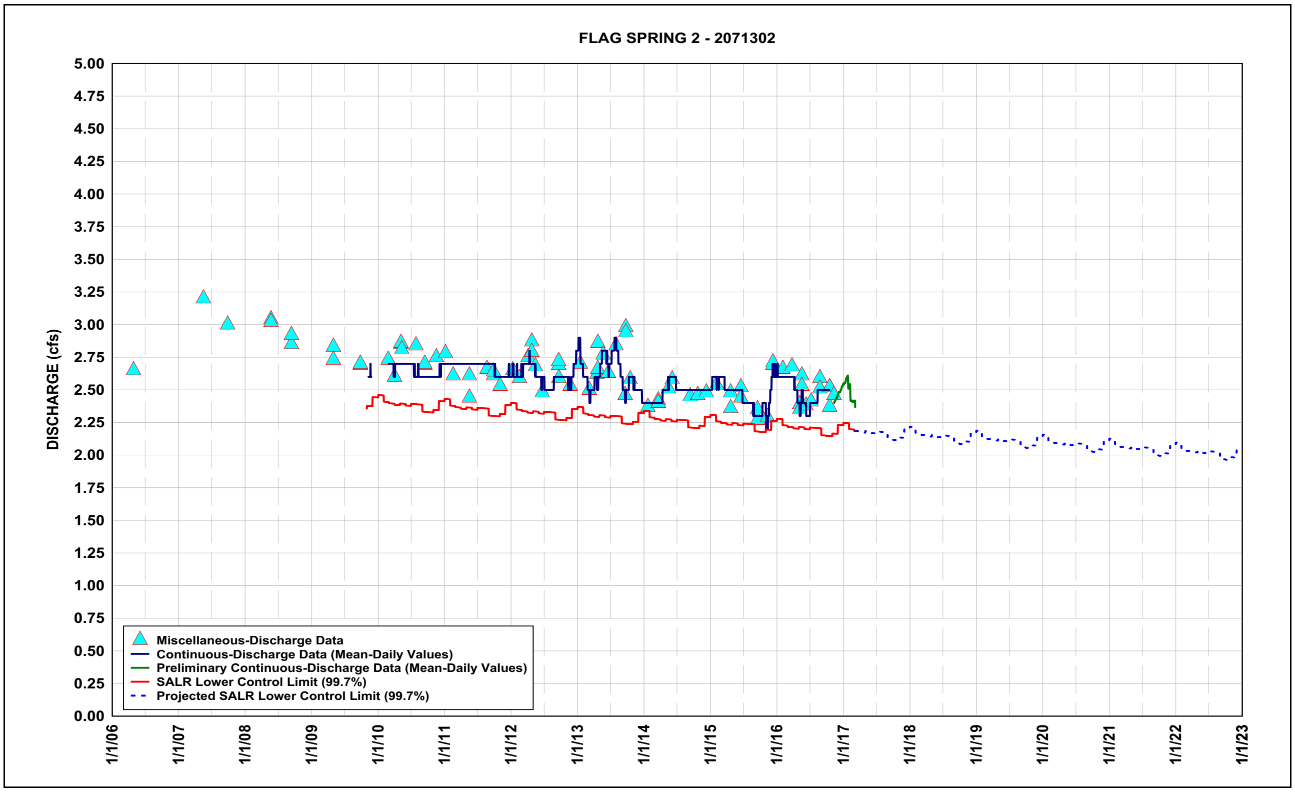

Figure 8-16
Flag Spring No. 2 - Trigger

Mitigation actions will be initiated if a mitigation trigger is activated caused by SNWA GDP pumping. Mitigation actions at the senior water rights including Flag Springs Complex and Butterfield Spring are listed in Section 3.2.8 and include the following:

Mitigation actions for senior underground water rights include:

- Lowering of the pump if the well has the depth and capacity to produce the water right.
- Compensate well owners for the incremental increase in power usage if the usage increase is greater than 25 percent to produce a similar volume of water.
- Deepen the well if the aquifer has the ability to yield the water right.
- Rehabilitate the well to increase well efficiency.
- Drill and equip a replacement well.
- Convey water to the site from an SNWA water right POD to the effected site.
- Transfer or exchange of the impacted senior water right for an SNWA water right of an equal or better priority at another location.

- Modify SNWA pumping rates, duration, and/or distribution.
- Temporary storage tank to supplement the well until other mitigation actions are implemented or water level recovers. Water supplying the tank can be sourced by pumping the impacted well for a longer period of time at a lower pumping rate or by a water truck.

Mitigation actions for Flag and Butterfield springs and other senior spring water rights include:

- Acquire or exchange water rights and construct a well(s) south of the Flag and Butterfield springs (beyond the influence of mitigation pumping on the springs) and convey water to the POD or place of beneficial use to supplement spring flow. Construction of well(s) located south of the Flag and Butterfield springs area to supplement spring flow.
- Transfer or exchange of the impacted senior water right for an SNWA water right of an equal or better priority at another location.
- Modify SNWA pumping rates, duration, and/or distribution.
- Temporary storage tank to supplement the spring until other mitigation actions are implemented or water level recovers. Water supplying the tank can be sourced by a water truck.

8.3 Environmental Resources

This section establishes triggers and monitoring, management, and mitigation actions to avoid unreasonable effects to environmental resources from SNWA GDP pumping in Cave Valley.

8.3.1 Cave Valley

Multiple lines of evidence indicate that there is no hydraulic connection between the producing aquifer in which SNWA GDP production wells will be installed in southern Cave Valley and the environmental resources in northern Cave Valley (see Section 8.2.2), or the shrubland habitat in southern Cave Valley (where depth to water is greater than 150 feet below ground surface; see Section 4.2.1) (Figure 8-17). Because effects to these resources from SNWA GDP pumping are thus improbable, triggers and mitigation actions are not established for environmental resources in Cave Valley.

SNWA purchased a 1,480-acre conservation easement on Cave Valley Ranch in northern Cave Valley (Figure 8-17), and shared its obligations as the easement holder with the Rocky Mountain Elk Foundation (Grant of Conservation Easement, 2009; and Assignment of Conservation Easement, 2013).[1] The conservation easement includes the headwaters of Cave Spring and approximately 250 acres of mesic habitat in the vicinity of Parker Station Spring, and provides habitat for a variety of wildlife species. Although triggers and mitigation are not required for SNWA GDP pumping in

1. SNWA has retained the "right of enforcement by a third party" (Assignment of Conservation Easement, 2013).

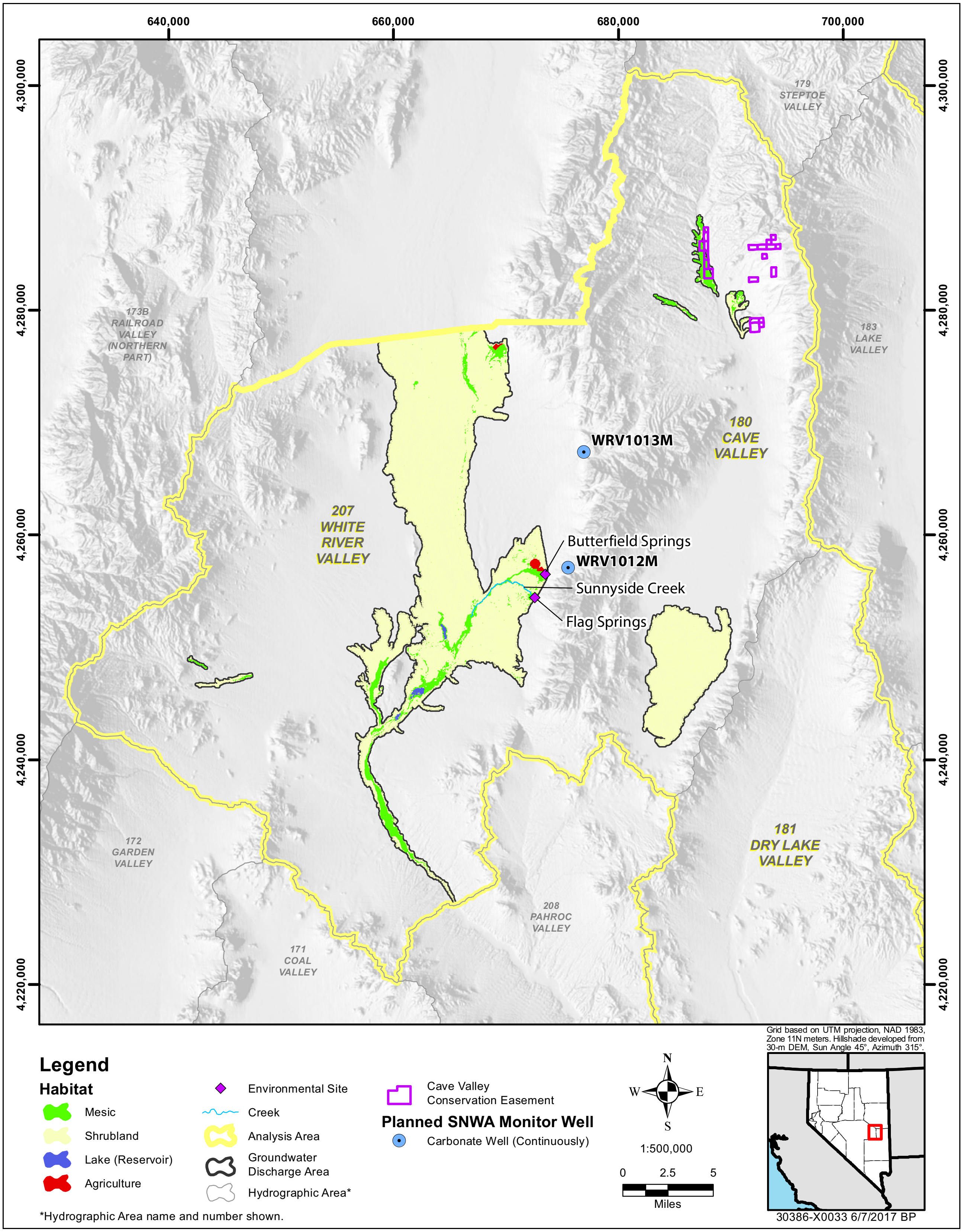

Figure 8-17
Environmental Resources in Cave and Southern White River Valleys

Cave Valley, this conservation easement ensures natural habitat located on the property is protected and conserved in perpetuity (Grant of Conservation Easement, 2009).

8.3.2 Southern White River Valley

Overview

Effects to environmental resources in southern White River Valley from SNWA GDP pumping are unlikely given the staged development, reserved groundwater, and management plan to protect spring flows at Flag and Butterfield springs (Section 8.2.3). Nonetheless, environmental triggers and mitigation actions are established to ensure unreasonable effects to environmental resources in southern White River Valley are avoided.

The groundwater discharge area in southern White River Valley encompasses approximately 73,000 acres (Figure 8-17). This area is largely comprised of shrubland habitat, and also includes mesic habitat, lake (reservoir) habitat, and agriculture (shrubland habitat = 68,000 acres (93%); mesic habitat = 4,500 acres (6%); lake (reservoir) habitat = 300 acres (<1%); agriculture = 300 acres (<1%)). As discussed in Section 8.2.3, groundwater outflow from Cave Valley may contribute to the discharge at Flag and Butterfield springs (Figures 8-9 and 8-17). A federally endangered fish species occurs in this area, as do other native aquatic-dependent special status fish and invertebrate species. Habitat descriptions, a summary of wildlife that use the habitats, and details about the listed and special status species occurrences are presented in Sections 5.2 and 5.3.

The federally endangered White River spinedace inhabits all three spring heads of the Flag Springs complex (Nos. 1, 2 and 3; a.k.a. north, middle and south), and the downstream Sunnyside Creek (NDOW, 2016) (Figure 8-9). Removal of a culvert in upper Sunnyside Creek in 2015 enabled the fish to expand throughout the entire creek in 2016. Various conservation efforts have been undertaken to assist with species recovery, including eradication of introduced predatory fish (deemed successful in 1995), removal of fish barriers (completed in 2015), and on-going stream restoration efforts (NDOW, 2016; and USFWS, 2012). White River spinedace counts have varied considerably over the past 15 years, although it is unclear how much of the variability is due to natural population fluctuations or other factors.[1] The species is considered to have a high degree of resilience, as the population has significantly rebounded multiple times; for example, the population rebounded following predation pressure reductions and habitat improvements (NDOW, 2016; and USFWS, 2012). According to NDOW, White River spinedace "continue to survive in healthy numbers," and habitat restoration efforts continue (NDOW, 2016).[2]

The approach to avoid unreasonable effects to environmental resources in southern White River Valley primarily relies on avoiding unreasonable effects to senior water rights. As described in detail in Section 8.2.3, this approach includes hydrologic monitoring, investigation triggers at intermediate

1. Snorkel surveys have been conducted by NDOW twice per year (spring and fall) in a relatively consistent manner since 2002. An example of other factors that likely cause variation in White River spinedace numbers are aquatic vegetation build-up and obstructed survey visibility.
2. Detailed information about the White River spinedace, its habitat, and its Recovery Plan are presented in the SNWA GDP BO (USFWS, 2012, at Chapters 12-14).

wells, preemptive management actions, mitigation triggers, and mitigation actions to avoid conflicts with senior water rights. NDOW's vested claim on Sunnyside Creek (permit number V04605; Table 8-3) is approximately equivalent to the combined flow at the three Flag Spring orifices (Nos. 1, 2, and 3), which provide the primary source of water for White River spinedace. Given the number and distribution of monitor wells and the senior water rights on Sunnyside Creek and Butterfield Springs (Figures 8-1 and 8-2), and the staged groundwater development and reserved groundwater in Cave Valley (discussed in Section 8.1), this approach also helps prevent unreasonable effects to environmental resources. Additional environmental triggers and management and mitigation actions are established below.

Federally listed and native aquatic-dependent special status animal species

The approach to avoid jeopardizing the continued existence of the federally listed species and extirpation of other native aquatic-dependent special status animal species includes habitat protection at Flag and Butterfield springs and Sunnyside Creek. The approach is as follows:

- Implement management and mitigation actions to avoid conflicts with senior water rights as described in Section 8.2.3.
- If the investigation trigger at the monitor well WRV1012M or WRV1013M is activated as a result of SNWA GDP pumping as described in Section 8.2.3, support NDOW with its native fish surveys at Flag and Butterfield springs and Sunnyside Creek to ensure the surveys are conducted, and incorporate presence/absence surveys of the other native aquatic-dependent special status animal species during the fish surveys (fish and invertebrates; see Section 5.3) (Figure 8-17).[1] Also continue to participate on the White River Valley Native Fishes Recovery Implementation Team. The purpose of the monitoring is to confirm the continued status of the listed species and the continued existence of the other special status species at the sites. These efforts will be conducted as long as the investigation trigger is activated at one of these wells, the hydrologic mitigation trigger is activated at Flag Springs, or as long as mitigation actions for the species are being conducted for the SNWA GDP.
    - Triggers and mitigation actions are not required for the remaining southern White River Valley habitats and species presented in Sections 5.2 and 5.3. All evidence indicates that these resources are supported by south-trending groundwater flow through the basin and/or local recharge and not inflow from Cave Valley (Section 8.2.3). Because effects from SNWA GDP pumping to these environmental resources are improbable, no further mitigation actions are required to avoid unreasonable effects in southern White River Valley.
- If a mitigation trigger is activated at Flag or Butterfield springs or Sunnyside Creek as a result of SNWA GDP pumping as described in Section 8.2.3, initiate mitigation actions at Flag and

1. The fish surveys are part of NDOW's regular monitoring efforts for native fish populations under the Nevada State's Native Aquatic Species Program. The surveys at Flag Springs and Sunnyside Creek are typically biannual (spring and fall), and the surveys at Butterfield Spring are typically biennial (every other year). Surveys on private land require landowner permission.

Butterfield springs and Sunnyside Creek. In addition to the mitigation actions identified for senior water rights (Section 8.2.3), environmental mitigation actions for the species will include at least one of the following:

- Collaborate with the private landowners and water right holders and fund measures to ensure water is available to support the species and their habitats.

- Collaborate with private landowners and NDOW and/or the White River Valley Native Fishes Recovery Implementation Team and fund improvements to improve existing habitat (e.g., thinning of dense aquatic vegetation increases suitable fish habitat).

- Collaborate with NDOW and fund expansion of habitat, creation of suitable habitat, and/or establishment of additional populations of the listed fish species.

These mitigation actions also protect the needs of other wildlife in Flag and Butterfield springs and Sunnyside Creek.

9.0 TRIGGERS, MANAGEMENT AND MITIGATION: DRY LAKE, DELAMAR, AND PAHRANAGAT VALLEYS (HYDROGRAPHIC AREAS 181, 182 AND 209)

9.1 Introduction

This section provides technical background and rationale for the DDC 3M Plan associated with SNWA GDP permits in Dry Lake and Delamar valleys. Analyses are presented for the thresholds, triggers, and monitoring, management, and mitigation actions that are established to avoid unreasonable effects to senior water rights and environmental resources in Dry Lake, Delamar, and Pahranagat valleys. As described in Section 9.2.4, effects in Pahranagat Valley from SNWA GDP pumping are unlikely. Nonetheless, triggers and management and mitigation actions are established to ensure unreasonable effects in Pahranagat Valley are avoided. The analyses were conducted in accordance with the conceptual approach described in Section 3.0.

The NSE granted SNWA water rights totaling 11,584 afa in Dry Lake Valley associated with permit numbers 53989 and 53990 (NDWR, 2012c Ruling 6166) and 6,042 afa in Delamar Valley associated with permit numbers 53991 and 53992 (NDWR, 2012d Ruling 6167). The analysis area, SNWA GDP PODs, senior water rights, and the 3M Plan hydrologic monitoring network within Dry Lake, Delamar, and Pahranagat valleys are shown on Figures 9-1 and 9-2.

9.2 Hydrologic Monitoring and Senior Water Rights

Numerous studies have been performed to define the hydrogeologic framework and baseline hydrologic conditions in Dry Lake, Delamar, and Pahranagat valleys. These studies are summarized by Burns and Drici (2011). The hydrologic monitoring program for this area is summarized in this section.

A query of the NDWR Water Rights Database for all active water rights in Dry Lake, Delamar, and Pahranagat valleys was performed. Active water rights are those that are not in application status, but it includes vested claims. The data set was reduced by removing water rights that are located in the basin mountain block, have priority dates junior to the SNWA GDP permits, reservoir rights, and those owned by SNWA.

The resulting data set of senior water rights are assigned a management category, as described in Section 3.2.5, which defines the monitoring strategy and establishes appropriate investigation triggers to evaluate the cause and significance of variations from baseline conditions. Appropriate management actions are implemented based upon the results of the investigation to avoid or minimize the likelihood of activating a mitigation trigger. The monitoring and management strategy,

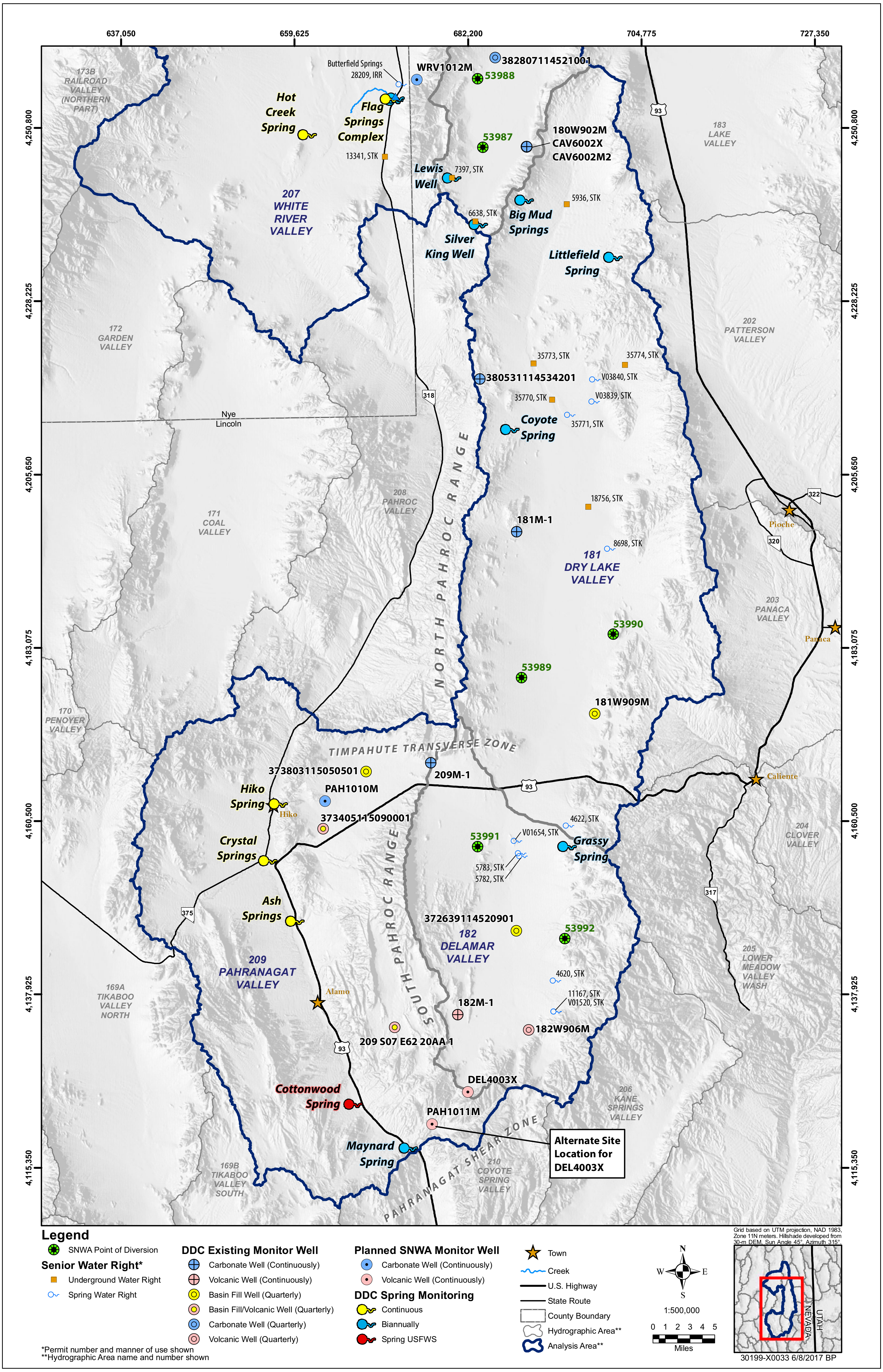

Figure 9-1
Dry Lake and Delamar Valley GDP PODs, Senior Water Rights, and Hydrologic Monitoring Network

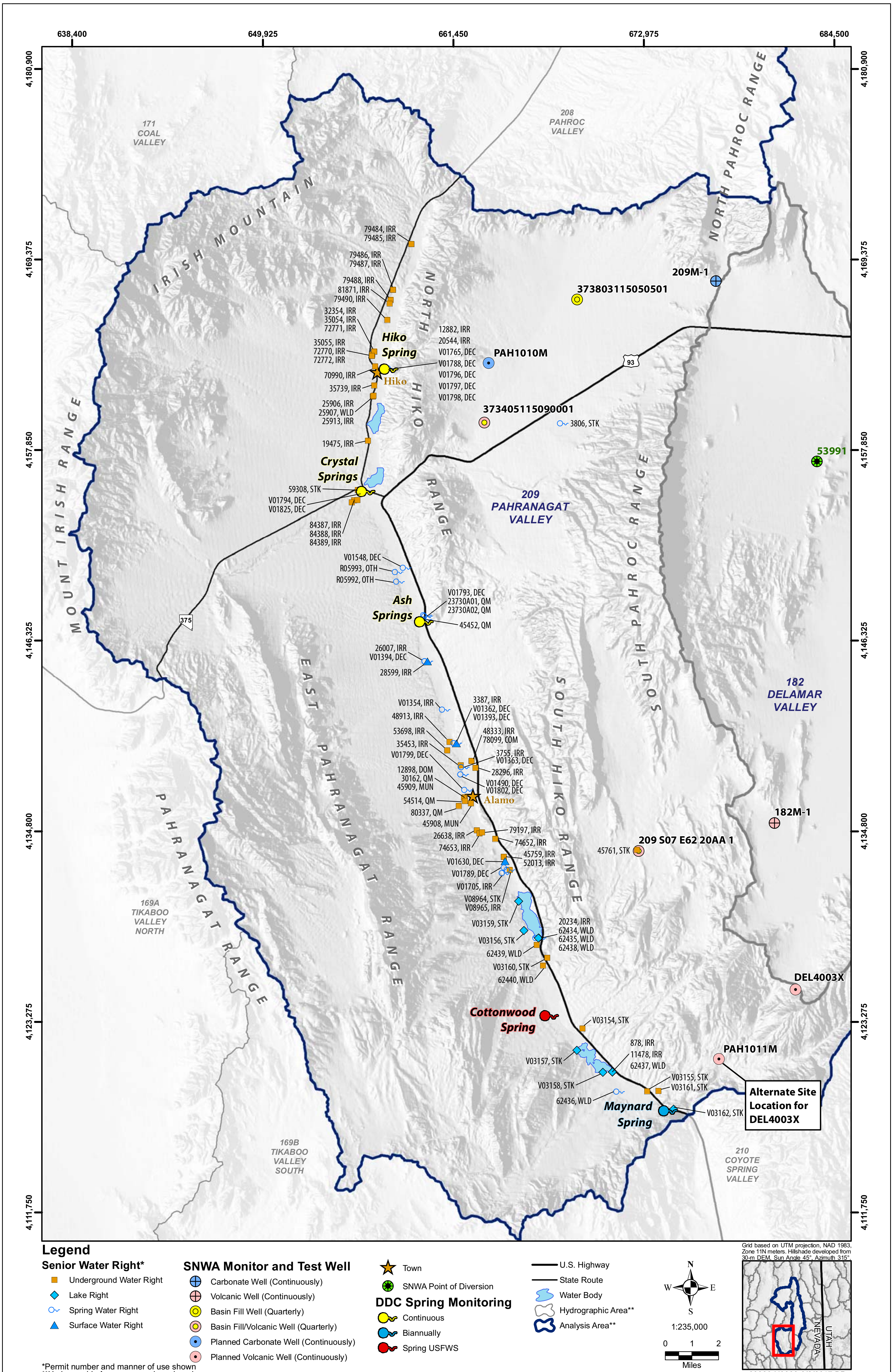

Figure 9-2
Pahranagat Valley Senior Water Rights and Hydrologic Monitoring Network

investigation triggers and management actions, and mitigation triggers and actions for Dry Lake, Delamar, and Pahranagat valleys are presented in this section.

9.2.1 Hydrologic Monitoring

SNWA established a hydrologic monitoring program associated with the DDC 3M Plan in Dry Lake, Delamar, and Pahranagat valleys. Baseline hydrologic data have been collected for this monitoring network since 2006. The NSE approved the original monitoring plan in December 2009 and a revised version in 2011 (SNWA, 2009d and 2011c). The DDC 3M Plan has been revised again as described in this report to address concerns stated in the Remand Order.

The monitoring element of the DDC 3M Plan associated with Dry Lake, Delamar, and Pahranagat valleys provides the ability to effectively detect and measure propagation of drawdown in order to implement appropriate management and mitigation actions to avoid unreasonable effects. The DDC 3M Plan monitoring network is presented in Section 10.3 and summarized for this area below:

- A spring monitoring network consisting of three springs in Dry Lake Valley (Coyote, Littlefield, and Big Mud springs), one spring in Delamar Valley (Grassy Spring), and five springs within Pahranagat Valley (gaging stations at Ash and Crystal springs, a flow meter at Hiko Spring, and two sites managed by USFWS at Cottonwood and Maynard springs are currently being monitored).

- Ten existing monitor wells consisting of three located in Dry Lake Valley, three in Delamar Valley, and four in Pahranagat Valley are currently being monitored.

- Two planned wells will be located east of Hiko Spring (PAH1010M) and at the southern edge of Delamar Valley (DEL4003X). An alternate monitoring well site for well DEL4003X is PAH1011M, which has been sited. BLM right-of way access has been granted for the three sites.

- One additional monitoring well for the DDC 3M Plan will be sited and installed after the production well locations are determined.

- Assemble and report data from selected existing regional precipitation stations in the vicinity of the DDC analysis area.

- Collect two rounds of water-chemistry data from up to 12 locations six months apart within the DDC analysis area prior to SNWA GDP pumping and every five years after pumping begins to document changes in chemistry.

Hydrologic monitoring data is provided to the NSE electronically on a quarterly basis. Annual data reports have been submitted since 2008. Historical data for each element of the monitoring program are presented in the *2016 DDC Hydrologic Monitoring, Management, and Mitigation Plan Status and Data Report* (SNWA, 2017a).

9.2.2 Dry Lake Valley

Dry Lake Valley Senior Water Rights

A query of the NDWR Water Rights Database for all active water rights and domestic wells in Dry Lake Valley was performed. Active water rights are those that are not in application status, but it includes vested claims. Based on this query, there are 107 active water rights in Dry Lake Valley as of November, 2016 that have an application status of certificated, decreed, permitted, reserved, or vested. The data set was reduced by excluding 98 water rights that are located in the basin mountain block, have priority dates junior to the SNWA GDP permits, reservoir rights, and those owned by SNWA. The water rights located in the basin mountain block were removed because they are not in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed, and are therefore not likely to be impacted by SNWA GDP permits. The resulting data set includes nine active water rights in Dry Lake Valley. One domestic wells identified in Dry Lake Valley using the analysis criteria is owned by SNWA.

The locations of nine water rights senior to the SNWA GDP permits within Dry Lake Valley are presented on Figure 9-1. A summary of the total senior water rights by source, status, and hydraulic connection to the producing aquifer in which SNWA GDP production wells will be installed is presented in Table 9-1. Individual senior water rights in Dry Lake Valley are listed in Table 9-2. The table includes information on water right status, source, manner of use, diversion rate, annual duty, ownership, distance to the closest SNWA POD, spring elevation, and management category (as described in Section 3.2.5). There are five certificated underground rights, two certificated spring rights, and two vested claims that are senior to SNWA's permits. All of the water rights senior to SNWA GDP permits in Dry Lake Valley are used for stock watering.

Table 9-1
Dry Lake Valley Water Rights by Source and Status Senior to SNWA GDP Permits

Source	Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)				Not Hydraulically Connected with SNWA POD Producing Aquifer (Number or Rights/Annual Duty)			
	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)	Certificated (afa)	Permitted (afa)	Reserved (afa)	Vested (afa)
Spring	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	2 / 15.31[a]	0 / 0.00	0 / 0.00	2 / 4.05[a]
Stream	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00
Underground	5 / 38.48	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00

[a]The reported duty includes both acre-ft per season and acre-ft per annum.

Table 9-2
Water Rights within Dry Lake Valley Senior to SNWA GDP Permits

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
5936	CER	UG	STK	1920	0.025	18.1*	Adams-McGill Company	Alluvial Fan / Valley Floor	35.0	5,630	C
8698	CER	SPR	STK	1928	0.017	12.1*,g	Vidler Water Company	Alluvial Fan / Valley Floor	6.9	4,780	E
18756	CER	UG	STK	1960	0.015	10.8*	Delmue, Albert	Valley Floor	10.5	4,710	C
35770	CER	UG	STK	1978	0.004	3.2*	Geyser Ranch, LLC	Valley Floor	19.6	4,970	C
35771	CER	SPR	STK	1978	0.005	3.3*	Geyser Ranch, LLC	Valley Floor	18.1	4,930	E
35773	CER	UG	STK	1978	0.004	3.2*	Geyser Ranch, LLC	Valley Floor	22.9	5,070	C
35774	CER	UG	STK	1978	0.004	3.2*	Geyser Ranch, LLC	Alluvial Fan	21.8	5,440	C
V03839	VST	SPR	STK	1890	0.004	2.0*,g	Imperial Farms Land and Cattle Co.	Alluvial Fan	18.9	5,040	E
V03840	VST	SPR	STK	1890	0.004	2.0*	Imperial Farms Land and Cattle Co.	Alluvial Fan	20.7	5,200	E

[a]CER - Certificated, VST - Vested
[b]SPR - Spring, UG - Underground
[c]STK - Stock watering
[d]Rounded to the nearest tenth of a mile.
[e]Rounded to the nearest 10 feet.
[f]See Section 3.2.5 for a detailed explanation of the Management Categories; C - Distant resource > 10 miles, E - Resource not in hydraulic connection with producing aquifer in which SNWA GDP production wells will be installed.
[g]acre-ft per season.
*The reported annual duty is not explicitly documented on the certificate or vested claim, but reported as such by the NDWR Hydrographic Abstract query.

Dry Lake Valley Monitoring Strategy

Senior water rights in Dry Lake Valley included in the analysis are listed in Table 9-2. The five senior underground water rights are located at a distance of 10 to 35 miles from the closest SNWA GDP PODs. These five sites are assigned Management Category C, as described in Table 3-1, because they are located over 10 miles from the nearest SNWA GDP POD. The monitoring and management strategy for this category consists of using monitor well 181W909 and 181M-1 and direct monitoring at senior underground water right permit number18756 POD, as shown in Figure 9-1 to detect and measure the propagation of drawdown from the SNWA GDP pumping. Additional hydrologic network sites (Well 380531114534201 and Coyote, Littlefield, and Big Mud springs) are measured to monitor hydrologic conditions in the northern portion of Dry Lake Valley.

Two senior certificated spring rights and two vested spring claims are assigned Management Category E, since they are not in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed and therefore, would not be effected by SNWA GDP pumping. This is due to the over 400 foot depth to water in the producing aquifer and the location, hydrogeologic setting, and high elevation of the springs.

Dry Lake Valley Investigation Triggers and Management Actions

Effects to senior water rights within Dry Lake Valley are unlikely due to the distance from the SNWA PODs, lack of hydraulic connection with the producing aquifer, and the high elevation of the spring which are locally recharged by precipitation. However, water levels will be monitored in wells 181M-1 and 181W909 and an investigation trigger will be activated if the static water level in either of the two monitor wells decreases below the 99.7 percent control limit for baseline data continuously for six months, as described in Appendix A.

Activation of the investigation trigger will result in an evaluation as described in Section 3.2.2. If investigation indicates cause of water level change is the result of SNWA GDP pumping, management actions include:

- Update and calibrate the numerical groundwater flow model with aquifer response data.
- Continue to observe water levels in the monitor wells to verify model projections.
- Install additional monitor wells or increase monitoring frequency at sites in Dry Lake Valley monitored quarterly.
- Prepare mitigation actions for implementation, including purchasing equipment, establishing contracts, obtaining any necessary land owner permissions and permits.

Dry Lake Valley Mitigation Triggers

The closest senior underground water right (permit number 18756 with annual duty of 10.8 afa) is located 10 miles north of the closest SNWA GDP POD with no intermediate monitor well. The well log for this site (log number 5511) indicates a well depth of 515 ft bgs with a water level of 400 feet.

An assessment of this well, as described in Section 3.2.7, will be performed with the owner's permission prior to GDP operations to verify well construction and performance.

The other underground senior water rights are located between approximately 20 and 35 miles from the closest SNWA POD. These water rights are unlikely to be effected by SNWA GDP pumping due to the distance to the rights and hydrogeologic setting. However, mitigation triggers for the senior underground rights, as described in Section 3.2.6.1, are summarized below:

Underground Senior Water Rights

The mitigation trigger for underground senior water rights are defined for two categories where: (1) the well and current pump production capacity is capable of producing more water than the water right's diversion rate allows; and (2) the well and current pump production capacity is capable of producing water only equal to or less than what the water right's diversion rate allows.

The mitigation triggers are based upon change in static groundwater level and specific capacity as described in Section 3.2.6.1. The mitigation triggers are detailed below:

- Well production > permitted diversion rate prior to SNWA GDP pumping: A decrease in groundwater level that reduces the column of water in the well needed to produce the permitted diversion rate based on the well's specific capacity range plus either a 10 percent or 10 foot buffer, which ever is greater. The buffer provides time to implement the mitigation action prior to reaching a conflict. An example of a mitigation trigger for this case is presented in Section 3.2.6.1. An alternative fixed mitigation trigger for the well is activated if the maximum production capacity from the well decreases to less than 10 percent above the permitted diversion rate and the static groundwater level has decreased as a result of SNWA GDP pumping. An evaluation would be made to determine if the changes are a result of SNWA GDP pumping or are due to a deterioration in the well or pump conditions and efficiency.

- Well production < permitted diversion rate prior to SNWA GDP pumping: The mitigation trigger is activated if the evaluation associated with the investigation trigger determines the cause of the change in water level to be SNWA GDP pumping.

- Increase of more than 25 percent in power usage to pump the same amount of water as a result of decreased water levels caused by SNWA GDP pumping.

The closest senior spring water right is approximately seven miles from the nearest SNWA POD and is located at an elevation of approximately 4,700 ft amsl. However, field visits to this spring indicate that the permitted POD for this spring is actually a delivery trough supplied via a pipeline from a mountain block spring which is located at a higher elevation than the trough to the northeast. The water level elevation at valley floor monitor wells 181W909M and 181M-1 are at 4,288 and 4,300 ft amsl, respectively. The hydrogeologic setting and difference in elevation between the mountain block spring and estimated groundwater level at the POD for SNWA permit number 53990 indicates no hydraulic connection between the spring and the producing aquifer for the SNWA GDP permits. Therefore, effects at the spring are not likely.

Dry Lake Valley Mitigation Actions

If SNWA GDP pumping causes the activation of a mitigation trigger, mitigation actions will be implemented. Mitigation actions for a well associated with a senior underground water right include the following:

- Lower the pump if the well has the depth and capacity to produce the water right.
- Rehabilitate the well to increase well efficiency.
- Deepen the well if the aquifer has the ability to yield the water right.
- Drill and equip a replacement well.
- Compensate well owners for the incremental increase in power usage if power usage increase is greater than 25 percent to produce a similar volume of water.
- Modify SNWA GDP pumping duration, rate, or distribution.
- Convey water to the site from an SNWA water right POD to the effected site.
- Transfer or exchange of the impacted senior water right for an SNWA water right of an equal or better priority at another location.
- Install a temporary storage tank to supplement the well's production while other mitigation actions are implemented. Water supplying the tank can be sourced by pumping the well for a longer period of time at a lower pumping rate or by a water truck delivering water.

9.2.3 Delamar Valley

Delamar Valley Senior Water Rights

A query of the NDWR Water Rights Database for all active water rights in Delamar Valley was performed. Active water rights are those that are not in application status, but it includes vested claims. Based on this query, there are 64 active water rights in Delamar Valley as of November, 2016 that have an application status of certificated, decreed, permitted, reserved, or vested. The data set was reduced by excluding 57 water rights that are located in the basin mountain block, have priority dates junior to the SNWA GDP permits, reservoir rights, and those owned by SNWA. The water rights located in the basin mountain block were removed because they are not in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed, and are therefore not likely to be impacted by SNWA GDP permits. The resulting data set includes seven active water rights in Delamar Valley. There were no domestic wells located in Delamar Valley in hydraulic connection with the producing aquifer.

The location of seven water rights senior to the SNWA GDP permits within Delamar Valley are presented on Figure 9-1. A summary of total senior water rights by source and status is presented in Table 9-3. Individual senior water rights in Delamar Valley are listed in Table 9-4. There are five certificated senior spring water rights and two vested claims used for stock watering. None of these rights are hydraulically connected to the producing aquifer.

Stock water permit numbers 5782 and 5783 and vested claim V01654 are shown in the incorrect locations in the NSE online database. Field visits to the locations identified in the NSE online database found no visible springs at the three locations. Those water rights appear to be located at a higher elevation to the east near Cottonwood Spring and are locally recharged due to their relative elevation compared to the regional aquifer.

Table 9-3
Delamar Valley Water Rights by Source and Status Senior to SNWA GDP Permits

	Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)				Not Hydraulically Connected with SNWA POD Producing Aquifer (Number of Rights/Annual Duty)			
Source	**Certificated (afa)**	**Permitted (afa)**	**Reserved (afa)**	**Vested (afa)**	**Certificated (afa)**	**Permitted (afa)**	**Reserved (afa)**	**Vested (afa)**
Spring	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	5 / 23.35[a]	0 / 0.00	0 / 0.00	2 / 1.48
Stream	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00
Underground	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00	0 / 0.00

[a]The reported duty includes both acre-ft per season and acre-ft per annum.

Table 9-4
Water Rights within Delamar Valley Senior to SNWA GDP Permits

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
4620	CER	SPR	STK	1917	0.001	0.7*,[g]	Gardner Ranch Co.	Alluvial Fan	3.5	5,050	E
4622	CER	SPR	STK	1917	0.002	0.6*	Gardner Ranch Company	Alluvial Fan	7.6	5,620	E
5782	CER	SPR	STK	1919	0.012	9.1*	Duffins, Press W. Jr.	Alluvial Fan	3.7	4,930	E
5783	CER	SPR	STK	1919	0.015	10.9*	Duffin, Mamie R.	Alluvial Fan	3.5	4,930	E
11167	CER	SPR	STK	1944	0.003	2.2*	LDS	Alluvial Fan	5.9	5,300	E
V01520	VST	SPR	STK	1900	0.0016[h]	0.80[h]	Gardner Ranch Co	Alluvial Fan	5.9	5,300	E
V01654	VST	SPR	STK	1900	0.025	0.7*	Duffin, Mame R.	Alluvial Fan	3.2	4,970	E

[a]CER - Certificated, VST - Vested
[b]SPR - Spring
[c]STK - Stock watering
[d]Rounded to the nearest tenth of a mile.
[e]Rounded to the nearest 10 feet.
[f]See Section 3.2.5 for a detailed explanation of the Management Categories; E - Resource not in hydraulic connection with producing aquifer in which SNWA GDP production wells will be installed.
[g]Acre-ft per season.
[h]Reported number was derived from an analysis documented in Stanka (2017).
*The reported annual duty is not explicitly documented on the certificate or vested claim, but reported as such by the NDWR Hydrographic Abstract query.

Delamar Valley Monitoring and Management Strategy

There are seven senior spring water rights in the analysis of Delamar Valley all of which are assigned Management Category E (Table 3-1) because they are not in hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed. Five are certificated spring rights and two vested claims used for stock watering. There are no senior underground water rights in Delamar Valley.

Impacts to these senior water rights within Delamar Valley are not expected due to the lack of hydraulic connection between the producing aquifer and the higher elevation springs which are locally recharged by precipitation. This is due to the hydrogeologic setting and depth to groundwater at monitor well 372639114520901 of 860 ft bgs. The monitor well is representative of the producing aquifer in which SNWA GDP production wells will be installed. Discharge from most of the springs is conveyed to places of use on the valley floor via an aqueduct or pipeline.

Groundwater levels within Delamar Valley are measured at existing monitor wells 372639114520901, 182M-1, and 182W906M to document aquifer conditions. An additional planned monitor well (DEL4003X or alternate site PAH1011M) (Figure 9-1) is located in the Pahranagat Shear Zone (PSZ) and will be used to monitor inter-basin groundwater outflow from southern Delamar Valley. Grassy Spring, a higher elevation spring modified with a collection system, is also included in the monitoring program even though it is not hydraulically connected to the producing aquifer.

Delamar Valley Investigation and Mitigation Triggers

There are no impacts to the senior water rights located in Delamar Valley are expected due to their lack of hydraulic connection with the producing aquifer in which SNWA GDP production wells will be installed.

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9.2.4 Pahranagat Valley

Pahranagat Valley Senior Water Rights

A query of the NDWR Water Rights Database for all active water rights in Pahranagat Valley was performed. Active water rights are those that are not in application status, but it includes vested claims. Based on this query, there are 137 active water rights in Pahranagat Valley as of March, 2017 that have an application status of certificated, decreed, permitted, reserved, or vested. The data set was reduced by excluding 42 water rights that are located in the basin mountain block, have priority dates junior to the SNWA GDP permits, or are reservoir rights. The water rights located in the basin mountain block were removed because they are not in hydraulic connection to the producing aquifer in which SNWA GDP production wells will be installed, and are therefore not likely to be impacted by SNWA GDP permits. The resulting data set includes 95 active water rights in Pahranagat Valley.

The locations of water rights and vested claims senior to the SNWA GDP permits within Pahranagat Valley are presented on Figure 9-2. Senior water rights are located at the three regional springs (Hiko, Crystal, and Ash springs) as listed in Table 9-5. Additional senior water rights in the valley including those dependent upon discharge from Hiko, Crystal, and Ash springs are presented in Appendix B.

The DDC 3M Plan focuses on the three regional springs because they are sensitive resources and a primary water supply for Pahranagat Valley. Spring stock water right permit number 3806 will also be evaluated do its location between the regional springs and Delamar Valley. The springs are not expected to be effected by SNWA GDP pumping. However, the 3M Plan will monitor aquifer conditions between SNWA GDP PODs and resources in Pahranagat Valley to verify no effects occur and provide detection of water level changes in order to implement management and mitigation actions to avoid unreasonable effects.

Senior water rights in Pahranagat Valley are assigned Management Category D (Table 3-1) because they are located in an adjacent basin to SNWA GDP pumping. The monitoring and management strategy consists of using three sentinel monitor wells, as described in Section 3.2.1 located in the Timpahute Transverse Zone in northeast Pahranagat Valley (209M-1), on the west side of the South Pahroc Range (209S07E6220AA1), and at the southern edge of Delamar Valley in the PSZ (DEL4003X). The sentinel monitor wells and other intermediate wells are located between the SNWA PODs and the more distant senior water rights to detect and measure propagation of drawdown. The sentinel wells are a key component of the monitoring and management strategy to avoid activating mitigation triggers at senior water rights and to protect environmental resources in Pahranagat Valley.

The background hydrogeology, monitoring and management strategies, and investigation and mitigation triggers are presented separately in this section for northern and southern Pahranagat Valley. Mitigation actions are presented together at the end of this section.

Northern Pahranagat Valley Background and Monitoring Strategy

The hydrogeologic relationship between Dry Lake, Delamar, and Pahranagat valleys is discussed in Ruling 6167 at pages 76 -78.

Table 9-5
Selected Water Rights at Pahranagat Valley Regional Springs Senior to SNWA GDP Permits

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Distance to Nearest POD[d] (mi)	DEM Elevation[e] (ft amsl)	Management Category[f]
Hiko Spring											
12882	CER	SPR	IRR	1929	6.72	2,400.0[g]	Hiko Irrigation & Water Co.	Valley Floor	16.5	3,880	D
20544	CER	SPR	IRR	1962	3.0	2,171.4	Hiko Irrigation & Water Co.	Valley Floor	16.4	4,020	D
V01765	DEC	SPR	DEC	1884	1.368	392.8	Castles, Mary A.	Valley Floor	16.5	3,880	D
V01788	DEC	SPR	DEC	1872	0.171	68.4	Wright, Mary E.	Valley Floor	16.5	3,880	D
V01796	DEC	SPR	DEC	1888	1.347	390.4	Nesbitt, Edgar	Valley Floor	16.5	3,880	D
V01797	DEC	SPR	DEC	1872	0.1	40.0	Castles, James	Valley Floor	16.5	3,880	D
V01798	DEC	SPR	DEC	1873	2.715	972.0	Schofield, W. U and W.J.	Valley Floor	16.5	3,880	D
Crystal Springs											
V01794	DEC	SPR	DEC	1867	6.75	2,295.4	LDS	Valley Floor	17.1	3,810	D
V01825	DEC	SPR	DEC	1866	5.795	1,541.6	Farmland Reserve, Inc.	Valley Floor	17.1	3,810	D
Ash Springs											
23730A01	CER	SPR	QM	1885	0.015	8.2[g]	Dimick, Orlando Ephriam Trustee	Valley Floor	15.8	3,620	D
23730A02	CER	SPR	QM	1885	0.005	3.0[g]	Reed, Inc.	Valley Floor	15.8	3,620	D
45452	CER	SPR	QM	1982	0.00	3.0[g]	Barker, Joseph & Andrea	Valley Floor	15.8	3,620	D
V01793	DEC	SPR	DEC	1880	5.208	1,194.2	Barker, Joseph & Andrea	Valley Floor	15.8	3,620	D

[a]CER - Certificated, DEC - Decreed
[b]SPR - Spring
[c]DEC - As Decreed, IRR - Irrigation, QM - Quasi-municipal
[d]Rounded to the nearest tenth of a mile.
[e]Rounded to the nearest 10 feet.
[f]See Section 3.2.5 for a detailed explanation of the Management Categories; D - Resource in adjacent hydrographic area.
[g]Acre-ft per season.
Note: Additional senior water rights in Pahranagat Valley including those dependent upon discharge from Hiko, Crystal, and Ash springs are presented in Appendix B.

> "The primary flow paths for groundwater between the valleys [Dry Lake and Delamar] is through the basin fill and the north-south trending range front faults of the North Pahroc and Burnt Spring ranges. This conclusion is supported by the applicant's hydrologic evidence, which demonstrated that the prevailing hydraulic gradient in the carbonate rock and basin-fill material in Dry Lake and Delamar valleys is to the south toward Coyote Spring Valley and the Pahranagat Shear Zone" (NDWR, 2012d, at page 76).

The Timpahute Transverse Zone extends from northwest Delamar Valley into northern Pahranagat Valley and consists of a structural feature orientated to the west (Rowley et al., 2011). This provides, at best, a minor groundwater flow path to northern Pahranagat Valley. The NSE also described the potential for groundwater flow through this zone in Ruling 6166.

> "The potential for a minor amount of flow westward into Pahranagat Valley along structures associated with the Timpahute transverse zone cannot be ruled out. Detailed monitoring of groundwater along this zone will determine whether such flow occurs and if there is a change in flow due to pumping in Dry Lake Valley. The State Engineer finds that most of the groundwater in Dry Lake Valley discharges via inter-basin outflow to Delamar Valley, rather than to adjacent valleys to the east or west" (NDWR, 2012c, at page 78).

The primary senior water rights in northern Pahranagat Valley are associated with regional warm springs (Hiko, Crystal, and Ash springs). The description, hydrogeologic setting, and water chemistry of these three springs are described in SNWA, (2009c at Sections 3.1 and 5.3).

In northeast Pahranagat Valley, a sentinel well (209M-1) and a series of three other intermediate monitor wells provide the ability to detect and measure the unlikely propagation of drawdown from northwestern Delamar Valley toward northern Pahranagat Valley and Hiko, Crystal, and Ash springs via the Timpahute Transverse Zone. The four monitor wells between Delamar Valley and the regional springs consist of wells 209M-1 (carbonate), 373803115050501 (basin fill), and 373405115090001 (basin fill), which have a period of record from 2006 to present. A planned well, PAH1010M, will be constructed on the west slope of the Hiko Range in carbonate rock prior to SNWA GDP pumping to meet baseline data collection requirements.

A geologic cross section between the SNWA GDP PODs in Dry Lake Valley and Hiko Spring illustrating the geology and monitor well locations is presented in Figures 9-3 and 9-4. The profile shows that the monitoring network provides at least 11 miles of buffer between well 209M-1 and Hiko, Crystal, and Ash springs with additional monitor wells in between to detect and measure any unlikely propagation of drawdown through the Timpahute Transverse Zone.

The 3M Plan monitoring in Dry Lake, Delamar, and Pahranagat valleys will include maintaining and operating the gaging stations at Ash and Crystal springs, and the flow meter at Hiko Spring. The gages at Ash and Crystal springs are currently operated through a joint funding agreement with USGS. The Hiko Spring flow meter is operated by SNWA with permission from the Hiko Irrigation District.

Ruling 6166 states that "[t]he State Engineer finds that these continued monitoring efforts will provide an informed understanding of the hydrologic system in this area and further confirm the State

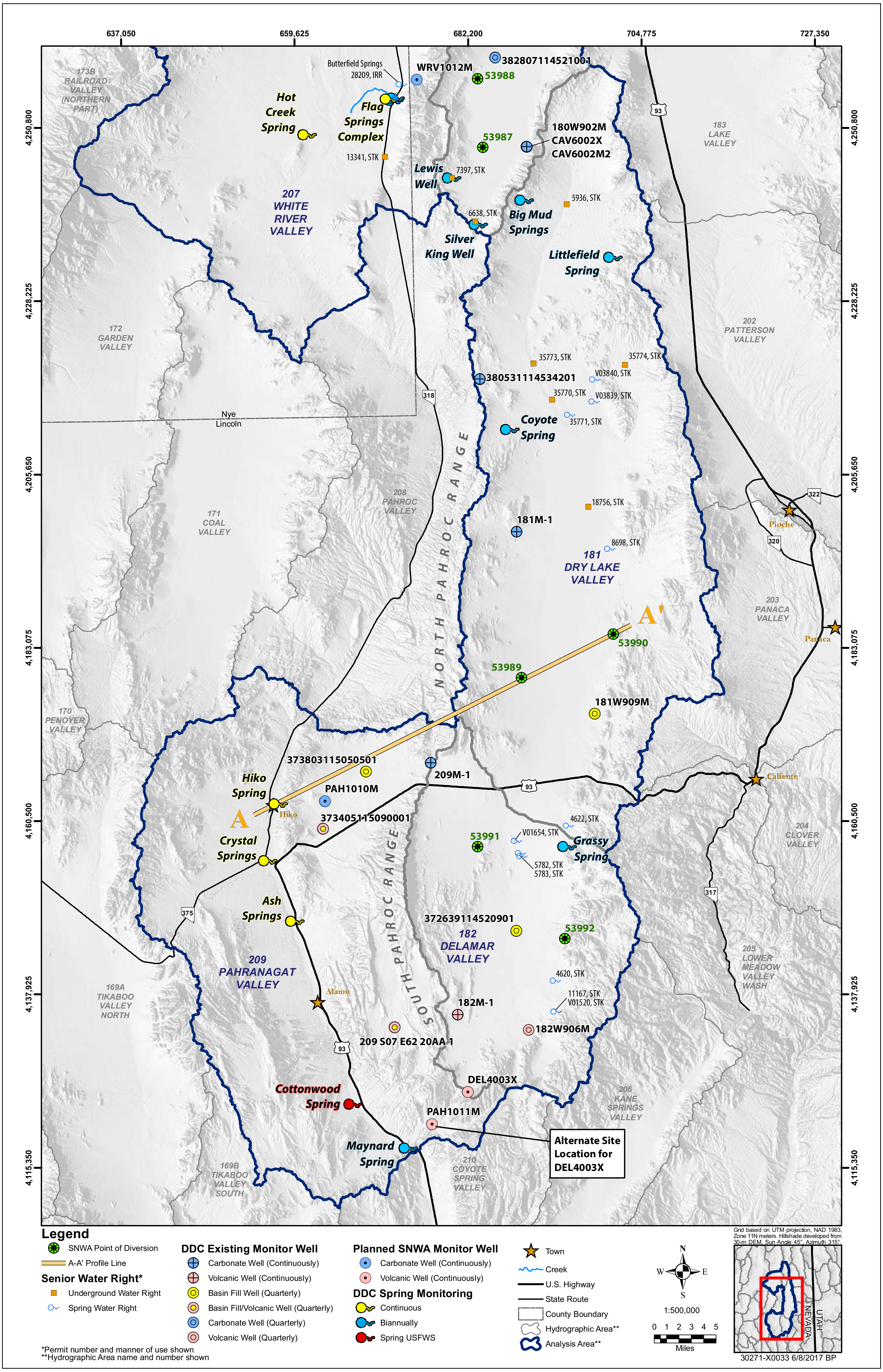

Figure 9-3
Geologic and Monitor Well Profile Location

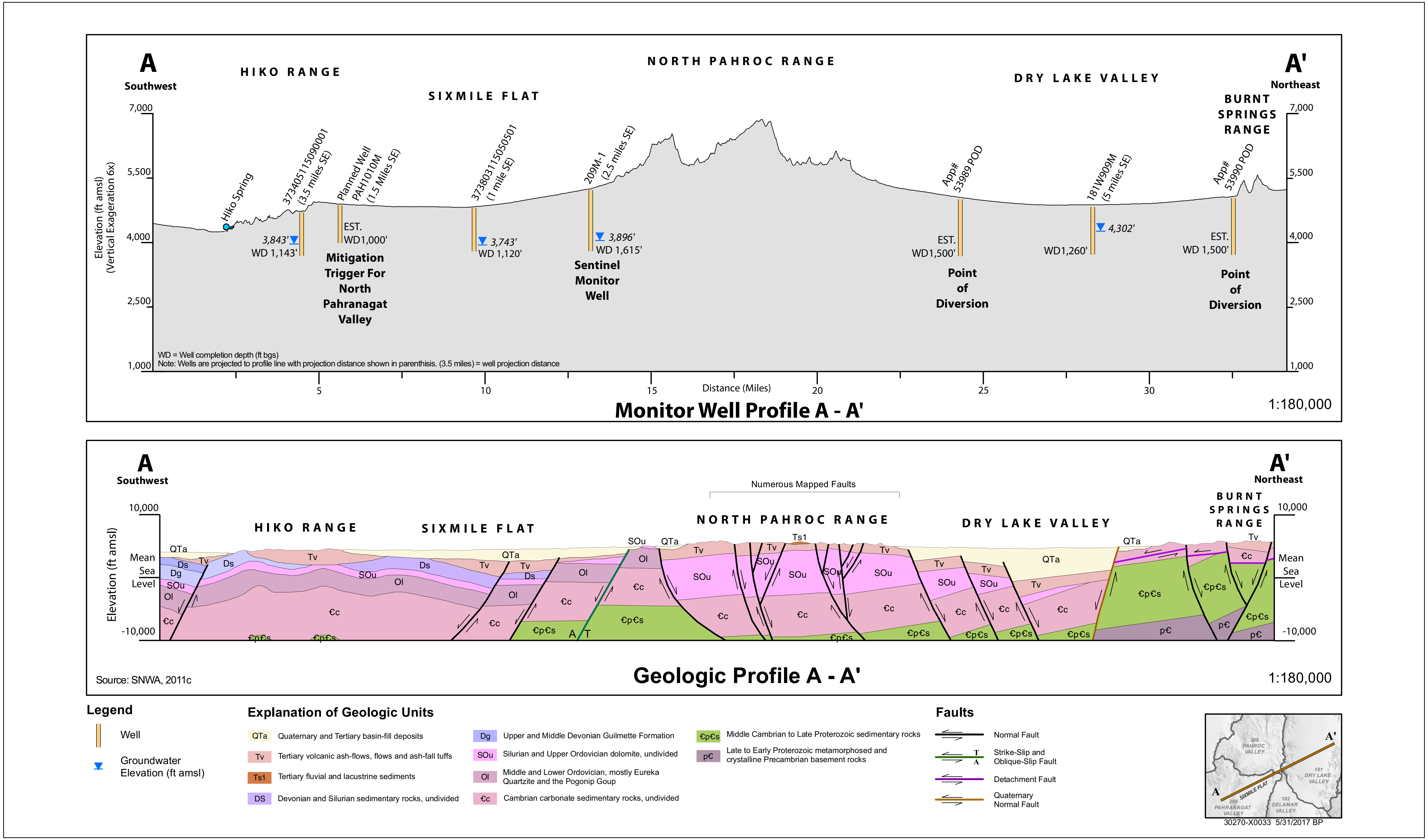

Figure 9-4
Geologic and Monitor Well Profile - Dry Lake PODs to Hiko Spring

Engineer's finding that there is no hydrologic connection (1) between Dry Lake and Pahranagat valleys, and (2) between Delamar and Pahranagat valleys except in the area of southern Delamar Valley near the Pahranagat Shear Zone" (NDWR, 2012c, at page 86).

North Pahranagat Valley Investigation Triggers and Management Actions

Well 209M-1 is designated as the sentinel monitor well to monitor groundwater conditions between Dry Lake and Delamar valleys and northern Pahranagat Valley. This well and intermediate wells 373803115050501 and 373405115090001 will detect propagation of drawdown, if any, along the Timpahute Transverse Zone. An investigation trigger will be activated if the water level in the wells decreases below the 99.7 percent lower control limit, as described in Appendix A, for a continuous period of six months. The current 99.7 percent lower control limit and baseline water level data for well 209M-1 is presented in Figure 9-5. The current lower control limit and baseline hydrographs for the other monitor wells are presented in Appendix C.

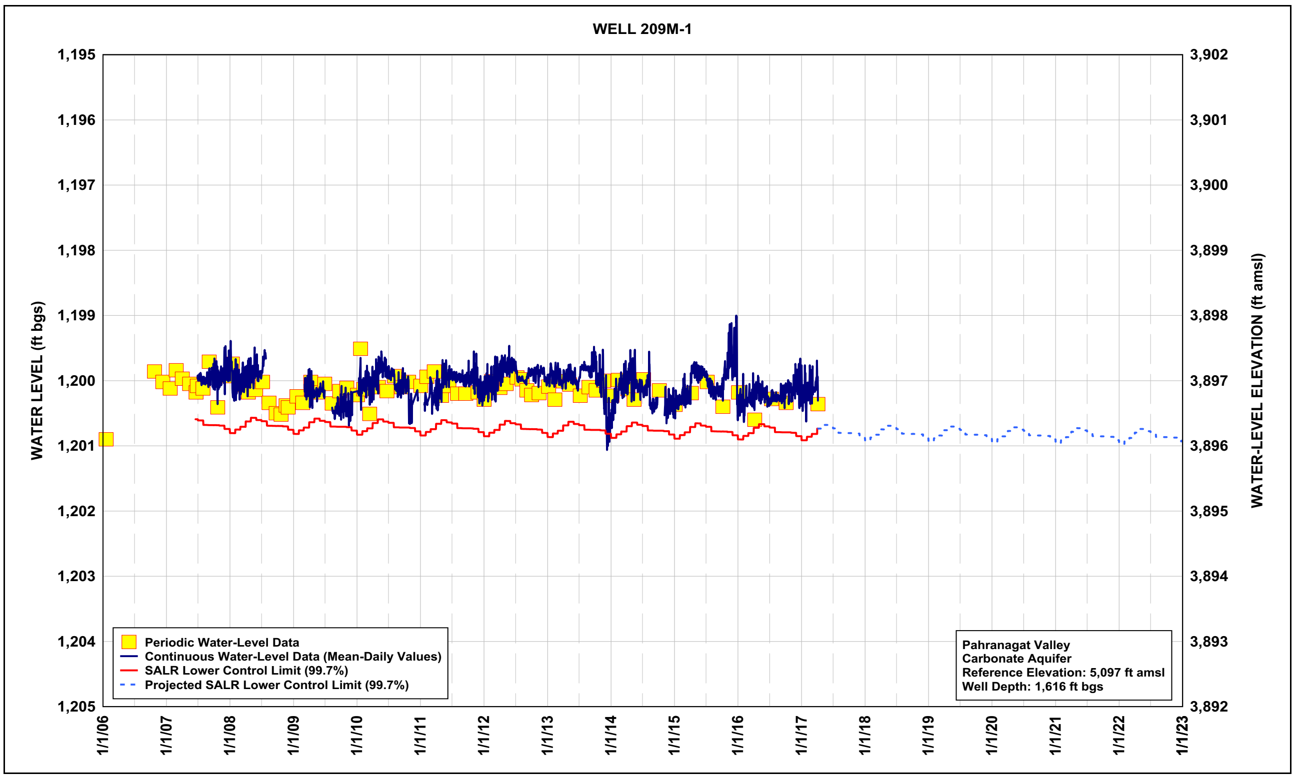

Figure 9-5
Monitor Well 209M-1 - Trigger

Activation of an investigation trigger at 209M-1 or the other intermediate monitor network wells in northern Pahranagat Valley will result in an evaluation to determine the cause and significance of the water level change observed using protocols described in Section 3.2.2. Should the cause of the water level change be attributed to SNWA GDP pumping, the following management actions may be taken:

- Prepare to implement mitigation actions for the senior spring water right permit number 3806 including purchasing equipment, establishing contracts, and obtaining any necessary landowner permissions and permits.

- Update and recalibrate the numerical groundwater flow model and other predictive tools with aquifer response data. The model will be used to predict drawdown with distance and time under different pumping scenarios to evaluate if and when a mitigation trigger would be activated at a distant senior water right in Pahranagat Valley.

- Continue to monitor water levels in the sentinel and other intermediate wells to verify model projections.

- Increase monitoring frequency in well being monitored quarterly.

- Evaluate the addition of other existing production wells downgradient of the sentinel wells for inclusion into the monitoring network.

- Request adjudication of selected vested claims associated with Hiko, Crystal and Ash springs.

- Adjust SNWA GDP pumping rates, durations, and/or distribution to avoid activating a mitigation trigger at monitor well PAH1010M or distant senior water right locations further down gradient in Pahranagat Valley.

The management actions would provide additional data that can be use to avoid activating the mitigation triggers in Pahranagat Valley.

North Pahranagat Valley Mitigation Triggers

A mitigation trigger for northern Pahranagat Valley is set at monitor well PAH1010M. This carbonate monitor well will be located on the east side of the Hiko Range seven miles downgradient of well 209M-1 and five miles upgradient from Hiko Spring to detect propagation of drawdown toward the senior water rights in northern Pahranagat Valley. BLM right-of-way has been acquired for this well site and the well will be installed at least three years prior to SNWA GDP pumping to develop a baseline record. The mitigation trigger at PAH1010M will be departure of water levels continuously for six months below the 99.7 percent lower control limit caused by SNWA GDP pumping, as described in Appendix A.

The sentinel monitor well 209M-1 and intermediate monitor well 373803115050501 provide a large buffer and early advance warning of potential effects to Hiko, Crystal, and Ash springs. The data from the sentinel wells and mitigation action at PAH1010M will provide sufficient time to avoid unreasonable effects at Hiko, Crystal, and Ash springs and associated senior water rights in northern Pahranagat Valley.

Mitigation triggers determine when a mitigation action is implemented, if the cause of the trigger being activated is SNWA GDP pumping.

Underground Senior Water Rights

The mitigation trigger for underground senior water rights are defined for two categories where: (1) The well and current production capacity is capable of producing more water than the water right diversion rate allows; and (2) the well and current production capacity is capable of producing water only equal to or less than the water right diversion rate allows.

The mitigation triggers are based upon specific capacity and change in static groundwater levels as described in Section 3.2.6.1. The mitigation triggers are summarized below:

Underground Senior Water Rights

The mitigation trigger for underground senior water rights are defined for two categories where: (1) the well and current pump production capacity is capable of producing more water than the water right's diversion rate allows; and (2) the well and current pump production capacity is capable of producing water only equal to or less than what the water right's diversion rate allows.

The mitigation triggers are based upon change in static groundwater level and specific capacity as described in Section 3.2.6.1. The mitigation triggers are detailed below:

- Well production > permitted diversion rate prior to SNWA GDP pumping: A decrease in groundwater level that reduces the column of water in the well needed to produce the permitted diversion rate based on the well's specific capacity range plus either a 10 percent or 10 foot buffer, which ever is greater. The buffer provides time to implement the mitigation action prior to reaching a conflict. An example of a mitigation trigger for this case is presented in Section 3.2.6.1. An alternative fixed mitigation trigger for the well is activated if the maximum production capacity from the well decreases to less than 10 percent above the permitted diversion rate and the static groundwater level has decreased as a result of SNWA GDP pumping. An evaluation would be made to determine if the changes were a result of SNWA GDP pumping or were due to a deterioration in the well or pump conditions and efficiency.

- Well production < permitted diversion rate prior to SNWA GDP pumping: The mitigation trigger is activated if the evaluation associated with the investigation trigger determines the cause of the change in water level to be SNWA GDP pumping.

- Increase of more than 25 percent in power usage to pump the same amount of water as a result of decreased water levels from SNWA GDP pumping.

Spring and Stream Senior Water Rights

The mitigation trigger for spring and stream rights is based upon change in flow rate in relation to the permitted diversion rate or historical baseline flow rate as described in Section 3.2.6.2. The mitigation trigger for a senior spring or stream water-right is presented under two cases: (1) spring or stream flow at the POD which has been measured consistently above the permitted diversion rate, or (2) spring or stream flow at the POD which has been measured consistently at or below the permitted diversion rate. The mitigation triggers are detailed below:

- If measured baseline spring or stream flow has been consistently above the permitted diversion rate, the mitigation trigger is 10 percent above the permitted diversion rate to provide a buffer and is activated if spring or stream discharge decreases below this mitigation trigger level as a result of SNWA GDP pumping.

- If measured baseline spring or stream flow has been consistently at or less than the permitted diversion rate, the mitigation trigger is activated if the evaluation associated with the investigation trigger determines the cause of the change to be SNWA GDP pumping.

A third case consist of springs which have intermittent flow or are consistently dry. A spring which has non-measurable intermittent flow or that is dry over extended periods of time will be studied as a special case using nearby shallow piezometers, if present, or visual observations. The spring conditions will be compared to water levels and regional precipitation conditions to determine the conditions under which the spring flows. After SNWA GDP pumping begins, the spring will be monitored to determine if there is a change in the observed spring flow compared what has been observed under similar baseline regional hydrologic conditions.

Pahranagat Valley Mitigation Actions

Mitigation actions are implemented if the mitigation trigger activation is caused by SNWA GDP pumping. The mitigation actions include:

Additional mitigation actions for wells include:

- Lowering of the pump if the well has the depth and capacity to produce the water right.

- Rehabilitate the well to increase well efficiency.

- Deepen the well if the aquifer has the ability to yield the water right.

- Drilling and equipping a replacement well.

- Modification of SNWA GDP pumping duration, rate, or distribution

- Compensate well owners for the incremental increase in power usage if power usage increase is greater than 25 percent to produce a similar volume of water.

- Convey water to the site from an SNWA water right POD to the effected site.

- Transfer or exchange of the impacted senior water right for an SNWA water right of an equal or better priority at another location.

- Temporary storage tank to supplement the well's production while other mitigation actions are implemented. Water supplying the tank can be sourced by pumping the well for a longer period of time at a lower pumping rate or by a water truck delivering water.

Additional mitigation actions for springs or streams include:

- Constructing a well and piping to convey the replacement water to the POD or place of beneficial use.

- Drilling a supply well to offset decrease in spring flow.

- Modify the springhead or construct a reservoir at the spring.

- Temporary storage tank to supplement the spring or stream flow while other mitigation actions are implemented. Water supplying the tank can be sourced by temporary piping from another source provided by SNWA or by deliveries from a water truck.

Another option to offset effects on a specific senior water right is irrigation improvements provided by SNWA for the senior water right holder facilities to increase effectiveness of irrigation for the impacted water right or other water rights. Irrigation improvements include but are not limited to the following:

- Lining of irrigation ditches over losing reaches.

- Providing aqueducts to reduce losses between the POD and point of beneficial use.

- Improving sprinkler efficiency.

- Other improvements in irrigation.

Additional mitigation actions for stock water right uses include:

- Providing alternative ranch grazing land for stock.

- Temporary trucking of stock water.

- Providing stock water improvements to offset impacts to a senior water right.

South Pahranagat Valley Background and Monitoring Strategy

The South Pahroc Range forms the north-south hydrographic boundary between Delamar and Pahranagat valleys and terminates to the south at the PSZ. Basin fill material and range front faults which parallel the South Pahroc Range provide the dominant pathway of groundwater flow through Delamar Valley. The PSZ provides structural features orientated to the southwest which provide a flow pathway from Delamar Valley through the southern edge of Pahranagat Valley and into Coyote Spring Valley.

Aquifer conditions in central and southern Delamar Valley are currently monitored at well 372639114520901. No significant groundwater flow is expected across the South Pahroc Range from Delamar Valley to Pahranagat Valley. However, water levels have been measured at monitor well 209S07E6220AA1 to detect propagation of drawdown across the range if it occurs. Monitor of this well was suspended because baseline record has been stable. Monitoring of well 209S07E6220AA1 will resume three years prior to SNWA GDP pumping with owner's permission. Monitor well DEL4003X is planned to be installed near the boundary between Delamar and Pahranagat valleys within the PSZ. The right-of-way has been granted by BLM along with an alternative site (PAH1011M) in Pahranagat Valley. These three wells will be used to monitor groundwater conditions and detect drawdown propagation outside the basin to the south and west of Delamar Valley if it occurs.

In southern Pahranagat Valley, Maynard Spring is monitored using shallow piezometers installed by USFWS as part of the DDC 3M Plan. The spring consists of ponded water and no measurable discharge has been recorded. The water source for Maynard Spring may be associated with underflow originating from surface water at the Pahranagat NWR based on the hydrogeologic setting. Other springs in southern Pahranagat Valley are likely sourced from local recharge. The source for these springs will be further evaluated during the water chemistry sampling program element of the DDC 3M Plan. USFWS monitors Cottonwood Spring located in western Pahranagat Valley. There is no current evidence that groundwater outflow from Delamar Valley contributes to the discharge at these springs, and effects from SNWA GDP pumping are unlikely. However the monitoring network provided the ability to detect propagation of drawdown to southern Pahranagat valley if it occurs.

South Pahranagat Valley Investigation Triggers and Management Actions

Two additional monitor wells on the west side of the South Pahroc Range 209S07E6220AA1 and at the southern edge of Delamar Valley (DEL4003X) are designated as the sentinel monitor wells to monitor changes in water level which may indicate propagation of drawdown into southern Pahranagat Valley. An investigation trigger will be activated if the water level in either of these sentinel wells decreases below the 99.7 percent control limit, as described in Appendix A, for a continuous period of six months. A hydrograph of 209S07E6220AA1 is presented in Figure 9-6 showing the 99.7 percent lower control limit. Water level monitoring was discontinued due to stability of the record. The systematic monitoring of the well will be reestablished at least three years prior to SNWA GDP pumping.

If an investigative trigger is activated at 209S07E6220AA1 or DEL4003X an additional monitor well will be installed between the sentinel wells and Maynard Spring.

South Pahranagat Valley Mitigation Triggers

Mitigation triggers associated with senior water rights in southern Pahranagat Valley are described in above in this section. No conflicts are expected to occur in southern Pahranagat Valley as a result of SNWA GDP pumping due to the hydrogeologic setting, distance from SNWA GDP PODs, and management actions which can be implemented. The 3M Plan monitoring activities will detect and measure propagation of drawdown at the sentinel monitor wells. Management actions will be implemented to avoid activating mitigation triggers on the senior water rights. The large distance

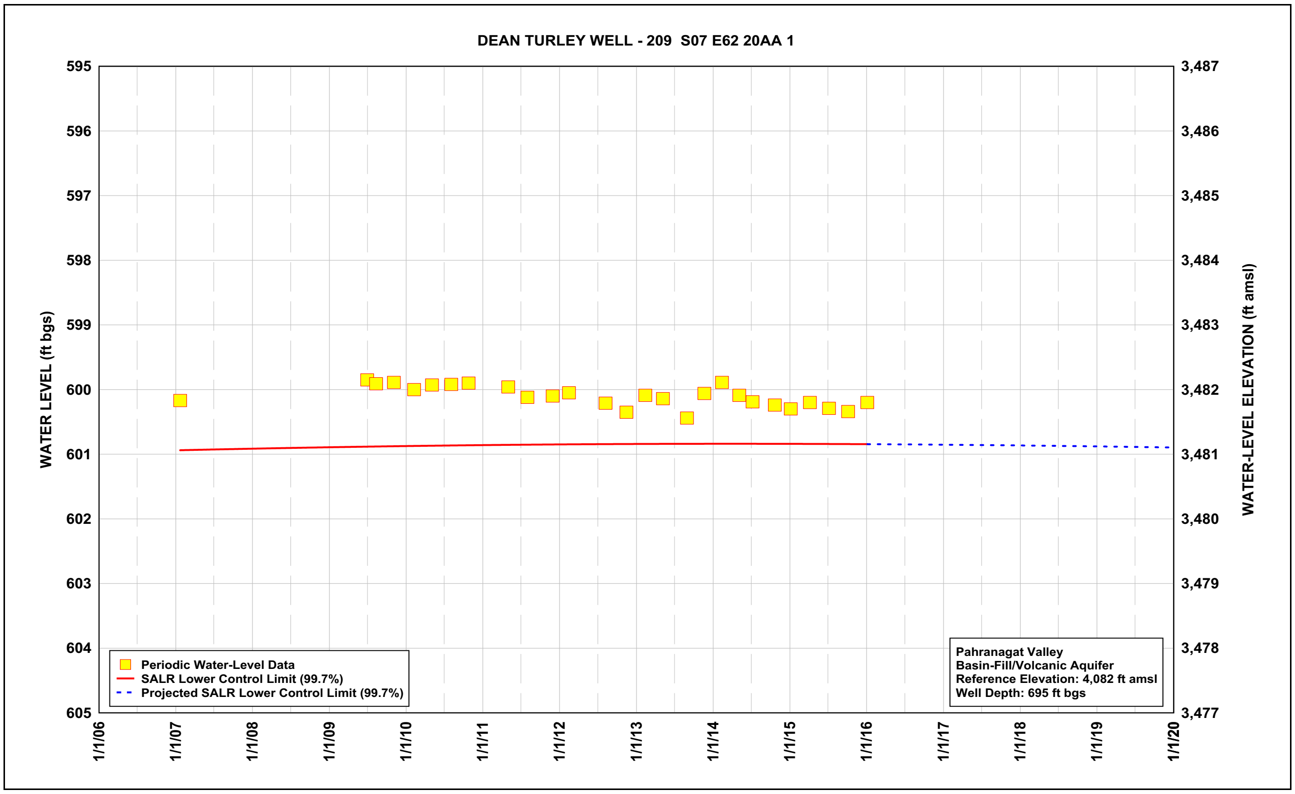

Figure 9-6
209 S07 E62 20AA1- Trigger

between the SNWA GDP PODs and the sentinel and other intermediate monitor wells located between Pahranagat Valley and SNWA GDP PODs provide a substantial buffer to implement actions to avoid activating mitigation triggers and having unreasonable effects.

Southern Pahranagat Valley Mitigation Triggers

Mitigation triggers in southern Pahranagat Valley are the same as those presented earlier in this section for the northern portion of the valley.

Southern Pahranagat Valley Mitigation Actions

Mitigation actions in southern Pahranagat Valley are the same as those presented earlier in this section for the northern portion of the valley.

9.3 Environmental Resources

Overview

This section establishes triggers and monitoring, management, and mitigation actions to avoid unreasonable effects to environmental resources from SNWA GDP pumping in Dry Lake and Delamar valleys.

No environmental resources in Dry Lake and Delamar valleys are hydraulically connected to the producing aquifer in which SNWA GDP production wells will be installed, as no groundwater discharge areas occur in the basins (Burns and Drici, 2011, at page 5-1) (Figure 9-7). Because effects from SNWA GDP pumping are improbable, no triggers or mitigation actions are required to avoid unreasonable effects to environmental resources in the basins.

As discussed in Section 9.2.4, effects in Pahranagat Valley from SNWA GDP pumping are unlikely. Nonetheless, triggers and management and mitigation actions are established to ensure unreasonable effects to environmental resources in Pahranagat Valley are avoided.

The groundwater discharge area in Pahranagat Valley encompasses approximately 8,600 acres (Figure 9-7). This area is largely comprised of mesic habitat, and also includes shrubland habitat, lake (reservoir) habitat, and agriculture (mesic habitat = 4,300 acres (50%); shrubland habitat = 2,200 acres (25%); lake (reservoir) habitat = 750 acres (10%); agriculture = 1,400 acres (15%)). The Hiko, Crystal, and Ash regional springs and their discharge that flows into Pahranagat Creek and the Key Pittman WMA and Pahranagat NWR lakes span 25 miles north-to-south. Three federally endangered fish subspecies and two federally endangered bird species occur in this area, as do other native aquatic-dependent special status fish, frog, and invertebrate species. Habitat descriptions, a summary of wildlife that use the habitats, and details about the listed and special status species occurrences are presented in Sections 5.2 and 5.3.

Federally listed species in the area include: Hiko White River springfish in Hiko and Crystal springs, White River springfish in Ash Springs, Pahranagat roundtail chub in Pahranagat Creek and a Key Pittman WMA pond, and southwestern willow flycatcher and western yellow-billed cuckoo in the mesic riparian areas around Key Pittman WMA Nesbitt Lake and Pahranagat NWR Upper Lake.[1] The regional springs and creek are highly modified by surface water diversions, and local land use and water management practices significantly affect the habitat. Hiko Spring is impounded, and the entire spring pool outflow is piped for agricultural and municipal use (USFWS, 2012, at page 358). Crystal Springs is impounded, spring pool outflows are diverted for agriculture use, and the discharge only reaches Pahranagat Creek outside of the irrigation season (USFWS, 2012, at page 357). Ash Springs is impounded by U.S. highway 93, and spring pool water levels fluctuate due to control gate operations that manage outflows for irrigation (USFWS, 2012, at page 356). The lakes experience large baseline water level fluctuations as a result of upstream water right management and reservoir irrigation management.

The approach to avoid unreasonable effects to environmental resources in Pahranagat Valley primarily relies on avoiding unreasonable effects to senior water rights. As described in detail in Section 9.2.4, this approach includes hydrologic monitoring, investigation triggers at intermediate wells, preemptive management actions, mitigation triggers, and mitigation actions to avoid conflicts with senior water rights. Given the number and spatial distribution of monitor wells and senior water rights (Figures 9-1 and 9-2), and the general co-location of senior water rights with environmental

1. Crystal and Ash springs are the headwaters for Pahranagat Creek and Upper Lake. An underground senior water right provides the source water for the Key Pittman WMA pond (permit number 25907), and water from the pond and Hiko and Crystal springs contribute to Nesbitt Lake (Figures 9-2 and 9-7). Detailed information about the listed species, their habitats, and their Recovery Plans are presented in the SNWA GDP BO (USFWS, 2012, at Chapter 9).

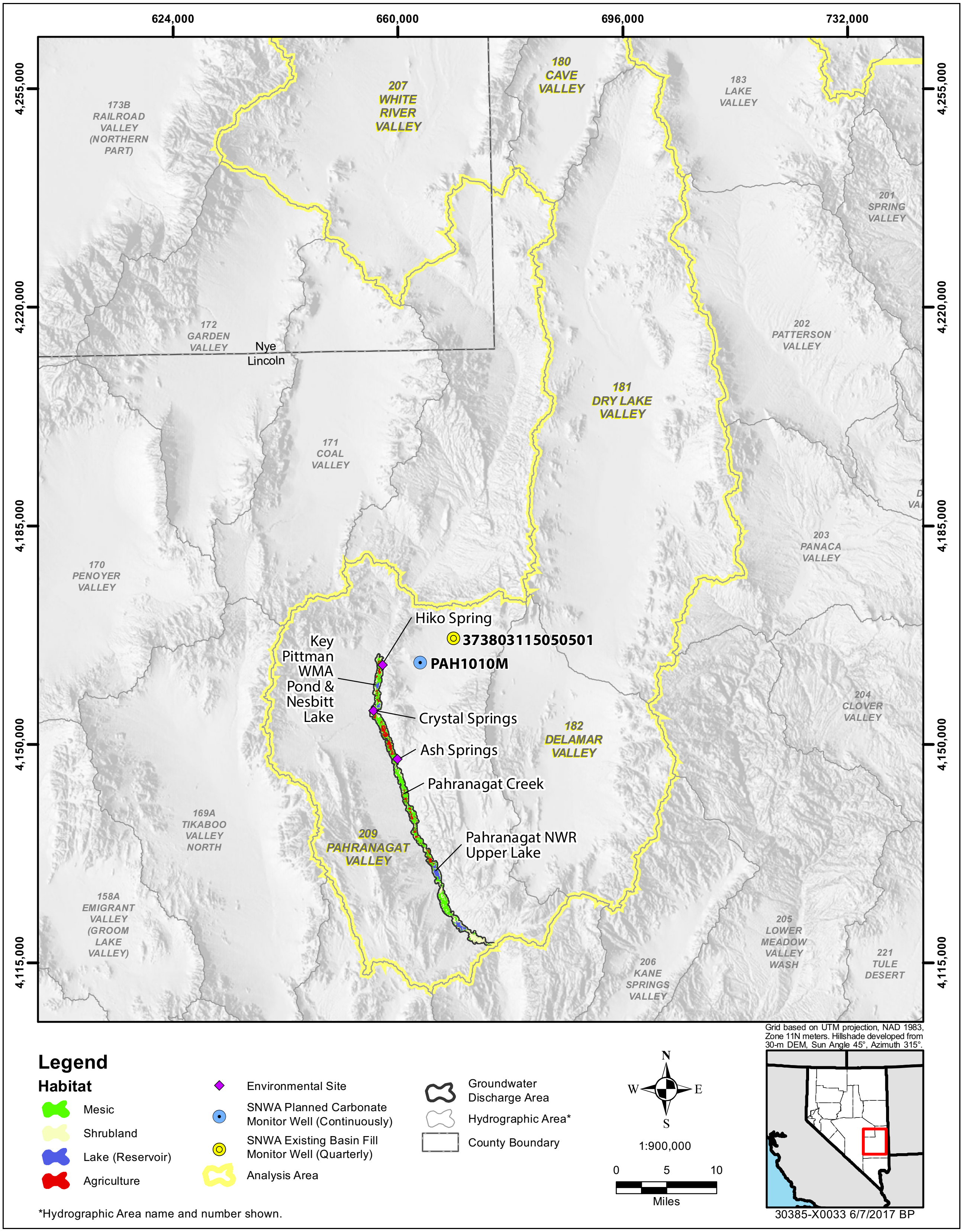

Figure 9-7
Habitats in Dry Lake, Delamar, and Pahranagat Valleys Groundwater Discharge Areas

resources, this approach also helps prevent unreasonable effects to environmental resources. Additional environmental triggers and management and mitigation actions are established below.

Federally listed and native aquatic-dependent special status animal species

The approach to avoid jeopardizing the continued existence of federally listed species and extirpation of other native aquatic-dependent special status animal species also includes habitat protection at Hiko, Crystal, and Ash springs. The approach is as follows:

- Implement management and mitigation actions to avoid conflicts with senior water rights as described in Section 9.2.4.

- If the investigation trigger at the monitor well 373803115050501 is activated as a result of SNWA GDP pumping as described in Section 9.2.4, support NDOW with its native fish surveys at Hiko, Crystal, and Ash springs to ensure the surveys are conducted, and incorporate presence/absence surveys of the other native aquatic-dependent special status animal species during the fish surveys (fish and invertebrates; see Section 5.3) (Figure 9-7).[1] Also continue to participate on the Pahranagat Valley Native Fishes Recovery Implementation Team. The purpose of the monitoring is to confirm the continued status of the listed species and the continued existence of the other special status animal species at the sites. These efforts will be conducted as long as the investigation trigger is activated at monitor well 373803115050501, the hydrologic mitigation trigger is activated at monitor well PAH1010M, or as long as mitigation actions for the species are being conducted for the SNWA GDP.

  - Triggers and mitigation actions are not required for the remaining Pahranagat Valley habitats and species presented in Sections 5.2 and 5.3. All evidence indicates that these resources are supported by south-trending groundwater flow through the basin, underflow originating from surface water at the Pahranagat NWR, and/or local recharge, and not inflow from Delamar Valley (Section 9.2.4). Because effects from SNWA GDP pumping to these environmental resources are improbable, no further mitigation actions are required to avoid unreasonable effects in Pahranagat Valley.

- If the mitigation trigger at the monitor well PAH1010M is activated as a result of SNWA GDP pumping as described in Section 9.2.4, initiate mitigation actions at Hiko, Crystal, and Ash springs. In addition to the mitigation actions identified for senior water rights (Section 9.2.4), environmental mitigation actions for the species will include at least one of the following:

  - Collaborate with private landowners and water right holders and fund measures to ensure water is available to support the species and their habitats.

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1. The fish surveys are part of NDOW's regular monitoring efforts for native fish populations under the Nevada State's Native Aquatic Species Program. The surveys at Hiko and Crystal springs are typically biannual (spring and fall), and the surveys at Ash Springs are typically biennial (every other year). Surveys on private land require landowner permission.

- Collaborate with private landowners and NDOW and/or the Pahranagat Valley Native Fishes Recovery Implementation Team and fund measures to improve existing habitat, (e.g., thin dense aquatic vegetation to increase suitable fish habitat).

- Collaborate with NDOW and fund expansion of habitat, creation of suitable habitat, and/or establishment of additional populations of the listed fish species.

These mitigation actions also protect the needs of other wildlife in Hiko, Crystal, and Ash springs, as well as downstream habitat and wildlife supported by the spring discharge (including the federally listed Pahranagat roundtail chub, southwestern willow flycatcher, and western yellow-billed cuckoo). As described in Section 9.2.4, effects in Pahranagat Valley from SNWA GDP pumping are unlikely. Nonetheless, this plan will help ensure that unreasonable effects are avoided.

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10.0 Monitoring Program and Reporting Requirements

Hydrologic and environmental monitoring activities associated with the SNWA GDP are presented in the DDC and Spring Valley 3M Plans (SNWA, 2017d and e) and summarized in this section. These monitoring activities are also discussed within the context of the analyses for thresholds, triggers, and management and mitigation actions in Sections 6.0 - 9.0.

The 3M Plan monitoring element provides representative hydrologic and environmental data to (1) characterize and quantify hydrologic and environmental conditions during the baseline period and SNWA GDP pumping, (2) detect and measure drawdown propagation from GDP pumping, (3) signal activation of investigation and mitigation triggers, (4) conduct investigations, (5) calibrate and refine predictive tools, (6) determine management and mitigation actions to be implemented, (7) assess management and mitigation efficacy, and (8) identify management and mitigation modifications needed to meet goals and requirements.

10.1 Hydrologic Monitoring Program

10.1.1 Background

This section describes the hydrologic monitoring program element of the Spring Valley and DDC 3M Plans. The plans establish and maintain a monitoring network representative of the hydrologic system to observe and document conditions associated with the SNWA GDP analysis area during the project baseline and staged development operations. The monitoring program provides a structured systematic process to collect, analyze, and report data used to manage the SNWA GDP in a responsible and sustainable manner.

Implementation of the hydrologic monitoring network and systematic baseline data collection began in 2006. The NSE approved the original Spring Valley and DDC 3M Plans in December 2009 (SNWA, 2009d and e) and revised versions in 2011 (SNWA, 2011c and d). The 3M Plans were revised again in 2017 (SNWA, 2017d and e) to address concerns stated in the Remand Order. Hydrologic monitoring data associated with the 3M Plans are provided to the NSE electronically on a quarterly basis. Annual data reports for each plan have been provided to the NSE since 2008 (SNWA, 2008a and b, 2009c and f, 2010a and b, 2011a and b, 2012a and b, 2013a and b, 2014a and b, 2015a and b, 2016a and b, and 2017a and b).

The hydrologic monitoring network includes monitor wells spatially distributed and constructed at different depths and within different types of lithology, spring discharge sites, stream gaging stations, regional precipitation measurement sites, and water chemistry sampling locations.

10.1.2 Hydrologic Baseline Monitoring

The hydrologic system in the SNWA GDP area is naturally dynamic. Variations in climate conditions and precipitation effects natural stream flow and aquifer recharge. Ground water levels and spring discharge volumes vary over time as a result of changes in magnitude of recharge pulses associated with relatively wet and dry years. The timing and amount of change at a well or spring from recharge depends upon the distance from recharge sources, aquifer properties, and other influences effecting the site. Monitoring and documenting representative baseline hydrologic conditions throughout the project area to understand the natural response and variation of the system is critical to the SNWA GDP 3M Plan program.

Regional precipitation measurements representative of the area was first recorded over 100 years and provides historical context of hydrologic conditions in the project area. The first stream flow measurement at Cleve Creek in Spring Valley occurred in the 1910s, with periods of measurements through 1990 when regular measurement resumed as shown in Figure 6-10. The Cleve Creek stream flow record provides a reference of the relationship between stream flow and the regional precipitation record. Groundwater levels, spring discharge, and stream flow from other creeks in the current monitor network can be compared to Cleve Creek to provide the historical context and expected natural response and lag time compared to regional precipitation.

The current hydrologic baseline record, since the establishment of the SNWA monitoring network and beginning of systematic measurements in 2006, is over 11 years. Baseline hydrologic monitoring will continue until project operations begin. The current baseline record already includes extremely wet years (2011 and 2017) with a four consecutive dry years (2012- 2015) which provides aquifer response data over a range of precipitation and recharge conditions. Baseline data in the project area provides increased understanding of hydrologic variability, hydraulic connection between locations, and aquifer response to a range of climate and precipitation conditions.

The baseline record is used as a reference benchmark to assist in evaluating the effects of SNWA GDP pumping. Baseline data documents monitoring site response to variations in the hydrologic system. Monitoring locations which respond in a similar hydrologic manner over time can be indexed to each other and compared to evaluate the presence and significance of SNWA GDP related drawdown.

The baseline data also documents outside human influence on the hydrologic system not related to SNWA GDP. Outside human influence affecting local groundwater levels and spring discharge include agricultural irrigation practices, water well pumping, and land use. Examples of these practices include irrigation well operations, diversion of stream flow and spring discharge, stock water use, and overland application of irrigation infiltrating into shallow or perched groundwater systems. Grazing and irrigation of pasture lands influences vegetation cover and extent of habitat. Monitoring and documentation of irrigation practices is critical in determining the cause of changes in habitat, groundwater levels, and spring discharge.

Changes in irrigation practice which are reflected in the natural baseline record assists in the assessment of the significance of the change on water levels and spring discharge both prior to and during SNWA GDP pumping. This is especially important in the area of Cleveland Ranch where irrigation practices and diversions from Cleve Creek affects local shallow groundwater conditions.

10.2 Spring Valley Hydrologic Monitoring Program

This section provides an overview of hydrologic monitoring associated with the Spring Valley 3M Plan monitoring element. The plan consists of all the elements included in the previous monitoring plan approved in 2011 with the addition of selected new monitoring sites described in Section 10.2.1. and direct monitoring at certain individual senior water right PODs. New proposed monitoring sites are discussed first followed by a summary of the Spring Valley 3M Plan network.

Supplemental SNWA monitoring sites used for basin characterization, increased understanding of the Spring Valley hydrologic system, and monitoring network development and effectiveness verification are discussed in Section 10.2.3. These sites are temporary and not included in the SNWA GDP 3M Plans.

10.2.1 Additional Proposed Spring Valley 3M Plan Monitoring

SNWA is proposing additional monitoring sites to be included in the 2017 Spring Valley 3M Plan. The purpose of these monitoring sites is to provide additional hydrologic data related to (1) the Swamp Cedar ACEC; (2) the senior water right at Shoshone Ponds; (3) shrubland habitat; 4) the aquifer conditions south of the Cleveland Ranch; and (5) the aquifer conditions in northern Hamlin Valley. These sites are listed in Table 10-1 and are described below:

- Swamp Cedar ACEC - Paired wells and shallow piezometers will be installed adjacent to the Swamp Cedar ACEC in Management Block 2. Monitoring will begin at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley to coincide with terrestrial woodland habitat monitoring (Section 10.4.1.1). A precipitation station has already been installed adjacent to the ACEC.

  - Paired Wells - One deep monitor well (SPR7041M) and one shallow piezometer (SPR7041Z) are proposed to be drilled in close proximity to each other to understand the vertical hydraulic gradient and relationship between shallow groundwater and the deeper aquifer in the Swamp Cedar ACEC area. The depth of the piezometer and monitor well will be dependent upon hydrogeologic conditions encountered. SPR7041M will be drilled to below a confining clay layer which was observed in nearby well SPR7008M or 300 feet.

  - Shallow Piezometers - To further understand the spatial variability of the shallow groundwater system in the Swamp Cedar ACEC, two additional shallow piezometers (SPR7042Z and SPR7043Z) will be drilled near the ACEC as shown on Figure 6-56. These piezometers will compliment SPR7041Z to better understand the shallow horizontal hydraulic gradient in the ACEC and conditions within the upper root zone of the swamp cedars.

- Precipitation Station- A continuously monitored precipitation station (PSPR7008) has been installed near the existing monitor well SPR7008M to provide information on precipitation in the vicinity of the Swamp Cedar ACEC and increase understanding of the relationship between precipitation, shallow groundwater and the deeper aquifer.

- Shoshone Ponds - Permission will be requested from NDOW to install a flow meter and pressure transducer or pressure gauge on the Shoshone NDOW Well, which is the POD for the senior water right permit number 27768 located at Shoshone Ponds. If permission to install instrumentation in the Shoshone Well is denied or not physically possible, Shoshone Well #2 will be used as a proxy monitoring well. The Shoshone Well #2 is located 100 feet away and constructed similarly to the Shoshone NDOW Well. Shoshone Well #2 is currently equipped with a pressure transducer and flow meter that provide head measurements and discharge data. Monitoring at Shoshone NDOW Well will begin at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley to coincide with Pahrump poolfish monitoring (Section 10.4.1.1).

- Shrubland Habitat Piezometers - SNWA will install six additional shallow piezometers in shrubland habitat (four in Management Block 1, and two in Management Block 2), as discussed in Section 10.4.1.1. The piezometers will be drilled to a depth of up to 50 ft, depending on hydrogeologic conditions encountered. Monitoring will begin at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley to coincide with shrubland monitoring. Data will be collected on at least a quarterly basis, on the same schedule as other GDP monitoring wells in the basin. Additional piezometers will be installed in shrubland habitat in Spring Valley Management Block 4, northern Hamlin Valley, and southern Snake valley if shrubland monitoring commences in those regions, as discussed in Section 10.4.1.1.

- Bastian South Well and Old Cleve Well - The existing Bastian South well, with an estimated completion depth of 700 feet, will be added to the monitoring network. The well is located to the south of the Cleveland Ranch, in the area of the 4WD Spring shallow piezometer (SPR7012Z) as shown on Figure 10-1. This well will provide data on the vertical hydraulic gradient and aquifer response between the producing aquifer in which SNWA GDP production wells will be installed compared to the shallow groundwater in the area of 4WD Spring. The existing Old Cleve Well (391224114293601) was replaced in the 3M Plan network by SPR7029M in 2012. However, the well will be returned to the monitoring network. Both wells will provide additional groundwater level data between SNWA GDP PODs and Cleveland Ranch. Monitoring at the Bastian South Well and Old Cleve Well will begin at least three years prior to SNWA GDP groundwater withdrawal from Spring Valley. The three year period provides time to establish a baseline record to compare with other monitoring sites.

- HAM1008M - A new monitor well is proposed in northern Hamlin Valley near the hydrographic boundary of Snake Valley as shown on Figure 10-1. The purpose of the well is to provide a location for a mitigation trigger for senior water rights in Snake Valley. Monitoring will begin at least three years prior to SNWA GDP groundwater withdrawal from Spring Valley. The three year period provides time to establish a baseline record to compare with other monitoring sites.

Table 10-1
Proposed Additional Monitoring Sites for the Spring Valley 3M Plan

Name	Type	Purpose	Approximate Depth (ft bgs)	Monitoring Frequency
SPR7041M[a]	Swamp Cedar ACEC deep monitor well paired withSPR7041Z	Monitor deep aquifer conditions near the Swamp Cedar	300	Continuous
SPR7041Z[a]	Swamp Cedar ACEC shallow paired piezometer	Monitor shallow groundwater conditions near the Swamp Cedar	20-30[b]	Continuous
SPR7042Z[a]	Swamp Cedar ACEC shallow piezometer	Monitor shallow groundwater conditions near the Swamp Cedar	20-30[b]	Continuous
SPR7043Z[a]	Swamp Cedar ACEC shallow Piezometer	Monitor shallow groundwater conditions near the Swamp Cedar	20-30[b]	Continuous
To be determined	Six shrubland piezometers in Management Blocks 1 and 2	Monitor shallow groundwater conditions in shrubland habitat	< 50[b]	Quarterly
Shoshone NDOW Well	Flowing artesian well	Monitor artesian conditions at Shoshone Ponds	440	Continuous
Bastian South Well	Deep monitor well	Monitor aquifer conditions south of Cleveland Ranch and provide vertical hydraulic gradient with 4WD piezometer.	700	Continuous
391224114293601 (Old Cleve Well)	Deep monitor well	Monitor aquifer conditions south of Cleveland Ranch	--	Quarterly
HAM1008M[a]	HAM1008M	Mitigation Trigger for Snake Valley	500	Continuous
PSPR7008	Swamp Cedar ACEC precipitation station	Precipitation Monitoring Station near Swamp Cedar ACEC	N/A	Continuous

[a]Proposed future site.
[b]Dependent upon hydrogeologic conditions.

10.2.2 Spring Valley 3M Plan Monitoring Network

SNWA established a hydrologic monitoring program associated with the Spring Valley 3M Plan in Spring, northern Hamlin, and southern Snake valleys. Baseline hydrologic data have been collected for this monitoring network since 2006.

The 3M Plan was developed based upon numerous geologic, geophysical, and hydrologic study reports conducted by SNWA and other organizations which defined basin characteristics and hydrologic baseline conditions in Spring Valley. These and other related studies are summarized by Burns and Drici (2011). SNWA supplemental monitoring of wells, springs, streams, and precipitation has been performed to provide data on basin characteristics and 3M Plan monitoring network design and efficacy.

The monitoring element of the Spring Valley 3M Plan provides the ability to effectively detect and measure propagation of drawdown in order to implement appropriate management and mitigation actions to avoid unreasonable effects. The monitoring program also provides data on hydrologic and aquifer conditions associated with the analysis area. The Spring Valley 3M Plan monitoring network is summarized below:

- Thirty-seven monitor and exploratory wells are completed in basin fill, carbonate, and volcanic materials to provide spatial and vertical water level data in varying hydrogeologic settings in the valley. Seventeen of these wells are currently monitored continuously (hourly) and the remainder on a quarterly basis.

- Eight planned monitor wells were committed to in the previous Spring Valley 3M Plans to be constructed prior to SNWA GDP pumping. In addition, three new shallow piezometers and one deep monitor well located near the Swamp Cedar ACEC, five piezometers in shrubland habitat in Management Blocks 1 and 2, and instrumentation of a Shoshone Ponds well are included in the revised 3M plan to be constructed prior to SNWA GDP pumping.

- Two existing wells located south of Cleveland Ranch will be added into the hydrologic monitoring network in the revised 3M Plan.

- Fifteen springs are currently monitored using shallow piezometers or spring discharge measurements.

- Additional monitoring will be performed directly at senior water right locations as described in this section and summarized in Table 10-3.

- Surface-water gages will be operated and maintained at Cleve Creek (intermittent period of record since 1914) and Big Springs Creek (period of record since 2006).

- A synoptic discharge study of the Big Springs-Lake Creek complex was performed during irritation and non-irrigation season in 2014. The study will be repeated every five years after SNWA GDP pumping in Spring Valley begins unless the schedule is modified by the NSE.

- A regional precipitation network consisting of five stations in Spring Valley is maintained by SNWA, and stations are operated by other entities with established historical records in the vicinity of the Spring Valley.

- A water chemistry monitoring program consists of sampling at 40 well, spring, and stream locations sampled prior to and every five years after SNWA GDP pumping.

Hydrologic monitoring data is provided to the NSE electronically on a quarterly basis. Annual data reports have been provided since 2008. Historical data for each element of the monitoring program is presented in the *2016 Spring Valley Hydrologic Monitoring and Mitigation Plan Status and Data Report* (SNWA, 2017b).

10.2.2.1 Well, Spring, and Stream Monitoring Network

The Spring Valley hydrologic monitoring network is summarized in this section. A basin wide view of the Spring Valley 3M Plan monitoring network wells are presented on Figure 10-1. Monitor network spring and stream sites are presented on Figure 10-2. Higher resolution figures presenting the monitoring network for each management block in Spring Valley are provided in Section 6.2. The specific monitoring sites associated with the Spring Valley 3M Plan are listed in Table 10-2. The table includes sites currently being monitored, planned sites that will be installed prior to GDP pumping operations and sites proposed in Section 10.2.1. The table includes the purpose of the site, period of record, and monitoring frequency. Monitoring associated with specific senior water rights are presented in Section 6.2 and also summarized in Table 10-2.

Senior water rights PODs will be monitored directly, as described in Section 6.2 at locations within 10 miles of SNWA GDP PODs if proxy or intermediate monitor wells are not available. A water resource assessment, as described in Section 3.2.7, will be performed at least three years prior to SNWA GDP pumping, with owner's permission to establish access to the wells. Wells and springs with access will be monitored on a quarterly basis. The senior water right sites with direct monitoring not already listed on Table 10-3.

The minimum period of record for baseline data collection required by NSE in Spring Valley ranges from 1 to 5 years depending on the location. However, the program currently has collected over 11 years of SNWA GDP baseline data to date. Baseline records for new wells will be compared to existing monitor wells. If water levels respond in a similar manner to an established record of other similarly constructed wells existing well, an estimated historical record can be constructed for the new well.

In addition to SNWA monitoring, other entities, such as UGS, conduct monitoring in the project area. UGS installed and operates three continuous gaging stations near Dearden Springs (one upstream and two downstream on Lake Creek) and one gage at Clay Spring North. UGS also operates a groundwater monitoring network in along the Nevada - Utah state line in Snake Valley as described on the UGS website <http://geology.utah.gov/databases/groundwater/projects.php. (UGS, 2017).

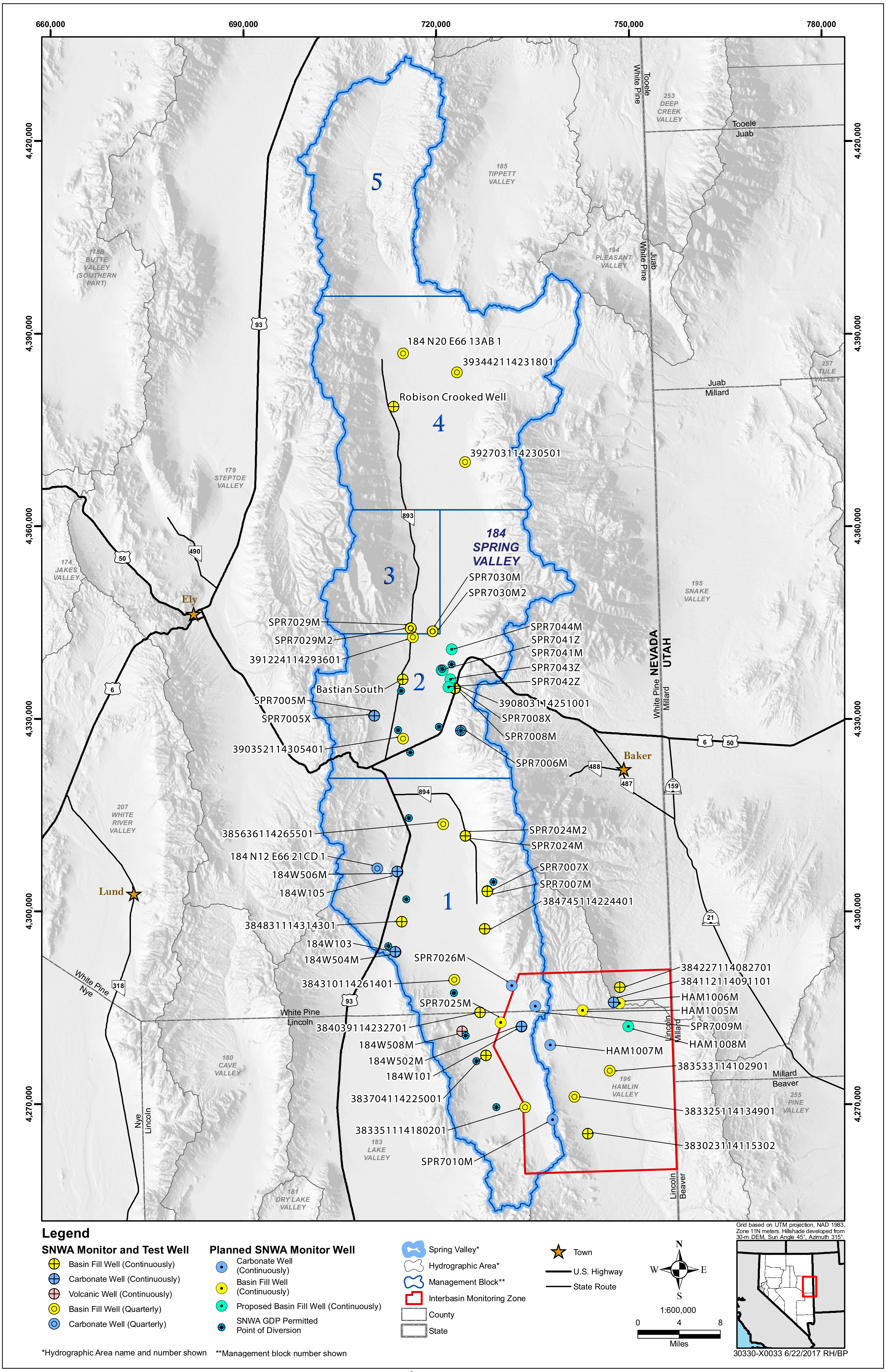

Figure 10-1
Spring Valley 3M Plan Monitor Well Network Locations

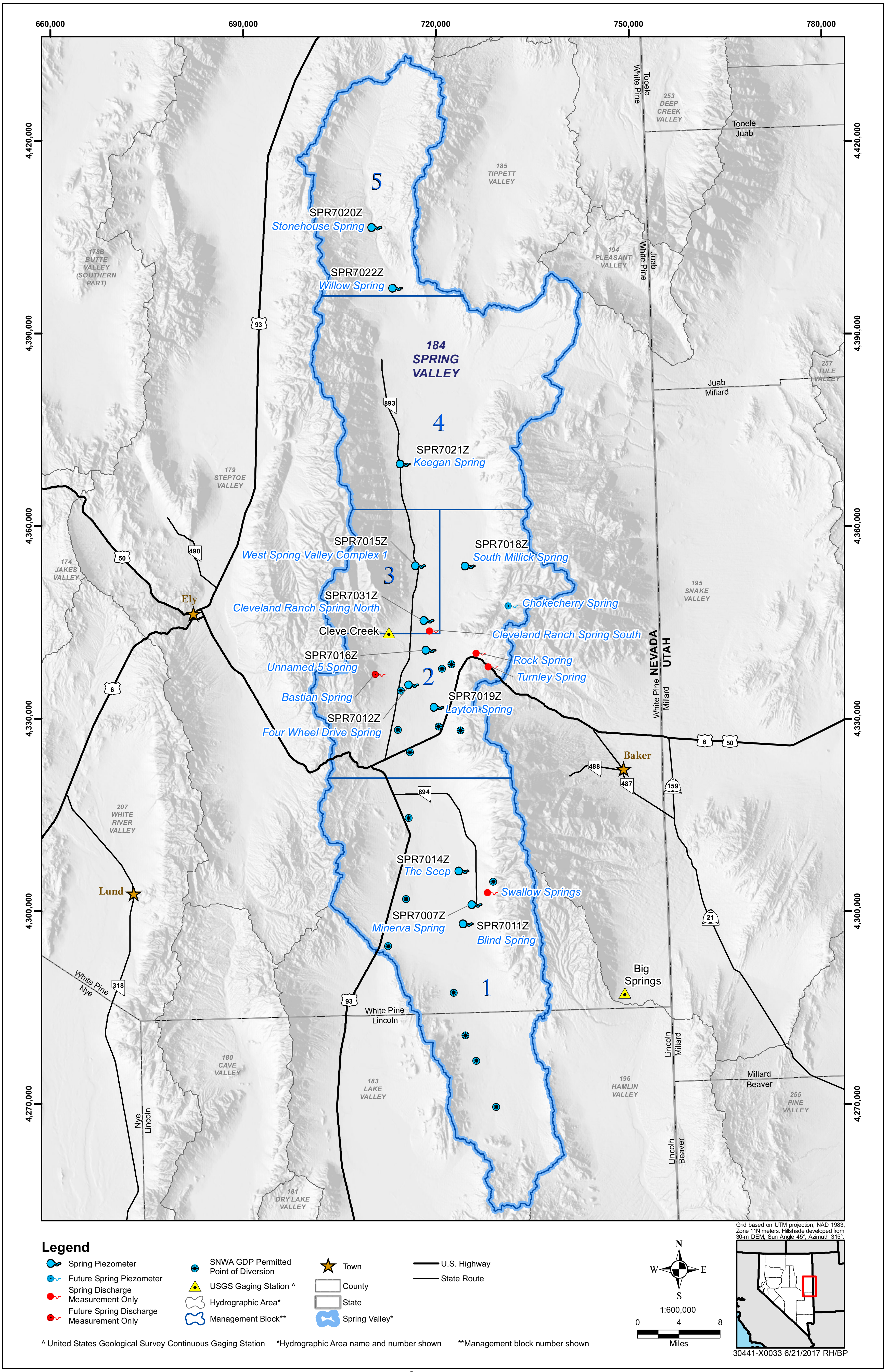

Figure 10-2
Spring Valley 3M Plan Spring and Stream Hydrologic Monitoring Locations

Table 10-2
Spring Valley 3M Plan Hydrologic Monitoring Network
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Site Type/ Completion	Primary Name	Purpose/Description	Begin POR	End POR	Monitoring Frequency	Monitoring/ Reporting Agency
MANAGEMENT BLOCK 1						
Well/Basin Fill	385636114265501	Near senior water rights	7/13/1998	Current	Quarterly	SNWA
Well/Basin Fill	384831114314301	Near POD for permit #54007 and #54008	3/8/1990	Current	Continuous	SNWA
Well/Basin Fill	384745114224401	Monitor aquifer conditions	3/8/1990	Current	Continuous	SNWA
Well/Basin Fill	384310114261401	Near POD for permit #54006	9/29/1991	Current	Quarterly	SNWA
Well/Basin Fill	384039114232701[b]	Near POD for permit #54005	9/28/1991	9/16/2014	---	---
Well/Basin Fill	383704114225001	Near POD for permit #54004	4/21/1983	Current	Continuous	SNWA
Well/Basin Fill	383351114180201	Near POD for permit #54003 and senior water right	7/16/1996	Current	Quarterly	SNWA
Well/Basin Fill	SPR7007X	Test Well (Aquifer test performed)	3/12/2008	Current	Quarterly	SNWA
Well/Basin Fill	SPR7007M	Near POD for permit #54019	9/4/2007	Current	Continuous	SNWA
Well/Carbonate	184W502M	Monitor aquifer conditions	1/24/2007	Current	Continuous	SNWA
Well/Carbonate	184W101	Test well (Aquifer test performed)	2/27/2007	Current	Quarterly	SNWA
Well/Volcanic	184W508M	Near POD for permit #54005	12/19/2006	Current	Continuous	SNWA
Well/Carbonate	184W504M	Near POD for permit #54007	11/18/2006	Current	Continuous	SNWA
Well/Carbonate	184W103	Test well (Aquifer test performed)	12/6/2006	Current	Quarterly	SNWA
Well/Carbonate	184W506M	Monitor aquifer conditions	10/19/2006	Current	Continuous	SNWA
Well/Carbonate	184W105	Test Well (Aquifer test performed)	11/7/2006	Current	Quarterly	SNWA
Well/Basin Fill	SPR7024M2	Vertical hydraulic gradient near Shoshone Ponds	4/6/2011	Current	Continuous	SNWA
Well/Basin Fill	SPR7024M	Vertical hydraulic gradient near Shoshone Ponds	4/6/2011	Current	Continuous	SNWA
Well/Carbonate	SPR7009M[a]	Sentinel Well for Hamlin Valley	---	---	Continuous	SNWA
Well/Carbonate	SPR7010M[a]	Sentinel Well for Hamlin Valley	---	---	Continuous	SNWA
Well/Basin Fill	SPR7025M[a]	Between inter-basin Monitoring Zone (IBMZ) and closest basin fill production well	---	---	Continuous	SNWA
Well/Carbonate	SPR7026M[a]	Between IBMZ and closest carbonate production well	---	---	Continuous	SNWA
Well/Carbonate	184 N12 E66 21CD 1	Dale's Seeding Well Monitor aquifer conditions in southwest Spring Valley	12/12/2006	Current	Quarterly	SNWA
Spring-Piezometer	SPR7014Z	The Seep Piezometer (No discharge for extend period)	6/13/2010	Current	Continuous	SNWA
Spring-Piezometer	SPR7007Z	Minerva Spring Piezometer	3/25/2008	Current	Continuous	SNWA
Spring-Piezometer	SPR7011Z	Blind Spring Piezometer	5/24/2010	Current	Continuous	SNWA
Spring-Discharge	1846201	Swallow Springs Discharge	7/28/2004	Current	Continuous	SNWA
Well/ Basin Fill	Shoshone Ponds NDOW Well	Monitor artesian conditions at Shoshone Ponds	---	---	Continuous	SNWA
Piezometer[c]	Proposed	Shrubland Habitat Piezometer (4)	---	---	Quarterly	SNWA

Table 10-2
Spring Valley 3M Plan Hydrologic Monitoring Network
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Site Type/ Completion	Primary Name	Purpose/Description	Begin POR	End POR	Monitoring Frequency	Monitoring/ Reporting Agency
MANAGEMENT BLOCK 2						
Well/[c]	SPR7044M[a]	Sentinel Monitor Well for northern Spring Valley	---	---	Continuous	SNWA
Well/Carbonate	SPR7005X	Test well (Aquifer test performed)	4/16/2008	Current	Quarterly	SNWA
Well/Carbonate	SPR7005M	Monitor aquifer conditions	12/18/2007	Current	Continuous	SNWA
Well/Carbonate	SPR7006M	Near POD for permit #54020	10/19/2007	Current	Continuous	SNWA
Well/Basin Fill	SPR7008X	Test well (Aquifer test performed)	3/13/2008	Current	Quarterly	SNWA
Well/Basin Fill	SPR7008M	Monitor aquifer conditions near Swamp Cedar ACEC	9/6/2007	Current	Continuous	SNWA
Well/Basin Fill	390352114305401	Near POD for permits #54010 and #54011	9/28/1991	Current	Quarterly	SNWA
Well/Basin Fill	390803114251001	Monitor aquifer conditions near Swamp Cedar ACEC	7/15/1996	Current	Continuous	SNWA
Well/Basin Fill	391224114293601[b]	Old Cleve Well (Provides data south of Cleveland Ranch)	7/17/1997	5/14/2014	---	---
Spring-Discharge	1847301	Rock Spring Discharge (Very low spring discharge)	8/27/2007	Current	Continuous	SNWA
Spring-Discharge	1848001	Turnley Spring (domestic water supply- in mountain block)	10/16/2008	Current	Quarterly	SNWA
Spring-Discharge	1845702	South Millick Spring Discharge	7/15/2004	Current	Quarterly	SNWA
Spring-Discharge	1841702 (planned)	Bastian Spring Discharge	---	---	Quarterly	SNWA
Spring-Piezometer	Chokecherry Piezometer (planned)	Chokecherry Spring Piezometer	---	---	Quarterly	SNWA
Spring-Discharge	1842006 (planned)	Chokecherry Spring Discharge	---	---	Continuous	SNWA
Spring-Piezometer	SPR7018Z	South Millick Spring Piezometer	6/17/2010	Current	Continuous	SNWA
Spring-Discharge	1845901	Layton Spring Discharge (Dry for extended period of time)	7/14/2004	Current	Quarterly	SNWA
Spring-Piezometer	SPR7019Z	Layton Spring Piezometer	6/18/2010	Current	Continuous	SNWA
Spring-Piezometer	SPR7012Z	4WD Spring Piezometer (pool no discharge)	6/17/2010	Current	Continuous	SNWA
Spring-Piezometer	SPR7016Z	Unnamed Spring 5 Piezometer	6/17/2010	Current	Continuous	SNWA
Well/[c]	SPR7041M (proposed)	Swamp Cedar ACEC Deep Paired Well	---	---	Continuous	SNWA
Piezometer[c]	SPR7041Z (proposed)	Swamp Cedar ACEC Shallow Paired Piezometer	---	---	Continuous	SNWA
Piezometer[c]	SPR7042Z (proposed)	Swamp Cedar ACEC Lateral Piezometer SE	---	---	Continuous	SNWA
Piezometer[c]	SPR7043Z (proposed)	Swamp Cedar ACEC Lateral Piezometer ESE	---	---	Continuous	SNWA
Well/Basin Fill	Bastian South	Deep well south of Cleveland Ranch	4/30/2008	Current	Continuous	SNWA
Piezometer[c]	Proposed	Shrubland Habitat Piezometer (2)	---	---	Quarterly	SNWA

Table 10-2
Spring Valley 3M Plan Hydrologic Monitoring Network
(Page 3 of 4)

Site Type/ Completion	Primary Name	Purpose/Description	Begin POR	End POR	Monitoring Frequency	Monitoring/ Reporting Agency
MANAGEMENT BLOCK 3						
Well/Basin Fill	SPR7029M2	Sentinel monitor well for northern Spring Valley	5/17/2011	Current	Quarterly	SNWA
Well/Basin Fill	SPR7029M	Sentinel monitor well for northern Spring Valley	6/14/2011	Current	Quarterly	SNWA
Well/Basin Fill	SPR7030M	Sentinel monitor well for northern Spring Valley	5/10/2011	Current	Quarterly	SNWA
Well/Basin Fill	SPR7030M2	Sentinel Monitor Well for northern Spring Valley	5/10/2011	Current	Quarterly	SNWA
Spring-Discharge	1848401	Cleveland Ranch Spring North	11/2/2010	Current	Quarterly	SNWA
Spring-Discharge	1848501	Cleveland Ranch Spring South	11/3/2010	Current	Continuous	SNWA
Stream-Discharge	1841611	Cleve Creek Gaging Station	10/20/1959	Current	Continuous	USGS
Spring-Piezometer	SPR7015Z	West Spring Valley Complex Piezometer	6/14/2010	Current	Continuous	SNWA
Spring-Piezometer	SPR7031Z	North Cleveland Ranch Spring Piezometer	5/24/2011	Current	Quarterly	SNWA
MANAGEMENT BLOCK 4						
Well/Basin Fill	184 N20 E66 13AB 1	Monitor aquifer conditions	8/15/2006	Current	Quarterly	SNWA
Well/Basin Fill	393442114231801	Monitor aquifer conditions	7/15/1996	Current	Quarterly	SNWA
Well/Basin Fill	392703114230501	Monitor aquifer conditions	7/15/1996	Current	Quarterly	SNWA
Well/Basin Fill	Robison Crooked Well	Monitor aquifer condition	9/6/2007	Current	Continuous	SNWA
Spring-Discharge	1847101	Keegan Spring discharge	8/29/2007	Current	Quarterly	SNWA
Spring-Piezometer	SPR7021Z	Keegan Spring piezometer	6/14/2010	Current	Continuous	SNWA
MANAGEMENT BLOCK 5						
Spring-Discharge	1845501	Willow Spring discharge	7/14/2004	Current	Quarterly	SNWA
Spring-Piezometer	SPR7020Z	Stonehouse Spring piezometer	6/14/2010	Current	Continuous	SNWA
Spring-Piezometer	SPR7022Z	Willow Spring piezometer	6/14/2010	Current	Continuous	SNWA
HAMLIN AND SNAKE VALLEY						
Well/Basin Fill	HAM1005M[a]	Inter-basin Monitoring Zone aquifer conditions	---	---	Continuous	SNWA
Well/Basin Fill	HAM1006M[a]	Inter-basin Monitoring Zone aquifer conditions	---	---	Continuous	SNWA
Well/Carbonate	HAM1007M[a]	Sentinel Well for Hamlin Valley and monitor senior water rights	---	---	Continuous	SNWA
Well/Basin Fill	HAM1008M[a]	Proposed well - mitigation trigger site for Snake Valley			----	SNWA
Well/Basin Fill	383023114115302	Near senior water rights	8/19/1992	Current	Continuous	SNWA
Well/Basin Fill	383325114134901	Monitor senior water right	8/2/2005	Current	Quarterly	SNWA
Well/Basin Fill	384227114082701	Near Big Springs	11/7/2009	Current	Continuous	SNWA
Well/Basin Fill	383533114102901[b]	Monitor senior water right	8/14/2006	5/13/2014	---	---
Well/Carbonate	384112114091101	Near Big Springs	9/9/2010	Current	Continuous	SNWA
Stream-Discharge	1951901	Big Springs Gaging Station	6/22/2004	Current	Continuous	USGS

Table 10-2
Spring Valley 3M Plan Hydrologic Monitoring Network
(Page 4 of 4)

Site Type/ Completion	Primary Name	Purpose/Description	Begin POR	End POR	Monitoring Frequency	Monitoring/ Reporting Agency
REGIONAL PRECIPITATON STATIONS						
Precipitation	Schellborne	Measurement record includes over 60 years of water year data near Management Block 5	1954	Current	Periodic	NDWR
Precipitation	Mount Wilson	Measurement record includes over 60 years of water year data near Management Block 1	1954	Current	Periodic	NDWR
Precipitation	McGill	Measurement record includes over 100 years of monthly data	1892	Current	Continuous	WRCC
Precipitation	Ely WBO	Measurement record includes over 90 years of monthly data	1888	Current	Continuous	WRCC
Precipitation	Great Basin NP	Measurement record includes over 80 years of monthly data	1948	Current	Continuous	WRCC
Precipitation	Bird Creek	High elevation precipitation gage near Management Block 4	2011	Current	Continuous	NRCS (Snotel)
Precipitation	Berry Creek	High elevation precipitation gage near Management Block 3	1980	Current	Continuous	NRCS (Snotel)
Precipitation	Kalamazoo	High elevation precipitation gage near Management Block 4	2011	Current	Continuous	NRCS (Snotel)
Precipitation	Cave Mountain	High elevation precipitation gage near Management Block 2	2011	Current	Continuous	NRCS (Snotel)
Precipitation	Takka Wiiya	High elevation precipitation gage near Management Block 4	2013	Current	Continuous	NRCS (Snotel)
Precipitation	Silver Creek Nv	High elevation precipitation gage near Management Block 2	2011	Current	Continuous	NRCS (Snotel)
Precipitation	Wheeler Peak	High elevation precipitation gage near Management Blocks 1 & 2	2010	Current	Continuous	NRCS (Snotel)
Precipitation	PSPR7008	Near Swamp Cedar ACEC and inside Management Block 2	2017	Current	Continuous	SNWA
Precipitation	P1840602	Mid-elevation precipitation gage inside Management Block 4	2007	Current	Continuous	SNWA
Precipitation	P1841701	Mid-elevation precipitation gage inside Management Block 2	2009	Current	Continuous	SNWA
Precipitation	P1841901	Mid-elevation precipitation gage inside Management Block 4	2009	Current	Continuous	SNWA
Precipitation	P1846201	Mid-elevation precipitation gage inside Management Block 1	2010	Current	Continuous	SNWA

[a]Planned SNWA Monitor Well
[b]Wells temporarily suspended from monitoring with consensus from NSE due to stable water levels over the baseline period. Monitoring will be resumed prior to SNWA GDP pumping.
[c]Location to be determined
[d]If access permission is denied, Shoshone Well #2 will be used as a proxy monitoring well.
Reporting agency: NDWR - Nevada Division of Water Resources; WRCC - Western Regional Climate Center; NRCS - Natural Resources Conservation Service; USGS - U.S. Geological Survey.

Table 10-3
Spring Valley Senior Water Right PODs - Monitoring Sites
(Page 1 of 2)

Senior Water Right	Monitoring Site	Notes
Management Block 1		
8074, 18045	Directly at one POD - Well	Stock water - two grouped at same location
8076, 18043,18044	Directly at one POD - Well	Stock water - three grouped at same location
8077	Directly at POD - Well	Stock water
8713	Directly at POD - Well	Stock water
12467	SPR7007Z	Milling and mining - may not be active
27768	Directly at POD - Well	Flowing artesian well at Shoshone NDOW Well. If not accessible substitute BLM well Shoshone well #2.
45496	383351114180201	Stock water
R05273	Directly at POD -Spring	Reserved right
Management Block 2		
3203, 3973, 5691, R05291, V10087	Sentinel Well SPR 7030M and SPR7044M (planned well)	---
8721,10921,10993, 80902, V10088	SPR7018Z proxy monitoring site and sentinel wells SPR7030M and SPR7044M (planned well)	Near south Millick Spring
V10078 - V10085, R05279, R05280, R05292, R05294	SPR7016Z proxy monitoring site	Near Unnamed 5 Spring
R05269, R05272, R05278, V10074, V10075	SPR7019Z proxy monitoring site	Near 4WD Spring
4171, V10073	SPR7018Z proxy monitoring site	Layton Spring - frequently dry
7446	Directly at POD - Well	Stock water
29371, 29567	Directly at one well POD	Milling and mining-tow grouped at same location
18841-18843 V10076, V10077	Directly at one or more POD - Wells and springs	Stock water - three wells and two spring vested claims in close proximity with each other
V02077	Directly at spring vested claim	Stock water

Table 10-3
Spring Valley Senior Water Right PODs - Monitoring Sites
(Page 2 of 2)

Senior Water Right	Monitoring Site	Notes
Management Block 2		
16890	Directly at POD - Well	Quasi-municipal
31239	Directly at POD - Well	Milling and mining
Management Block 3		
All Senior Water Rights	Sentinel wells and wells to monitor aquifer conditions	Sentinel Monitor Wells SPR7029M, SPR7029M2, SPR7030M, SPR7030M2, SPR7044M (planned well) and wells SPR7031Z, Cleveland Ranch Spring South, and SPR7015Z
Management Block 4		
All Senior Water Rights	Sentinel wells and wells to monitor aquifer conditions	Sentinel Monitor Wells SPR7029M, SPR7029M2, SPR7030M, SPR7030M2, SPR7044M (planned well) and wells SPR7021Z, 392703114230501, 393442114231801, 184 N20 E66 13AB 1, Robison Crooked well
Management Block 5		
All Senior Water Rights	Sentinel wells and wells to monitor aquifer conditions	Sentinel Monitor Wells SPR7029M, SPR7029M2, SPR7030M, SPR7030M2, SPR7044M (planned well) and wells SPR7020Z, SPR7022Z
Hamlin Valley		
45495 (Spring), V02198 (OGW)	Sentinel wells and HAM1007M	Sentinel Monitor Wells SPR7009M,SPR7010M and HAM1007M
45497 (UG), V02199 (UG)	Sentinel wells and 383325114134901	Sentinel Monitor Wells SPR7009M,SPR7010M and HAM1007M
45498 (UG), 45500 (UG)	Sentinel wells and 383023114115302	Sentinel Monitor Wells SPR7009M,SPR7010M and HAM1007M
45499 (UG)	Sentinel wells and 383533114102901	Sentinel Monitor Wells SPR7009M,SPR7010M and HAM1007M
Snake Valley and other senior water rights Hamlin Valley		
All Senior Water Rights	Sentinel wells and HAM1008M mitigation trigger	Sentinel Monitor Wells SPR7009M,SPR7010M and HAM1007M

10.2.2.2 Synoptic Discharge Study of Big Springs-Lake Creek

A synoptic discharge study was performed by SNWA with support from NSE, UGS, and DOI staff during irrigation and non-irrigation periods for the Big Springs Creek and Lake Creek surface water system from Big Springs to Pruess Lake during the Spring and Fall of 2014 (SNWA, 2015e). Two sets of measurements will be repeated every 5 years following the start of SNWA GDP pumping in Spring Valley unless the schedule is modified by the NSE.

10.2.2.3 Baseline Water Chemistry

Chemical analyses of selected parameters will be performed on three rounds of samples collected from wells, piezometers, and surface water sites. The purpose of water chemistry sampling is to document baseline water quality conditions prior to SNWA GDP pumping. Site will be sampled every five years after SNWA GDP pumping begins to evaluate changes over time. The program will consist of three sampling events at 6-month intervals. An initial round of sampling at 35 locations was completed in late 2010 and early 2011. The second and third rounds of the program will collect samples from the 35 locations sampled in the initial round and five additional inter-basin monitor wells planned to be constructed. Sampling will be performed after the five inter-basin monitor wells are constructed. Sample chemical analysis parameters are presented on Table 10-4.

Table 10-4
Water Chemistry Parameters

Field Parameters	Major Ions	Isotopes	Metals
Water temperature Air temperature pH Electrical conductivity Dissolved oxygen	TDS Calcium Sodium Potassium Chloride Bromide Fluoride Nitrate Phosphate Sulfate Carbonate alkalinity Alkalinity Silica Magnesium	Oxygen-18 Deuterium Tritium Carbon-14 Carbon-13 Strontium-87	Arsenic Barium Cadmium Chromium Lead Mercury Selenium Silver Manganese Aluminum Iron

10.2.2.4 Precipitation Monitoring

Data is obtained from operating regional precipitation stations in the vicinity of Spring Valley with established historical records. The stations will continue to be part of the 3M Plan monitoring network as long as they are operated by the current entities that operate them. Five additional SNWA precipitation stations are spatially distributed within Spring Valley as part of the 3M Plan hydrologic monitoring network including near the Swamp Cedar ACEC (PSPR7008). The precipitation stations are listed in Table 10-2 and shown on Figure 10-3. Additional precipitation stations operated by other entities are also available in the region to supplement the 3M Plan precipitation station data.

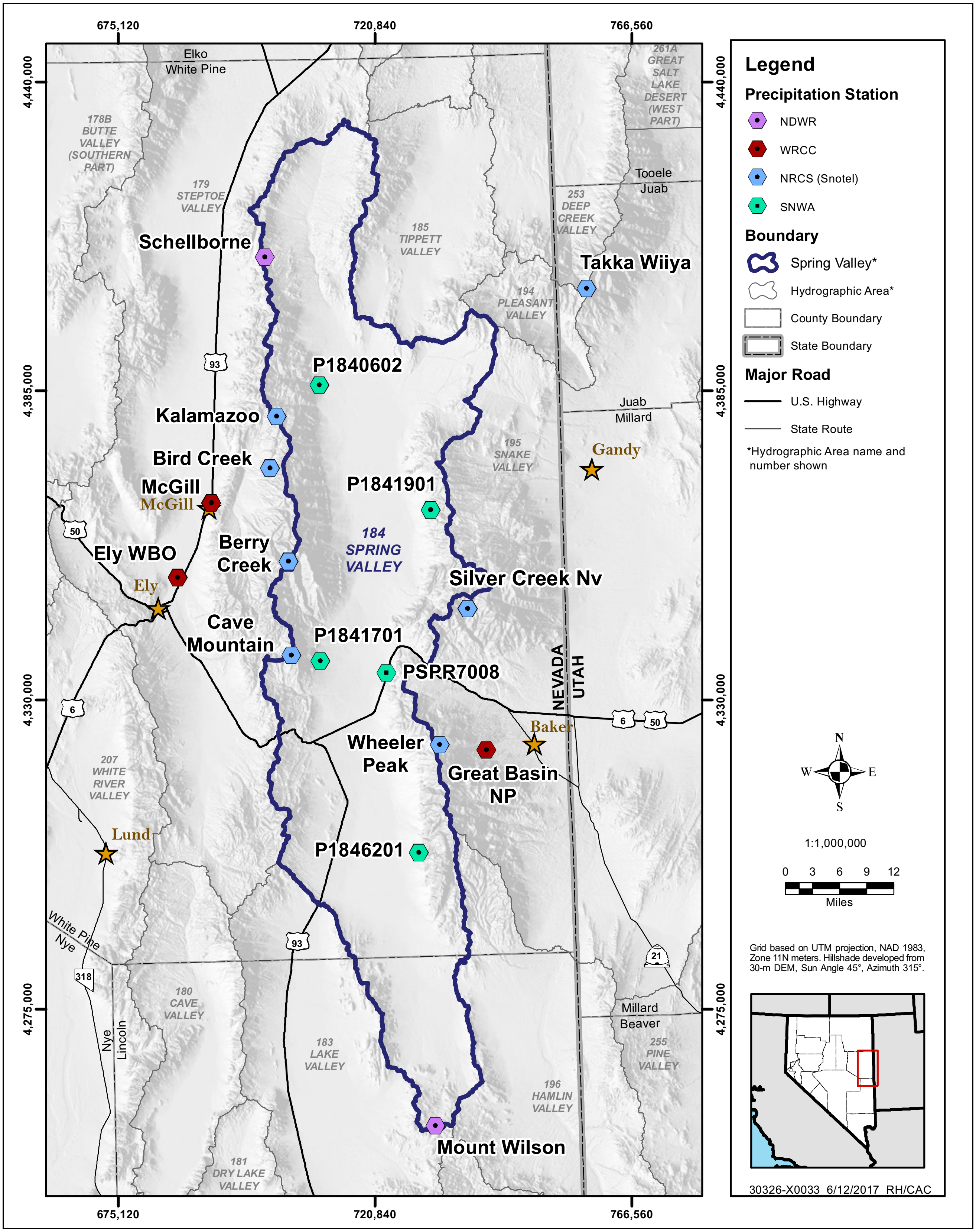

Figure 10-3
Spring Valley Precipitation Station Locations

The SNWA precipitation stations are equipped with the OTT Pluvio² weighing rain gage is an all-weather precipitation gage that uses weight-base technology to measure rainfall, snow, and hail. The high resolution electronic weighing system allows for liquid and solid precipitation to be measured immediately with no time delay for melting solid precipitation. The OTT Pluvio² weighing rain gage complies with World Meteorological Organization guideline 306 NO. 8 for automatic recording precipitation gages (Nemeth, 2008).

10.2.2.5 Numerical Groundwater Flow Modeling

SNWA will update and maintain a numerical flow model of the regional groundwater flow system. The model will be refined at the end of the baseline period prior to SNWA GDP pumping. The model will be calibrated and refined further as transient aquifer response data become available after SNWA GDP pumping began. The model will be refined at least every five years during SNWA GDP pumping, or more often if activation of an investigation trigger requires it.

10.2.3 Supplemental Spring Valley Hydrologic Monitoring (not part of the 3M Plan)

SNWA is performing additional temporary monitoring to provide for basin characterization, increased understanding of the Spring Valley hydrologic system, and monitoring network effectiveness verification. The current supplemental monitoring includes:

- Continuous gaging stations on ten streams in Spring and Snake valleys. This monitoring allows more precise tracking of peak stream flow, and enhances understanding of the precipitation, stream flow and groundwater recharge relationships in Spring Valley.
- SNWA measures at a minimum biannual stream flow of sixteen additional regional streams in June and October to enhance the understanding of the base and peak stream flow.
- SNWA maintains and measures nine additional temporary precipitation stations located in Spring Valley to supplement the 3M Plan precipitation network.

10.3 DDC Hydrologic Monitoring Program

This section provides an overview of hydrologic monitoring network associated with the 2017 DDC 3M Plan. The plan consists of all the elements included in the previous DDC 3M Plan approved in 2011 with the addition of one monitor well (WRV1013M) in White River Valley at Shingle Pass. The new well will provide more data on the relationship between outflow from Cave Valley through Shingle Pass and White River Valley.

10.3.1 DDC Well and Spring Monitoring Network

The DDC 3M Plan hydrologic monitoring network well and spring sites are presented in Figure 10-4. Information on the specific monitoring sites are listed in Table 10-5 and includes sites included in the current 3M Plan, planned sites, and WRV1013M that will be installed prior to GDP pumping. The table includes the purpose of the site, period of record, and monitoring frequency. Monitoring associated with specific senior water rights are presented in Section 8.2 and Section 9.2 also summarized in Table 10-6.

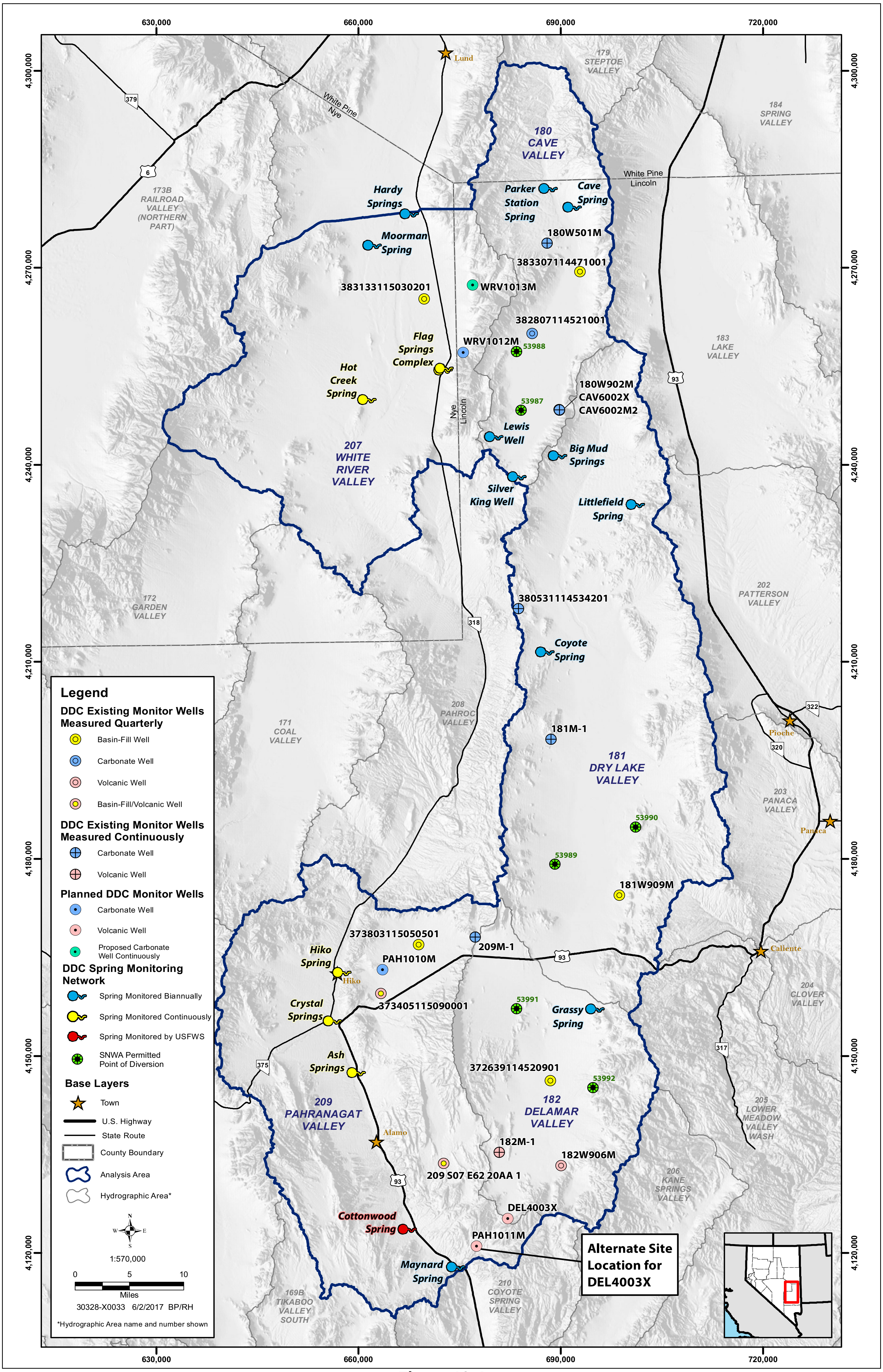

Figure 10-4
DDC 3M Plan Monitor Well and Spring Network

The DDC monitor network sites were selected in consensus with the NSE with emphasis placed on selecting existing wells with known well construction attributes and integrity. Wells were selected to provide spatial and vertical data in varying hydrogeologic conditions in the valley and include wells completed in carbonate, basin fill and volcanic materials.

The DDC 3M Plan monitor well network and monitoring frequency includes:

- Collection of quarterly water-level data at nine existing monitor wells and continuous water-level data at six existing monitor wells in DDC and adjacent basins, (started in 2007 and continuing to the present).

- Installation and continuous water level monitoring of up to four planned monitor wells located in or around DDC and adjacent hydrographic areas. Three well locations (WRV1012M, PAH 1010M, and DEL4003X) were selected and access right-of-way granted by BLM with installation planned to occur prior to SNWA GDP pumping. The fourth well location will be selected after the production well network configuration is established.

- Construction of proposed monitor well WRV1013M located in White River Valley at the base of Shingle Pass to evaluate groundwater outflow from Cave Valley.

- Collection of quarterly water-level data at SNWA exploratory and test wells located in DDC (started in 2007 and continuing to the present). Two existing SNWA exploratory wells (CAV6002M2 and CAV6002X), which were installed in 2007, are located in southern Cave Valley near Monitor Well 180W902M. Aquifer testing was performed using the three wells.

- Record groundwater production and continuous water-level data in all future SNWA production wells in DDC;

- Perform a constant-rate aquifer test on all SNWA production and test wells located in DDC.

Table 10-5
DDC 3M Plan Hydrologic Monitoring Network
(Page 1 of 2)

Site Type/ Completion	Primary Name	Purpose / Description	Begin POR	End POR	Monitoring Frequency	Monitoring/ Reporting Agency
CAVE VALLEY						
Well/Carbonate	180W902M	Monitor aquifer conditions (aquifer test performed)	12/22/2005	Current	Continuous	SNWA
Well/Carbonate	382807114521001	Near POD for permit #53988	3/21/1990	Current	Quarterly	SNWA
Well/Basin Fill	383307114471001	Sentinel monitor well in Cave Valley	7/19/1996	Current	Quarterly	SNWA
Well/Carbonate	180W501M	Sentinel monitor well near Shingle Pass	12/22/2005	Current	Continuous	SNWA
Well/Carbonate	CAV6002X	Test well (aquifer test performed)	11/8/2007	Current	Quarterly	SNWA
Well/Carbonate	CAV6002M2	Monitor aquifer conditions	10/19/2007	Current	Quarterly	SNWA
Spring	1800101	Cave Spring	6/23/2004	Current	Bi-Annual	SNWA
Spring	1800301	Parker Station Spring	5/14/2009	Current	Bi-Annual	SNWA
Spring	381624114540302	BLM/Silver King Well	5/14/2009	Current	Bi-Annual	SNWA
Spring	381943114562201	Lewis Well	5/14/2009	Current	Bi-Annual	SNWA
WHITE RIVER VALLEY						
Well/Basin Fill	383133115030201	Upgradient monitor well in White River Valley	3/22/1990	Current	Quarterly	SNWA
Well/Carbonate	WRV1012M[a]	Sentinel monitor well for White River Valley	---	---	Continuous	SNWA
Well/Carbonate	WRV1013M[a]	Sentinel monitor well for White River Valley	---	---	Continuous	SNWA
Spring-Discharge	2070501	Hot Creek Spring near Sunnyside, Nevada	7/23/1982	Current	Continuous	USGS
Spring-Discharge	2071101	Moorman Spring	7/23/1982	Current	Bi-Annual	USGS
Spring-Discharge	2071501	Hardy Spring	9/14/2004	Current	Bi-Annual	SNWA
Spring-Discharge	2071301	Flag Spring 3	7/24/1982	Current	Quarterly	SNWA
Spring-Discharge	2071302	Flag Spring 2	7/24/1982	Current	Continuous	SNWA
Spring-Discharge	2071303	Flag Spring 1	7/25/1982	Current	Quarterly	SNWA
DRY LAKE VALLEY						
Well/Carbonate	380531114534201	Monitor aquifer conditions	4/17/1983	Current	Continuous[b]	SNWA/USGS
Well/Basin Fill	181W909M	Monitor aquifer conditions	1/9/2006	Current	Quarterly	SNWA
Well/Carbonate	181M-1	Monitor aquifer conditions	1/9/2006	Current	Continuous	SNWA
Spring	1810301	Littlefield Spring	6/3/2004	Current	Bi-Annual	SNWA
Spring	1810401	Coyote Spring	6/3/2004	Current	Bi-Annual	SNWA
Spring	1810501	Big Mud Spring	5/8/2008	Current	Bi-Annual	SNWA
DELAMAR VALLEY						
Well/Basin Fill	372639114520901	Monitor aquifer conditions	4/5/1993	Current	Quarterly[b]	SNWA/USGS
Well/Volcanic	182W906M	Monitor aquifer conditions	1/9/2006	Current	Quarterly	SNWA
Well/Volcanic	182M-1	Monitor aquifer conditions	1/9/2006	Current	Continuous	SNWA
Spring	1820101	Grassy Spring	6/2/2004	Current	Bi-Annual	SNWA

Table 10-5
DDC 3M Plan Hydrologic Monitoring Network
(Page 2 of 2)

Site Type/ Completion	Primary Name	Purpose / Description	Begin POR	End POR	Monitoring Frequency	Monitoring/ Reporting Agency
PAHRANAGAT VALLEY						
Well/ Basin Fill//Volcanic	209 S07 E62 20AA 1	Sentinel monitor well for southern Pahranagat Valley	6/24/2003	Current	Quarterly	SNWA
Well/ Basin Fill/Volcanic	373405115090001	Monitor aquifer conditions	6/24/2003	Current	Quarterly	SNWA
Well/Basin Fill	373803115050501	Sentinel monitor well for northern Pahranagat Valley	6/24/2003	Current	Quarterly	SNWA
Well/Carbonate	209M-1	Sentinel monitor well for northern Pahranagat Valley	1/19/2006	Current	Continuous	SNWA
Well/Carbonate	PAH1010M[a]	Mitigation Trigger for northern Pahranagat Valley	---	---	Continuous	SNWA
Well/Volcanic	DEL4003X (PAH1011M)[a]	Planned sentinel well in southern Delamar Valley	---	---	Continuous	SNWA
Well/Not sited	Future Monitoring Well #4[a]	Additional future well in DDC analysis area not yet sited	---	---	Continuous	SNWA
Spring-Discharge	2090101	Hiko Spring	7/29/1982	Current	Continuous	SNWA
Spring-Discharge	2090201	Cottonwood Spring	5/24/2004	Current	Quarterly	USFWS
Spring	2090801	Maynard Spring	5/12/2009	Current	Bi-Annual[c]	SNWA
Spring-Discharge	09415589	Crystal Spring Diversion near Hiko, NV	5/24/2004	Current	Continuous	USGS
Spring-Discharge	2090401	Crystal Springs near Hiko, NV	7/29/1982	Current	Continuous	USGS
Spring-Discharge	09415639	Ash Springs Diversion at Ash Springs, NV	12/3/2003	Current	Continuous	USGS
Spring-Discharge	2090501	Ash Springs Creek below Highway 93 at Ash Springs, NV	7/30/1982	Current	Continuous	USGS
REGIONAL PRECIPITATON STATIONS						
Precipitation	Currant	Measurement record includes over 60 years of water year data	1953	Current	Periodic	NDWR
Precipitation	Blue Eagle Ranch Hanks	Measurement record includes over 40 years of monthly data near DDC Hydrographic Study Area	1978	Current	Continuous	WRCC
Precipitation	Pioche[c]	Measurement record includes over 80 years of monthly data near DDC Hydrographic Study Area	1888	Current	Continuous	WRCC
Precipitation	Caliente[c]	Measurement record includes over 90 years of monthly data near DDC Hydrographic Study Area	1903	Current	Continuous	WRCC
Precipitation	Sunnyside[c]	Measurement record includes over 60 years of monthly data near the Flag Springs Complex	1891	Current	Continuous	WRCC
Precipitation	Lund	Measurement record includes over 60 years of monthly data near DDC Hydrographic Study Area	1957	Current	Continuous	WRCC
Precipitation	Hiko	Measurement record includes 29 years of monthly data inside DDC Hydrographic Study Area	1989	Current	Continuous	WRCC
Precipitation	Ward Mountain	High elevation precipitation gage near DDC Hydrographic Study Area	1980	Current	Continuous	NRCS (Snotel)
Precipitation	Defiance Mines	High elevation precipitation gage near DDC Hydrographic Study Area	2011	Current	Continuous	NRCS (Snotel)
Precipitation	Corduroy Flat	High elevation precipitation gage near DDC Hydrographic Study Area	2011	Current	Continuous	NRCS (Snotel)
Precipitation	White River Nv	High elevation precipitation gage near DDC Hydrographic Study Area	2011	Current	Continuous	NRCS (Snotel)

[a] Planned SNWA Monitor Well
[b] Location to be determined
[c] Period of Record (POR) is not inclusive of all years between begging and end dates.
Monitoring agencies: NDWR - Nevada Division of Water Resources; WRCC - Western Regional Climate Center; NRCS - Natural Resources Conservation Service; USGS - U.S. Geological Survey; USFWS - U.S. Fish and Wildlife Service

Table 10-6
DDC Senior Water Right PODs - Monitoring Sites

Senior Water Right	Monitoring Site	Notes
Cave Valley/ White River Valley		
28209, 49476, V04605	Sentinel Wells and direct monitoring	Sentinel Monitor Wells 180W501M, WRV1012M, WRV1013M and direct monitoring at Flag and Butterfield Springs
All senior water rights in White River Valley Analysis Area	Sentinel wells and wells to monitor aquifer conditions	Sentinel Monitor Wells 180W501M, WRV1012M, WRV1013M
Dry Lake Valley/Delamar Valley		
18756	181M-1 proxy monitoring well and direct monitoring	Stock watering
5936, 35770, 35773, 35774	181M-1, 380531114534201	Stock watering
Pahranagat Valley		
Senior water rights in northern Pahranagat Valley	Sentinel Wells and direct monitoring	Sentinel Monitor Wells 209M-1, PAH1010M, 373803115050501, 373405115090001 and direct monitoring at Hiko, Crystal, and Ash Springs
Senior water rights in southern Pahranagat Valley	Sentinel Wells and direct monitoring	Sentinel Monitor Wells DEL4003X, 209 S07 E62 20AA 1 and direct monitoring at Maynard Spring

The spring monitoring network component of the DDC 3M Plan includes:

- Monitoring of eight spring locations in White River and Pahranagat valleys. These consist of Flag Springs Complex, Hot Creek, Moorman, Hardy, Hiko, Maynard, Ash, and Crystal Springs (started in 2009 and is currently ongoing). Table 10-5 identifies the individual party monitoring each of these sites.
- Report and evaluate spring discharge data from Cottonwood Spring as provided by the USFWS, located in Pahranagat Valley.
- Perform biannual monitoring of eight additional springs in DDC (started in 2009 and is currently ongoing). The sites are Parker Station, Cave, Lewis Well, Silver King Well, Big Mud, Littlefield, Coyote, and Grassy springs. Sites where physical discharge measurement are not feasible due to low spring discharge or construction are monitored visually and documented with photographs in the Spring and Fall of each year. Discharge measurements are taken whenever possible.

10.3.2 Baseline Water Chemistry

Water chemistry samples will be collected from up to 12 well and spring site locations. The purpose of water chemistry sampling is to document baseline water quality conditions prior to SNWA GDP pumping. Site will be sampled every five years after SNWA GDP pumping begins to evaluate changes over time. The sampling consists of two events at 6-month intervals. Sample chemical analysis parameters are presented in the 3M Plan. The locations will be resampled every 5 years after the commencement of GDP pumping operations. The chemical analysis parameters for the sampling program are presented in Table 10-7.

Table 10-7
Water-Chemistry Parameters

Field Parameters	Major Ions	Isotopes	Minor and Trace Elements
Water temperature	TDS	Oxygen-18	Arsenic
Air temperature	Calcium	Deuterium	Barium
pH	Sodium	Tritium	Cadmium
Electrical conductivity	Potassium	Chlorine-36[a]	Chromium
Dissolved oxygen	Chloride	Carbon-14[a]	Lead
	Bromide	Carbon-13[a]	Mercury
	Fluoride	Strontium-87[a]	Selenium
	Nitrate	Uranium-238[a]	Silver
	Phosphate		Manganese
	Sulfate		Aluminum
	Alkalinity		Iron
	Silica		Bromide
	Magnesium		Fluoride

[a]These parameters will be included only in the first sampling event and will not be included in any further water-chemistry sampling performed pursuant to this Monitoring and Mitigation Plan.

The sites to be included in the sampling are Flag Springs, Butterfield Spring, Hardy Spring, Hiko Springs, Ash Spring, Crystal Springs, Maynard Spring, 209M-1, 180W501M, 182M-1,181W909M, and 382807114521001.

10.3.3 Precipitation Monitoring

Data is obtained from operating regional precipitation stations in the vicinity of DDC with an established historical records. The stations will continue to be part of the 3M Plan monitoring network as long as operated by the current entities that operate them. The precipitation stations are listed in Table 10-5 and is shown in Figure 10-5. Additional station are also available in the region to supplement the precipitation data.

10.3.4 Numerical Groundwater Flow Modeling

SNWA will update and maintain a numerical flow model of the regional groundwater flow system. The model will be refined at the end of the baseline period prior to SNWA GDP pumping. The model will be calibrated and refined further as transient aquifer response data become available after SNWA

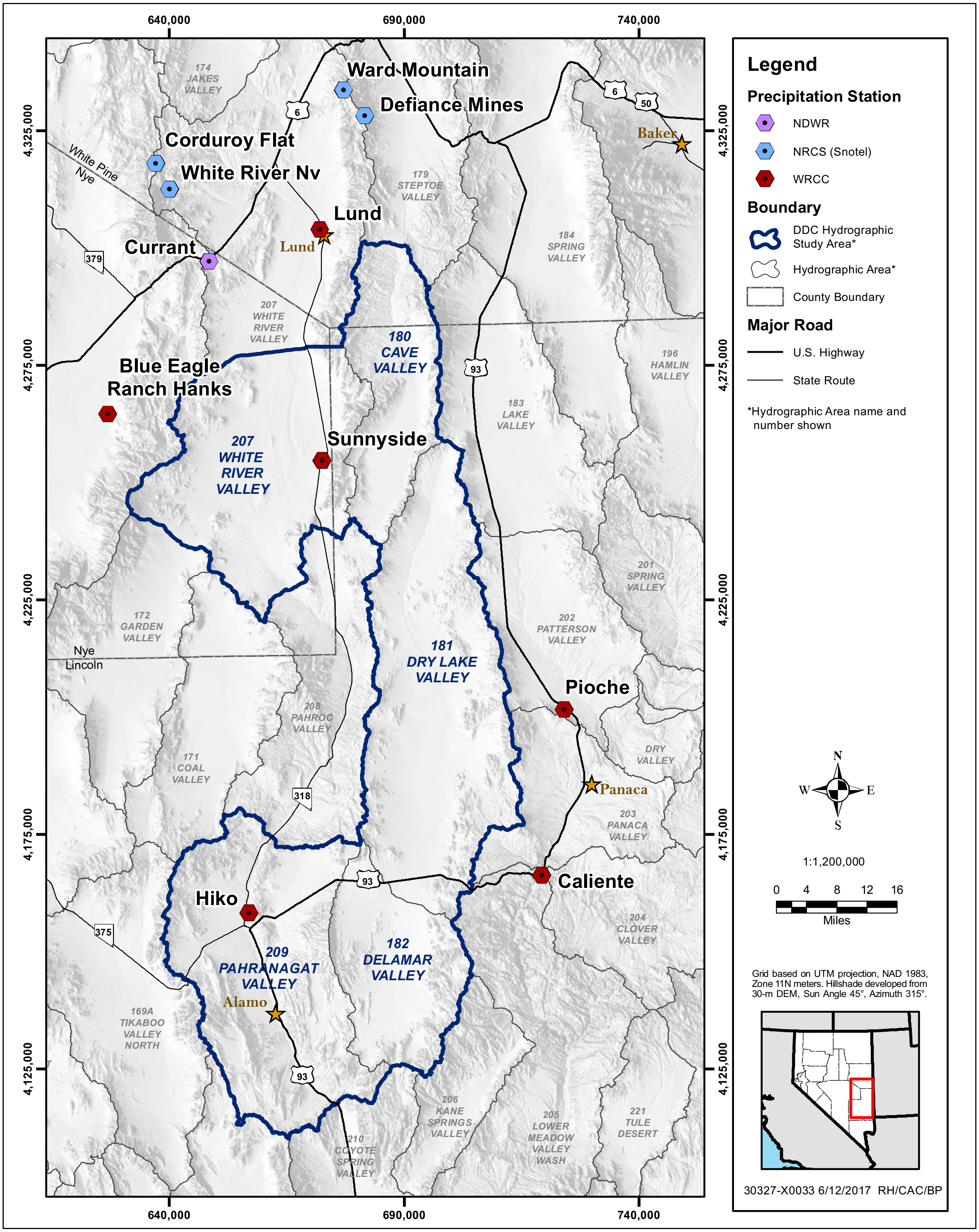

Figure 10-5
DDC Regional Precipitation Station Locations

GDP pumping began. The model will be refined at least every five years during SNWA GDP pumping, or more often if activation of an investigation trigger requires it.

10.4 Environmental Monitoring

Implementation of environmental monitoring in support of SNWA GDP water rights in Spring Valley began in 2009. The original Spring Valley and DDC biological monitoring plans were approved by the NSE in 2009 and 2011, respectively (BWG, 2009, and BRT, 2011), and annual reports have been provided regarding monitoring efforts and studies associated with the plans (SNWA, 2010d, 2011e, 2013c and f, 2014c and e, 2015c and d, 2016d and h, and 2017c and f). These biological monitoring plans were prepared in accordance with the Spring Valley and DDC Stipulated Agreements (Section 10.6), and will continue to be implemented in accordance with those agreements.

The 2017 DDC and Spring Valley 3M Plans (SNWA, 2017d and e) detail the monitoring activities to avoid unreasonable effects to environmental resources as described in this report. SNWA requests that the NSE adopt the 2017 3M Plans as part of the rulings issued after the Remand Order hearings are complete. The 2017 Spring Valley and DDC 3M Plans are completely separate from the plans prepared in accordance with the Stipulated Agreements. The 2017 3M Plans will be implemented to comply with Nevada water law pursuant to the NSE's regulatory authority.

10.4.1 Spring Valley Environmental Monitoring Program

The hydrologic monitoring network presented in Section 10.2 provides a major element of the environmental monitoring program. Key habitat components being monitored include groundwater level, spring discharge, stream flows, and precipitation. Given the number and spatial distribution of monitor wells and senior water rights, and the general co-location of senior water rights with environmental resources, the hydrologic monitoring network provides extensive information about environmental conditions in Spring, northern Hamlin, and southern Snake valleys.

Additional environmental monitoring is summarized below. For more information on how these monitoring activities dovetail with management and mitigation, see the analyses in Section 6.0 (Spring Valley) and Section 7.0 (northern Hamlin and southern Snake valleys).

10.4.1.1 Spring Valley

Pahrump Poolfish

Unreasonable effect to avoid: Jeopardy to the continued existence of the federally endangered Pahrump poolfish.

Approach: Protect the senior water right and Pahrump poolfish habitat at Shoshone Ponds (Figure 10-6).

Monitoring activity: Support NDOW with its annual Pahrump poolfish survey at Shoshone Ponds. SNWA's support will ensure that these efforts are conducted on an annual basis for at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley, and will continue as long as SNWA pumps groundwater under the Spring Valley GDP permits. Continue to participate on the Pahrump Poolfish Recovery Implementation Team. See monitoring of the senior water right in Section 10.2.1.

Monitoring purpose: Document the senior water right flows and the Pahrump poolfish population at Shoshone Ponds, including natural fluctuations.

Mesic Habitat and Northern Leopard Frog

Unreasonable effect to avoid: Elimination of mesic habitat from the Spring Valley groundwater discharge area, and extirpation of the native aquatic-dependent special status animal species northern leopard frog.

Approach: Avoid unreasonable effects to senior water rights that support mesic habitat and northern leopard frogs, and ensure sufficient mesic habitat is preserved in Management Block 3 to support a viable, reproducing population of northern leopard frog. As part of this approach, SNWA will manage the SNWA McCoy Creek Property to maintain and/or enhance the mesic habitat for the benefit of northern leopard frog and other wildlife species (Figure 10-6).

Monitoring activity: On an annual basis on the McCoy Creek Property: (1) map the extent of mesic habitat on the McCoy Creek Property using springtime satellite or aerial imagery, and (2) during the breeding season, conduct an egg mass survey on the McCoy Creek Property. Prior to initiating monitoring, conduct a field reconnaissance to establish the egg mass sample design based on ground conditions at that time. Collect data for at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley and continue as long as SNWA pumps groundwater under the Spring Valley GDP permits. See monitoring of senior water rights in Section 10.2.

Monitoring purpose: Document the senior water right flows, and verify the continued status of northern leopard frog and mesic habitat at McCoy Creek Property.

Shrubland Habitat

Unreasonable effect to avoid: Elimination of shrubland habitat from the Spring Valley groundwater discharge area, and excessive loss of shrub cover that results in extensive bare ground.

Approach: Within the groundwater discharge area, maintain shrub cover at or above the low-density shrubland threshold level in those areas currently covered by medium-density or low-density shrubland habitat.

Monitoring activity: On an annual basis: (1) quantify mean NDVI for medium-density and low-density shrubland polygons in the groundwater discharge area of Monitoring Blocks 1 and 2 using July-September Landsat imagery; and (2) conduct a ground vegetation transect survey in the summer (August) to coincide with the remotely sensed NDVI data, and quantify percent live shrub cover. On a quarterly basis, collect data from piezometers in medium-density and low-density shrubland. Prior to initiating monitoring, conduct a ground-truthing exercise and remote-sensing

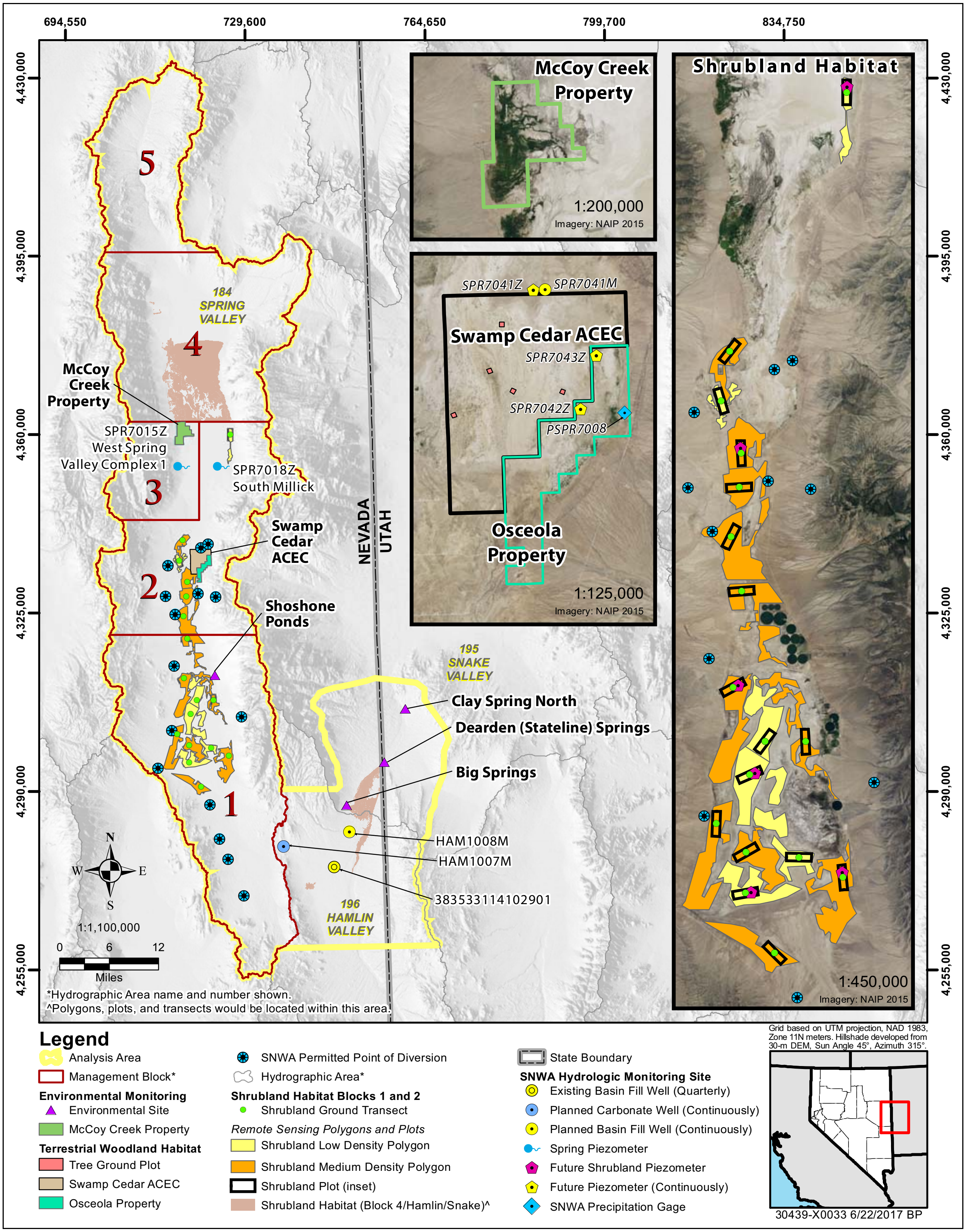

Figure 10-6
Environmental Monitoring Sites in Spring, Hamlin, and Snake Valleys

analysis to confirm configurations of remote sensing polygons and plots, ground vegetation transects, and piezometers. Collect ground vegetation transect and piezometer data for at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley and continue as long as SNWA pumps groundwater under the Spring Valley GDP permits. Analyze the full available baseline for NDVI. See discussion on the shrubland piezometers in Section 10.2.1 and the hydrologic monitoring network in 10.2.2.

If an investigation trigger at the West Spring Valley Complex piezometer or South Millick Spring piezometer (Figure 10-6) is activated due to SNWA GDP pumping, establish and conduct shrubland monitoring in the groundwater discharge area of Management Block 4 using the methods above.

Monitoring purpose: Document groundwater levels and shrub cover, signal trigger activation, and inform and assess efficacy of management and mitigation actions.

Terrestrial Woodland Habitat

Unreasonable effect to avoid: Elimination of terrestrial woodland habitat from the Spring Valley groundwater discharge area.

Approach: Maintain a viable Rocky Mountain juniper population within the Swamp Cedar ACEC (Figure 10-6) by maintaining tree cover area within the baseline percent range of cover. Also use the SNWA Osceola Property contiguous to the ACEC to offset loss below the baseline percent range of cover.

Monitoring activity: On an annual basis, (1) quantify tree cover area in the Swamp Cedar ACEC using at least 0.5-m resolution imagery captured in the summertime (primarily August); and (2) conduct a ground vegetation plot survey in the summer (August) to coincide with the remotely sensed tree cover area data. On at least a quarterly basis, collect data from monitor wells adjacent to the Swamp Cedar ACEC. Also collect continuous data from the adjacent precipitation station. Prior to initiating monitoring, conduct a ground-truthing exercise and remote sensing analysis to confirm the ground monitoring plot configuration. Install three shallow piezometers and one deep monitor well to collect data on the relationship between junipers, precipitation, shallow groundwater, and the deep producing aquifer. Collect high-resolution imagery, ground tree plot, and piezometer data for at least five years prior to SNWA GDP groundwater withdrawal from Spring Valley and continue as long as SNWA pumps groundwater under the Spring Valley GDP permits. To calculate the baseline percent range in cover, analyze the full available baseline for NDVI. See discussion on adjacent monitor wells and precipitation station in Section 10.2.1 and the hydrologic monitoring network in 10.2.2.

If mitigation is implemented on the SNWA Osceola Property, establish and conduct mitigation monitoring using the methods above.

Monitoring purpose: Document groundwater levels and tree cover area, signal trigger activation, and inform and assess efficacy of management and mitigation actions.

10.4.1.2 Northern Hamlin and Southern Snake Valleys

Longitudinal Gland Pyrg

Unreasonable effect to avoid: Extirpation of the native aquatic-dependent special status animal species longitudinal gland pyrg from the Snake Valley groundwater discharge area.

Approach: Protect longitudinal gland pyrg habitat at Dearden (Stateline) Springs.

Monitoring activity: If the hydrologic investigation trigger at the Hamlin Valley monitor well 383533114102901 is activated as a result of SNWA GDP pumping, conduct annual presence/absence monitoring of the longitudinal gland pyrg at Dearden Springs, Big Springs, and Clay Spring North (Figure 10-6). Continue monitoring as long as the investigation trigger is activated at monitor well 383533114102901, the hydrologic mitigation trigger is activated at monitor well HAM1008M, or as long as mitigation actions for the longitudinal gland pyrg are being conducted for the GDP. See monitoring of interim monitor wells in Section 10.2.2.2.

Monitoring purpose: Identify drawdown propagation, and verify the continued existence of the species at the sites.

Shrubland Habitat

Unreasonable effect to avoid: Elimination of shrubland habitat from each basin's groundwater discharge area, and excessive loss of shrub cover that results in extensive bare ground.

Approach: Within the groundwater discharge areas, maintain shrub cover at or above the low-density shrubland threshold level in those areas currently covered by medium-density or low-density shrubland habitat.

Monitoring activity: If the hydrologic investigation trigger at the Limestone Hills sentinel well HAM1007M is activated as result of SNWA GDP pumping, conduct shrubland monitoring in the northern Hamlin Valley groundwater discharge area (Figure 10-6). If the hydrologic investigation trigger at the Hamlin Valley monitor well HAM1008M is activated as result of SNWA GDP pumping, conduct shrubland monitoring in the groundwater discharge area in southern Snake Valley, Nevada, east of Big Springs Creek (Figure 10-6). On an annual basis: (1) quantify mean NDVI for shrubland polygons using July-September Landsat imagery; and (2) conduct a ground vegetation transect survey in the summer (August) to coincide with the remotely sensed NDVI data. On a quarterly basis, collect data from piezometers in the monitored shrubland. Prior to initiating monitoring, conduct a ground-truthing exercise and remote-sensing analysis to assist in establishing remote sensing polygons and plots, ground vegetation transects, and piezometers in the shrubland monitoring areas. Analyze the full available baseline for NDVI. Continue monitoring in Hamlin Valley as long as the investigation trigger is activated at sentinel well HAM1007M, or as long as mitigation actions for Hamlin Valley shrublands are being conducted for the GDP. Continue monitoring in Snake Valley as long as the investigation trigger is activated at sentinel well HAM1008, or as long as mitigation actions for Snake Valley shrublands are being conducted for the GDP. See discussion on the hydrologic monitoring network in Section 10.2.2.

Monitoring purpose: Document groundwater levels and shrub cover, signal trigger activation, and inform and assess efficacy of management and mitigation actions.

10.4.2 DDC Environmental Monitoring Program

The hydrologic monitoring network presented in Section 10.3 composes a major element of the environmental monitoring program. Key habitat components being monitored include groundwater level, spring discharge, stream flows, and precipitation. Given the number and spatial distribution of monitor wells and senior water rights, and the general co-location of senior water rights with environmental resources, the hydrologic monitoring network provides extensive information about environmental conditions in DDC, southern White River Valley, and Pahranagat Valley.

Additional monitoring of species and habitats is summarized below. For more information on how these monitoring activities dovetail with management and mitigation, see the analyses in Section 8.0 (southern White River Valley) and Section 9.0 (Pahranagat Valley).

Listed Species and Native Aquatic-Dependent Special Status Animal Species (White River Valley)

Unreasonable effect to avoid: Jeopardy to the continued existence of federally endangered species, and extirpation of native aquatic-dependent special status animal species from the White River Valley groundwater discharge area.

Approach: Avoid unreasonable effects to senior water rights, and protect the habitat for the listed species and native aquatic-dependent special status animal species in Butterfield and Flag springs and Sunnyside Creek (Figure 10-7).

- Federally endangered species:
  - White River spinedace (Flag Springs and the downstream Sunnyside Creek)
- Native aquatic-dependent special status animal species:
  - White River speckled dace (Butterfield Springs, Flag Springs, Sunnyside Creek)
  - White River spinedace (Flag Springs, Sunnyside Creek)
  - White River desert sucker (Flag Springs, Sunnyside Creek)
  - White River sculpin (Butterfield Springs)
  - Butterfield pyrg (Butterfield Springs)
  - Hardy pyrg (Butterfield Springs)
  - Flag pyrg (Flag Springs)

- White River Valley pyrg (Flag Springs)

Monitoring activity: If the hydrologic investigation trigger at the monitor well WRV1012M or WRV1013M is activated as a result of SNWA GDP pumping, support NDOW with their native fish surveys at Flag and Butterfield springs and Sunnyside Creek to ensure the surveys are conducted, and incorporate presence/absence surveys of the native aquatic-dependent special status fish and invertebrate species during the fish surveys (Figure 10-7). Continue monitoring as long as the investigation trigger is activated at monitor well WRV1012M or WRV1013M, the hydrologic mitigation trigger is activated at Flag Springs, or as long as mitigation actions for the species are being conducted for the GDP. Also continue to participate on White River Valley Native Fishes Recovery Implementation Team. See monitoring of senior water rights and interim monitor wells in Section 10.3.1.

Monitoring purpose: Document groundwater levels and verify the continued status of the species at the sites.

Listed Species and Native Aquatic-Dependent Special Status Animal Species (Pahranagat Valley)

Unreasonable effect to avoid: Jeopardy to the continued existence of federally endangered species, and extirpation of native aquatic-dependent special status animal species from the Pahranagat Valley groundwater discharge area.

Approach: Avoid unreasonable effects to senior water rights, and protect the habitat for the listed species and native aquatic-dependent special status animal species in Hiko, Crystal, and Ash springs (Figure 10-7).

- Federally endangered species:
    - Hiko White River springfish (Hiko and Crystal springs)
    - White River springfish (Ash Springs)
- Native aquatic-dependent special status animal species:
    - Pahranagat pebblesnail (Ash Springs)
    - Grated tryonia (Ash Springs)
    - Ash Springs riffle beetle (Ash Springs)
    - Pahranagat naucorid bug (Ash Springs)
    - Hubbs Pyrg (Crystal Springs)

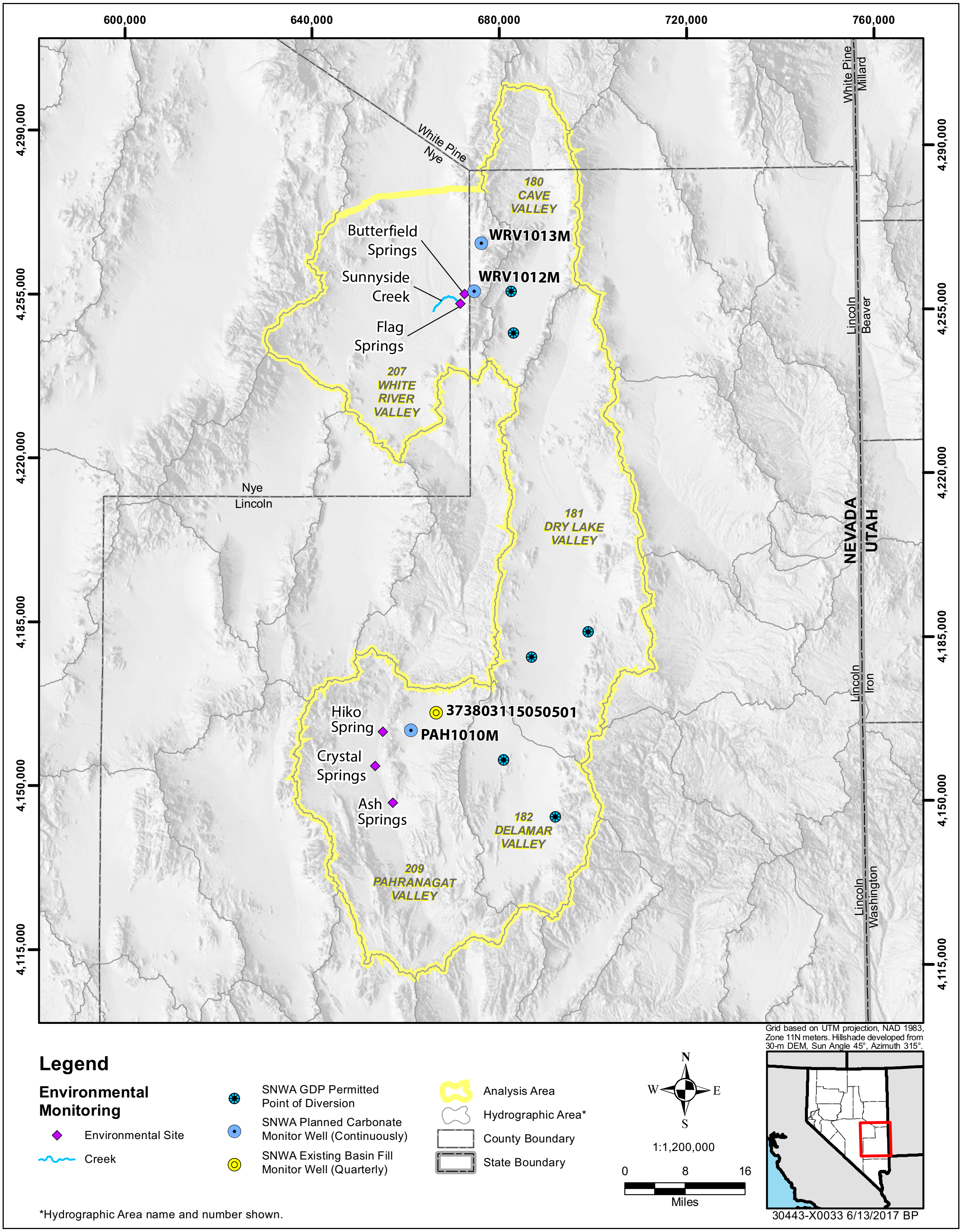

Figure 10-7
Environmental Monitoring Sites in DDC, White River, and Pahranagat Valleys

This approach also protects other federally listed and native aquatic dependent special status species that occur in downstream habitat supported by the regional spring discharge (including the federally listed Pahranagat roundtail chub, southwestern willow flycatcher, and western yellow-billed cuckoo).

Monitoring activity: If the hydrologic investigation trigger at the monitor well 373803115050501 is activated as a result of SNWA GDP pumping, support NDOW with their native fish surveys at Hiko, Crystal, and Ash springs to ensure the surveys are conducted, and incorporate presence/absence surveys of native aquatic-dependent special status fish and invertebrate species during the fish surveys (Figure 10-7). Continue monitoring as long as the investigation trigger is activated at monitor well 373803115050501, the hydrologic mitigation trigger is activated at monitor well PAH1010M, or as long as mitigation actions for the species are being conducted for the GDP. Also continue to participate on Pahranagat Valley Native Fishes Recovery Implementation Team. See monitoring of senior water rights and interim monitor wells in Section 10.3.1.

Monitoring purpose: Document groundwater levels and verify the continued status of the species at the sites.

10.5 SNWA Reporting Commitments

This section presents SNWA reporting commitments that are included in the SNWA (2017d and e) DDC and Spring Valley 3M plans. Submission of monitoring data and operation plans are presented in Section 10.5.1. Notification of trigger activation and submission of investigation findings and management and mitigation actions are presented in Section 10.5.2.

10.5.1 Monitoring Data and Operation Plans

SNWA will submit all data collected for the 3M plans in an electronic format to the NSE. Hydrologic data will be submitted quarterly, and environmental data will be submitted annually. Water chemistry laboratory reports will be made available to the NSE within 90 calendar days of receipt or within an alternative time frame required by the NSE.

SNWA will also present the hydrologic and environmental monitoring data in annual reports, submitted to the NSE by March 31 for each year that each 3M Plan is in effect. Annual operations plans will also be submitted to the NSE by December 1 of the prior year. The operation plans will present the anticipated pumping distributions for the following calendar year, and will include planned or on-going SNWA GDP pumping management and mitigation actions.

10.5.2 Trigger Activation, Investigations, and Management and Mitigation Actions

SNWA will notify the NSE when investigation and mitigation triggers are activated, and will submit data and technical findings to the NSE as follows:

- A memorandum will be submitted to the NSE within 30 days of activating a mitigation trigger. The memorandum will describe the mitigation trigger and planned mitigation actions. Mitigation actions will be implemented no later than 30 days after a mitigation trigger is activated to avoid unreasonable effects and comply with Nevada water law.

- Implemented mitigation actions, assessments of mitigation efficacy, and plans for continuing mitigation will be submitted in annual reports.

- Notification of investigation trigger activation will be included in the quarterly data submittal to the NSE.

- Investigation findings, preemptive management actions, and mitigation planning will also be submitted in the annual reports. Mitigation planning will be conducted in advance of activating a mitigation trigger, and will include purchasing equipment, establishing contracts, and obtaining landowner permissions and permits.

The NSE may also perform independent investigations at any time, and senior water right holders and other parties may pursue independent investigations and submit reports for NSE review. The NSE will distribute information among parties as needed.

10.6 Other Compliance Processes

The SNWA GDP must comply with federal laws, other State of Nevada requirements, and Stipulated Agreements. The information below summarizes these other requirements; a more detailed discussion can be found in Marshall and Luptowitz (2011 at Sections 3 and 5).

- The SNWA GDP must comply with various federal laws, including the ESA, NEPA, Clean Water Act, National Historic Preservation Act, Migratory Bird Treaty Act, and Bald and Golden Eagle Protection Act (Marshall and Luptowitz 2011 at Section 5). In accordance with these federal Acts, the BLM EIS and USFWS BO were completed in 2012 for the SNWA GDP (BLM 2012a; USFWS 2012). The federal right-of-way for the main conveyance pipeline and power line (Tier 1 facilities) was issued by BLM in 2013 (BLM 2013). When locations of future groundwater production wells and collector pipelines are determined and SNWA submits associated requests for rights-of-way across federal lands, tiered site-specific NEPA and ESA consultation will be conducted (BLM 2012a). The BLM is requiring a comprehensive Construction, Operation, Maintenance, Monitoring, Management, and Mitigation Plan to ensure that monitoring, management, and mitigation will be implemented to satisfy federal environmental compliance requirements (BLM 2012b at page 50).

- In addition to the water rights process under Nevada water law, the SNWA GDP is subject to other permits and approvals required by the State of Nevada for construction and operation of the GDP. State permits and reviews that may be required for the SNWA GDP are presented in Marshall and Luptowitz (2011 at Table 5-2). The SNWA GDP is also subject to the newly created Nevada Conservation Credit System, which addresses compensatory mitigation for the greater sage-grouse (*Centrocercus urophasianus*) (State of Nevada 2016).

- The SNWA GDP is also subject to Spring Valley and DDC Stipulated Agreements between SNWA and the DOI and U.S. Forest Service (Stipulation 2006, 2008, 2011).[1] The Stipulations require monitoring, management, and mitigation plans to achieve common goals, such as to manage the development of groundwater by SNWA without causing "injury to Federal Water Rights" or "unreasonable adverse effects to Federal Resources" (Marshall and Luptowitz 2011 at Section 3; Stipulation 2006, 2008, 2011).

These compliance processes are not part of Nevada water law or under the jurisdiction of the NSE. However, they represent extensive requirements with which the SNWA GDP must comply in addition to the requirements under Nevada water law.

1. Signatories to the 2006 Spring Valley Stipulation and 2008 DDC Stipulation: SNWA, BLM, USFWS, National Park Service, and Bureau of Indian Affairs. Signatories to the 2011 Spring Valley Stipulation: SNWA and USFS.

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Appendix A

Hydrologic Data and Statistical Methods for Establishing Triggers for Senior Water Rights

A.1.0 Hydrologic Data and Statistical Methods for Establishing Triggers for Senior Water Rights

Hydrologic data and statistical methods used to establish and activate triggers associated with senior water rights for the SNWA GDP are presented in this appendix. The conceptual approach to establishing thresholds, triggers, and monitoring, management, and mitigation actions are described in Section 3.0.

A.1.1 Baseline Data

SNWA maintains hydrologic monitoring networks associated with SNWA GDP 3M Plans for Spring Valley and Cave, Dry Lake and Delamar valleys. Systematic hydrologic baseline data collection efforts began in 2006 to document natural variability in the hydrologic system and identify other background influences prior to SNWA GDP pumping. The baseline period currently is approximately 11 years and may extend over several decades depending upon initiation of SNWA GDP pumping. The baseline record already reflects a variety of hydrologic conditions including wet periods in 2011 and 2017 and drought conditions from 2012 through 2015. The baseline periods for specific new monitoring sites are presented within the individual 3M Plans.

SNWA's field and standard operating procedures for data collection, data evaluation, and QA/QC are consistent with industry best practices including USGS and ASTM standards to assure a high quality measurement record for each monitoring site. The program assures the measurements collected are representative of true hydrologic conditions minimizing influence from instrumentation or measurement error. Location and measurement frequency for the individual monitoring sites in the GDP hydrologic monitoring network are summarized in Section 10.0. Regular program measurement frequency of groundwater levels and spring and stream discharge consist of the following:

- quarterly physical depth to water level measurements in wells
- hourly (continuous) water levels measurements in wells and converted to a mean daily value
- quarterly physical spring or stream discharge measurements
- 15-minute (continuous) stage data collected at spring and stream gaging stations which are converted to discharge using a stage-discharge rating curve for the station and is then converted to a mean daily value

The measurement frequency, collection methods, and quality control of data collected before 2006 prior to the establishment of the baseline monitoring program may not be consistent with data collected after 2006, and therefore may not used in the baseline analysis. Where different measurement frequencies occur within the same data set, the higher resolution and more extensive data may be averaged so as not to weight the results to that period of higher frequency measurements.

Continuous data is averaged to daily values depending upon the location, length of record, and data characteristics. USGS reports daily-averages for stream-flow and depth-to-water data (USGS, 2017).

Example data for wells and springs are presented in hydrographs which plot water level elevation or spring/stream discharge versus time. Example baseline hydrographs for groundwater elevation and spring discharge are presented in Figures A-1 and A-2, respectively.

New and baseline hydrologic datasets may indicate a change in local hydrologic conditions attributable to either natural processes or human development of water resources, or a combination of both. Examples of natural processes that could influence local hydrologic conditions include changes in the barometric pressure or earth tides, variability in seasonal groundwater recharge, or regional trends from extreme wet and dry periods. Human development of water resources typically involve diverting water from the aquifer, streams, and springs and conveying the water through closed pipe or open water channel systems for use.

A.1.2 Triggers

Data collected after initiation of SNWA GDP pumping will be compared to baseline data to identify significant changes in groundwater levels and spring discharge. Investigation triggers are set at specific monitoring and senior water right locations to identify change regardless of the cause. Activation of an investigation trigger initiates a comprehensive statistical and scientific evaluation of the data set to determine cause and significance of the change in the measured parameter as described in Section 3.2.2. The investigation evaluates natural influences such as seasonal variability, precipitation, recharge, tidal effects, barometric pressure and long- and short-term regional trends. The investigation also compares the dataset to other reference monitoring locations outside the influence of pumping which have responded in a similar manner throughout the baseline period. If the cause of the change is SNWA GDP pumping, appropriate management actions are implemented to avoid activating mitigation triggers.

Triggers are utilized in basin groundwater management programs for several purposes including identification of drought conditions, basin sustainability management, and resource and groundwater development projects. Other groundwater management plans have used both fixed and flexible triggers as described in Section 3.1.5. Investigation and mitigation triggers have been established on other groundwater projects using various methods depending upon the objectives of the management programs. The two basic approaches are: (1) setting a fixed trigger which is related to a specific water level, pumping rate, or spring discharge; or (2) establishing a trigger level tied to the behavior of the baseline data record.

Fixed triggers can be associated with a specific permitted water right diversion rate. However, they do notadjust for trends or reoccurring patterns, such as seasonality, in the baseline data set. Baseline data linked triggers can be linked to seasonal variability and account for trends in the dataset which are more responsive in accounting for variation in natural hydrologic conditions.

SNWA GDP 3M Plan uses both types of triggers, as described in Section 3.1.2. Examples include the investigation trigger linked to the lower control limit which is derived statistically from the baseline data. The investigation trigger is activated when new water level or spring/stream discharge data are beyond the lower control limit for a specified period of time indicating that change outside the baseline dataset has occurred. Another example is a fixed trigger level linked to a senior water right diversion rate requiring management or mitigation action if activated.

A.1.3 Seasonally Adjusted Linear Regression Method

The seasonally adjusted linear regression (SALR) method is used to establish a trigger based upon the behavior of the baseline dataset. A linear regression is a method that can be used to construct a model to fit time-series data (Chandler and Scott, 2011). The method for fitting a regression line used here is the method of ordinary least-squares, which calculates a best-fit line for the observed data by minimizing the sum of the squares of the vertical deviations from each data point to the line. “Linear least squares regression is by far the most widely used modeling method. It is what most people mean when they say they have used "regression", "linear regression" or "least squares" to fit a model to their data.”(NIST/SEMATECH, 2017)

Evaluating hydrologic time-series data using a linear regression model provides the ability to assess the trend of groundwater elevation or surface-water flow over a period of time and captures the aggregate effects of the natural and human induced processes on the baseline measurement data. For example, an observed trend at a hydrologic monitoring site may reflect the aggregate effects of climate variability, consumptive use of nearby phreatophytes or groundwater production unrelated to the SNWA GDP.

The baseline data will likely exhibit aggregate, seasonal trends related to natural hydrologic processes, (runoff from snow-melt or groundwater recharge), atmospheric conditions (barometric pressure), and gravitational oscillations (earth tides), as well as, recurring human induced affects (groundwater pumping during a growing season). The application of ordinary least squares in the SALR model uses a discrete variable approach to evaluate the statistical significance of monthly variability, making it a suitable method to evaluate seasonal trends.

The SALR model uses the data inclusive in each month starting with January, which is considered 0 – reference period, and applies a discrete variable, known as a dummy variable, to evaluate if data in the remaining months from the dataset, February through December, exhibit seasonal variation. If the seasonal variation of data within any month is found to be statistically significant (i.e., its p-value is less than 0.05) then the dummy variable is used to identify the unique character of the monthly data and is used to adjust the regression line at a monthly time-scale. This seasonal adjustment and evaluation of statistical significance is done automatically using statistical software. If the seasonal variability in the data for an individual month is found not to be statistically significant, then the dummy variable for that month is removed and the SALR is re-created. This process is repeated until all of the remaining months have been evaluated for statistical significance. Since the data is being evaluated for monthly seasonality, the regression model can reflect up to 11 variables to account for the months after January (February through December).

The ability of the SALR method to capture the long-term and seasonal influences on the observed hydrologic conditions makes it a reasonable choice to establish triggers at hydrologic monitoring sites exhibiting long-term and seasonal variability in the baseline record.

The SALR model can be expressed as derived from (Chandler and Scott, 2011):

$$\hat{y}_t = \beta_o + \beta_1 t + \beta_2 Feb + \ldots + \beta_{12} Dec + \varepsilon_i$$

Where:

t = *day* (for daily series data; or other specified period), $t = 1,2,\ldots, N$ (N = number of observations)

β_o = y-axis intercept

β_1 = overall slope

$\beta_{2,\ldots,}\ \beta_{12}$ = offset to account for seasonality (monthly variations)

Feb = coefficient of the indicator variable for the month of February

Dec = coefficient of the indicator variable for the month of December

ε_i = error term

The control limits typically used for least squares regression models are Prediction Intervals (PI). A PI for the SALR model represents a range that is likely to contain a single future response for a value of the predictor variable. Assuming there were no changes to natural or human induced processes captured in the SALR analysis of baseline data, if the PI with set as 99.7 percent, one can be 99.7 percent confident any new observations will fall within the PI established for the data collection month. The PI can be varied by adjusting the percentage, usually at the same intervals as standard deviations. The least squares estimates of the SALR model (i.e. the specific statistical parameters of the regression) and the PI are easily computed using statistical software programs like R and SAS-Statistical Analysis Software.

A specific PI, usually 95 or 99.7 percent, are used to establish upper and lower control limits by which future data can be compared. Future data observed outside the lower PI control limit for a specified period of time would constitute exceeding the trigger. The PI value, and the required period of observed data below the lower PI control limit are presented for each monitoring location in Section 6.0 - 9.0.

Prediction Intervals (Moore et al., 2015) for a new y-value are calculated as:

$$y \pm t_{(0.003,\, n-2)} \sqrt{\left(MSE \times \left(1 + \frac{1}{n} + \frac{(x_h - \bar{x})^{2}}{\sum (x_i - \bar{x})^2} \right) \right)}$$

Where:

y = SALR Value at any time x_h.

MSE = Mean square error.

n = Number of observations.

xbar = Mean of predictor variable.

$t_{0.003,N-2}$ = value from the t-table with degrees of freedom (N-2) corresponding to probability 0.003.

The baseline time-series data will be visually inspected for characteristics of data demonstrating long-term or seasonal trends before establishing a hydrologic trigger. The SALR method will be used to analyze the baseline data. For baseline data that demonstrates no apparent trend and seasonality, the PI method is equivalent to setting a trigger three times the standard deviation away from the mean, which is similar to the Shewhart Control Chart Method.

When applying a SALR model to baseline data, the regularity of the data (i.e, number of data points in a specific time interval) needs to be considered to avoid weighting the regression to a specific time period. For example, a site with several years of periodically collected monthly baseline data followed with several years of daily average data will likely weight the regression to the later years simply due to the number of observations provided by the daily average data exceeding the number of observations for monthly periodic data. Under these circumstances, the periodic data will be combined with a complementary sample of the daily average data (e.g. average monthly or quarterly). This, in combination with long periods-of-records, will minimize applying a greater number of data points to different time periods and weighting the regression.

A.1.4 Case Examples

Three examples using the SALR method are presented. The first example, shown in Figure A-1, uses the SALR method applied to a hypothetical baseline dataset which exhibits a strong reoccurring seasonal behavior. The example illustrates the activation of an investigation trigger for the hypothetical dataset. An artificial water-level record was constructed for the period 2006 through 2026 to demonstrate hypothetical hydrologic conditions over an assumed 20 year baseline monitoring period at the hydrologic monitoring location.

As shown in Figure A-1, SNWA GDP pumping is hypothetically assumed to begin in early 2026, from which point the artificial record is extended to demonstrate a decline in water-level for the purpose of illustrating the timing of an investigative trigger. The investigative trigger established for this hypothetical example is a decrease in groundwater level below the 99.7 percent lower control limit for a continuously period of six months. A close-up of the plot, presented in Figure A-2, shows the water level crossing the 99.7 percent lower control limit during the third quarter of 2026 and remaining for six continuous months at which point the investigative trigger would be activated.

Another example of a dataset which exhibits limited seasonality and trend is shown in Figure A-3. The figure demonstrates how the SALR method is applied to the site using the baseline record to construct a 99.7 percent lower control limit. The figure shows the seasonal trends exhibited by both the observed water levels (physical and continuous) and lower control limit.

The final example uses an artificial dataset to demonstrate activation of a investigation trigger with a hypothetical data set that exhibits low seasonality. The example assumed a 20 year baseline monitoring period with an artificial water-level record constructed for the period 2006 through 2026. The artificial baseline data and the lower control limit are shown in Figure A-4. Like the earlier example, the figure shows SNWA GDP production beginning in 2026, from which point the artificial record is extended to demonstrate a decline in water-level for the purpose of illustrating the timing of the investigative trigger. The investigative trigger established for this hypothetical dataset is the decrease of groundwater level below the 99.7 percent lower control limit for a continuous period of six months. The figure shows the artificial water level decline below the lower control limit in the first quarter of 2027 and remained below the control limit for six months at which time an investigative trigger would be activated.

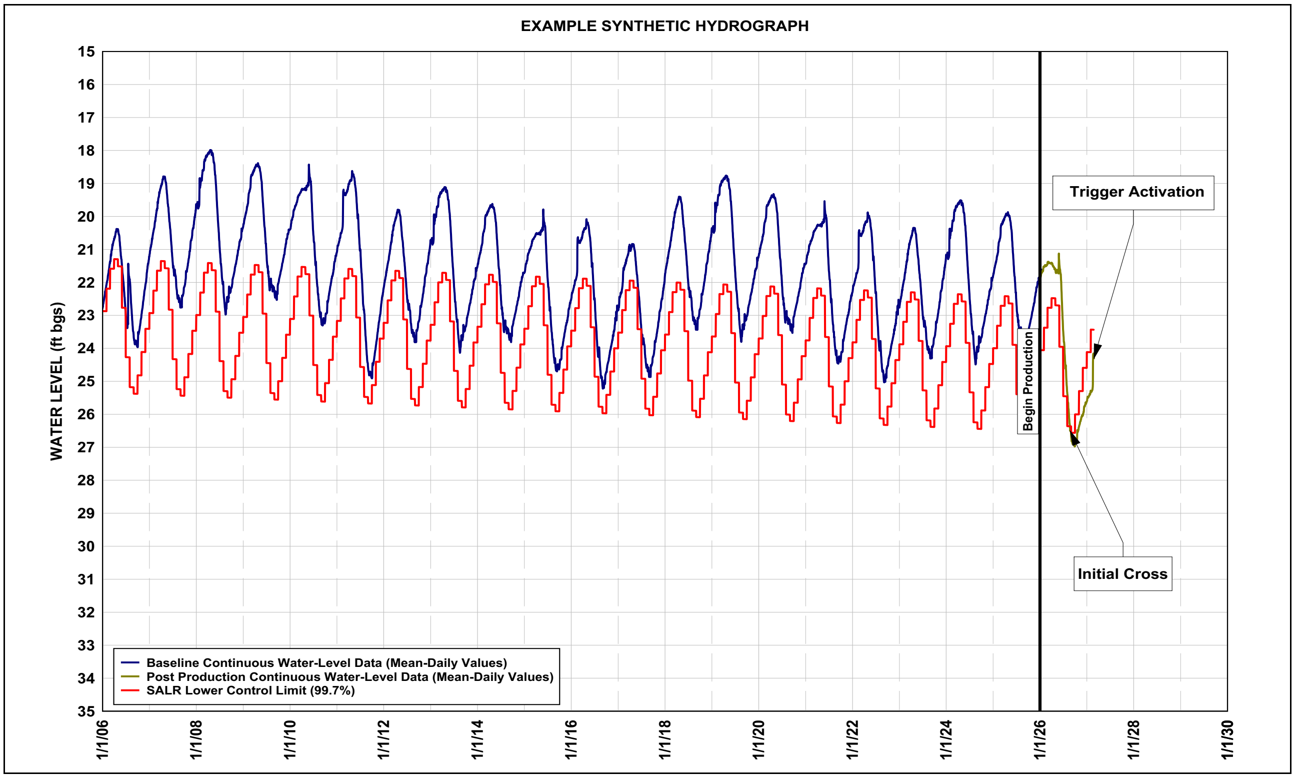

Figure A-1
Example of Trigger Activation - Strong Seasonality

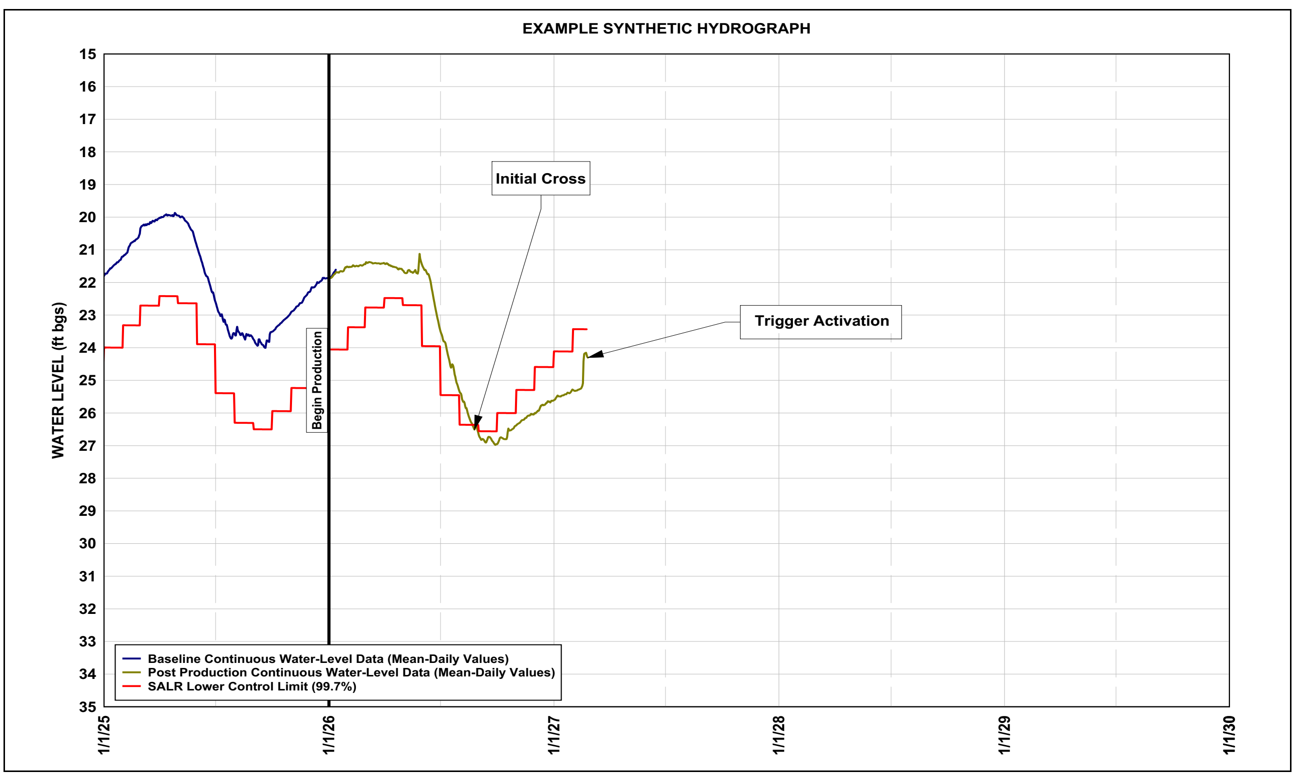

Figure A-2
Example of Trigger Activation Close up of Figure A-3

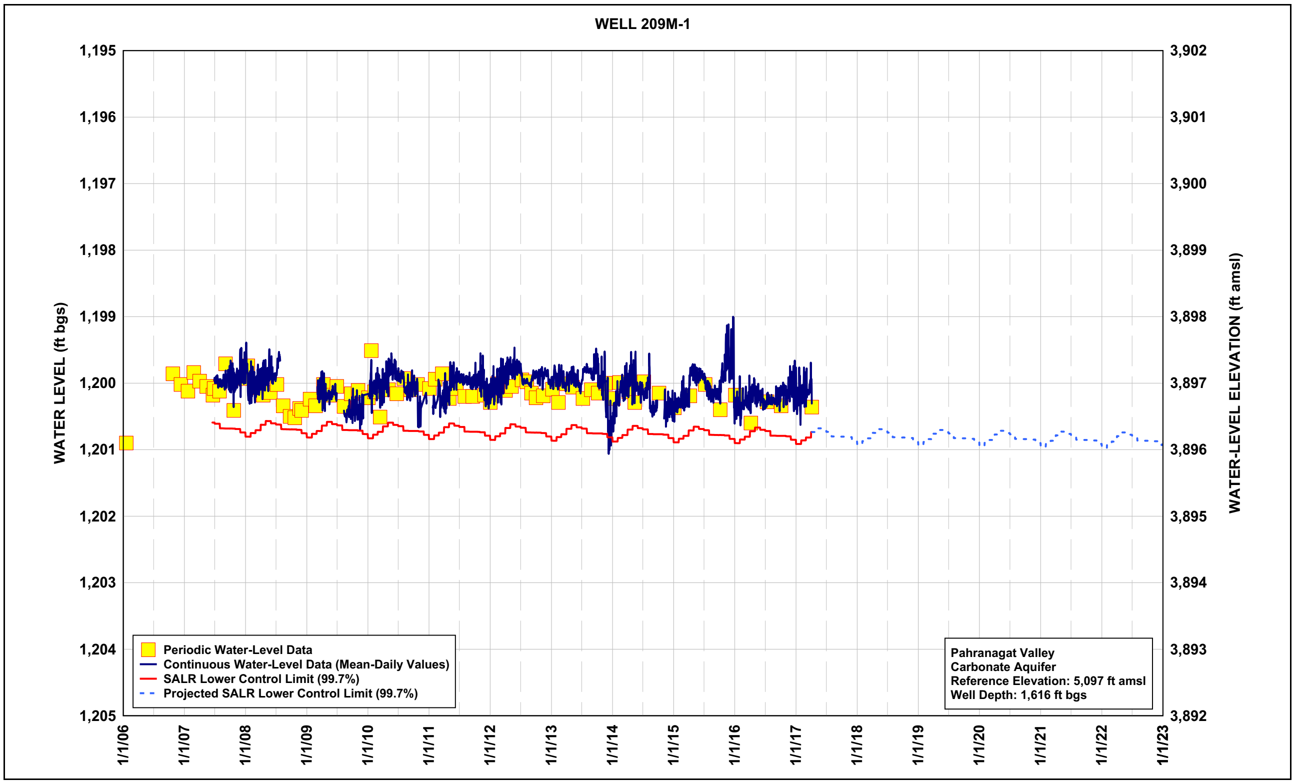

Figure A-3
Example Dataset with Limited Seasonality

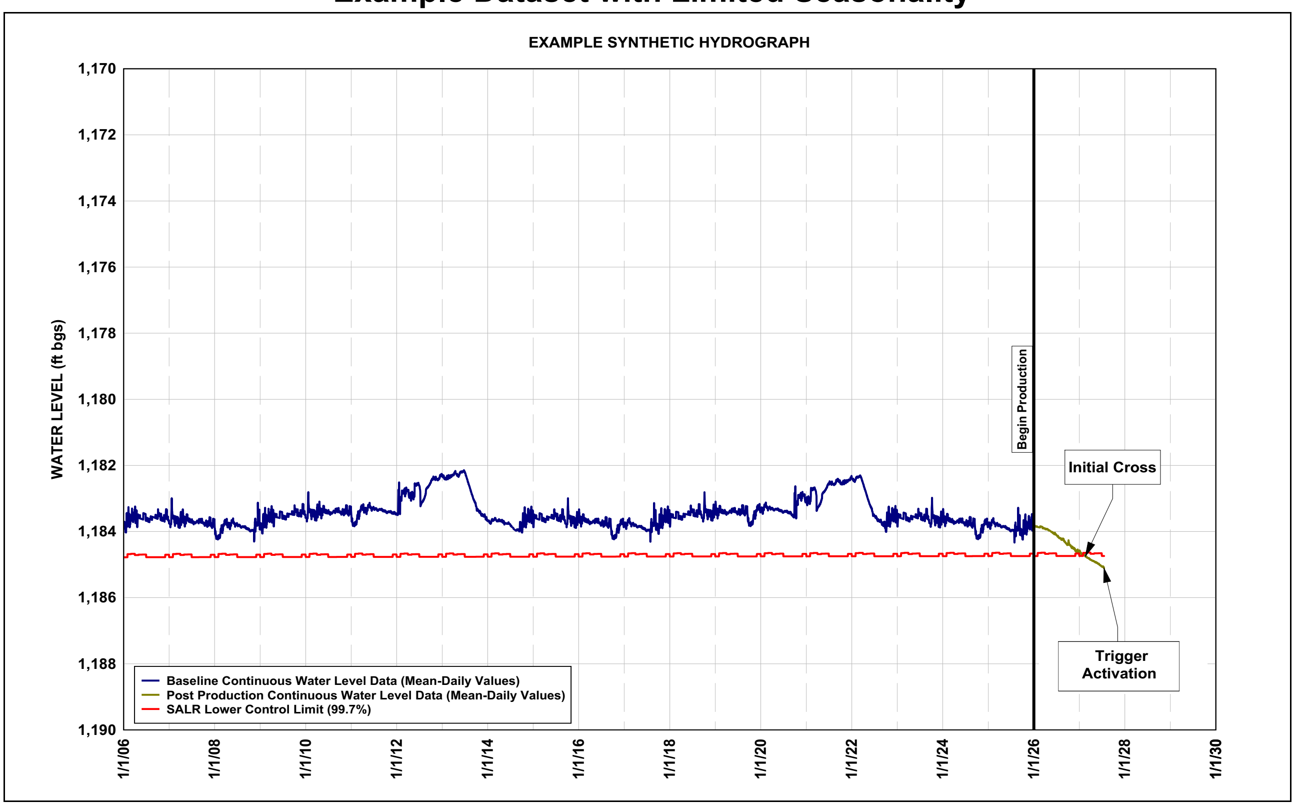

Figure A-4
Example of Trigger Activation - Weak Seasonality

Appendix B

Domestic Wells and Well Logs in the Project Basins and Senior Water Rights in Southern White River and Pahranagat Valleys

Table B-1
Domestic Water Wells
(Page 1 of 2)

Well Log No.	Construction End Date	Hole Depth (ft)	Cased To (ft)	Static Water Level (ft bls)[a]	Geographic Location	Distance to Nearest POD[b] (mi)	DEM Elevation[c] (ft amsl)	Management Category[d]
Cave Valley (HA 180)								
71199	04/24/1998	140	140	91	Alluvial Fan	23.5	7,000	E
104299	09/14/2007	400	400	240	Alluvial Fan	14.7	6,480	E
105365	12/19/2006	748	748	250	Alluvial Fan	15.7	6,600	E
Spring Valley (HA 184)								
Management Block 2								
1452	08/28/1950	317	187	6	Valley Floor	8.0	5,580	B
3207	10/05/1955	45	45	15	Mountain Block / Alluvial Fan	4.6	6,530	B
10216	08/10/1968	452	452	102	Alluvial Fan	2.9	6,150	A
16633	06/04/1977	294	294	250	Alluvial Fan	0.7	5,890	A
21278	06/18/1980	120	120	25	Valley Floor	1.5	5,720	A
76375	06/29/1999	168	168	24	Mountain Block / Alluvial Fan	3.3	6,600	B
76376	06/29/1999	265	265	167	Mountain Block / Alluvial Fan	3.6	6,810	B
81770	09/07/2000	123	123	39	Mountain Block / Alluvial Fan	3.6	6,620	B
98402	11/10/2005	203	203	102	Mountain Block / Alluvial Fan	4.4	6,950	B
100565	06/16/2006	215	215	58	Alluvial Fan	2.5	5,790	A
101457	09/11/2006	190	190	10	Valley Floor	0.8	5,720	A
107076	08/28/2008	320	320	86	Mountain Block / Alluvial Fan	4.3	6,960	B

Table B-1
Domestic Water Wells
(Page 2 of 2)

Well Log No.	Construction End Date	Hole Depth (ft)	Cased To (ft)	Static Water Level (ft bls)[a]	Geographic Location	Distance to Nearest POD[b] (mi)	DEM Elevation[c] (ft amsl)	Management Category[d]
Management Block 3								
12584	08/26/1972	100	100	Flowing	Alluvial Fan	10.2	5,710	C
63014	06/03/1996	125	125	21	Valley Floor	11.6	5,620	C
94786	06/21/2004	120	120	Flowing	Alluvial Fan	10.2	5,710	C
Management Block 4								
20404	09/25/1979	111	108	Flowing	Valley Floor	21.8	5,660	C
108832	09/04/2009	420	420	315	Alluvial Fan	30.1	5,960	C
Management Block 5								
114077	06/15/2011	220	220	25	Valley Floor	46.1	6,360	C
Snake Valley (HA 195)								
67360	04/27/1997	400	400	28	Valley Floor	21.3	5,470	D
67897	06/02/1997	120	120	52	Alluvial Fan	26.7	6,270	D

[a]Static water level at the time of drilling.
[b]Rounded to the nearest tenth of a mile.
[c]Rounded to the nearest ten feet.
[d]See Section 3.2.5 for a detailed explanation of the Management Categories; A - Senior water right < 3 miles from the closest SNWA GDP POD, B - Senior water right 3 to 10 miles from the closest SNWA GDP POD, C - Distant senior water right >10 miles from SNWA GDP POD, and is within the same basin, D - Senior water right site located in a hydrographic area adjacent to SNWA GDP basins, E - Senior water right site not in hydraulic connection with SNWA GDP producing aquifer in which SNWA GDP production wells will be installed.

Table B-2
Water Rights within Southern White River Valley Senior to SNWA GDP Permits
(Page 1 of 2)

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Management Category[d]
2661	CER	STR	IRR	1913	0	3,330.0[e]	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
3232	CER	STR	IRR	1915	1.929	817.4[e]	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
3235	CER	STR	IRR	1915	1.222	443.0[e]	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
4818	CER	STR	IRR	1918	0.816	297.3[e]	HOLMGREN DAIRY, LLC	Alluvial Fan	D
5486	CER	OSW	IRR	1919	1.537	370.0[e]	JENSEN, BRUCE A.	Valley Floor	D
7979	CER	SPR	STK	1927	0.156	65.1*[,e]	JENSEN, BRUCE A.	Valley Floor	D
12517	CER	STR	IRR	1948	10	1,853.0	JENSEN, BRUCE A.	Valley Floor	D
13341	CER	UG	STK	1950	0.008	4.0*[,e]	JENSEN, Pamela G.	Alluvial Fan	D
13760	CER	SPR	IRR	1945	5	1,513.0[e]	GURLEY, JOHN E. & RUTH A.	Valley Floor	D
19294	CER	SPR	IRR	1960	0.096	53.0	HOLMGREN DAIRY, LLC	Valley Floor	D
20329	CER	SPR	STK	1962	0.015	11.4*	HOLMGREN DAIRY, LLC	Valley Floor	D
20465	CER	STR	IRR	1962	0	680.0[e]	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
20466	CER	STR	WLD	1962	0	3,040.0	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
20797	CER	UG	IRD	1962	4.45	360.0	HOWARD, MRS. LOUISE E.	Valley Floor	D
20819	CER	STR	IRR	1962	0	507.0	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
22882	CER	SPR	STK	1965	0.015	10.8*	JENSEN, BRUCE A.	Valley Floor	D
23590	CER	UG	IRR	1967	2.67	432.0	HOWARD, LOUISE	Valley Floor	D
23624	CER	STR	WLD	1967	2.403*	1,120.0[e]	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
28206	CER	SPR	IRR	1974	0.671	268.0	JENSEN, BRUCE A.	Alluvial Fan	D
28207	CER	SPR	IRR	1974	0.41	132.6	JENSEN, BRUCE A.	Valley Floor	D
28208	CER	SPR	IRR	1974	1.279	824.0	JENSEN, BRUCE A.	Alluvial Fan	D
28209	CER	SPR	IRR	1974	2.150	1,556.5	JENSEN, BRUCE A.	Valley Floor	D
38205	CER	STR	WLD	1979	80	1,230.0	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D

Table B-2
Water Rights within Southern White River Valley Senior to SNWA GDP Permits
(Page 2 of 2)

App No.	Status[a]	Source[b]	Manner of Use[c]	Priority Date	Diversion Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Management Category[d]
49476	CER	SPR	QM	1985	0.022	1.8	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
V00801	VST	STR	IRR	1891	0	0.0*	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
V01351	VST	STR	IRR	1885	0	11,600.0*	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
V02091	VST	SPR	STK	1893	0.25	7.4*[,e]	JENSEN, BRUCE A.	Valley Floor	D
V02092	VST	SPR	IRR	1902	1	24.4*[,e]	JENSEN, Pamela G.	Valley Floor	D
V02232	VST	OSW	STK	1904	0.25	75.4*[,e]	JENSEN, BRUCE A.	Valley Floor	D
V02429	VST	OSW	STK	1904	5	11.2*[,e]	JENSEN, BRUCE A.	Valley Floor	D
V04605	VST	STR	IRR	1880	7.69	2,206.4	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
V09237	VST	SPR	STK	1887	0.01	4.74[f]	WHEELER FAMILY TRUST	Alluvial Fan	D
V10515	VST	STR	IRR	1874	4.16[f]	1,107.60[f]	JENSEN, BRUCE A. AND PAMELA G.	Valley Floor	D

[a]CER - Certified, VST - Vested
[b]OSW - Other Surface Water, SPR - Spring, STR - Stream, UG - Underground
[c]IRD - Irrigation Desert Land Entry, IRR - Irrigation, QM - Quasi-municipal, STK - Stock watering, WLD - Wildlife
[d]See Section 3.2.5 for a detailed explanation of the Management Categories; D - Resource in adjacent hydrographic area,
[e]Acre-ft per season.
[f]Reported number was derived from an analysis documented in Stanka (2017).
*The reported annual duty is not explicitly documented on the certificate or vested claim, but reported as such by the NDWR Hydrographic Abstract query.

Table B-3
Water Rights within Pahranagat Valley Senior to SNWA GDP Permits
(Page 1 of 4)

App No.	Status[a]	Source[b]	Use[c]	Priority Date	Div Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Management Category[d]
878	CER	LAK	IRR	1908	0.105	0.0*[,e]	RICHARD, JOHN W.	Valley Floor	D
3387	CER	STR	IRR	1915	0.11	44	HIGBEE, JOE V.	Valley Floor	D
3755	CER	SPR	IRR	1915	0.091	43.7[e]	KOYEN, CHRISTIAN AUGUST	Valley Floor	D
3806	CER	SPR	STK	1916	0.025	18.0*	RYAN, JAMES	Alluvial Fan	D
11478	CER	LAK	IRR	1946	0	211.6	RICHARD, J.W.	Valley Floor	D
12882	CER	SPR	IRR	1929	6.72	2,400.0[e]	HIKO IRRIGATION & WATER COMPANY	Valley Floor	D
12898	CER	UG	DOM	1949	0.133	96.3*	ALAMO SEWER AND WATER G.I.D.	Alluvial Fan	D
19475	CER	UG	IRR	1961	0.8	73.5	SCHOFIELD, FREEDA M. JR.	Alluvial Fan	D
20234	PER	SPR	IRR	1962	18.14	0.0*	USFWS	Valley Floor	D
20544	CER	SPR	IRR	1962	3	2,171.4	HIKO IRRIGATION & WATER CO.	Valley Floor	D
23730A01	CER	SPR	QM	1885	0.015	8.2[e]	Dimick, Orlando Ephriam Trustee	Valley Floor	D
23730A02	CER	SPR	QM	1885	0.005	3.0[e]	REED, INC.	Valley Floor	D
25906	CER	UG	IRR	1971	1.11	405.0[e]	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
25907	CER	UG	WLD	1971	1.11	407.3*[,e]	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
25913	CER	UG	IRR	1966	0.74	270.0[e]	NEVADA-DEPARTMENT OF WILDLIFE	Valley Floor	D
26007	CER	SPR	IRR	1971	0.382	152.8[e]	GERTRUDE NELSON TRUST	Valley Floor	D
26638	CER	UG	IRR	1972	2.236	465.0	CRAIG L. TURLEY & ANNETTE H. TURLEY, HUSBAND AND WIFE AS JTWROS	Valley Floor	D
28296	CER	UG	IRR	1974	0.53	149.3	GIFFORD, OMER	Valley Floor	D
28599	CER	STR	IRR	1974	1.898	759.2	KENT WHIPPLE RANCH LLC	Valley Floor	D
30162	PER	UG	QM	1989	2	560.1	ALAMO SEWER AND WATER G.I.D.	Alluvial Fan	D
32354	CER	UG	IRR	1960	0.693	289.3	HIKO PROPERTIES, LLC	Alluvial Fan	D
35054	CER	UG	IRR	1978	0.867	283.4	Whipple, Keith Murray	Alluvial Fan	D
35055	CER	UG	IRR	1978	0.446	106.7	WHIPPLE, KEITH MURRAY	Alluvial Fan	D
35453	CER	UG	IRR	1978	0.5	140.0	HIGBEE, EVELYN Y	Valley Floor	D
35739	CER	UG	IRR	1978	0.1	66.8	WADSWORTH, CHARLES E. JR.	Alluvial Fan	D
45452	CER	SPR	QM	1982	0.06	3.0[e]	BARKER, JOSEPH & ANDREA	Valley Floor	D
45759	CER	UG	IRR	1982	0.2	144.8	BARLOW 1978 TRUST & BUNKER, W & S	Valley Floor	D

Table B-3
Water Rights within Pahranagat Valley Senior to SNWA GDP Permits
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App No.	Status[a]	Source[b]	Use[c]	Priority Date	Div Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Management Category[d]
45761	CER	UG	STK	1982	0.003	2.2*	LDS	Alluvial Fan	D
45908	PER	UG	MUN	1982	2	184.8	ALAMO SEWER AND WATER G.I.D.	Valley Floor	D
45909	PER	UG	MUN	1979	3	291.2	ALAMO SEWER AND WATER G.I.D.	Valley Floor	D
48333	CER	UG	IRR	1978	0.191	54.5	PHYLLIS M. FRIAS MANAGEMENT TRUST, PHYLLIS M. FRIAS TRUSTEE	Valley Floor	D
48913	CER	UG	IRR	1985	0.125	17.3	SPENCER, ISAAC T.	Valley Floor	D
52013	CER	UG	IRR	1982	0.2	144.8	BARLOW 1978 TRUST & BUNKER, W & S	Valley Floor	D
53698	CER	UG	IRR	1989	0.05	25.0	LANGE, RUSSELL	Alluvial Fan	D
54514	PER	UG	QM	1989	2	560.1	ALAMO SEWER AND WATER G.I.D.	Valley Floor	D
59308	CER	UG	STK	1988	0.011	7.9*	LDS	Alluvial Fan	D
62434	PER	SPR	WLD	1970	6.634	1,514.4	USFWS	Valley Floor	D
62435	PER	LAK	WLD	1908	1.517	460.4	USFWS	Valley Floor	D
62436	PER	SPR	WLD	1928	1.1	795.0	USFWS	Valley Floor	D
62437	PER	LAK	WLD	1946	1.01	729.6	USFWS	Valley Floor	D
62438	PER	LAK	WLD	1946	1.64	1,186.0	USFWS	Valley Floor	D
62439	PER	UG	WLD	1972	1.327	960.9	USFWS	Valley Floor	D
62440	PER	UG	WLD	1970	1	723.8	USFWS	Valley Floor	D
70990	PER	UG	IRR	1960	0.446	0.0*	HIKO PROPERTIES, LLC	Alluvial Fan	D
72770	PER	UG	IRR	1978	0.394	13.4	HIKO PROPERTIES, LLC	Alluvial Fan	D
72771	PER	UG	IRR	1960	0.021	5.2	HIKO PROPERTIES, LLC	Alluvial Fan	D
72772	PER	UG	IRR	1978	0.293	95.6	HIKO PROPERTIES, LLC	Alluvial Fan	D
74652	PER	UG	IRR	1972	0.021	4.3	JENSEN, KARLA R.	Valley Floor	D
74653	PER	UG	IRR	1972	0.058	12.0	JENSEN, KARLA R.	Alluvial Fan	D
78099	PER	UG	COM	1978	0.046	13.0	PHYLLIS FRIAS MANAGEMENT TRUST	Valley Floor	D
79197	PER	UG	IRR	1972	0.18	37.5	CASTANEDA, VERONA	Valley Floor	D
79484	CER	UG	IRR	1949	1.973	364.9	STEWART-NEVADA ENTERPRISES LLC	Alluvial Fan	D
79485	CER	UG	IRR	1950	0.257	62.9	STEWART-NEVADA ENTERPRISES LLC	Alluvial Fan	D
79486	CER	UG	IRR	1950	0.89	72.5	STEWART-NEVADA ENTERPRISES LLC	Alluvial Fan	D

Table B-3
Water Rights within Pahranagat Valley Senior to SNWA GDP Permits
(Page 3 of 4)

App No.	Status[a]	Source[b]	Use[c]	Priority Date	Div Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Management Category[d]
79487	CER	UG	IRR	1973	0.89	387.8	STEWART-NEVADA ENTERPRISES LLC	Alluvial Fan	D
79488	CER	UG	IRR	1973	2.01	218.4	STEWART-NEVADA ENTERPRISES LLC	Alluvial Fan	D
79490	CER	UG	IRR	1950	1.674	231.7	STEWART-NEVADA ENTERPRISES LLC	Alluvial Fan	D
80337	PER	UG	QM	1989	2	560.1	ALAMO SEWER AND WATER GID	Alluvial Fan	D
81871	CER	UG	IRR	1973	2.85	584.3	STEWART-NEVADA ENTERPRISES LLC	Alluvial Fan	D
84387	PER	UG	IRR	1974	1.34	600.0	CORPORATION OF THE PRESIDING BISHOP OF THE CHURCH OF JESUS CHRIST OF LATTER-DAY SAINTS	Alluvial Fan	D
84388	PER	UG	IRR	1974	1.11	792.0	CORPORATION OF THE PRESIDING BISHOP OF THE CHURCH OF JESUS CHRIST OF LATTER-DAY SAINTS	Alluvial Fan	D
84389	PER	UG	IRR	1988	0.2	120.2	CORPORATION OF THE PRESIDING BISHOP OF THE CHURCH OF JESUS CHRIST OF LATTER-DAY SAINTS	Alluvial Fan	D
R05992	RES	SPR	OTH	1926	0.002	1.4*	BLM	Valley Floor	D
R05993	RES	SPR	OTH	1926	0.003	2.2*	BLM	Valley Floor	D
V01354	DEC	SPR	IRR	1894	1.659	663.6	SHARP. J.L.	Valley Floor	D
V01362	DEC	SPR	DEC	1882	0.82	304.0	RICHARD J. W.	Valley Floor	D
V01363	DEC	SPR	DEC	1866	0.82	328.0	WEDGE, JOHN W.	Valley Floor	D
V01393	DEC	SPR	DEC	1868	1.09	436.0	RICHARD J. W.	Valley Floor	D
V01394	DEC	SPR	DEC	1875	4.594	1,837.6	KENT WHIPPLE RANCH LLC	Valley Floor	D
V01490	DEC	SPR	DEC	1882	0.595	238.0	RICHARD, LAWRENCE	Valley Floor	D
V01548	DEC	SPR	DEC	1872	3.387	1,259.8	FARMLAND RESERVE, INC.	Valley Floor	D
V01630	DEC	STR	DEC	1872	0.513	184.4	STEWART, RACHEL	Valley Floor	D
V01705	VST	SPR	IRR	1979	4	0.0*	SHARP, J.L.	Valley Floor	D
V01765	DEC	SPR	DEC	1884	1.368	392.8	CASTLES, MARY A.	Valley Floor	D
V01788	DEC	SPR	DEC	1872	0.171	68.4	WRIGHT, MARY E.	Valley Floor	D
V01789	DEC	SPR	DEC	1867	1	400.0	SHARP, J.L.	Valley Floor	D
V01793	DEC	SPR	DEC	1880	5.208	1,194.2	BARKER, JOSEPH AND ANDREA	Valley Floor	D
V01794	DEC	SPR	DEC	1867	6.75	2,295.4	NEVADA ROCK AND SAND COMPANY	Valley Floor	D
V01796	DEC	SPR	DEC	1888	1.347	390.4	NESBITT, EDGAR	Valley Floor	D

Table B-3
Water Rights within Pahranagat Valley Senior to SNWA GDP Permits
(Page 4 of 4)

App No.	Status[a]	Source[b]	Use[c]	Priority Date	Div Rate (cfs)	Annual Duty (afa)	Owner of Record	Geographic Location	Management Category[d]
V01797	DEC	SPR	DEC	1872	0.1	40.0	CASTLES, JAMES	Valley Floor	D
V01798	DEC	SPR	DEC	1873	2.715	972.0	SCHOFIELD, W. U AND W. J.	Valley Floor	D
V01799	DEC	SPR	DEC	1877	0.114	45.6	THORNE, W.F.	Valley Floor	D
V01802	DEC	SPR	DEC	1868	5.015	1,873.2	ALAMO IRRIGATION CO. INC.	Valley Floor	D
V01825	DEC	SPR	DEC	1866	5.795	1,541.6	FARMLAND RESERVE, INC.	Valley Floor	D
V03154	VST	UG	STK	1904	0.1	11.9*	BUCKHORN LAND & CATTLE CO. (DBA)	Valley Floor	D
V03155	VST	UG	STK	1904	0.1	11.9*	BUCKHORN LAND & CATTLE CO (DBA)	Valley Floor	D
V03156	VST	LAK	STK	1904	0.1	0.0*	BUCKHORN LAND AND CATTLE CO.(DBA)	Alluvial Fan	D
V03157	VST	LAK	STK	1905	0.1	0.0*	BUCKHORN LAND & CATTLE CO.(DBA)	Valley Floor	D
V03158	VST	LAK	STK	1904	0.1	0.0*	BUCKHORN LAND & CATTLE CO. (DBA)	Valley Floor	D
V03159	VST	LAK	STK	1904	0.1	0.0*	BUCKHORN LAND AND CATTLE CO.(DBA)	Valley Floor	D
V03160	VST	UG	STK	1905	0.1	11.9*	BUCKHORN LAND & CATTLE CO.(DBA)	Valley Floor	D
V03161	VST	UG	STK	1904	0.1	11.9*	LAMB, FLOYD R.	Valley Floor	D
V03162	VST	LAK	STK	1904	0.1	0.0*	BUCKHORN LAND & CATTLE COMPANY (DBA)	Valley Floor	D
V08964	VST	UG	STK	NA	0.001	0.7*	ROBINSON, ELWYN L.	Valley Floor	D
V08965	VST	SPR	IRR	NA	0.022	16.1*	R0BINSON, ELWYN L.	Valley Floor	D

[a]DEC - Decreed, CER - Certificated, PER - Permitted, VST - Vested
[b]LAK - Lake, SPR - Spring, STR - Stream, UG - Underground
[c]COM - Commercial, DOM - Domestic, DEC - As Decreed, IRR - Irrigation, MUN - Municipal, OTH - Other, QM - Quasi-municipal, STK - Stock watering, WLD - Wildlife
[d]See Section 3.2.5 for a detailed explanation of the Management Categories; D - Resource in adjacent hydrographic area.
[e]Acre-ft per season.
*The reported annual duty is not explicitly documented on the certificate, permit, or vested claim, but reported as such by the NDWR Hydrographic Abstract query.
NA - Not Available

B.0.1 Well Driller's Reports for Senior Water Rights

Well driller's reports for senior, underground water rights were identified for the following hydrographic areas: Dry Lake Valley, Spring Valley, and Hamlin Valley. The well driller's reports are organized by hydrographic area number and then by water-right application number. The following bulleted list documents the water right application number and well log number for which the well driller's reports are provided:

- HA181 (Dry Lake Valley) - App no. 18756, well log no. 5511
- HA181 (Dry Lake Valley) - App no. 35773, well log no. 39356
- HA184 (Spring Valley/MB1) - App no. 18045, well log no. 5139
- HA184 (Spring Valley/MB1) - App no. 27768, well log no. 15172
- HA184 (Spring Valley/MB2) - App no. 29371, well log no. 10816
- HA184 (Spring Valley/MB2) - App no. 31239, well log no. 17124
- HA184 (Spring Valley/MB4) - App no. 39818, well log no. 35969
- HA184 (Spring Valley/MB4) - App no. 56050, well log no. 1256
- HA184 (Spring Valley/MB4) - App no. 56051, well log no. 20404
- HA196 (Hamlin Valley) - App no. 45499, well log no. 548

WELL LOG AND REPORT TO THE STATE ENGINEER OF NEVADA

Log No. 5511
Rec. Oct. 28, 1960
Well No.
Permit No. 18756
Do not fill in

Owner [illegible] Driller [illegible]

Address [illegible] Address [illegible] Lic. No. [illegible]

Location of well: NE ¼ NW ¼ Sec. 24, T. 1 N, R. 64 E, in [illegible] County

or [illegible]

Water will be used for [illegible] Total depth of well 515

Size of drilled hole [illegible] Weight of casing per linear foot

Thickness of casing [illegible] Temp. of water

Diameter and length of casing 5" 515'
(Casing 12" in diameter and under give inside diameter; casing 12" in diameter give outside diameter.)

If flowing well give flow in c.f.s. or g.p.m. and pressure

If nonflowing well give depth of standing water from surface 328'

If flowing well describe control works
(Type and size of valve, etc.)

Date of commencement of well [illegible] Date of completion of well [illegible]

Type of well rig [illegible]

LOG OF FORMATIONS

From feet	To feet	Thickness feet	Type of material
0	3	3	clay
3	15	12	[illegible]
15	60	45	clay
60	350	290	[illegible]
350	420	70	[illegible] sand
420	428	8	cemented [illegible]
428	515	87	clay

Water-bearing Formation, Casing Perforations, Etc.

Chief aquifer (water-bearing formation)

from [illegible] to [illegible] ft.

Other aquifers

First water at [illegible] feet.

Casing perforated

from [illegible] to [illegible] ft.

Size of perforations

[illegible]

Figure B-1
Dry Lake Valley (HA 181) Well Driller's Report For Log 5511

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 39356
Permit No.
Basin 181

NOTICE OF INTENT NO. 17428

1. OWNER Gyser Ranch Limited
MAILING ADDRESS c/o Kerry Holt
Enterprise, Ut. 84725

ADDRESS AT WELL LOCATION Gyser Ranch
Lake Valley, NV.

2. LOCATION SE ¼ NW ¼ Sec. 20 T 3 N/S R 64 E ast Lincoln County
PERMIT NO. 39773 (Issued by Water Resources) — Parcel No. — Subdivision Name —

3. WORK PERFORMED
☐ New Well ☐ Replace ☐ Recondition
☐ Deepen ☐ Abandon ☒ Other Abandonment

4. PROPOSED USE
☐ Domestic ☐ Irrigation ☐ Test
☐ Municipal/Industrial ☐ Monitor ☒ Stock

5. WELL TYPE
☐ Cable ☐ Rotary ☐ RVC
☐ Air ☐ Other N/A

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Bottom of hole was 300' and dry. Had 2 liners in it 8 5" & a 4". Unable to remove casing and unable to perforate below 150'. Cement was placed in the well from bottom up. Used 27 bags cement. Casing was terminated 3' below ground level and covered over.				

'92 JUN 29 P2:33
STATE ENGINEERS OFFICE

Date started May 29, 1992
Date completed June 13, 1992

7. WELL TEST DATA
TEST METHOD: ☐ Bailer ☐ Pump ☐ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
N/A		

8. WELL CONSTRUCTION
Depth Drilled N/A Feet Depth Cased ________ Feet

HOLE DIAMETER (BIT SIZE)

	From	To
N/A Inches	Feet	Feet
Inches	Feet	Feet
Inches	Feet	Feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6"		.250	0	N/A

Perforations:
Type perforation N/A
Size perforation
From ______ feet to ______ feet
From ______ feet to ______ feet
From ______ feet to ______ feet
From ______ feet to ______ feet
From ______ feet to ______ feet

Surface Seal: ☐ Yes ☒ No
Depth of Seal
Placement Method: ☐ Pumped ☐ Poured
Seal Type: ☐ Neat Cement ☐ Cement Grout ☐ Concrete Grout

Gravel Packed: ☐ Yes ☐ No
From ______ feet to ______ feet

9. WATER LEVEL
Static water level None feet below land surface
Artesian flow — G.P.M. — P.S.I.
Water temperature — °F Quality —

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.

Name GARDNER DRILLING (Contractor)
Address Box 18 (Contractor)
NEW CASTLE, UT. 84756

Nevada contractor's license number issued by the State Contractor's Board 31759

Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1710

Signed Dale Gardner (By driller performing actual drilling on site or contractor)
Date June 18, 1992

Figure B-2
Dry Lake Valley (HA 181) Well Driller's Report For Log 39356

WELL LOG AND REPORT TO THE STATE ENGINEER OF NEVADA

Log No. 5139
Rec. April 17 1960
Well No.
Permit No. 18045
Do not fill in

I

Owner: Dee Heckethorne — Driller: F. D. Hill

Address: Spring Valley, via Ely, Nev. — Address: Ely, Nevada — Lic. No. 14

Location of well: NW 1/4 SE 1/4 Sec 35, T 11N, R 66E, in White Pine County

or

Water will be used for: Stockwatering — Total depth of well: 240

Size of drilled hole: 6" & 4" — Weight of casing per linear foot: 20#

Thickness of casing: ¼" — Temp. of water:

Diameter and length of casing: 120 ft of 6" and 120 Ft. Of 4"
(Casing 12" in diameter and under give inside diameter; casing 12" in diameter give outside diameter.)

If flowing well give flow in c.f.s. or g.p.m. and pressure: 5 gals per minute

If nonflowing well give depth of standing water from surface:

If flowing well describe control works:
(Type and size of valve, etc.)

Date of commencement of well: April 8 — Date of completion of well: April 16, 1959

Type of well rig: Churn drill

LOG OF FORMATIONS

From feet	To feet	Thickness feet	Type of material
0	220	220	Clay
220	221	1	Sand
221	238	17	Clay
238	240	2	Sand

OFFICE STATE ENGINEER
1960 APR 18 AM 10 06

Water-bearing Formation, Casing Perforations, Etc.

Chief aquifer (water-bearing formation)
from 238 to 240 ft.

Other aquifers: Smaal amount of water in clay all the way down

First water at 10 feet.

Casing perforated
from 220 to 240 ft.

Size of perforations
¼" x 6

(OVER)

919

Figure B-3
Spring Valley Management Block 1 Well Driller's Report For Log 5139

Log No. 15172
Permit 27768

Form 7420–1 (September 1970)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

WELL RECORD

Township	12 N
Range	67 E
Section	Sec 2 — SW ¼ NE ¼
District	Ely
State	Nevada
County	White Pine

1. Job Number: 4067
2. Job Name: Shoshone Fish Pond Well
3. Name of Site: Shoshone
4. Site selected by: Donald Cain — Date: 7-2-69
5. Driller (name): Cecil M. Stephenson — Address (include zip code): Holden, Utah
6. Type of drilling rig used: Churn Drill
7. Date well started: 7-7-71 — Completed: 10-24-71
8. Topographic setting (in valley, on hill, etc.): Flat
9. Altitude of land surface (ft): 5790 — Determined by: USGS, Wheeler Peak Quadrangle, Nevada, White Pine Co. 1:62500, 15 minute series (topographic) 40 ft. Contour interval
10. Total depth (ft below): 441 — [X] Land surface [ ] Top of casing
11. Static water level (ft below): N.A. — [ ] Land surface [ ] Top of casing
12. Aquifer(s) and depths: 27 to 162 feet, gravel & sand; 170 to 383 feet, gravel & sand; 385 to 441 feet sand
13. Shut-in pressure (flowing well, psi): 21 PSI — Determined by: Gauge
14. Yield (gpm): 25 — after (hrs) — [ ] Pumping [ ] Bailing [X] Flowing
15. Drawdown: N.A. — feet — after (hrs) — discharging at (gpm)
16. Quality of water: color Clear — taste Poor — odor – — hardness –
17. Casing: Distance top [ ] above [ ] below land surface (ft)
    Type perf 0.040" — Diam. (in) — Weight (ft) — Depth (ft) — to (ft)
    Type Standard Black Steel — Diam. (in) 8 — Weight (ft) — Depth (ft) 0 — to (ft) 421
18. Perforations: Type None — Spacing — Size — Depth (ft) 421 — to (ft) 441
    Well equipped with 20 ft. screen
19. Pump: N.A. — Type
20. Information obtained from (name): Cecil M. Stephenson — Date: 10-25-71
21. Remarks: Well is equipped with 20 feet of screen manufactured by the Cook Well Strainer Company, it is set from 421 feet to 441 feet. The well is grouted on the outside of the 8 inch casing from the surface to 50 feet deep.

(Instructions on reverse)

Figure B-4
Spring Valley Management Block 1 Well Driller's Report for Log 15172

DIVISION OF WATER RESOURCES

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLERS REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No. 10816
Permit No. 23556
Basin Spring Valley

29371, 29567

1. OWNER Ace Turner + Rex L. Frandsen ADDRESS Rt. 4 Box 142
Blackfoot, Idaho 83221

2. LOCATION SW ¼ SW ¼ Sec. 22 T. 14 N/S R. 67 E. White Pine County
PERMIT NO. 23556

3. TYPE OF WORK
New Well ☒ Recondition ☐
Deepen ☐ Other ☐

4. PROPOSED USE
Domestic ☐ Irrigation ☐ Test ☐
Municipal ☐ Industrial ☒ Mine Stock ☐

5. TYPE WELL
Cable ☒ Rotary ☐
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Clay Large Rocks.	No	0	20	20
Clay Small Rocks	No	20	40	20
Clay + Gravel	No	40	50	10
Clay + Mostly Gravel	Yes	50	64	14
First Water	Yes		64	
Clay + Rock	Yes	64	70	6
" "	Yes	70	80	10
" "	Little	80	90	10
Clay, small gravel	Yes	90	105	15
105-238 Drilled Aug 1969				
Clay, gravel water	Little	105	140	35
Drilled Through big		140	155	15
Limestone rock. Couldn't				
Drive 16" Casing,				
Reduced to 14"				
Clay, gravel	Little	155	209	54
Clay gravel	Yes	209	220	11
~~Fine Gravel wc Clay~~	No	220	225	5
Fine gravel water	Yes	225	235	10
Bed Rock	No	235	238	03

Date started Aug 15, 1969
Date completed Aug 30, 1969

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump

BAILER TEST
G.P.M. 1000 + Draw down ....feet ....hours
G.P.M. .... Draw down ....feet ....hours
G.P.M. .... Draw down ....feet ....hours

8. WELL CONSTRUCTION
Diameter hole 16"-14" inches Total depth 238 feet
Casing record
Weight per foot .... Thickness 1/4

Diameter	From	To
16 inches	0 feet	150 feet
14 inches	140 feet	235 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☐ No ☐ Type........
Depth of seal........feet
Gravel packed: Yes ☐ No ☐
Gravel packed from........feet to........feet

Perforations:
Type perforation Torch cut
Size perforation 1/4 x 12
From 60 feet to 235 feet
From........feet to........feet
From........feet to........feet
From........feet to........feet
From........feet to........feet

9. WATER LEVEL
Static water level........Feet below land surface........
Flow........G.P.M........
Water temperature........° F. Quality........

10. DRILLERS CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.

Name REX L Frandsen
Address Rt 4 Box 142
Blackfoot Idaho.
Nevada contractor's license number........
Nevada driller's license number........
Signed........
Date........

Information from file in 23556 filed New 12-2-69 1969

USE ADDITIONAL SHEETS IF NECESSARY

Figure B-5
Spring Valley Management Block 2 Well Driller's Report for Log 10816

DIVISION OF WATER RESOURCES

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLERS REPORT

Please complete this form in its entirety

31239

OFFICE USE ONLY
Log No. 17124
Permit No. 31239
Basin

1. OWNER CLARK Mining Corp. ADDRESS PO Box 418
Ely, NV 89301

2. LOCATION NW ¼ [illegible] ¼ Sec. 15 T. 14 N R. 67 E. White Pine County
PERMIT NO. SE

3. TYPE OF WORK: New Well ☐ Reconditioning ☐ Deepen ☒ Other ☐

4. PROPOSED USE: Domestic ☒ Irrigation ☐ Test ☐ Municipal ☐ Industrial ☒ Stock ☐

5. TYPE WELL: Cable ☒ Rotary ☐ Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Silt & Gravel		294	361	67
Sand	✓	361	363	2
Silt & Gravel		363	385	22
Large Gravel & Silt		385	397	12
Silt & Sand		397	505	108
Sand	✓	505	506	1
Silt & Gravel		506	527	21
Gravel	✓	527	528	1
Silt & Sand		528	535	7

Date started Aug 21, 1977
Date completed Sept 6, 1977

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump

BAILER TEST

G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours

8. WELL CONSTRUCTION

Diameter hole 8" inches Total depth 535 feet
Casing record CASED TO 397'
Weight per foot .... Thickness .250
Galvanized [illegible] 11477

Diameter	From	To
8 inches	0 feet	397 feet

Surface seal: Yes ☒ No ☐ Type CEMENT
Depth of seal 6" IN BASEMENT feet
Gravel packed: Yes ☐ No ☒
Gravel packed from .... feet to .... feet

Perforations: UNKNOWN – No
Type perforation
Size perforation PERFORATIONS IN
From LAST feet to .... feet
From 103' ADDED feet to .... feet
From TO TOP feet to .... feet

9. WATER LEVEL

Static water level 231' Feet below land surface
Flow .... G.P.M.
Water temperature .... ° F. Quality ....

10. DRILLERS CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Brent Eldridge
Address SR 1 Box 42 Ely, NV
Nevada contractor's license number 7514A
Nevada driller's license number 844
Signed Brent Eldridge
Date Sept 8, 1977

USE ADDITIONAL SHEETS IF NECESSARY 5471

Figure B-6
Spring Valley Management Block 2 Well Driller's Report for Log 17124

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No. 35969
Permit No.
Basin 184

PRINT OR TYPE ONLY

NOTICE OF INTENT NO. 11772

1. OWNER Geo. Eldridge & Son, Inc
MAILING ADDRESS SR 1 Box 42
Ely, Nv

ADDRESS AT WELL LOCATION N. Spring Valley
Ely, Nv 89301

2. LOCATION SE ¼ SE ¼ Sec. 24 T. 18 N/S R. 66 E White Pine County

PERMIT NO. 39818
Issued by Water Resources | Parcel No. | Subdivision Name

3. TYPE OF WORK
New Well ☒ Recondition ☐ Deepen ☐ Other ☐

4. PROPOSED USE
Domestic ☐ Irrigation ☒ Test ☐ Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☒ Rotary ☐ Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Topsoil		0	2'	2'
Gravel		2'	7'	5'
Clay		7'	12'	5'
Gravel	X	12'	14'	2'
Clay		14'	28'	14'
Gravel	X	28'	30'	2'
Clay		30'	38'	8'
Gravel	X	38'	42'	4'
Clay		42'	50'	8'
Gravel	X	50'	58'	8'
Clay		58'	64'	6'
Gravel	X	64'	70'	6'
Clay		70'	95'	25'
Gravel	X	95'	97'	2'
Clay / Hardpan		97'	123'	26'
Gravel	X	123'	125'	2'
Hardpan		125'	127'	2'
Quicksand	X	127'	132'	5'
Clay		132'	168'	36'
Gravel	X	168'	170'	2'
Hardpan		170'	172'	2'
Clay		172'	182'	10'
Gravel	X	182'	187'	5'
Clay		187'	211'	24'
Gravel	X	211'	220'	9'

Date started 2-20, 1991
Date completed 3-18, 1991

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump

BAILER TEST
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours

8. WELL CONSTRUCTION
Diameter 16-24 inches Total depth 220 feet
.... inches 22" to 24" from
.... inches surface to 60'.
Casing record
Weight per foot .... Thickness .250"

Diameter	From	To
16 inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type Cement
Depth of seal 51' feet
Gravel packed: Yes ☐ No ☒
Gravel packed from — feet to — feet

Perforations:
Type perforation Torch, & Perforator
Size perforation 1/4" X 3"
From 38 feet to 210 feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet

9. WATER LEVEL
Static water level Flows ~~feet below land surface~~
Flow 30 G.P.M. .... P.S.I.
Water temperature 52 °F Quality Delicious

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name Delbert D. Eldridge Drilling
Contractor
Address SR 1 Box 42 AA
Contractor
Nevada contractor's license number issued by the State Contractor's Board 7514 A
Nevada contractor's driller's number issued by the Division of Water Resources ~~844~~ ?
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 844
Signed Brent Eldridge
By driller performing actual drilling on site or contractor
Date 4-15-91

(Rev. 11-85) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-7
Spring Valley Management Block 4 Well Driller's Report for Log 35969

WELL LOG AND REPORT TO THE STATE ENGINEER OF NEVADA

Log No. 1256
Rec. 3/21 1950
Well No.
Permit No.
Do not fill in

(Delbert?)

Owner George Eldridge Driller Arthur Lopez

Address McGill Nevada Address Ely Lic. No. 14

Location of well: ¼ NE¼ Sec. 31, T. 18 N/S, R. 68 E, in White Pine County

or on 8 mile ranch on East Side Spring valley

Water will be used for irradation Total depth of well 460

Size of drilled hole 6" Weight of casing per linear foot 28

Thickness of casing 1/4 Temp. of water

Diameter and length of casing 6 - 330
(Casing 12" in diameter and under give inside diameter; casing 12" in diameter give outside diameter.)

If flowing well give flow in c.f.s. or g.p.m. and pressure

If nonflowing well give depth of standing water from surface 40

If flowing well describe control works
(Type and size of valve, etc.)

Date of commencement of well Jan 2 Date of completion of well Feb - 18

Type of well rig Churm

LOG OF FORMATIONS

From feet	To feet	Thickness feet	Type of material
220	460		Cemented Quartz Bolders. this well Has been Drilled Serval year to 220. feet with 100 feet of 10. I. D. pipe set ~~at 100 feet~~

Water-bearing Formation, Casing Perforations, Etc.

Chief aquifer (water-bearing formation)

from .... to .... ft.

Other aquifers
[illegible] water aquafers unknown

First water at .... feet.

Casing perforated
from 100 to 330 ft.

Size of perforations
1/4 x 3"

(OVER)

Figure B-8
Spring Valley Management Block 4 Well Driller's Report for Log 1256

DIVISION OF WATER RESOURCES

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLERS REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No. 20404
Permit No.
Basin

1. OWNER Geo. Eldridge & Son, Inc. ADDRESS SR 1 Box 42, Ely NV 89301

2. LOCATION SE ¼ SE ¼ Sec. 26 T. 19 N R. 66 E. White Pine County
PERMIT NO.

3. TYPE OF WORK
New Well ☒ Recondition ☐
Deepen ☐ Other ☐

4. PROPOSED USE
Domestic ☒ Irrigation ☒ Test ☐
Municipal ☐ Industrial ☐ Stock ☒

5. TYPE WELL
Cable ☒ Rotary ☐
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Silt		0	2	2
Sand & Gravel	✓	2	6	4
Clay & Sand		6	10	4
Silt & Boulders		10	24	14
Sand & Gravel	✓	24	28	4
Silt & Sand		28	77	49
Sand & Gravel	✓	77	80	3
Silt & Gravel		80	82	2
Gravel	✓	82	89	7
Silt		89	94	5
Gravel	✓	94	98	4
Silt		98	103	5
Gravel	✓	103	107	4
Silt		107	111	4

Date started (Card Filed) Fall, 19 78
Date completed Sept 25, 19 79

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
No test			

BAILER TEST
G.P.M. 7 Draw down 2 feet ½ hours
G.P.M. Draw down feet hours
G.P.M. Draw down feet hours

8. WELL CONSTRUCTION
Diameter hole 9 inches Total depth 111 feet
Casing record 108'
Weight per foot Thickness .250"

Diameter	From	To
8 inches	0 feet	108 feet

Surface seal: Yes ☒ No ☐ Type Cement
Depth of seal 50 feet
Gravel packed: Yes ☐ No ☒
Gravel packed from feet to feet

Perforations:
Type perforation Acet. Torch
Size perforation 3/16" x 4"
From 83 feet to 108 feet

9. WATER LEVEL
Static water level One Feet above land surface
Flow ± Five G.P.M. May - Oct
Water temperature Cold Quality Unknown

10. DRILLERS CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Brent Eldridge
Address SR 1 Box 42 Ely, NV
Nevada contractor's license number 7514A
Nevada driller's license number 844
Signed [signature]
Date 10-12-79

USE ADDITIONAL SHEETS IF NECESSARY 5471

Figure B-9
Spring Valley Management Block 4 Well Driller's Report for Log 20404

WELL LOG AND REPORT TO THE STATE ENGINEER OF NEVADA

Project No. 2-C-175
Monument Well

Log No.	548
Rec.	7/5 1948
Well No.	
Permit No.	

Do not fill in

Owner: BUREAU OF LAND MANAGEMENT, 100 OLD MINT BLDG., 5TH & MISSION STS.
Address: SAN FRANCISCO 3, CALIFORNIA

Driller: Dennis Smith
Address: Garrison, Utah   Lic. No.

Location of well: NW ¼ NE ¼ Sec. 6, T. 8 N/~~S~~ R. 70 E, in Lincoln County
or Grazing Dist. N-4

Water will be used for Stock watering   Total depth of well 164'

Size of drilled hole 6"   Weight of casing per linear foot

Thickness of casing Standard   Temp. of water

Diameter and length of casing 6" – 164'
(Casing 12" in diameter and under give inside diameter; casing 12" in diameter give outside diameter.)

If flowing well give flow in c.f.s. or g.p.m. and pressure

If nonflowing well give depth of standing water from surface ~~152~~ 92'

If flowing well describe control works
(Type and size of valve, etc.)

Date of commencement of well 6/19/1947   Date of completion of well ~~1947~~ 7/22/47

Type of well rig Solid tool

LOG OF FORMATIONS

From feet	To feet	Thickness feet	Type of material
0	85	85	Cemented, sandy clay
85	152	67	Soft sandy clay
152	164	12	Sand, water bearing

Water-bearing Formation, Casing Perforations, Etc.

Chief aquifer (water-bearing formation)
from 152 to 164 ft.

Other aquifers first water at 111 feet.

First water at ~~152~~ 111 feet.

Casing perforated
from ~~152'~~ 111' to ~~164'~~ 115' ft.

Size of perforations
3/8 X 3"
4 perforations to a row, rows one foot apart

Figure B-10
Hamlin Valley Well Driller's Report for Log 548 (Monument Well), Page 1

LOG OF FORMATIONS—*Continued*

From feet	To feet	Thickness	Type of material

CASING RECORD

Diam. casing	From feet	To feet	Length	"Remarks"—Seals, Grouting, Etc.
6"	0	164	164	

GENERAL INFORMATION—Pumping Test, Quality of Water, Etc.

Well pumped 5 gal per minute for 100 hours

Well equipped with windmill & gas engine, storage tank and watering troughs.

WELL DRILLERS STATEMENT

This well was drilled under my jurisdiction and the above information is true to my best information and belief.

Signed..
Well Driller

By..

License No............................

Dated..., 194.....

(Not to be filled in by Driller)

Figure B-11
Hamlin Valley Well Driller's Report for Log 548 (Monument Well), Page 2

B.0.2 Well Driller's Reports for Domestic Wells

Well driller's reports for domestic wells were obtained for the following hydrographic areas: Cave Valley, Spring Valley, and Snake Valley. The well driller's reports are organized by hydrographic area number and then by well log number. The following bulleted list documents the domestic wells for which well driller's reports are provided:

- HA180 (Cave Valley) - Well log no. 71199
- HA180 (Cave Valley) - Well log no. 104299
- HA180 (Cave Valley) - Well log no. 105365
- HA184 (Spring Valley/MB2) - Well log no. 1452
- HA184 (Spring Valley/MB2) - Well log no. 3207
- HA184 (Spring Valley/MB2) - Well log no. 10216
- HA184 (Spring Valley/MB2) - Well log no. 16633
- HA184 (Spring Valley/MB2) - Well log no. 21278
- HA184 (Spring Valley/MB2) - Well log no. 76376
- HA184 (Spring Valley/MB2) - Well log no. 81770
- HA184 (Spring Valley/MB2) - Well log no. 98402
- HA184 (Spring Valley/MB2) - Well log no. 100565
- HA184 (Spring Valley/MB2) - Well log no. 101457
- HA184 (Spring Valley/MB2) - Well log no. 107076
- HA184 (Spring Valley/MB3) - Well log no. 12584
- HA184 (Spring Valley/MB3) - Well log no. 63014
- HA184 (Spring Valley/MB3) - Well log no. 94786
- HA184 (Spring Valley/MB4) - Well log no. 20404
- HA184 (Spring Valley/MB4) - Well log no. 108832
- HA184 (Spring Valley/MB5) - Well log no. 114077
- HA195 (Snake Valley) - Well log no. 67360
- HA195 (Snake Valley) - Well log no. 67897

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 71199
Permit No.
Basin 180

NOTICE OF INTENT NO. 3[illegible]801

1. OWNER Bill Kingston
MAILING ADDRESS 2283 ½ Ault mur
Ely NV 89301

ADDRESS AT WELL LOCATION 172 N. Street Parcell No 3
McGill Hwy.

2. LOCATION SE ¼ SE ¼ Sec 25 T 11 N/S R 63 E White Pine County

PERMIT NO. N/A (Issued by Water Resources) | Parcel No. | none (Subdivision Name)

3. WORK PERFORMED
☒ New Well ☐ Replace ☐ Recondition
☐ Deepen ☐ Abandon ☐ Other

4. PROPOSED USE
☒ Domestic ☐ Irrigation ☐ Test
☐ Municipal/Industrial ☐ Monitor ☐ Stock

5. WELL TYPE
☒ Cable ☐ Rotary ☐ RVC
☐ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Top Soil		0	16"	
gravel cobbles		16"	24'	
clay		24	28	
gravel cobbles		28	44	
clay gravel con.		44	71	
clay		71	73	
clay-gravel conglomerate		73	89	
clay con.		89	91	
gravel con.	water	91	103	
clay con.		103	106	
gravel	water	106	123	
clay con.		123	126	
gravel	water	126	128	
clay con		128	134	
gravel	water	134	135	
clay con		135	140	

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Date started April 4, 1998
Date completed April 24, 1998

7. WELL TEST DATA

TEST METHOD: ☒ Bailer ☐ Pump ☐ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
40	4	1 hr.

8. WELL CONSTRUCTION

Depth Drilled 140 Feet Depth Cased 140 Feet

HOLE DIAMETER (BIT SIZE)

Inches	From (Feet)	To (Feet)
10	0	50
8	50	120
6	120	140

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6 5/8	12.9	.188	-1	140

Perforations:
Type perforation Mill
Size perforation 1/8 x 2.5" x 6 row
From ... feet to ... feet
From 100 feet to 140 feet
From ... feet to ... feet
From ... feet to ... feet
From ... feet to ... feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 50
Placement Method: ☐ Pumped ☒ Poured

Seal Type:
☐ Neat Cement
☐ Cement Grout
☐ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 50 feet to 120 feet

9. WATER LEVEL

Static water level 91 feet below land surface
Artesian flow ... G.P.M. ... P.S.I.
Water temperature cold °F Quality good

10. DRILLER'S CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Nathan R Maynard (Contractor)
Address Po Box 176 Lund N.V. 89317 (Contractor)

Nevada contractor's license number issued by the State Contractor's Board 0022869

Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1556

Signed Oramon Maynard (By driller performing actual drilling on site or contractor)
Date April 30 - 98

(Rev. 3-91) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-12
Cave Valley (HA 180) Driller's Report For Domestic Well Log 71199

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 104299
Permit No.
Basin 180

NOTICE OF INTENT NO. 25354

1. OWNER Bill Mull
MAILING ADDRESS P.O. Box 145
Enterprise, UT 84725
ADDRESS AT WELL LOCATION North Cave Valley

2. LOCATION NE ¼ NW ¼ Sec. 16 T. 9 N/S R. 64 East Lincoln County
PERMIT NO. (Issued by Water Resources) 005-021-06 (Parcel No.) District 5 (Subdivision Name)

3. WORK PERFORMED	4. PROPOSED USE	5. WELL TYPE
☒ New Well ☐ Replace ☐ Recondition ☐ Deepen ☐ Abandon ☐ Other	☒ Domestic ☐ Irrigation ☐ Test ☐ Municipal/Industrial ☐ Monitor ☐ Stock	☐ Cable ☒ Rotary ☐ RVC ☐ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Cobbles, Boulder		0	10	10
Brown Limestone		10	80	70
White Quartzite		80	155	75
Brown Limestone		155	205	50
Pink Limestone		205	230	25
5% Clay, Limestone		230	260	30
Gray Limestone	✓	260	400	140

(from NOI)
N 38° 38' 33.7"
W 114° 47' 57.1" NAD27)

N 38.642694
W 114.799194 NAD27

Date started August 30, 2007
Date complated September 14, 2007

7. WELL TEST DATA

TEST METHOD: ☐ Bailer ☐ Pump ☒ Air Lift

	G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
9-14-07	20	–	1 Hour

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8. WELL CONSTRUCTION

Depth Drilled 400 Feet Depth Cased 400 Feet

HOLE DIAMETER (BIT SIZE)

Inches	From (Feet)	To (Feet)
10	0	400

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6.625	17.02	.250	+ 18"	20
6.625	5.006	.390	20	400

Perforations:
Type perforation Mill
Size perforation 1/8"
From 280 feet to 300 feet
From 320 feet to 340 feet
From 360 feet to 380 feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 100'
Placement Method: ☐ Pumped ☒ Poured
Seal Type: ☐ Neat Cement ☐ Cement Grout ☒ Concrete Grout 3150 lbs.

Gravel Packed: ☒ Yes ☐ No
From 100 feet to 400 feet

9. WATER LEVEL
Static water level 240 feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature 48 °F Quality good

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name Gardner Brothers Drilling, Inc. (Contractor)
Address P.O. Box 965 (Contractor)
Enterprise, UT 84725
Nevada contractor's license number issued by the State Contractor's Board 0068459
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1710
Signed Dale Gardner (By driller performing actual drilling on site or contractor)
Date 9-20-07

(Rev. 12-01) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-13
Cave Valley (HA 180) Driller's Report For Domestic Well Log 104299

WASHOE #

STATE OF NEVADA
DIVISION OF WATER RESOURCES
WELL DRILLER'S REPORT

office use only
Log No. 105365
Permit No. ....
Basin 180

NOTICE OF INTENT NO 57338

1. OWNER Bill McBeth
MAILING ADDRESS 2212 Paiute Meadows
Las Vegas, NV 89134

ADDRESS AT WELL LOCATION Cave Valley Ranch
Latitude N 38.39.619
Longitude W 114.48.450

2. Location SE 1/4 SE 1/4 Sec 5 T 9 N R 64 E Lincoln County
PERMIT NO. PARCEL NO. 012-670-03 SUBDIVISION NAME

3. WORK PERFORMED: X New Well; Replace; Recondition; Deepen; Abandon; Other

4. PROPOSED USE: X Domestic; Irrigation; Test; Municipal/Industrial; Monitor; Stock

5. WELL TYPE: Cable; X Rotary; RVC; Air; Other; X Mud

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Boulder & Sand		0	10	10
Clay		10	17	7
Sand		17	25	8
Cobble		25	173	148
Rock & Clay		173	315	142
Clay & Rock		315	382	67
Clay		382	429	47
Rock & Clay		420	452	32
Rock		452	495	43
Red Rock		495	707	212
Gray Rock		707	748	41

N 38.660372
W 114.806645 NAD27

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8. WELL CONSTRUCTION

Depth Drilled 748 feet Depth Cased 748 feet

HOLE DIAMETER (BIT SIZE)

Diameter	From	To
12 1/4 inches	0 feet	220 feet
10 5/8 inches	220 feet	495 feet
7 7/8 inches	495 feet	748 feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To Feet
8 5/8	16.9	188	+2	495
6 5/8	12.9	188	488	748

Perforations::
Type Perforation Factory
Size perforation 3/32 x 3
From 135 feet to 495 feet
From 508 feet to 748 feet
From feet to feet
From feet to feet
From feet to feet
From feet to feet

Surface Seal X YES No
Depth of Seal 100 feet
x Pumped
Poured
Seal Type: Neat Cement; X Cement Grout; Concrete Grout

Gravel Packed: x Yes No
From 100 feet to 195 feet

9 WATER LEVEL
Static water level 250 feet below land surface
Artesian flow GPM 0 P.S.I.
Water Temperature Degrees F Quality

Date started 11/14 -06
Date completed 12/19 -06

7. WELL TEST DATA
TEST METHOD: Bailer Pump x Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (hours)
60	400	5
75	500	
100+	600	

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name McKay Drilling, Inc.
4850 Joule St.
Reno, NV 89502
NV Contractors No. 14170
NV Driller's Lic (on site) 2121
Signed Steve McKay
By driller performing actual drilling on site or contractor
Date -06

Figure B-14
Cave Valley (HA 180) Driller's Report For Domestic Well Log 105365

WELL LOG AND REPORT TO THE STATE ENGINEER OF NEVADA

Log No. 1452
Rec. 10/16 1950
Well No.
Permit No.
Do not fill in

Owner Rogers Bros   Driller Dennis Smith
Address McGill Nevada   Address Garrison Utah Lic. No. 23
Location of well: ¼ NE ¼ Sec. 3, T. 16 N/S, R. 67 E, in White Pine County
or
Water will be used for Culinary   Total depth of well 317'
Size of drilled hole 6"   Weight of casing per linear foot 20#
Thickness of casing 3/8" 187'   Temp. of water Cool
Diameter and length of casing 6" 187'
(Casing 12" in diameter and under give inside diameter; casing 12" in diameter give outside diameter.)
If flowing well give flow in c.f.s. or g.p.m. and pressure none
If nonflowing well give depth of standing water from surface 6 ft.
If flowing well describe control works None
(Type and size of valve, etc.)
Date of commencement of well July 21   Date of completion of well Aug 28 1950
Type of well rig Cable Tool

LOG OF FORMATIONS

From feet	To feet	Thickness feet	Type of material
0	3	3	sandy Clay
3	4	1	hard pan
4	18	14	Clay
18	21	3	sand & gravel (water)
21	47	26	sandy Clay
47	68	21	white clay
68	72	4	hard pan
72	78	6	sandy clay
78	79	1	hard pan
79	80	1	sand (water)
80	88	8	conglomerate
88	105	17	gravel (water)
105	145	40	sandy Clay
145	149	4	hard Pan
149	173	24	white clay
173	178	5	hard Pan
178	223	45	sandy clay
223	226	3	hard Pan
226	227	1	sand & gravel (water)
227	308	81	sandy Clay
308	312	4	hard Pan
312	317	5	sandy clay

Water-bearing Formation, Casing Perforations, Etc.

Chief aquifer (water-bearing formation)
from 88 to 105 ft.
Other aquifers 18 to 21
79 to 80 - 226 - 227

First water at 18 feet.

Casing perforated
from 167 to 187 ft.

Size of perforations
3/8 x 3
pre perforated
4 to each round
and 12" apart

Figure B-15
Spring Valley (HA 184) Driller's Report For Domestic Well Log 1452, Page 1

LOG OF FORMATIONS—*Continued*

From feet	To feet	Thickness	Type of material

CASING RECORD

Diam. casing	From feet	To feet	Length	"Remarks"—Seals, Grouting, Etc.

GENERAL INFORMATION—Pumping Test, Quality of Water, Etc.

WELL DRILLERS STATEMENT

This well was drilled under my jurisdiction and the above information is true to my best information and belief.

Signed Dennis Smith
Well Driller

By

License No. 23

Dated Sept. 19, 1950

(Not to be filled in by Driller)

Figure B-16

Spring Valley (HA 184) Driller's Report For Domestic Well Log 1452, Page 2

Log No. 3207
Rec. OCT 24 19 55
Well No.
Permit No.
Do not fill in

WELL LOG AND REPORT TO THE STATE ENGINEER OF NEVADA

Owner [illegible] Driller [illegible]

Address Ely, Nevada Address [illegible] Lic. No. 177

Location of well: NW ¼ NE ¼ Sec. 5, T. 13 N/S, R. 66 E, in White Pine County

or

Water will be used for ordinary purposes Total depth of well 45

Size of drilled hole 6 inch Weight of casing per linear foot

Thickness of casing 12 gauge Temp. of water cold

Diameter and length of casing 6" in inside diameter
(Casing 12" in diameter and under give inside diameter; casing 12" in diameter give outside diameter.)

If flowing well give flow in c.f.s. or g.p.m. and pressure

If nonflowing well give depth of standing water from surface 15 feet

If flowing well describe control works
(Type and size of valve, etc.)

Date of commencement of well 11/2/55 Date of completion of well 11/3/55

Type of well rig cable

LOG OF FORMATIONS

From feet	To feet	Thickness feet	Type of material
0	20	20	Boulders + gravel
20	40	20	Hard lime + cracks
40	45	5	Hard lime + cracks

Water-bearing Formation, Casing Perforations, Etc.

Chief aquifer (water-bearing formation)

from 40 to 45 ft.

Other aquifers

First water at 40 feet.

Casing perforated

from 20 to 40 ft.

Size of perforations

¼ x 12 inch

(OVER)

919

Figure B-17
Spring Valley (HA 184) Driller's Report For Domestic Well Log 3207

DIVISION OF WATER RESOURCES

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLERS REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No. 10216 15490
Permit No. [redacted]
Basin Spring Val.

1. OWNER Nevada State Department of Highways ADDRESS Equip. Div. - P. O. Box 930
Reno, Nevada 89504

2. LOCATION SE ¼ SW ¼ Sec. 34 T. 14 N/S R. 66 E. White Pine County
PERMIT NO.

3. TYPE OF WORK
New Well ☒ Reconditions ☐
Deepen ☐ Other ☐

4. PROPOSED USE
Domestic ☒ Irrigation ☐ Test ☐
Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Cemented Cong.		0	10'	10'
Hand Gravel & Boulders		10	95	85
Cemented Cong.		95	305	210
Cemented Cong. W/ streaks of clay		305	350	45
Sand & Gravel	1'	350	351	1
Cemented Cong. W/ streaks of clay		351	385	34
Sand and Gravel	1'	385	386	1
Cemented Cong W/ streaks of Clay		386	425	31
Sand & Gravel	1"	425	426	1
Cemented Cong W/ Streak of Clay		426	452	26

Date started June 27, 19 68
Date completed August 10, 19 68

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
	25	7	9 hrs.

BAILER TEST
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours

8. WELL CONSTRUCTION

Diameter hole 9 inches Total depth 452 feet
Casing record 455'
Weight per foot .... Thickness 1/4

Diameter	From	To
10 inches	0 feet	50 feet
6 inches	0 feet	452 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type Groute
Depth of seal .... feet
Gravel packed: Yes ☒ No ☐
Gravel packed from 50 feet to 452 feet

Perforations:
Type perforation Torch Cut
Size perforation 1/8 x 5" 5 to the round
From 330 feet to 452 feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet

9. WATER LEVEL
Static water level 102 Feet below land surface 350
Flow .... G.P.M. 25 gal.
Water temperature 65 ° F. Quality ....

10. DRILLERS CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.

Name /S/ James A. Wakeling

Address Dept. of Highways, Box 930, Reno

Nevada contractor's license number NSHD

Nevada driller's license number 554

Signed /S/ James A. Wakeling

Date 8/12/68

USE ADDITIONAL SHEETS IF NECESSARY 5471

Figure B-18
Spring Valley (HA 184) Driller's Report For Domestic Well Log 10216

DIVISION OF WATER RESOURCES

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLERS REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No. 16633
Permit No.
Basin

1. OWNER Clark Mining Corp. ADDRESS P.O.Box 418 Ely,Nevada 89301

2. LOCATION N W ¼ S E ¼ Sec. 15 T. 14 N/S R. 67 E. White Pine County
PERMIT NO.

3. TYPE OF WORK
New Well [X] Recondition [ ]
Deepen [ ] Other [ ]

4. PROPOSED USE
Domestic [X] Irrigation [ ] Test [ ]
Municipal [ ] Industrial [ ] Stock [ ]

5. TYPE WELL
Cable [X] Rotary [ ]
Other [ ]

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Fill Dirt		0		47ft
Rock		47 ft		70 ft
Rock &Clay		70 ft		191 ft
Water Sand		191 ft		192
Rock		192ft		253 ft
Water sand		253 ft		294 ft

Date started April 16, 1977
Date completed June 4, 19 77

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump

BAILER TEST

G.P.M. Draw down feet hours
G.P.M. Draw down feet hours
G.P.M. Draw down feet hours

8. WELL CONSTRUCTION

Diameter hole 8 inches Total depth 294 feet
Casing record
Weight per foot Thickness .188

Diameter	From	To
8 inches	0 feet	294 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes [X] No [ ] Type cement
Depth of seal 50 feet
Gravel packed: Yes [ ] No [ ]
Gravel packed from feet to feet

Perforations:
Type perforation Factory
Size perforation 3/16 x 2½ in
From 154 feet to 294 feet
From feet to feet
From feet to feet
From feet to feet
From feet to feet

9. WATER LEVEL

Static water level 250 Feet below land surface
Flow G.P.M.
Water temperature ° F. Quality

10. DRILLERS CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name F.B. Hicks Drilling Co
Address P.O.Box 756 East Ely,Nev 89315
Nevada contractor's license number 10705
Nevada driller's license number 701
Signed F.B. Hicks
Date 6-29-77

USE ADDITIONAL SHEETS IF NECESSARY 5471

Figure B-19
Spring Valley (HA 184) Driller's Report For Domestic Well Log 16633

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLERS REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No. 21278
Permit No.
Basin

1. OWNER Les Huckaley ADDRESS Spring Valley
Ely, Nevada

2. LOCATION NW ¼ SW ¼ Sec. 21 T. 14 N/S R. 67 E. White Pine County
PERMIT NO.

3. TYPE OF WORK
New Well ☒ Reconditon ☐
Deepen ☐ Other ☐

4. PROPOSED USE
Domestic ☒ Irrigation ☐ Test ☐
Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Top Soil		0	10	10
Sand and Gravel and Clay		10	120	110

Date started June 6, 19 80
Date completed June 18, 19 80

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
NONE			

BAILER TEST
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours

8. WELL CONSTRUCTION
Diameter hole 10" inches Total depth 120 feet
Casing record 0 - 120
Weight per foot 22.5 Thickness ¼

Diameter	From	To
10" inches	0 feet	120 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type CEMENT
Depth of seal 50 feet
Gravel packed: Yes ☒ No ☐
Gravel packed from 50 feet to 120 feet

Perforations:
Type perforation By Cutting torch
Size perforation 3/16
From 80 feet to 120 feet
From feet to feet
From feet to feet
From feet to feet
From feet to feet

9. WATER LEVEL
Static water level 25 Feet below land surface
Flow NONE G.P.M.
Water temperature Cold ° F. Quality

10. DRILLERS CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.

Name William Cooper
Address Box 683 Ely NEVADA
Nevada contractor's license number 9416
Nevada driller's license number 511
Signed William Cooper
Date 6 - 18 - 80

USE ADDITIONAL SHEETS IF NECESSARY 5471

Figure B-20
Spring Valley (HA 184) Driller's Report For Domestic Well Log 21278

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES
WELL DRILLER'S REPORT
Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 76375
Permit No.
Basin. 184

NOTICE OF INTENT NO. 39999

1. OWNER Pat Fillman
MAILING ADDRESS 1780 East Aultman
Ely, Nevada 89301

ADDRESS AT WELL LOCATION Sacramento Pass
(46 miles east of Ely)

2. LOCATION NW ¼ SE ¼ Sec 17 T 15 N R 68 E White Pine County
Waiver ~~PERMIT~~ NO. R-347 (Issued by Water Resources) A.P.N. 12-740-01 (Parcel No.) Subdivision Name

3. WORK PERFORMED
☒ New Well ☐ Replace ☐ Recondition
☐ Deepen ☐ Abandon ☐ Other

4. PROPOSED USE
☒ Domestic ☐ Irrigation ☐ Test
☐ Municipal/Industrial ☐ Monitor ☐ Stock

5. WELL TYPE
☐ Cable ☒ Rotary ☐ RVC
☐ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Cemented Gravel & Boulders		0	30	30
Clay & Gravel		30	50	20
Gravel		50	60	10
Clay Sand & Gravel		60	70	10
Clay & Large Gravel	x	70	80	10
Clay & Gravel		80	110	30
Cemented Gravel & Boulders		110	120	10
Clay Sand & Gravel		120	150	30
Clay & Large Gravel		150	160	10
Clay		160	168	8

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Date started May 29, 1999
Date completed June 29, 1999

7. WELL TEST DATA
TEST METHOD: ☐ Bailer ☐ Pump ☒ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
9	136	2

8. WELL CONSTRUCTION
Depth Drilled 168 Feet Depth Cased 168 Feet

HOLE DIAMETER (BIT SIZE)
10 Inches From 0 Feet To 168 Feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6 5/8	12.92	.188	0	168

Perforations:
Type perforation Factory
Size perforation 1/8" x 2½" 6 rows
From 87 feet to 168 feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 50 waiver No R-347
Placement Method: ☐ Pumped ☒ Poured
Seal Type: ☐ Neat Cement ☒ Cement Grout ☐ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 50 feet to 168 feet

9. WATER LEVEL
Static water level 24 feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature cold °F Quality good

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name Christiansen Drilling, Inc. (Contractor)
Address 557 Ely Avenue
Ely, NV 89301 (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 14790
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 641
Signed Gerald D. Christiansen (By driller performing actual drilling on site or contractor)
Date July 21, 1999

(Rev. 3-91) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-21
Spring Valley (HA 184) Driller's Report For Domestic Well Log 76375

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES
WELL DRILLER'S REPORT
Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 76376
Permit No.
Basin 184

NOTICE OF INTENT NO. 40001

1. OWNER Paul Fava
MAILING ADDRESS 980 El Camio
Boulder City, NV 89005
ADDRESS AT WELL LOCATION Sacramento Pass (46 Miles East of Ely)

2. LOCATION SE ¼ SE ¼ Sec. 17 T. 15 N R. 68 E White Pine County
PERMIT NO. (Issued by Water Resources) A.P.N. 12-740-02 (Parcel No.) (Subdivision Name)

3. WORK PERFORMED: ☒ New Well ☐ Replace ☐ Recondition ☐ Deepen ☐ Abandon ☐ Other

4. PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ Test ☐ Municipal/Industrial ☐ Monitor ☐ Stock

5. WELL TYPE: ☐ Cable ☐ Rotary ☒ RVC ☒ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Alluvial fill & Boulders		0	20	20
Clay & Gravel		20	40	20
Cemented Gravels		40	70	30
Fractured Limestone		70	100	30
Void		100	108	8
Limestone		108	160	52
Oxidized Fractured Limestone		160	170	10
Limestone		170	210	40
Fractured Limestone	x	210	215	5
Limestone		215	230	15
Fractured Limestone	x	230	235	5
Limestone		235	265	30

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Date started May 28, 1999
Date completed June 29, 1999

7. WELL TEST DATA
TEST METHOD: ☐ Bailer ☐ Pump ☒ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
30	93	1½

8. WELL CONSTRUCTION
Depth Drilled 265 Feet Depth Cased 265 Feet

HOLE DIAMETER (BIT SIZE)
10 Inches From 0 Feet To 265 Feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6 5/8	12.92	.188	0	265

Perforations:
Type perforation Factory
Size perforation 1/8" x 2½" 6 rows
From 201 feet to 265 feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 50 ft.
Placement Method: ☐ Pumped ☒ Poured
Seal Type: ☐ Neat Cement ☒ Cement Grout ☐ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 50 feet to 265 feet

9. WATER LEVEL
Static water level 167 feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature cold °F Quality good

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name Christiansen Drilling, Inc. (Contractor)
Address 557 Ely Avenue
Ely, Nevada 89301 (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 14790
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1793
Signed Rick Lewis By Gerald D. Christiansen (By driller performing actual drilling on site or contractor)
Date July 21, 1999

(Rev. 3-91) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-22
Spring Valley (HA 184) Driller's Report For Domestic Well Log 76376

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 81770
Permit No.
Basin. 184

NOTICE OF INTENT NO. 40015

1. OWNER Wes McNutt
MAILING ADDRESS 1295 Avenue K
Ely, Nevada

ADDRESS AT WELL LOCATION Sacramento Pass
(46 Miles East of Ely)

2. LOCATION NE ¼ SE ¼ Sec. 17 T. 15 N/S R. 68 E. White Pine County
PERMIT NO. Waiver R-374 (Copy Attached) APN 12-740-03
Issued by Water Resources — Parcel No. — Subdivision Name

3. WORK PERFORMED	4. PROPOSED USE	5. WELL TYPE
☒ New Well ☐ Replace ☐ Recondition ☐ Deepen ☐ Abandon ☐ Other	☒ Domestic ☐ Irrigation ☐ Test ☐ Municipal/Industrial ☐ Monitor ☐ Stock	☐ Cable ☐ Rotary ☒ RVC ☒ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Top Soil		0	10	10
Cemented Calitche &		10		
Gravel			85	75
Void	X	85	90	5
Red Fault Gouge		90	100	10
White Quartzite		100	123	23

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STATE ENGINEER'S OFFICE

Date started August 21, 2000
Date completed September 7, 2000

7. WELL TEST DATA

TEST METHOD: ☐ Bailer ☐ Pump ☐ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
50	40	1

8. WELL CONSTRUCTION

Depth Drilled 123 Feet Depth Cased 123 Feet

HOLE DIAMETER (BIT SIZE)

Inches	From (Feet)	To (Feet)
10	0	123

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6-5/8	12.92	.188	0	123

Perforations:
Type perforation Factory
Size perforation 1/8" x 2½" 6 Rows
From 82 feet to 123 feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 82 Waiver No. R-374
Placement Method: ☒ Pumped ☐ Poured
Seal Type: ☒ Neat Cement ☐ Cement Grout ☐ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 82 feet to 123 feet

9. WATER LEVEL

Static water level 39 feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature Cold °F Quality Good

10. DRILLER'S CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Christiansen Drilling, Inc.
Contractor
Address 557 Ely Avenue
Ely, Nevada 89301
Contractor

Nevada contractor's license number issued by the State Contractor's Board 14790

Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1793

Signed Rick Lewis By Gerald D. Christiansen
By driller performing actual drilling on site or contractor

Date September 7, 2000

(Rev. 3-91) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-23
Spring Valley (HA 184) Driller's Report For Domestic Well Log 81770

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 98402
Permit No.
Basin 184

NOTICE OF INTENT NO. 51404

1. OWNER John & Julie Gianoli
MAILING ADDRESS 1180 So. Bell Avenue
Ely, Nevada 89301

ADDRESS AT WELL LOCATION 1 Mile North of Sacramento Pass

2. LOCATION SE ¼ NW ¼ Sec. 21 T. 15 N/S R. 68 E. White Pine County
PERMIT NO. 72643 N/E (Issued by Water Resources) | 4 B APN 12-070-07 (Parcel No.) | The Meadows (Subdivision Name)

3. WORK PERFORMED
☒ New Well ☐ Replace ☐ Recondition
☐ Deepen ☐ Abandon ☐ Other

4. PROPOSED USE
☒ Domestic ☐ Irrigation ☐ Test
☐ Municipal/Industrial ☐ Monitor ☐ Stock

5. WELL TYPE
☐ Cable ☒ Rotary ☐ RVC
☒ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Top Soil		0	2	2
Sand & Boulders		2	13	11
Altered Limestone		13	55	42
Quartz & Limestone		55	65	10
Altered Limestone		65	98	33
Fractured Limestone	X	98	105	7
Altered Limestone		105	142	37
Fractured Limestone	X	142	146	4
Fractured Limestone &		146		
some clay			151	5
Altered Limestone		151	172	21
Fractured Limestone	X	172	176	4
Altered Limestone		176	203	27

2005 NOV 20 PM 12:40

Date started October 11, 2005
Date completed November 10, 2005

7. WELL TEST DATA

TEST METHOD: ☐ Bailer ☐ Pump ☒ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
50	98	1

8. WELL CONSTRUCTION

Depth Drilled 203 Feet Depth Cased 203 Feet

HOLE DIAMETER (BIT SIZE)

Inches	From (Feet)	To (Feet)
10	0	203

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6-5/8	12.92	.188	0	203

Perforations:
Type perforation Factory
Size perforation 1/8" X 2½" 6 Rows
From 103 feet to 203 feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 50 Feet
Placement Method: ☐ Pumped ☒ Poured
Seal Type: ☐ Neat Cement ☒ Cement Grout ☐ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 50 feet to 203 feet

9. WATER LEVEL
Static water level 102 feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature Cold °F Quality Good

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Christiansen Drilling, Inc. (Contractor)
Address 557 Ely Avenue
Ely, Nevada 89301 (Contractor)

Nevada contractor's license number issued by the State Contractor's Board 14790

Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1793

Signed [signature] (By driller performing actual drilling on site or contractor)
Date November 14, 2005

(Rev. 3-91) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-24
Spring Valley (HA 184) Driller's Report For Domestic Well Log 98402

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES
WELL DRILLER'S REPORT
Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 100565
Permit No.
Basin 184

NOTICE OF INTENT NO. 56908

1. OWNER Richard Sears
MAILING ADDRESS HC 10 1963 South 17 East Ely NV 89301
ADDRESS AT WELL LOCATION 6 miles East of Jctn 93 and Hwy 50 Spring Valley

2. LOCATION S/W ¼ S/E ¼ Sec. 28 T 14 N/S R 67 E White Pine County
PERMIT NO. ⊘ (Issued by Water Resources) 012-160-07 (Parcel No.) ⊘ (Subdivision Name)

3. WORK PERFORMED
☒ New Well ☐ Replace ☐ Recondition ☐ Deepen ☐ Abandon ☐ Other

4. PROPOSED USE
☒ Domestic ☐ Irrigation ☐ Test ☐ Municipal/Industrial ☐ Monitor ☐ Stock

5. WELL TYPE
☐ Cable ☒ Rotary ☐ RVC ☐ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Sand-Boulders		0	68	68
Pea gravel	V	68	78	10
Clay-Sand-Boulders	X	78	192	114
Fractured Rock	X	192	210	18
Hard Rock		210	215	5

Date started 6-12-06, 20
Date completed 6-16-06, 20

7. WELL TEST DATA
TEST METHOD: ☐ Bailer ☐ Pump ☒ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
90		2

8. WELL CONSTRUCTION
Depth Drilled 215 Feet Depth Cased 215 Feet

HOLE DIAMETER (BIT SIZE)

Inches	From (Feet)	To (Feet)
10 5/8	0	215

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6 ½	PVC	sch 40	0	215

Perforations:
Type perforation Saw cut
Size perforation 1/8" X 3"
From 60' feet to 80' feet
From 100' feet to 120' feet
From 140' feet to 160' feet
From 200' feet to 215' feet
From feet to feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 50'
Placement Method: ☐ Pumped ☒ Poured
Seal Type: ☐ Neat Cement ☐ Cement Grout ☒ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 50' feet to 215' feet

9. WATER LEVEL
Static water level 58' feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature cold °F Quality good

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name Davis Drilling + Pumps (Contractor)
Address HC 61 Box 54 Hiko NV 89017 (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 0028966
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1191
Signed [signature] (By driller performing actual drilling on site or contractor)
Date 6-16-06

(Rev. 12-01) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-25
Spring Valley (HA 184) Driller's Report For Domestic Well Log 100565

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES
WELL DRILLER'S REPORT
Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 101457
Permit No.
Basin 184

NOTICE OF INTENT NO. 56947

1. OWNER Robert Benson
MAILING ADDRESS 11720 E Henderson Road
Dewey Arizona 86327

ADDRESS AT WELL LOCATION 4 miles East of JCN 93 and 50 in North Spring Valley

2. LOCATION N/W ¼ N/E ¼ Sec. 21 T. 14 N R. 67 E. White Pine County
PERMIT NO. 0 (Issued by Water Resources) 012-170-03 (Parcel No.) (Subdivision Name)

3. WORK PERFORMED: ☒ New Well ☐ Replace ☐ Recondition ☐ Deepen ☐ Abandon ☐ Other

4. PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ Test ☐ Municipal/Industrial ☐ Monitor ☐ Stock

5. WELL TYPE: ☐ Cable ☒ Rotary ☐ RVC ☐ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Sand- Boulders		0	15	15
Clay		15	110	95
Clay boulders		110	115	5
Clay		115	140	25
Clay, Gravel- Boulders	X	140	143	3
Clay		143	170	27
Gravel- Sand	X	170	185	15
Hard Rock		185	190	5
GPS	N 39°	04.221'		
	W 114	27.937'		
W 6584.				
	37.0204 °N			
	114.4494 °W			
	[illegible] Co. US			

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Date started 9-6-06, 20
Date complated 9-11-06, 20

7. WELL TEST DATA
TEST METHOD: ☐ Bailer ☐ Pump ☒ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
70		1

8. WELL CONSTRUCTION
Depth Drilled 190 Feet Depth Cased 190 Feet

HOLE DIAMETER (BIT SIZE)
10 5/8 Inches From 0 Feet To 190 Feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6 1/2	sch 40	PVC	0	190

Perforations:
Type perforation Saw cut
Size perforation 1/8" x 3"
From 90 feet to 110 feet
From 130 feet to 190 feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 50'
Placement Method: ☒ Pumped ☐ Poured
Seal Type: ☒ Neat Cement ☐ Cement Grout ☐ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 50 feet to 190 feet

9. WATER LEVEL
Static water level 10' feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature cold °F Quality good

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name Doug's Drilling and Pumps (Contractor)
Address HC 61 Box 54, Hiko NV 89017 (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 0028966
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1191
Signed [signature] (By driller performing actual drilling on site or contractor)
Date 9-12-06

(Rev. 12-01) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-26
Spring Valley (HA 184) Driller's Report For Domestic Well Log 101457

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 107076
Permit No.
Basin 184

NOTICE OF INTENT NO. 61752

1. OWNER Richard Fillman
MAILING ADDRESS 23217 So. 182nd Street
Gilbert, Az 85297

ADDRESS AT WELL LOCATION Sacramento Pass

2. LOCATION SE ¼ NW ¼ Sec 21 T 15 N/S R 68 E White Pine County
PERMIT NO. (Issued by Water Resources) | APN 012-070-09 (Parcel No.) | (Subdivision Name)

3. WORK PERFORMED
☒ New Well ☐ Replace ☐ Recondition ☐ Deepen ☐ Abandon ☐ Other

4. PROPOSED USE
☒ Domestic ☐ Irrigation ☐ Test ☐ Municipal/Industrial ☐ Monitor ☐ Stock

5. WELL TYPE
☐ Cable ☒ Rotary ☐ RVC ☒ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Rocks & Boulders		0	5	5
Hard Pan		5	15	10
Cemented Rock & Bldrs		15	60	45
Limestone		60	85	25
Altered Limestone		85	95	10
Altered Limestone w/ Clay Stringers	X	95	120	25
Limestone		120	150	30
Altered Limestone		150	240	90
Altered Limestone w/ Clay Stringers	X	240	255	15
Clay		255	260	5
Limestone		260	300	40
Fractured Limestone	X	300	320	20

N 39.152116
W 114.347125 NAD27

WGS 84
Lat. N39°09' 07.4"
Long. W 114°20' 52.7"
Elevation 6,982'

Date started August 13, 2008
Date complated August 28, 2008

7. WELL TEST DATA

TEST METHOD: ☐ Bailer ☐ Pump ☐ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
20	229	1 1/2

8. WELL CONSTRUCTION

Depth Drilled 320 Feet Depth Cased 320 Feet

HOLE DIAMETER (BIT SIZE)

Inches	From (Feet)	To (Feet)
10-5/8	0	320

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6-5/8	12.92	.188	0	320

Perforations:
Type perforation Factory
Size perforation 1/8" x 2 1/3" 6 Rows
From 100 feet to 140 feet
From 160 feet to 200 feet
From 220 feet to 240 feet
From 280 feet to 320 feet
From feet to feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 50
Placement Method: ☐ Pumped ☒ Poured
Seal Type: ☐ Neat Cement ☒ Cement Grout ☐ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 50 feet to 320 feet

9. WATER LEVEL

Static water level 86 feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature Cold °F Quality Good

10. DRILLER'S CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Christiansen Drilling, Inc. (Contractor)
Address 557 Ely Avenue (Contractor)
Ely, Nv 89301

Nevada contractor's license number issued by the State Contractor's Board 14790

Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1793

Signed [signature] (By driller performing actual drilling on site or contractor)

Date September 26, 2008

(Rev. 12-01) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-27
Spring Valley (HA 184) Driller's Report For Domestic Well Log 107076

DIVISION OF WATER RESOURCES

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLERS REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No. 12584
Permit No.
Basin Spring V. CARD

1. OWNER Eric Peterson ADDRESS Spring Valley Rte Ely Nev 89301

2. LOCATION NW ¼ SW ¼ Sec. 30 T 17 N/S R 67 E. White Pine County
PERMIT NO.

3. TYPE OF WORK
New Well ☑ Reconditon ☐
Deepen ☐ Other ☐

4. PROPOSED USE
Domestic ☑ Irrigation ☐ Test ☐
Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☑ Rotary ☐
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Fill dirt		0		4'
Clay		4		20
Water ?ble Stone Clay		20		25
Rock & Clay		25		80
Water Sand & ?ble Stone		80		100'

Date started Aug 22, 19 72
Date completed Aug 26, 19 72

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump

BAILER TEST
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours

8. WELL CONSTRUCTION
Diameter hole 6 inches Total depth 100 feet
Casing record 6 wall
Weight per foot 4 Thickness

Diameter	From	To
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☑ No ☐ Type
Depth of seal 50 ft. feet
Gravel packed: Yes ☐ No ☐
Gravel packed from .... feet to .... feet

Perforations:
Type perforation torch
Size perforation ¼ X 12"
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet

9. WATER LEVEL
Static water level flowing Feet below land surface
Flow 2 galls G.P.M.
Water temperature ° F. Quality

10. DRILLERS CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.

Name J. B. Hicks Drilling Co —
Address Box 756 East Ely Nevada
Nevada contractor's license number 10705
Nevada driller's license number 653
Signed Donald Dee Eldridge
Date 8-31-72

Figure B-28
Spring Valley (HA 184) Driller's Report For Domestic Well Log 12584

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 63014
Permit No.
Basin. 184

NOTICE OF INTENT NO. 33035

1. OWNER Gene Degler
MAILING ADDRESS HCR 33 Box 33960
Ely, NV 89301

ADDRESS AT WELL LOCATION North Spring Valley

2. LOCATION NW 1/4 NW 1/4 Sec. 19 T 17 N/S R 67 E White Pine County

PERMIT NO. (Issued by Water Resources) | Parcel No. | Subdivision Name

3. WORK PERFORMED: ☒ New Well ☐ Replace ☐ Recondition ☐ Deepen ☐ Abandon ☐ Other

4. PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ Test ☐ Municipal/Industrial ☐ Monitor ☐ Stock

5. WELL TYPE: ☐ Cable ☒ Rotary ☐ RVC ☐ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Quartz cobbles		0	15	15
Clay & Quartz Gravel		15	25	10
Quartz sand & Gravel	x	25	90	65
Clay & Quartz Gravel		90	95	5
Quartz Sand & Gravel	x	95	100	5
Clay & Quartz Gravel		100	110	10
Quartz Sand & Gravel	x	110	125	15

Date started May 22, 19 96
Date completed June 3, 19 96

7. WELL TEST DATA

TEST METHOD: ☐ Bailer ☐ Pump ☒ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
250	99	1

8. WELL CONSTRUCTION

Depth Drilled 125 Feet Depth Cased 125 Feet

HOLE DIAMETER (BIT SIZE)

Inches	From (Feet)	To (Feet)
10	0	125

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6 5/8	12.92	.188	0	125

Perforations:
Type perforation Factory
Size perforation 1/8" x 2½" 6 rows
From 65 feet to 125 feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 50 ft
Placement Method: ☒ Pumped ☐ Poured
Seal Type: ☒ Neat Cement ☐ Cement Grout ☐ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 50 feet to 125 feet

9. WATER LEVEL

Static water level 21 feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature Cold °F Quality Good

10. DRILLER'S CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Christiansen Drilling, Inc (Contractor)
Address 557 Ely Avenue (Contractor)
Ely, NV 89301

Nevada contractor's license number issued by the State Contractor's Board 14790

Nevada driller's license number issued by the Division of Water Resources, the on-site driller 641

Signed Jerald D. Christiansen (By driller performing actual drilling on site or contractor)
Date June 5, 1996

(Rev. 3-91) USE ADDITIONAL SHEETS IF NECESSARY (01-627)

Figure B-29
Spring Valley (HA 184) Driller's Report For Domestic Well Log 63014

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 94786
Permit No.
Basin 184

NOTICE OF INTENT NO. 51386

1. OWNER Beverly Bender
MAILING ADDRESS HCR/P.O. Box 33965
Ely, Nevada 89301

ADDRESS AT WELL LOCATION North Spring Valley Ranch

2. LOCATION NW ¼ SW ¼ Sec. 30 T. 17 N/S R. 67 E White Pine County
PERMIT NO. (Issued by Water Resources) — APN 010-380-16 (Parcel No.) — (Subdivision Name)

3. WORK PERFORMED: ☒ New Well ☐ Deepen ☒ Replace ☐ Abandon ☐ Reconditio‍n ☐ Other

4. PROPOSED USE: ☒ Domestic ☐ Municipal/Industrial ☐ Irrigation ☐ Monitor ☐ Test ☐ Stock

5. WELL TYPE: ☐ Cable ☐ Air ☒ Rotary ☐ Other ☐ RVC

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Top Soil		0	3	3
Brown Clay		3	5	2
Blue Clay		5	19	14
Water Bearing Sand	X	19	23	4
Brown Clay & Sand		23	27	4
Boulders		27	35	8
Sand & Small Gravel		35	45	10
Boulders		45	50	5
Dark Brown Sediments		50		
& Clay			60	10
Cemented Sand & Gravel		60	73	13
Quartz Boulders		73	85	12
Sand & Gravel with		85		
Clay Stringers			91	6
Quartz Boulders		91	94	3
Water Bearing Sand &	X	94		
Gravel			107	13
Boulders		107	114	7
Gravel & Clay		114	120	6

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2004 JUL 19 PM 2:47
STATE ENGINEERS OFFICE

Date started May 24, 2004
Date completed June 21, 2004

7. WELL TEST DATA

TEST METHOD: ☐ Bailer ☐ Pump ☒ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
35	110	2

8. WELL CONSTRUCTION

Depth Drilled 120 Feet Depth Cased 120 Feet

HOLE DIAMETER (BIT SIZE)

11 Inches From 0 Feet To 120 Feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6-5/8	12.92	.188	0	120

Perforations:
Type perforation Factory
Size perforation 1/8" X 2½" 6 Rows
From 60 feet to 120 feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 50
Placement Method: ☒ Pumped ☐ Poured
Seal Type: ☒ Neat Cement ☐ Cement Grout ☐ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 50 feet to 120 feet

9. WATER LEVEL

Static water level Flowing feet below land surface
Artesian flow 5 G.P.M. P.S.I.
Water temperature Cold °F Quality Good

10. DRILLER'S CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Christiansen Drilling, Inc. (Contractor)
Address 557 Ely Avenue (Contractor)
Ely, Nevada 89301

Nevada contractor's license number issued by the State Contractor's Board 14790

Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1793

Signed Rick Lewis By Jerald D. Christiansen (By driller performing actual drilling on site or contractor)
Date July 13, 2004

(Rev. 3-91) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-30
Spring Valley (HA 184) Driller's Report For Domestic Well Log 94786

DIVISION OF WATER RESOURCES

STATE OF NEVADA
DIVISION OF WATER RESOURCES
WELL DRILLERS REPORT
Please complete this form in its entirety

OFFICE USE ONLY
Log No. 20404
Permit No.
Basin

1. OWNER Geo. Eldridge & Son, Inc. ADDRESS SR 1 Box 42, Ely NV 89301

2. LOCATION SE ¼ SE ¼ Sec. 26 T. 19 N R. 66 E. White Pine County
PERMIT NO.

3. TYPE OF WORK: New Well ☒ Reconditioned ☐ Deepen ☐ Other ☐

4. PROPOSED USE: Domestic ☒ Irrigation ☒ Test ☐ Municipal ☐ Industrial ☐ Stock ☒

5. TYPE WELL: Cable ☒ Rotary ☐ Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Silt		0	2	2
Sand & Gravel	✓	2	6	4
Clay & Sand		6	10	4
Silt & Boulders		10	24	14
Sand & Gravel	✓	24	28	4
Silt & Sand		28	77	49
Sand & Gravel	✓	77	80	3
Silt & Gravel		80	82	2
Gravel	✓	82	89	7
Silt		89	94	5
Gravel	✓	94	98	4
Silt		98	103	5
Gravel	✓	103	107	4
Silt		107	111	4

Date started (Card Filed) Fall, 19 78
Date completed Sept 25, 19 79

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
No test			

BAILER TEST
G.P.M. 7 Draw down 2 feet ½ hours
G.P.M. Draw down feet hours
G.P.M. Draw down feet hours

8. WELL CONSTRUCTION
Diameter hole 9 inches Total depth 111 feet
Casing record 108'
Weight per foot Thickness .250"

Diameter	From	To
8 inches	0 feet	108 feet

Surface seal: Yes ☒ No ☐ Type Cement
Depth of seal 50 feet
Gravel packed: Yes ☐ No ☒
Gravel packed from feet to feet

Perforations:
Type perforation Acet. Torch
Size perforation 3/16" x 4"
From 83 feet to 108 feet
From feet to feet
From feet to feet
From feet to feet
From feet to feet

9. WATER LEVEL
Static water level One Feet above land surface
Flow ± Five G.P.M. May – Oct
Water temperature Cold °F. Quality Unknown

10. DRILLERS CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Brent Eldridge
Address SR 1 Box 42 Ely, NV
Nevada contractor's license number 7514 A
Nevada driller's license number 844
Signed Brent Eldridge
Date 10-12-79

USE ADDITIONAL SHEETS IF NECESSARY 5471

Figure B-31
Spring Valley (HA 184) Driller's Report For Domestic Well Log 20404

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 108832
Permit No.
Basin 184

NOTICE OF INTENT NO. 61855

1. OWNER Geo. Eldridge and Son Inc.
MAILING ADDRESS HCR 33 Box 33980 Ely, NV 89301
ADDRESS AT WELL LOCATION North Spring Valley Ely, NV 89301

2. LOCATION SE ¼ SW ¼ Sec. 15 T. 20 (N) S R. 66 E White Pine County
PERMIT NO. (Issued by Water Resources) | 10-050-02 (Parcel No.) | (Subdivision Name)

3. WORK PERFORMED
☒ New Well ☐ Replace ☐ Recondition ☐ Deepen ☐ Abandon ☐ Other

4. PROPOSED USE
☒ Domestic ☐ Irrigation ☐ Test ☐ Municipal/Industrial ☐ Monitor ☐ Stock

5. WELL TYPE
☐ Cable ☒ Rotary ☐ RVC ☒ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Gravel, 4-6" cobbles & boulders		0	15	15
White silts, Fine-md sand, gravel		15	100	85
Lg sand & gravel, silt, cobbles		100	150	50
Sand, 3/8" gravel-well rounded		150	220	70
Silt, cemented sand very dense		220	300	80
White silt, fine sand, gravel	✓	300	350	50
Lg. Sand, well-rounded gravel		350	400	50
Very rounded gravel, Lg. Sand	✓	400	420	20

39.595478° N
114.534103° W
NOD 27 (TA)

N 39° - 35.725
W 114° - 32.097

2009 SEP 30 AM 10:58
STATE ENGINEERS OFFICE

Date started Aug. 3, 2009
Date completed Sep. 4, 2009

7. WELL TEST DATA

TEST METHOD: ☐ Bailer ☐ Pump ☒ Air Lift

	G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
9-4-09	40		3 HRS

8. WELL CONSTRUCTION

Depth Drilled 420 Feet Depth Cased 420 Feet

HOLE DIAMETER (BIT SIZE)

Inches	From	To
12 3/4	0 Feet	100 Feet
9 7/8	100 Feet	420 Feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
8.625	22.36	.250	+2	111
6.625	17.02	.250	100	420

Perforations:
Type perforation Mill
Size perforation 1/8 x 2 1/2
From 360 feet to 420 feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 111
Placement Method: ☒ Pumped ☐ Poured
Seal Type: ☒ Neat Cement ☐ Cement Grout ☐ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 111 feet to 420 feet

9. WATER LEVEL

Static water level 315 feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature °F Quality

10. DRILLER'S CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name Gardner Brothers Drilling (Contractor)
Address PO Box 965 (Contractor)
Enterprise, UT 84725

Nevada contractor's license number issued by the State Contractor's Board 0068459

Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1710

Signed Dale Gardner (By driller performing actual drilling on site or contractor)

Date 9-28-09

(Rev. 12-01) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-32
Spring Valley (HA 184) Driller's Report For Domestic Well Log 108832

STATE OF NEVADA
DIVISION OF WATER RESOURCES
WELL DRILLER'S REPORT

OFFICE USE ONLY
Log No. 114077
Permit No.
Basin 184

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

NOTICE OF INTENT NO. 66479

1. OWNER HANK VOGLER
MAILING ADDRESS HC 33 BOX 33920
ELY, NV, 89301

ADDRESS AT WELL LOCATION SPRING VALLEY
Subdivision Name:
County: WHITE PINE

2. LOCATION SW ¼ NE ¼ Sec 31 T 23N N/S R 66 E
PERMIT/WAIVER No.
Issued by Water Resources
Parcel No. 008-400-01

Latitude
Longitude
UTM E 11T 0709206 [X] NAD 27
N 4411215 [ ] NAD 83/WGS 84

3. WORKED PERFORMED
[X] New Well [ ] Replace [ ] Recondition
[ ] Deepen [ ] Other

4. PROPOSED USE
[X] Domestic [ ] Irrigation [ ] Test
[ ] Municipal/Industrial [ ] Monitor [ ] Stock

5. WELL TYPE
[ ] Cable [X] Rotary [ ] RVC
[ ] Air [X] Other MUD

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
TOPSOIL		0	2	2
COARSE GRAVEL AND SAND	X	2	50	48
HARD RED BROWN BASALT & BOULDERS		50	60	10
HARD RED BROWN FINE GRAVEL		60	85	15
GRAVEL WITH CLAY		85	120	35
HARD CONSOLIDATED GRAVEL		120	130	10
SOFT RED BROWN GRAVEL WITH CLAY		130	160	30
GRAVEL	XX	160	180	20
GRAVEL WITH CLAY		180	200	20
RED BROWN GRAVEL	XX	200	220	20
1ST WATER X	20			
SEALED OFF				
2ND WATER XX	170			
3RD WATER XX	200			

Date started: 13-Jun , 20 11
Date completed: 15-Jun , 20 11

STATE ENGINEERS OFFICE 2011 JUL -5 PM 12: 47

7. Water Level
Static water level: 25 feet below land surface
Artesian Flow: G.P.M. P.S.I.
Water Temperature: 70 °F
Quality: GOOD

8. WELL TEST DATA
TEST METHOD: [ ] Bailer [ ] Pump [X] Air Lift

G.P.M.		Draw Down (Feet Below Static)	Time (Hours)
125 PSI @			
825 CFM	150		3 HOURS

9. *WELL CONSTRUCTION*
Depth Drilled 220 Feet Depth Cased 220 Feet

HOLE DIAMETER (BIT SIZE)

		From		To	
12 3/4	Inches	0	Feet	220	Feet
	Inches		Feet		Feet
	Inches		Feet		Feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
8.625	17	.188	+2	220

Perforations:
Type of perforation MACHINE MILL SLOT
Size of perforation 3/16" X 3", 16 ROW
From 160 feet to 180 feet
From 200 feet to 220 feet
From feet to feet
From feet to feet
From feet to feet

Annular Seal: [X] Yes [ ] No
[X] Neat Cement 4 to 100 [X] Pumped [ ] Poured
[ ] Cement Grout to [ ] Pumped [ ] Poured
[ ] Concrete Grout to [ ] Pumped [ ] Poured
[ ] ≥30% Bentonite Grout to [ ] Pumped [ ] Poured
Gravel Pack: [X] Yes [ ] No 100 to 220 [ ] Pumped [X] Poured
Type: 3/8" WASHED PEA GRAVEL
Bentonite Chips: [ ] Yes [X] No to [ ] Pumped [ ] Poured
Type:

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name HACKWORTH DRILLING, INC.
Contractor
Address P. O. BOX 850
Contractor
ELKO, NV 89803
Nevada contractor's license number issued by the *State Contractor's Board* 020582
Nevada driller's license number issued by the Division of Water Resources, the *on-site driller* 1653
Signed [signature]
By driller performing actual drilling on site or contractor
Date 6/16/2011

(Rev. 05-06)
USE ADDITIONAL SHEETS IF NECESSARY

39.827083°N NAD27
114.555479°W

Figure B-33
Spring Valley (HA 184) Driller's Report For Domestic Well Log 114077

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 67360
Permit No.
Basin 195

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

NOTICE OF INTENT NO. 33048

1. OWNER Granite Peak Properties LC Nevada Limited Liability Co.
MAILING ADDRESS 1725 So. Berry Knoll Blvd Centenial Park, Arizona 86021
ADDRESS AT WELL LOCATION 20 miles SW of Garrison, Utah

2. LOCATION NW ¼ NE ¼ Sec. 24 T. 10 N/S R. 70 E White Pine County
PERMIT NO. (Issued by Water Resources) | Parcel No. | Subdivision Name

3. WORK PERFORMED
☒ New Well ☐ Replace ☐ Recondition
☐ Deepen ☐ Abandon ☐ Other

4. PROPOSED USE
☒ Domestic ☐ Irrigation ☐ Test
☐ Municipal/Industrial ☐ Monitor ☐ Stock

5. WELL TYPE
☐ Cable ☒ Rotary ☐ RVC
☐ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Sand & Gravel		0	5	5
Clay & Gravel		5	10	5
Water Sand & Gravel	x	10	50	40
Clay		50	60	10
Water Sand & Gravel	x	60	65	5
Clay		65	240	175
Water Sand & Clay	x	240	245	5
Clay		245	360	115
Clay Gravel & Sand	x	360	400	40

Date started April 20, 19 97
Date completed April 27, 19 97

7. WELL TEST DATA

TEST METHOD: ☐ Bailer ☐ Pump ☒ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
200	352	1

8. WELL CONSTRUCTION
Depth Drilled 400 Feet Depth Cased 400 Feet

HOLE DIAMETER (BIT SIZE)

Inches	From (Feet)	To (Feet)
10	0	400

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6 5/8	12.92	.188	0	400

Perforations:
Type perforation Factory
Size perforation 1/8" x 2½" 6 rows
From 300 feet to 400 feet

Surface Seal: ☒ Yes ☐ No
Depth of Seal 100 ft.
Placement Method: ☒ Pumped ☐ Poured
Seal Type: ☒ Neat Cement ☐ Cement Grout ☐ Concrete Grout

Gravel Packed: ☒ Yes ☐ No
From 300 feet to 400 feet

9. WATER LEVEL
Static water level 28 feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature cold °F Quality good

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name Christiansen Drilling, Inc. (Contractor)
Address 557 Ely Avenue Ely, Nevada 89301 (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 14790
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 641
Signed Jerrold D. Christiansen (By driller performing actual drilling on site or contractor)
Date June 23, 1997

(Rev. 3-91) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

Figure B-34
Snake Valley (HA 195) Driller's Report For Domestic Well Log 67360

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 67897
Permit No.
Basin 195

NOTICE OF INTENT NO. 29696

1. OWNER Ronald and Robin Crouch
MAILING ADDRESS P.P. Box 66
Baker, Nevada 89311

ADDRESS AT WELL LOCATION Sec 34 T 12 N/S R 70
2000 Big Wash Road

2. LOCATION ¼ ¼ Sec 34 T 12 (N)/S R 70 E White Pine County
PERMIT NO. N/A (Issued by Water Resources) N/A (Parcel No.) Subdivision Name

3. WORK PERFORMED
- [x] New Well
- [ ] Replace
- [ ] Recondition
- [ ] Deepen
- [ ] Abandon
- [ ] Other

4. PROPOSED USE
- [x] Domestic
- [ ] Irrigation
- [ ] Test
- [ ] Municipal/Industrial
- [ ] Monitor
- [ ] Stock

5. WELL TYPE
- [x] Cable
- [ ] Rotary
- [ ] RVC
- [ ] Air
- [ ] Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Black top soil		0	1	1 ft
Tan clay		1	5	4 ft
Gravel		5	8	3 ft
Tan clay		8	13	5 ft
Gravel		13	14	1 ft
Clay		14	40	26 ft
Gravel	64-69	40	69	29 ft
Limestone	105 ft	69	120	51 ft

RECEIVED 97 JUN 12 AM 11:53

Date started December 14, 19 96
Date completed June 2, 19 97

7. WELL TEST DATA

TEST METHOD: [ ] Bailer [x] Pump [ ] Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
21	10 ft 6 in	6 hours

8. WELL CONSTRUCTION

Depth Drilled 120 Feet Depth Cased 120 Feet

HOLE DIAMETER (BIT SIZE)

8 Inches From 0 Feet To 120 Feet

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
8 5/8	28.55	.320	0	120

Perforations:
Type perforation mills [redacted]
Size perforation ¼ inch by 2 inch
From 104 feet to 109 feet

Surface Seal: [x] Yes [ ] No
Depth of Seal 100
Placement Method: [x] Pumped [ ] Poured

Seal Type: [ ] Neat Cement [x] Cement Grout [ ] Concrete Grout

Gravel Packed: [ ] Yes [x] No
From feet to feet

9. WATER LEVEL

Static water level 52ft 3 inches feet below land surface
Artesian flow G.P.M. P.S.I.
Water temperature 51 °F Quality good

10. DRILLER'S CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name George Douglass (Contractor)
Address HC 61 Box 380 Wendover Ut 84083 (Contractor)

Nevada contractor's license number issued by the State Contractor's Board 0041559

Nevada driller's license number issued by the Division of Water Resources, the on-site driller 2014

Signed George Douglass
By driller performing actual drilling on site or contractor

Date 7 June 1997

(Rev. 3-91)

USE ADDITIONAL SHEETS IF NECESSARY

(O)-627

Figure B-35
Snake Valley (HA 195) Driller's Report For Domestic Well Log 67897

Appendix C

Triggers for Sentinel and other Selected Monitor Wells and Springs

Table C-1
Triggers for Spring Valley Sentinel and Select Monitor Wells
(Page 1 of 2)

Well	Type	Spring Valley Block # or Basin
SPR7029M	Sentinel Monitor Well	Spring Valley Block 3
SPR7029M2	Sentinel Monitor Well	Spring Valley Block 3
SPR7030M	Sentinel Monitor Well	Spring Valley Block 3
SPR7030M2	Sentinel Monitor Well	Spring Valley Block 3
383351114180201	Select Monitor Well	Spring Valley Block 1
383704114225001	Select Monitor Well	Spring Valley Block 1
384039114232701[a]	Select Monitor Well	Spring Valley Block 1
384310114261401	Select Monitor Well	Spring Valley Block 1
384745114224401	Select Monitor Well	Spring Valley Block 1
384831114314301	Select Monitor Well	Spring Valley Block 1
385636114265501	Select Monitor Well	Spring Valley Block 1
184 N12 E66 21CD 1	Select Monitor Well	Spring Valley Block 1
184W502M	Select Monitor Well	Spring Valley Block 1
184W504M	Select Monitor Well	Spring Valley Block 1
184W506M	Select Monitor Well	Spring Valley Block 1
184W508M	Select Monitor Well	Spring Valley Block 1
SPR7007M	Select Monitor Well	Spring Valley Block 1
SPR7007X	Select Monitor Well	Spring Valley Block 1
SPR7007Z	Select Monitor Well	Spring Valley Block 1
SPR7011Z	Select Monitor Well	Spring Valley Block 1
SPR7014Z	Select Monitor Well	Spring Valley Block 1
SPR7024M2	Select Monitor Well	Spring Valley Block 1
Swallow Springs South	Select Spring	Spring Valley Block 1

[a]Well removed from program previously.

Note: Planned Sentinel Monitor Wells that have not been constructed yet will be included after construction and data are available. These wells are: HAM1007M, HAM1008M, SPR7009M, and SPR7010M.

Table C-1
Triggers for Spring Valley Sentinel and Select Monitor Wells
(Page 2 of 2)

Well	Type	Spring Valley Block # or Basin
390352114305401	Select Monitor Well	Spring Valley Block 2
391224114293601[a]	Select Monitor Well	Spring Valley Block 2
Bastian South	Select Monitor Well	Spring Valley Block 2
SPR7005M	Select Monitor Well	Spring Valley Block 2
SPR7006M	Select Monitor Well	Spring Valley Block 2
SPR7008M	Select Monitor Well	Spring Valley Block 2
SPR7012Z	Select Monitor Well	Spring Valley Block 2
SPR7016Z	Select Monitor Well	Spring Valley Block 2
SPR7018Z	Select Monitor Well	Spring Valley Block 2
SPR7019Z	Select Monitor Well	Spring Valley Block 2
SPR7015Z	Select Monitor Well	Spring Valley Block 3
SPR7031Z	Select Monitor Well	Spring Valley Block 3
184 N20 E66 13AB 1	Select Monitor Well	Spring Valley Block 4
392703114230501	Select Monitor Well	Spring Valley Block 4
393442114231801	Select Monitor Well	Spring Valley Block 4
Robison Crooked Well	Select Monitor Well	Spring Valley Block 4
SPR7021Z	Select Monitor Well	Spring Valley Block 4
SPR7020Z	Select Monitor Well	Spring Valley Block 5
SPR7022Z	Select Monitor Well	Spring Valley Block 5
383023114115302	Select Monitor Well	Hamlin Valley
383325114134901	Select Monitor Well	Hamlin Valley
383533114102901[a]	Select Monitor Well	Hamlin Valley
384112114091101	Select Monitor Well	Hamlin Valley
384227114082701	Select Monitor Well	Snake Valley
Cleveland Ranch South Spring - 1848501	Select Spring	Spring Valley Block 3

[a]Well removed from program previously.

Note: Planned Sentinel Monitor Wells that have not been constructed yet will be included after construction and data are available. These wells are: HAM1007M, HAM1008M, SPR7009M, and SPR7010M.

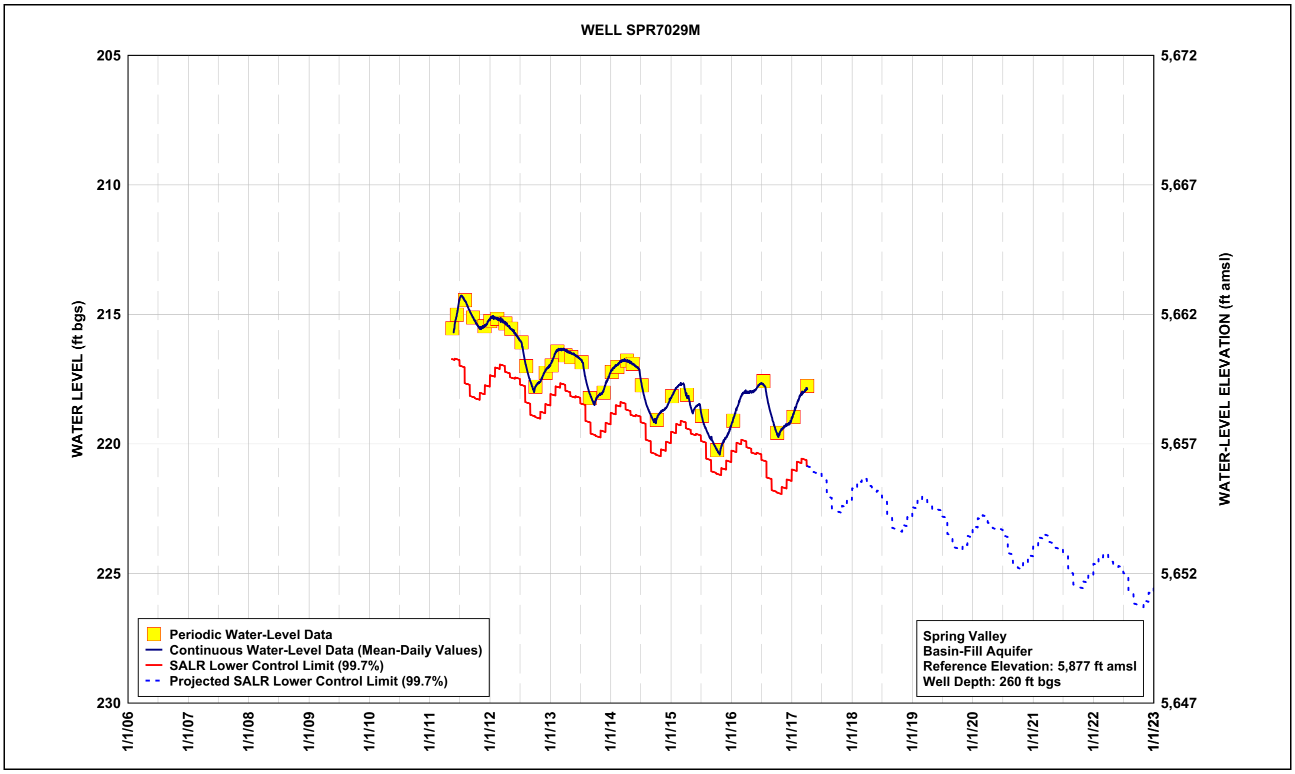


Figure C-1
Trigger, SPR7029M, Spring Valley Block 3

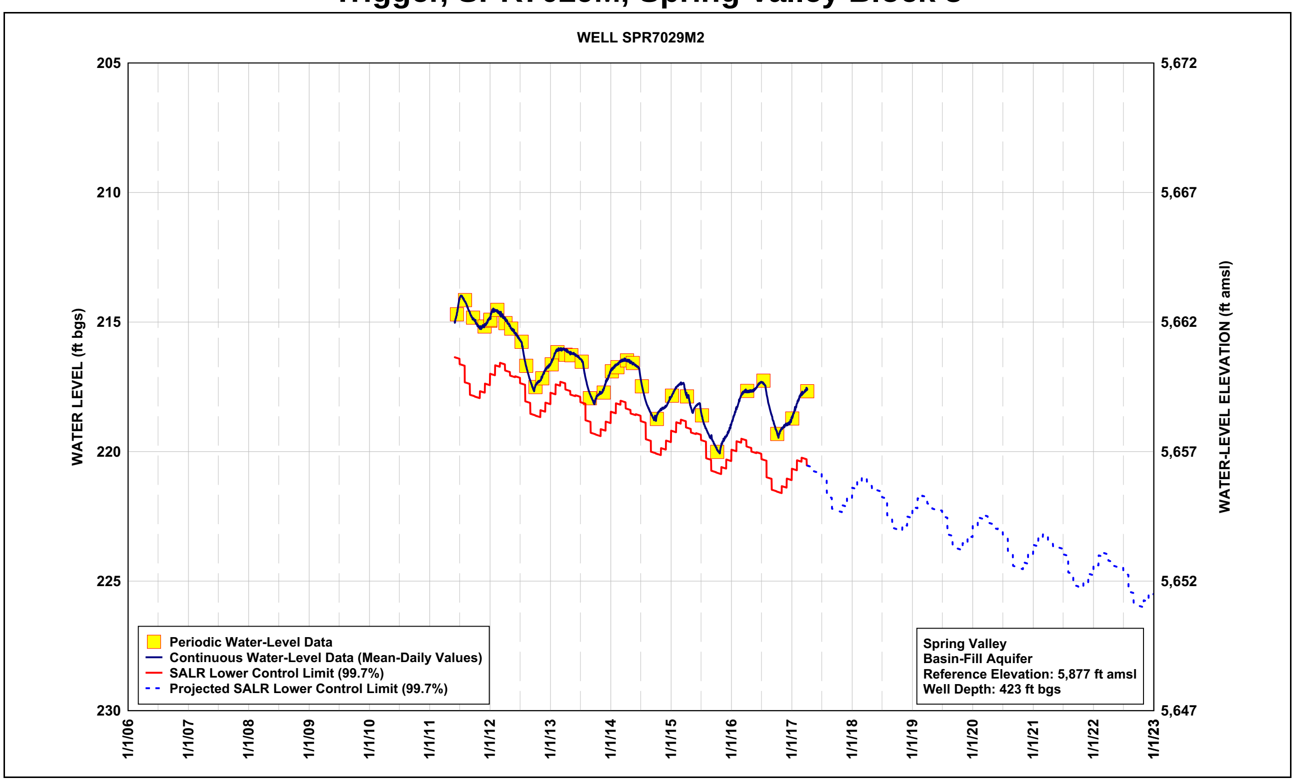


Figure C-2
Trigger, SPR7029M2, Spring Valley Block 3

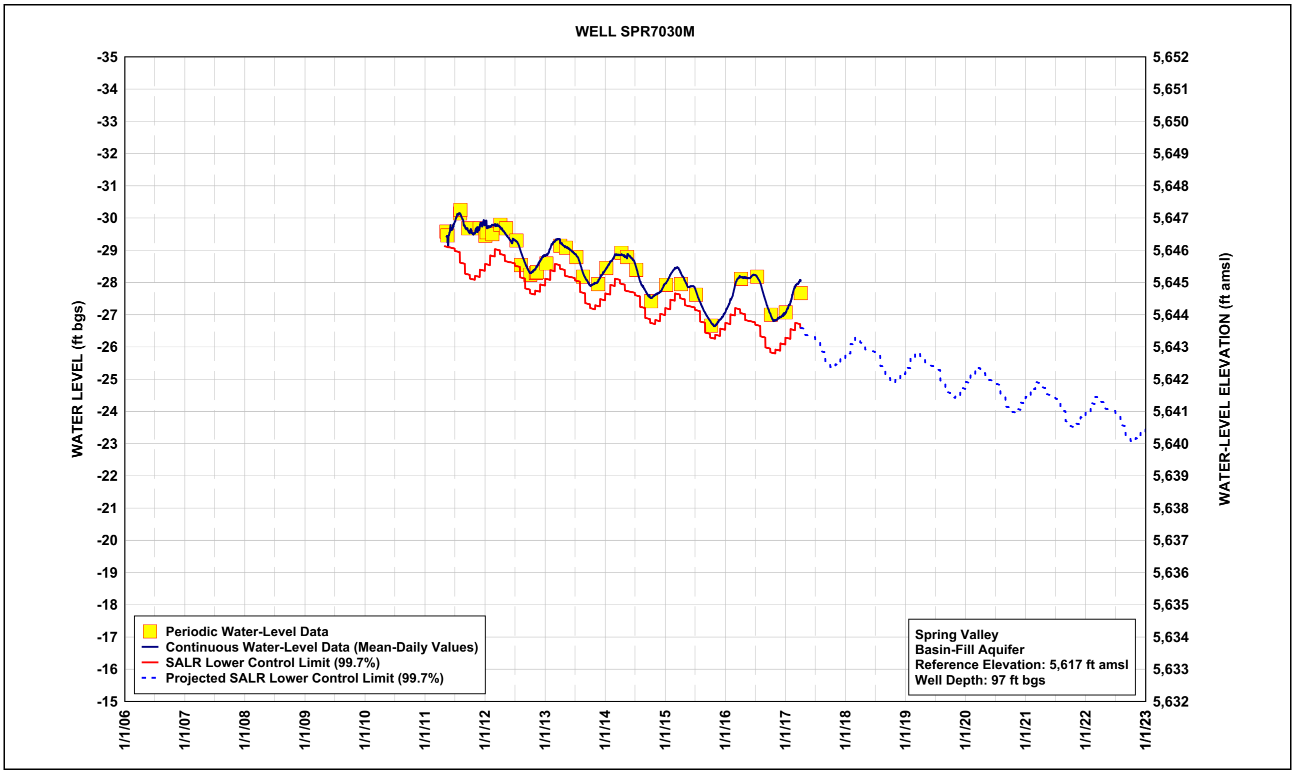


Figure C-3
Trigger, SPR7030M, Spring Valley Block 3

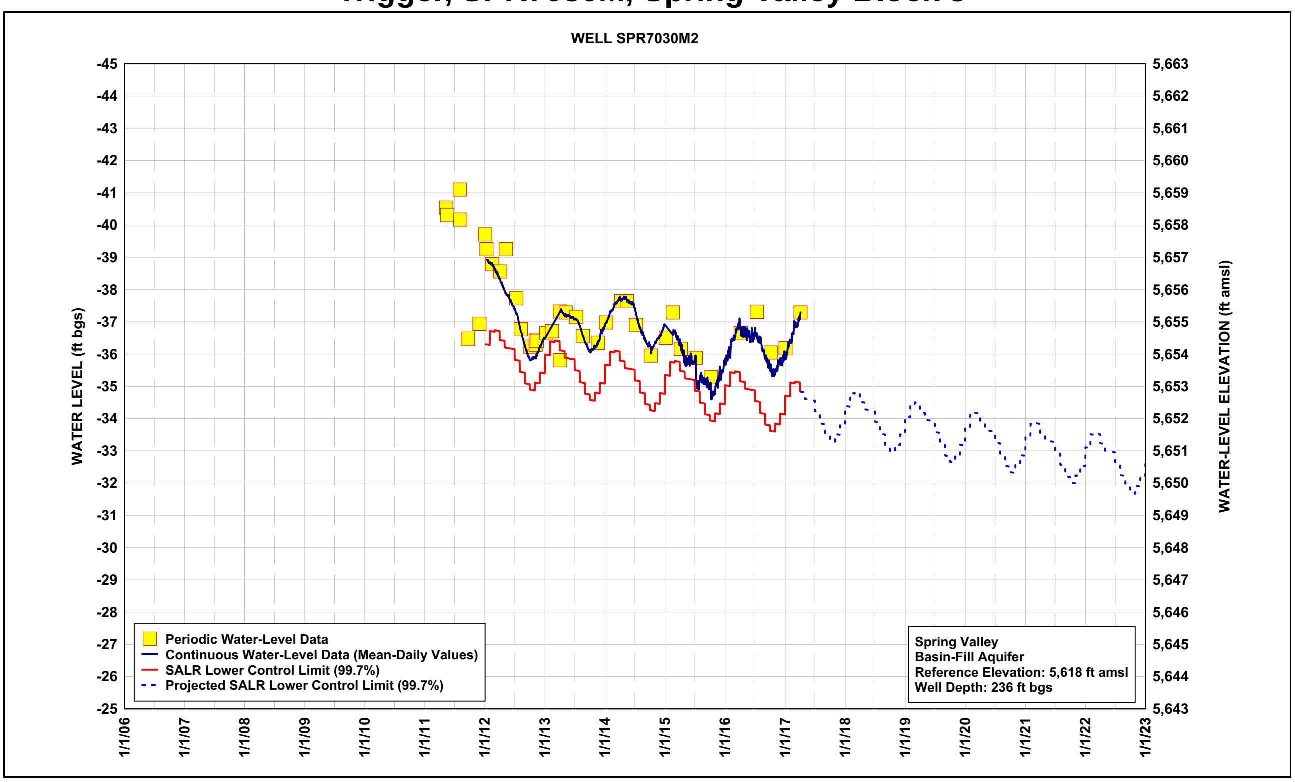


Figure C-4
Trigger, SPR7030M2, Spring Valley Block 3

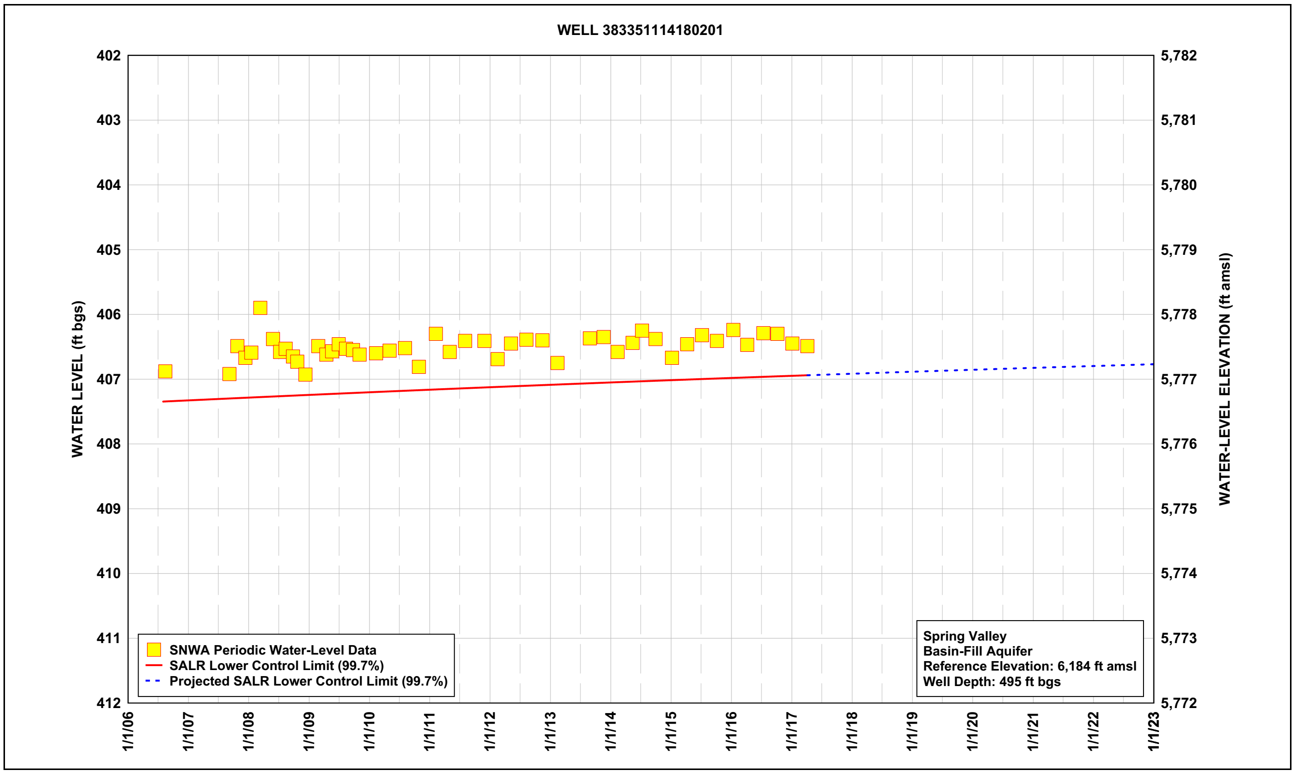


Figure C-5
Trigger, Well 383351114180201, Spring Valley Block 1

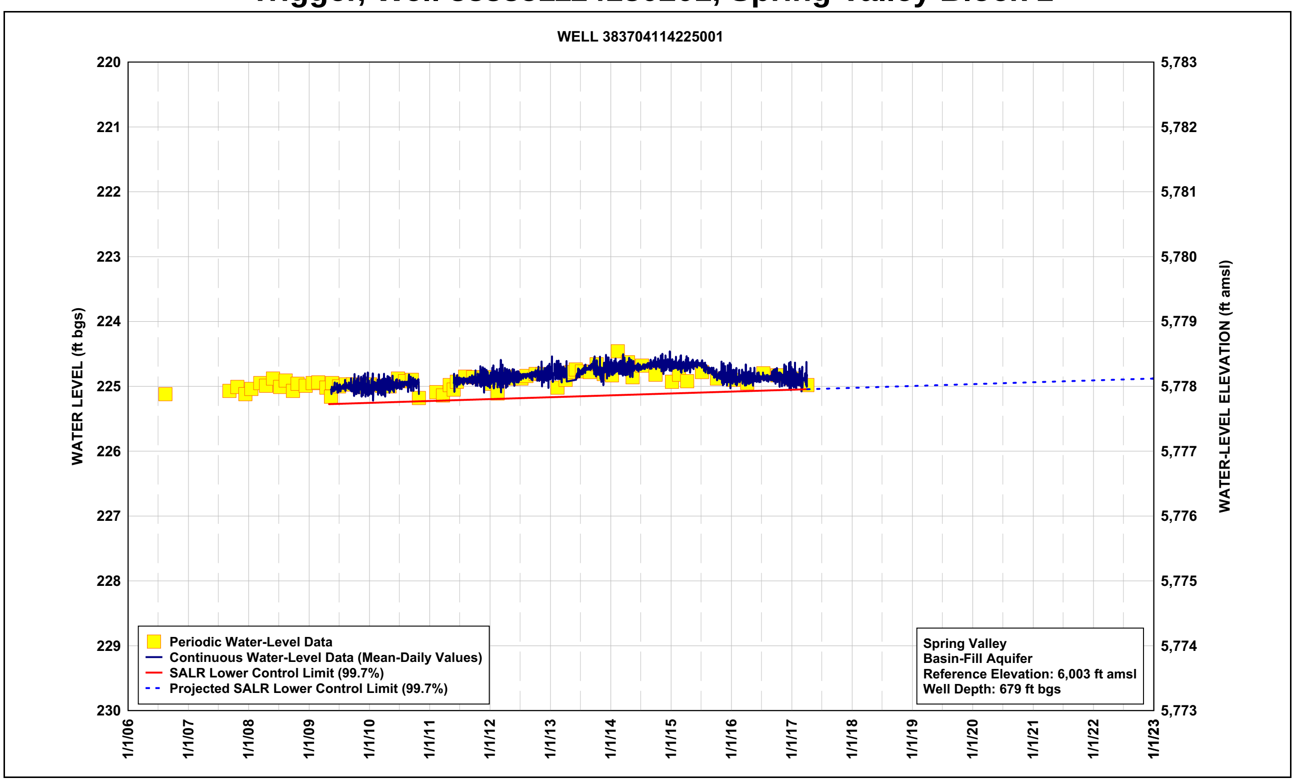


Figure C-6
Trigger, Well 383704114225001, Spring Valley Block 1

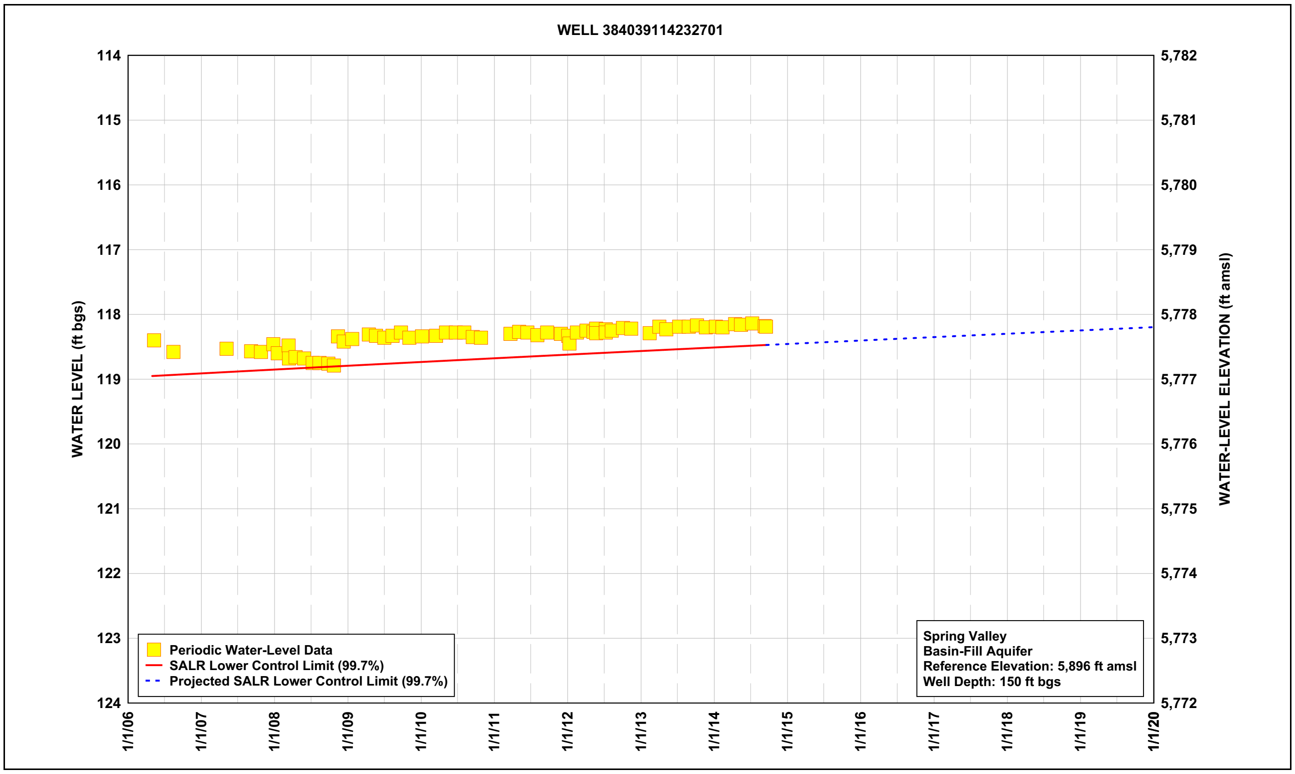


Figure C-7
Trigger, Well 384039114232701, Spring Valley Block 1

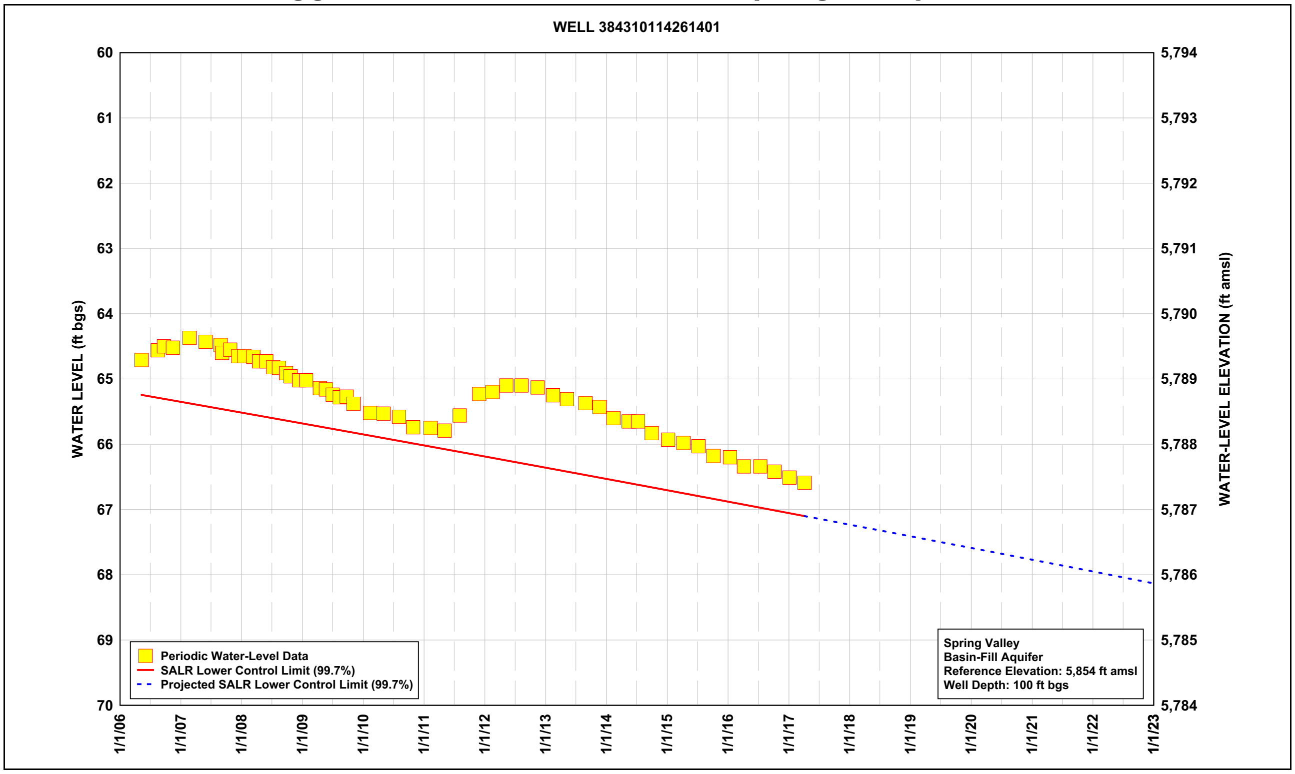


Figure C-8
Trigger, Well 384310114261401, Spring Valley Block 1

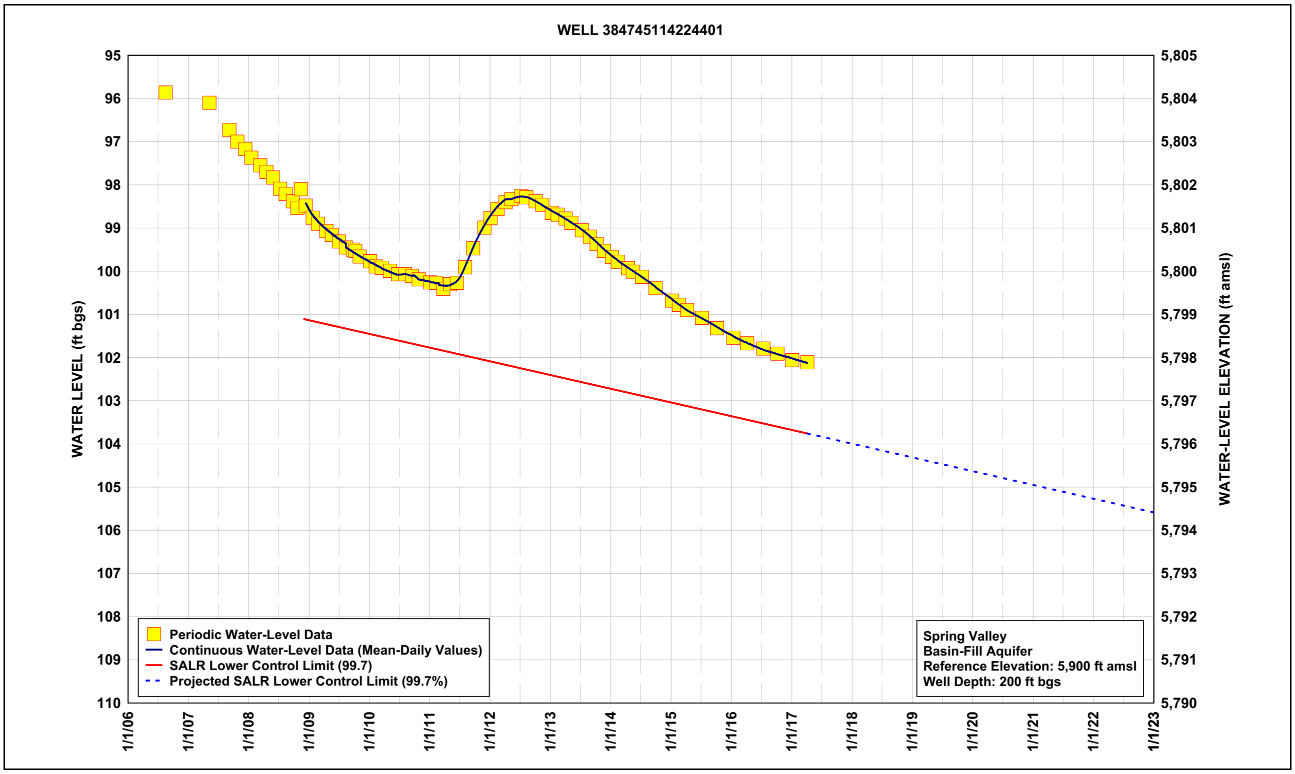


Figure C-9
Trigger, Well 384745114224401, Spring Valley Block 1

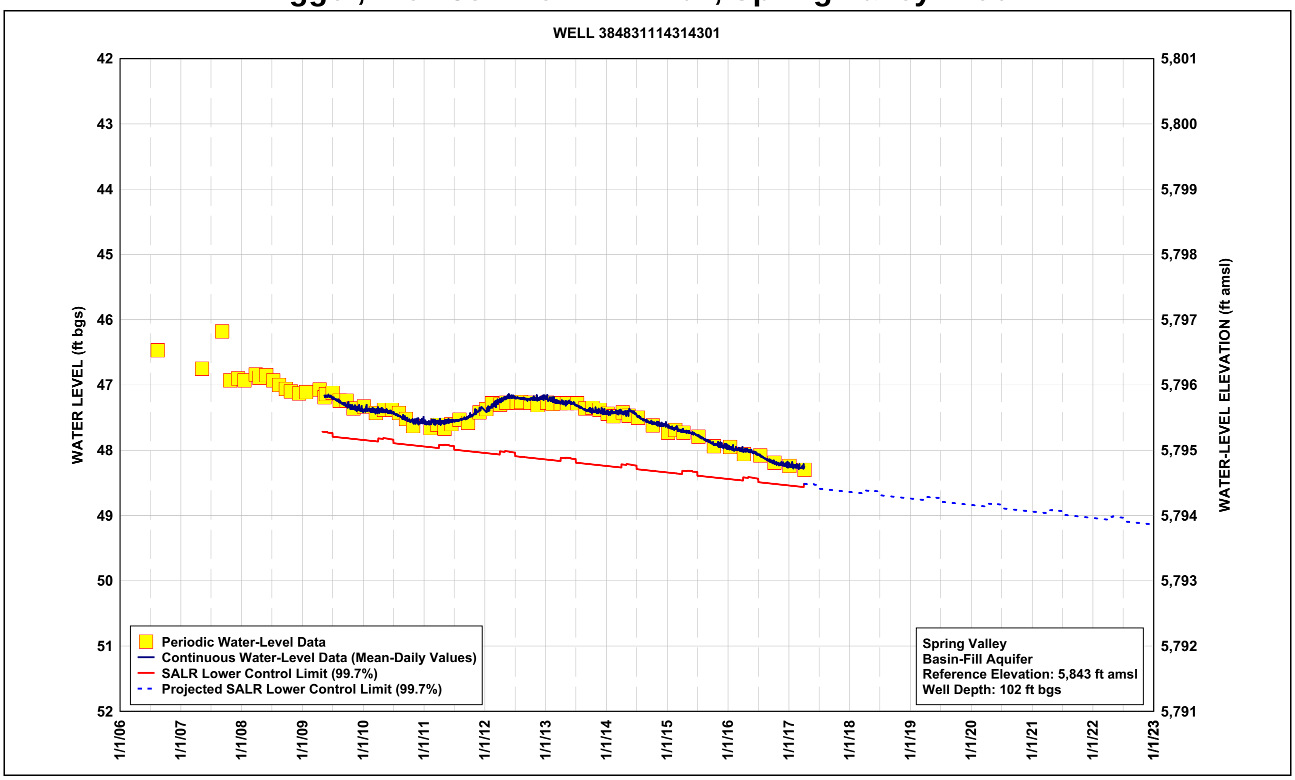


Figure C-10
Trigger, Well 384831114314301, Spring Valley Block 1

Figure C-11
Trigger, Well 385636114265501, Spring Valley Block 1

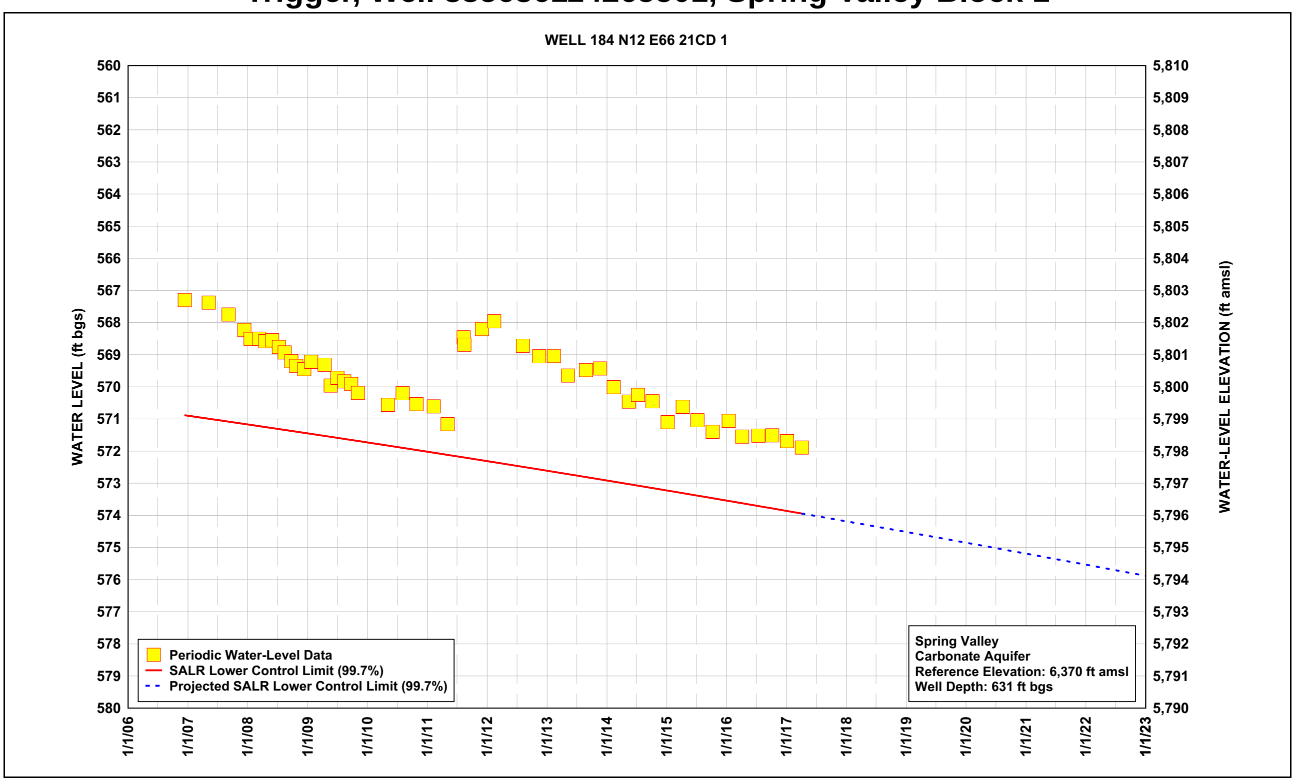


Figure C-12
Trigger, Well 184 N12 E66 21CD 1, Spring Valley Block 1

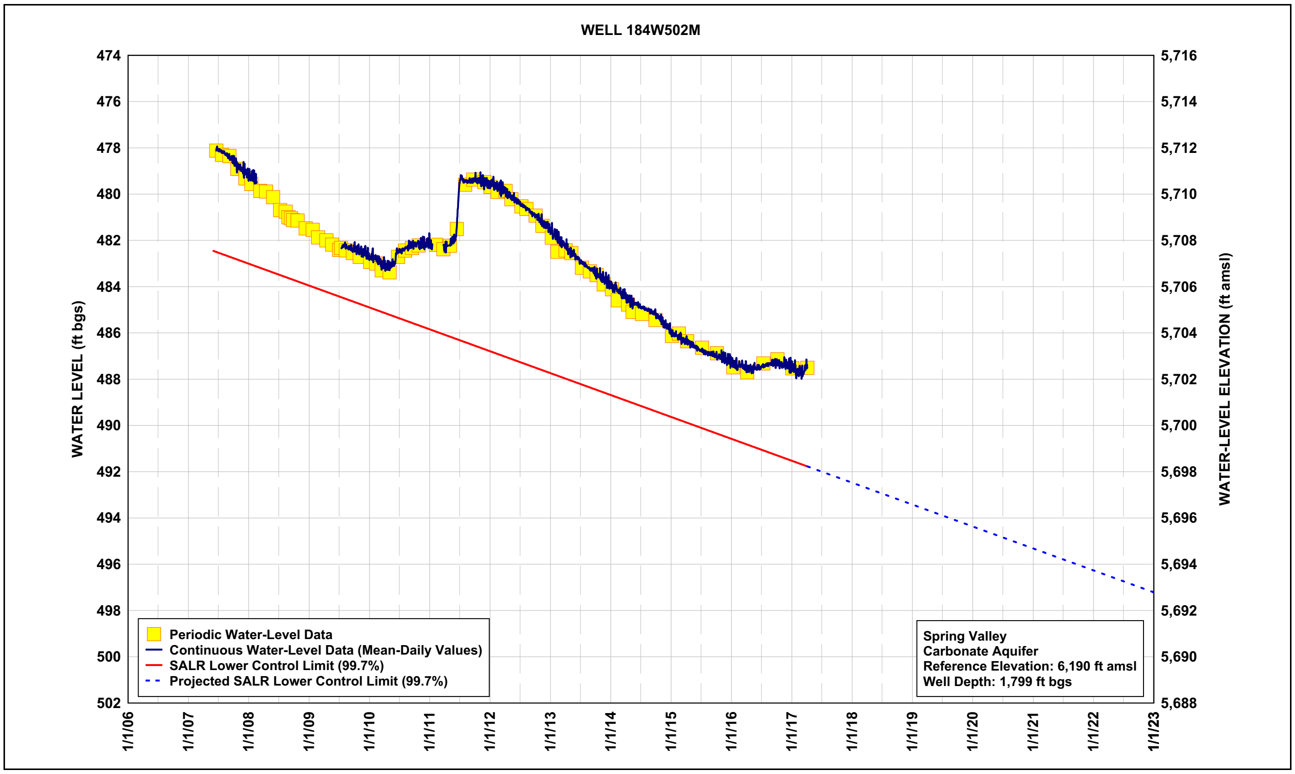


Figure C-13
Trigger, Well 184W502M, Spring Valley Block 1

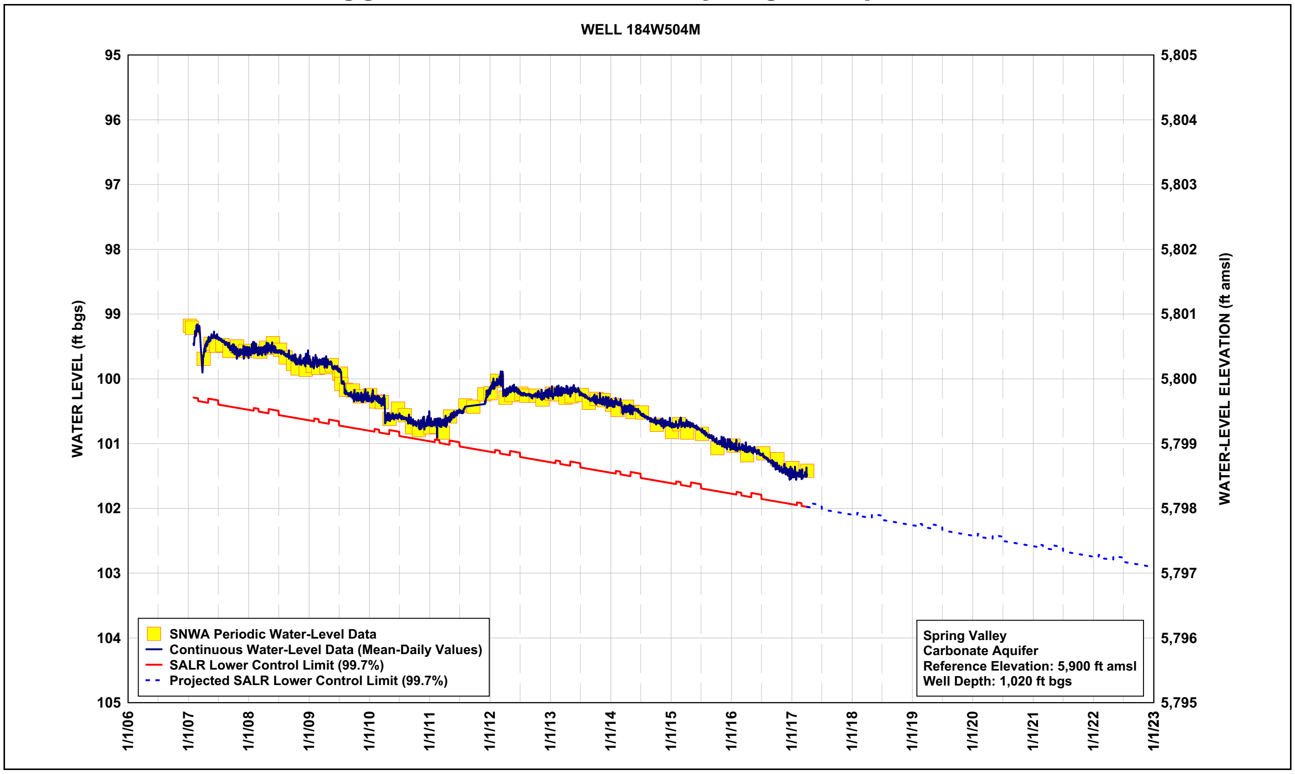


Figure C-14
Trigger, Well 184W504M, Spring Valley Block 1

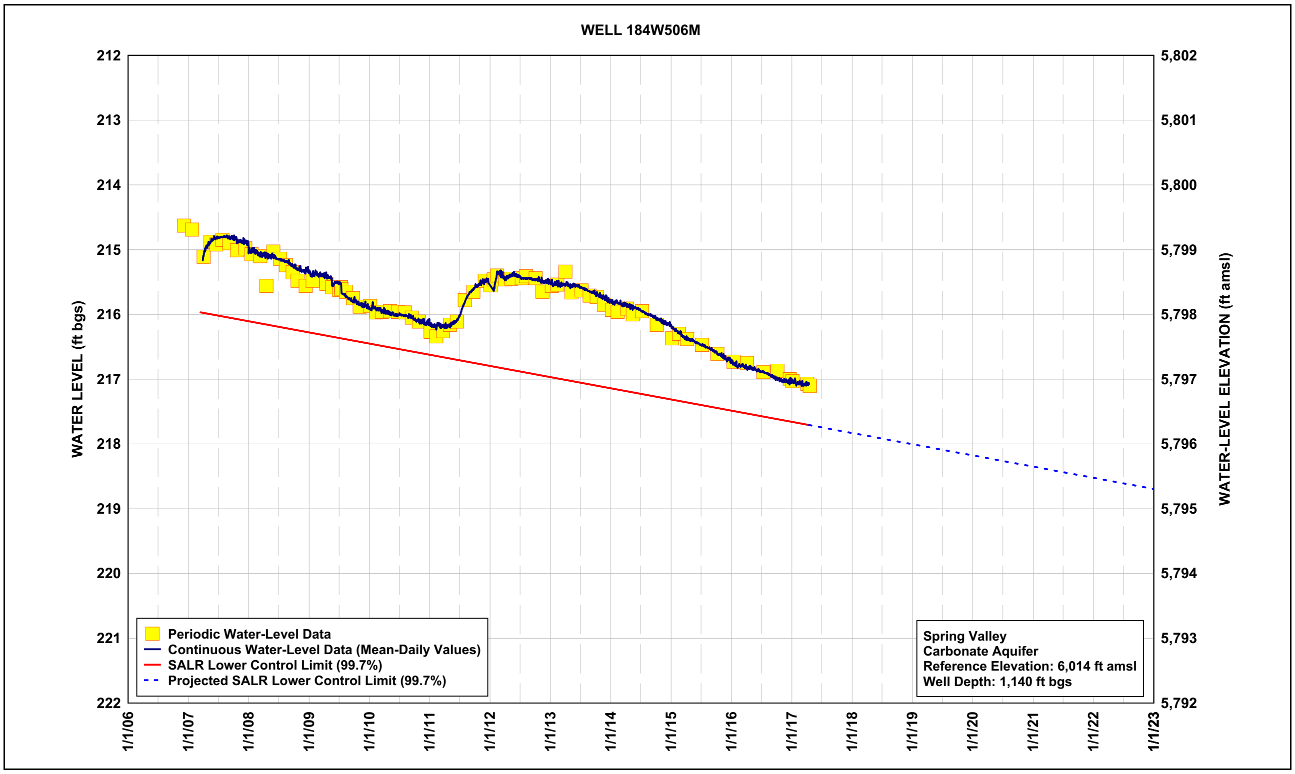


Figure C-15
Trigger, Well 184W506M, Spring Valley Block 1

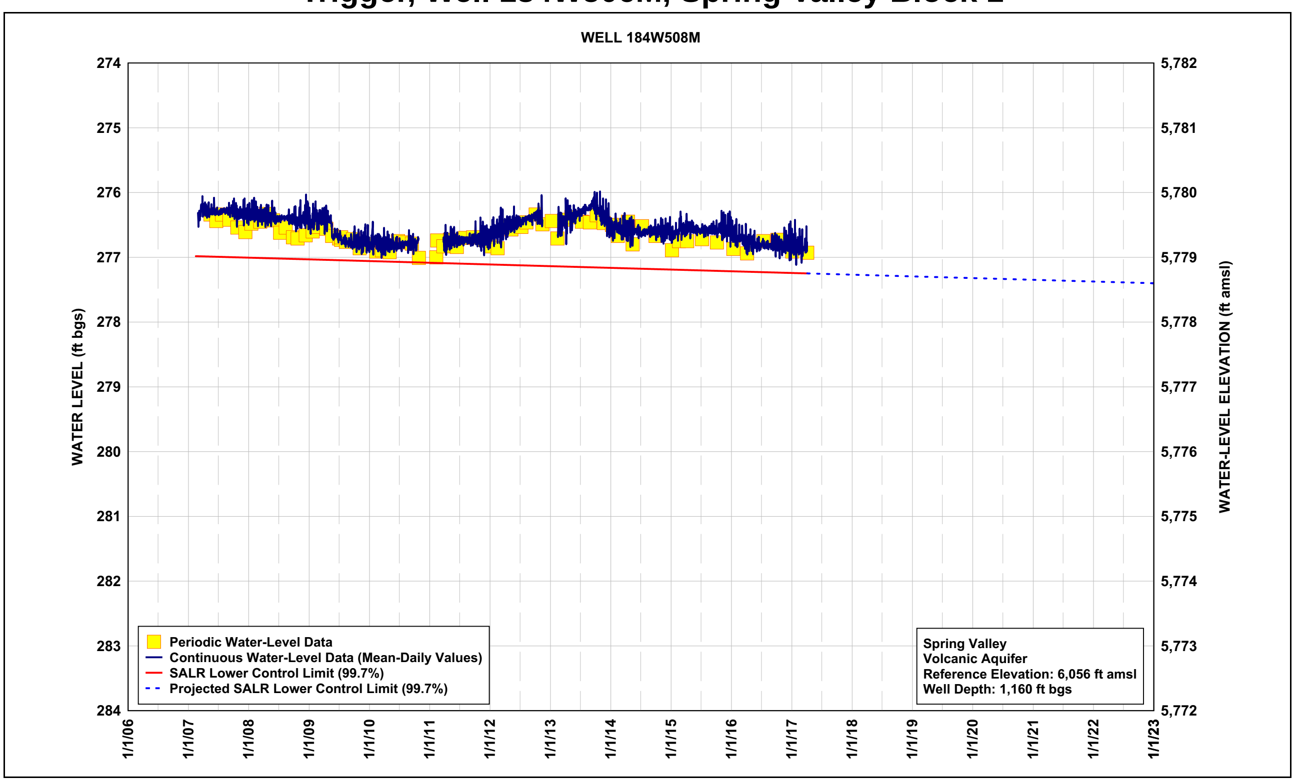


Figure C-16
Trigger, Well 184W508M, Spring Valley Block 1

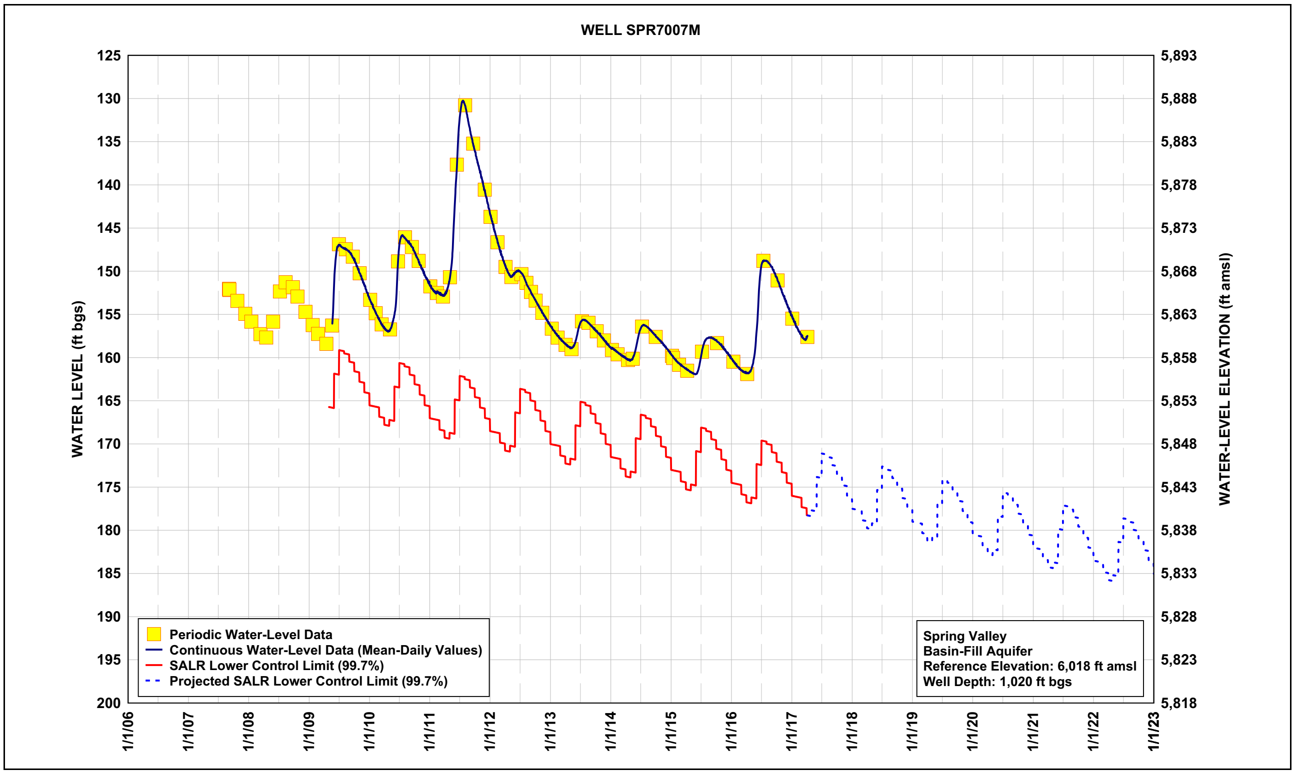


Figure C-17
Trigger, Well SPR7007M, Spring Valley Block 1

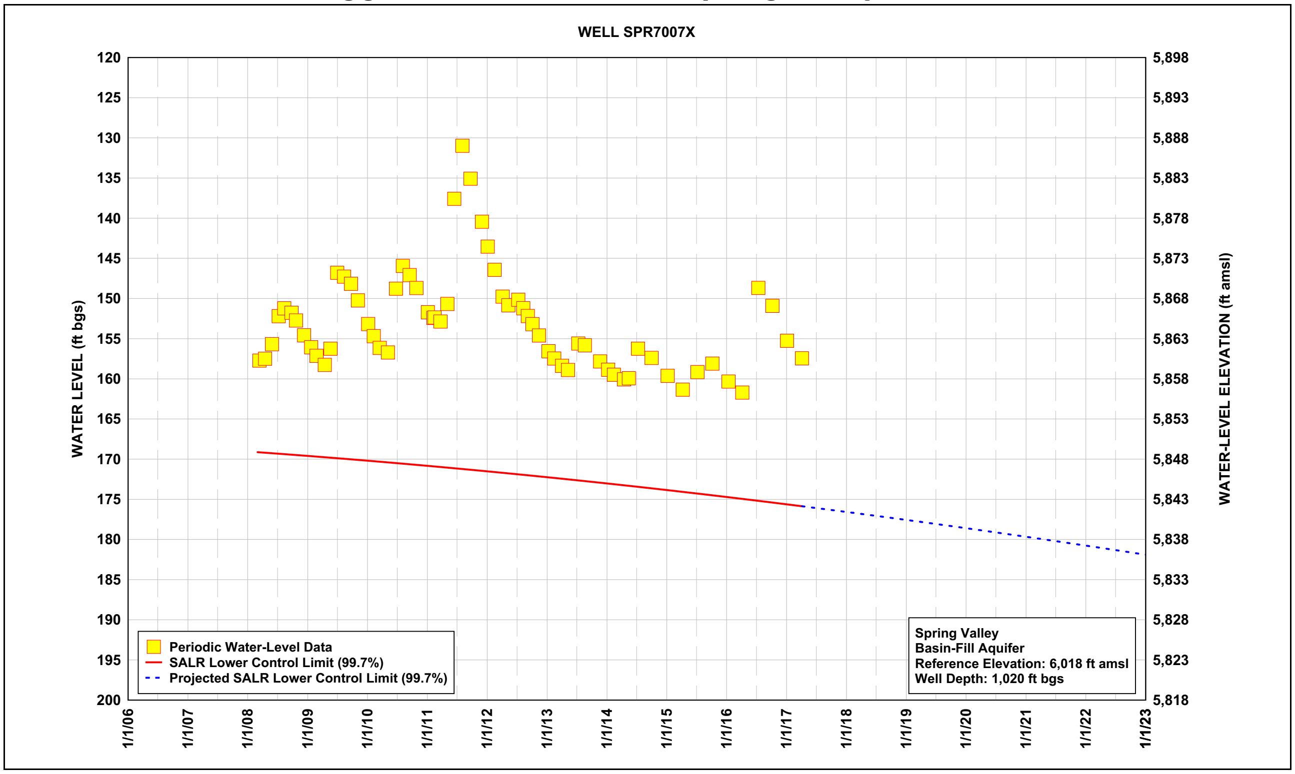


Figure C-18
Trigger, Well SPR7007X, Spring Valley Block 1

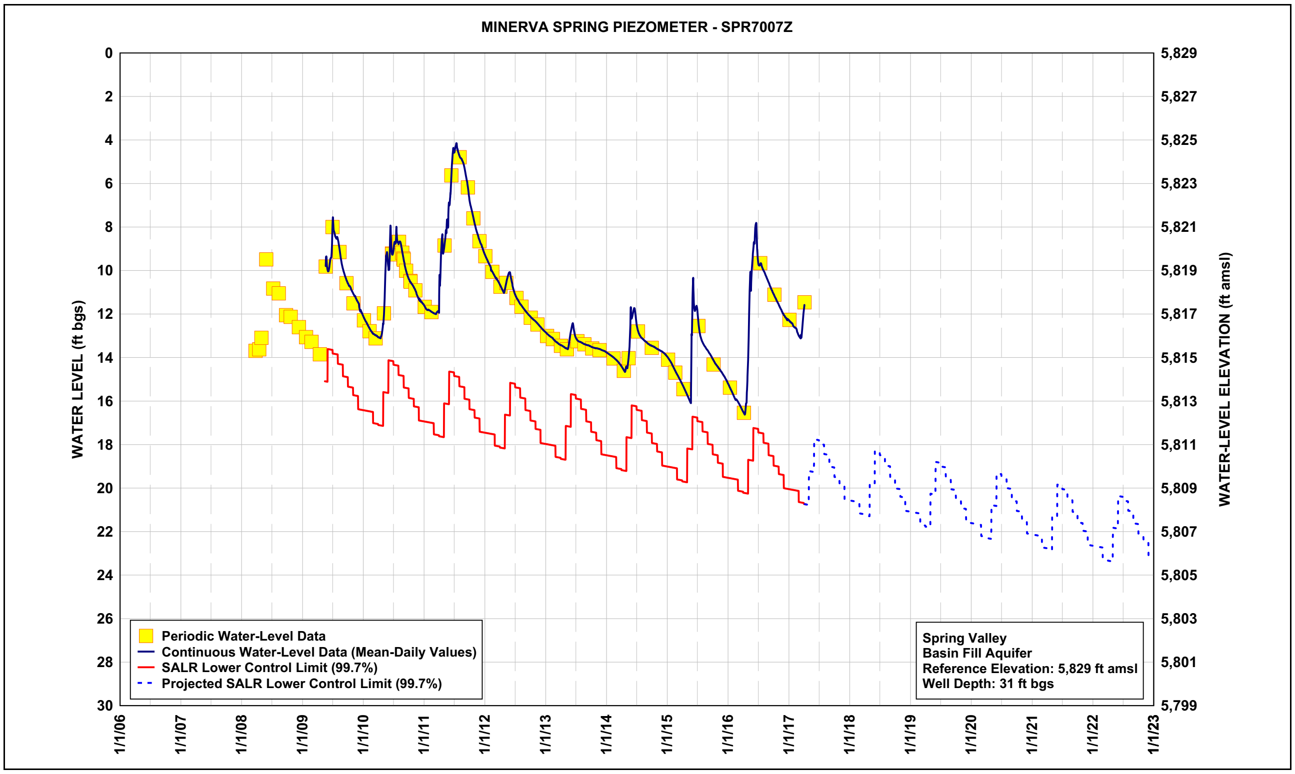


Figure C-19
Trigger, Well SPR7007Z, Spring Valley Block 1

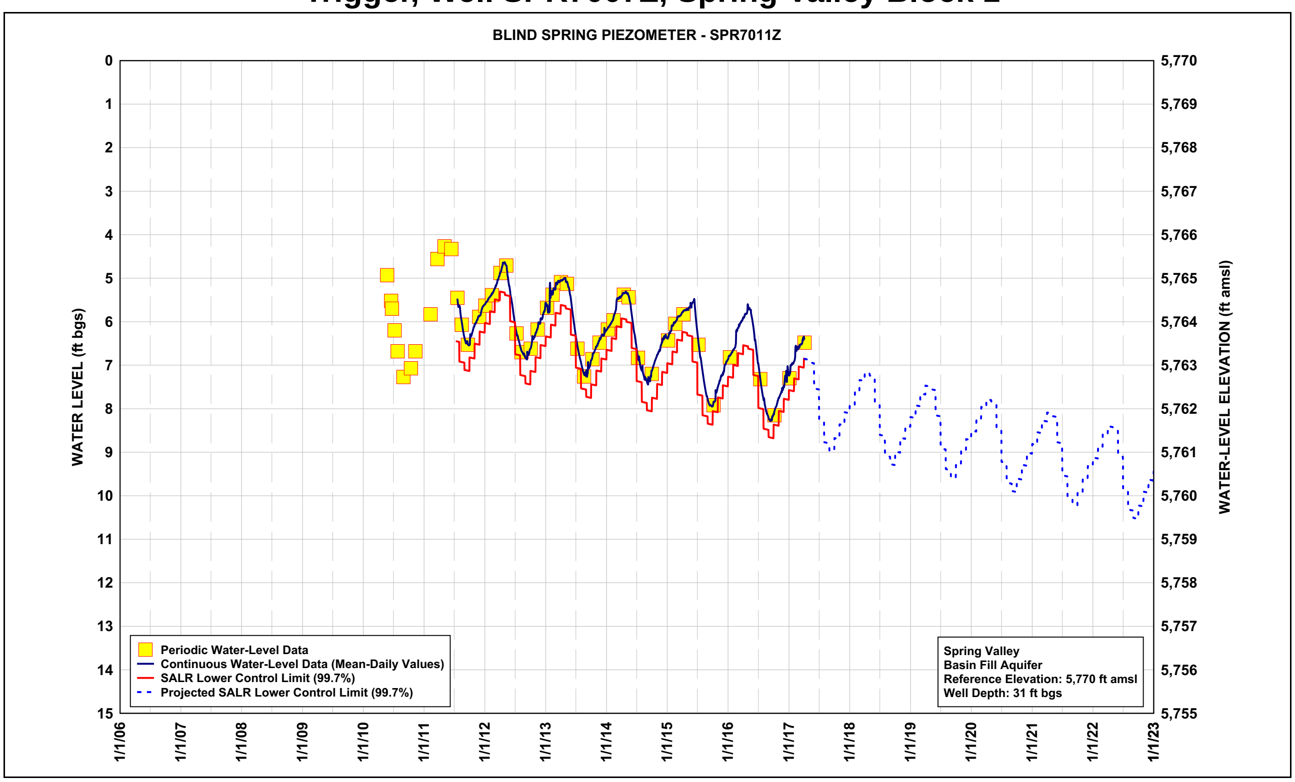


Figure C-20
Trigger, Well SPR7011Z, Spring Valley Block 1

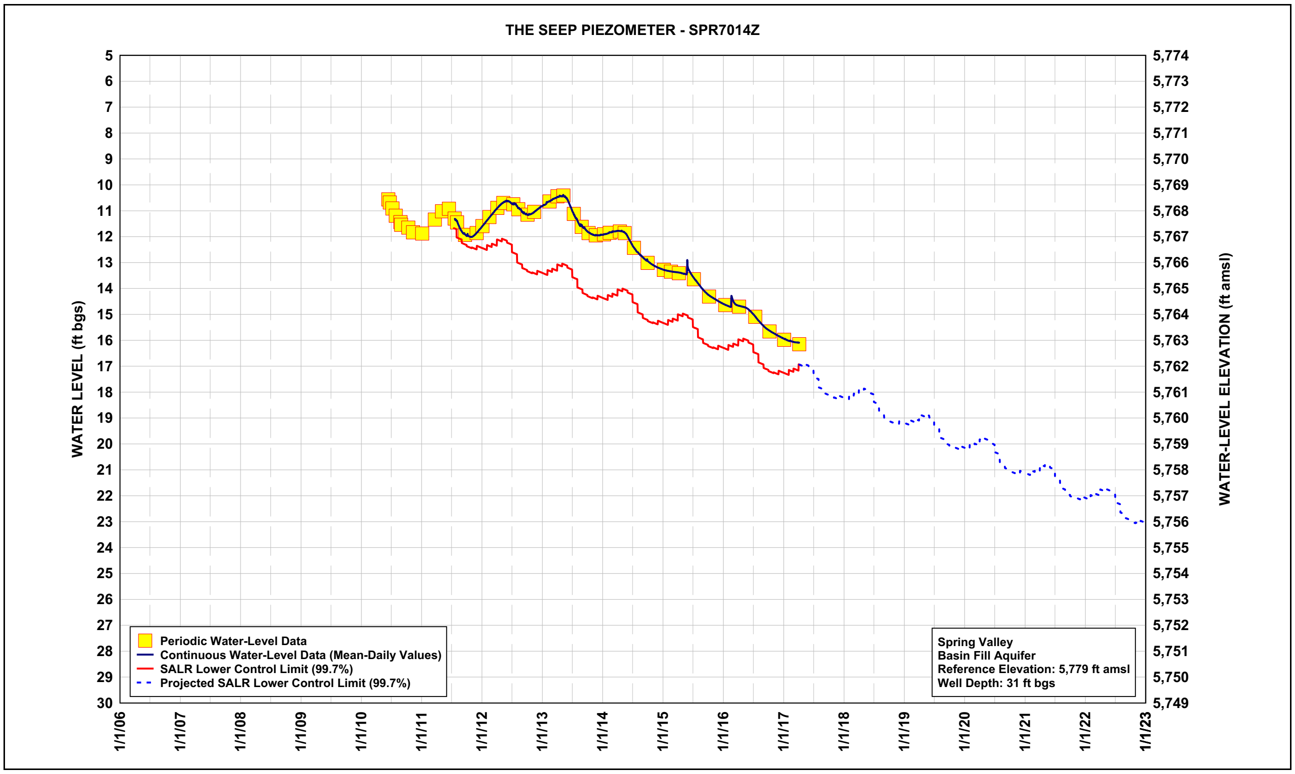


Figure C-21
Trigger, Well SPR7014Z, Spring Valley Block 1

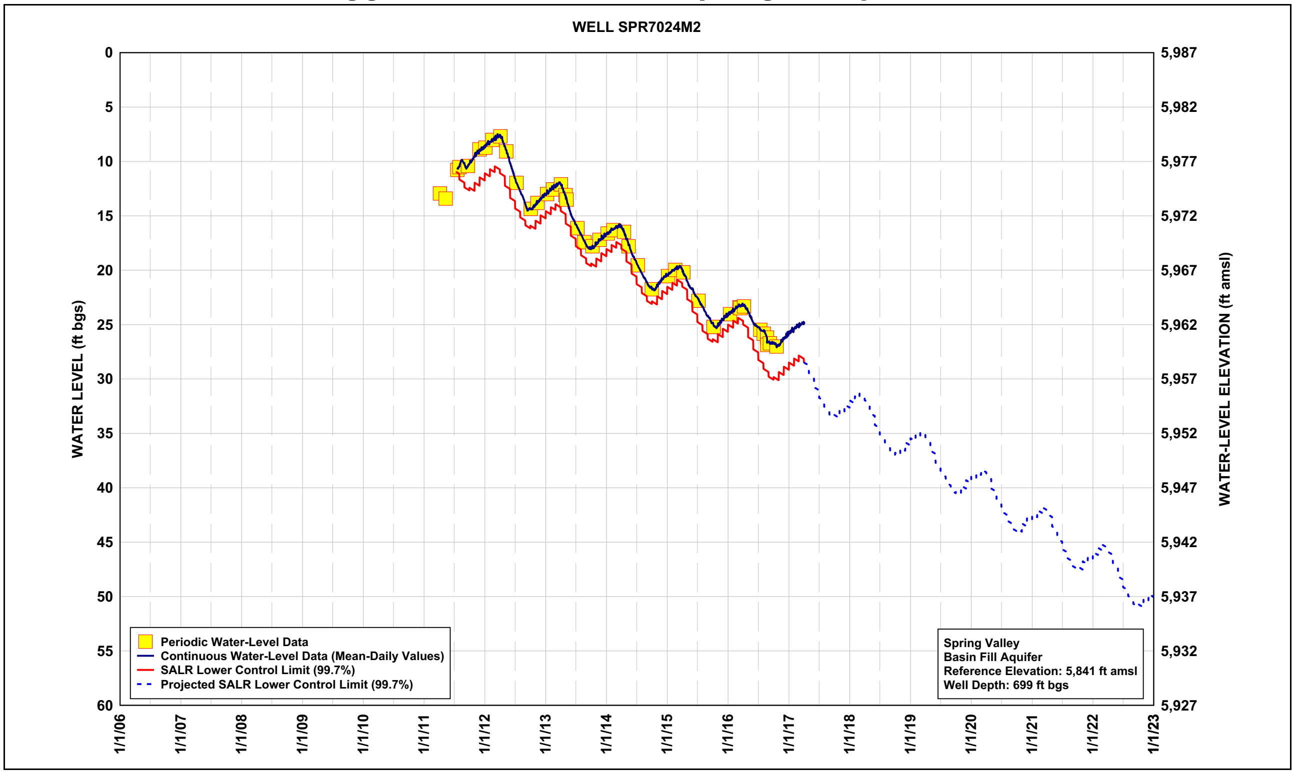


Figure C-22
Trigger, Well SPR7024M2, Spring Valley Block 1

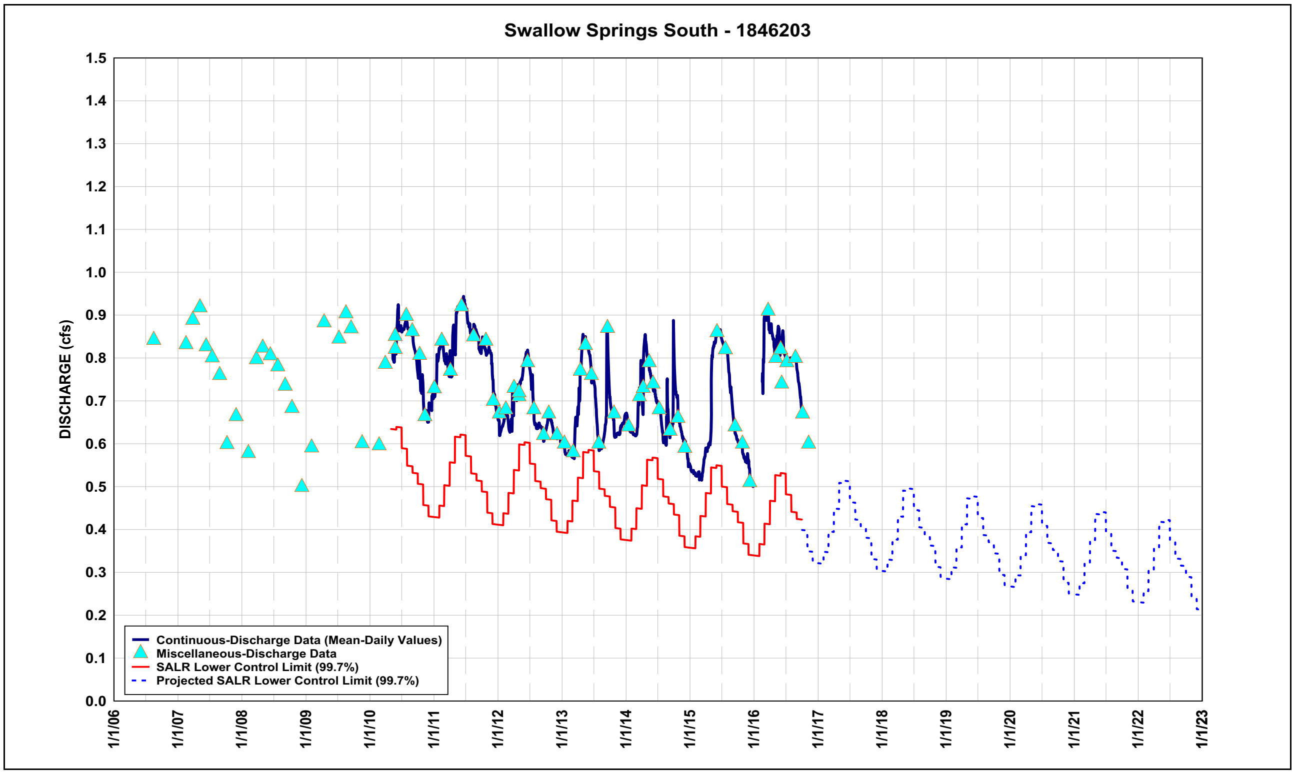


Figure C-23
Trigger, Swallow Springs South, Spring Valley Block 1

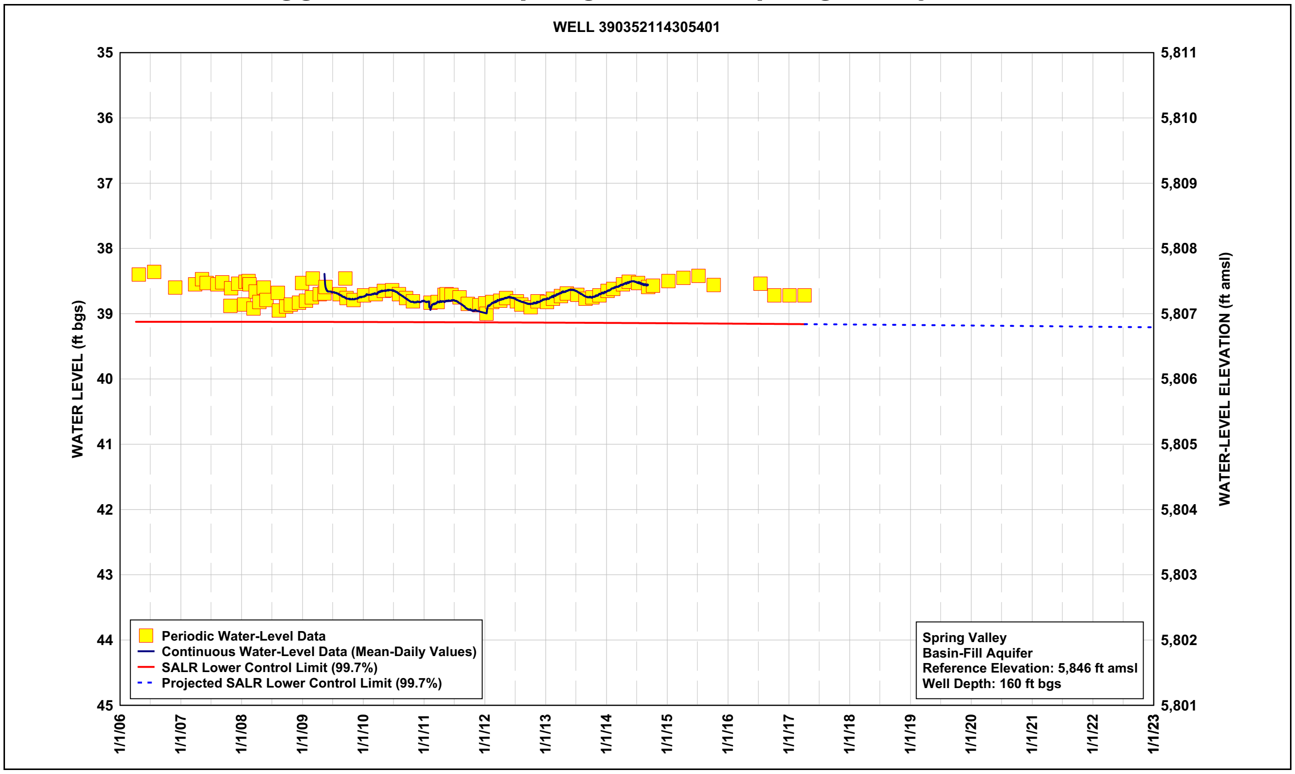


Figure C-24
Trigger, Well 390352114305401, Spring Valley Block 2

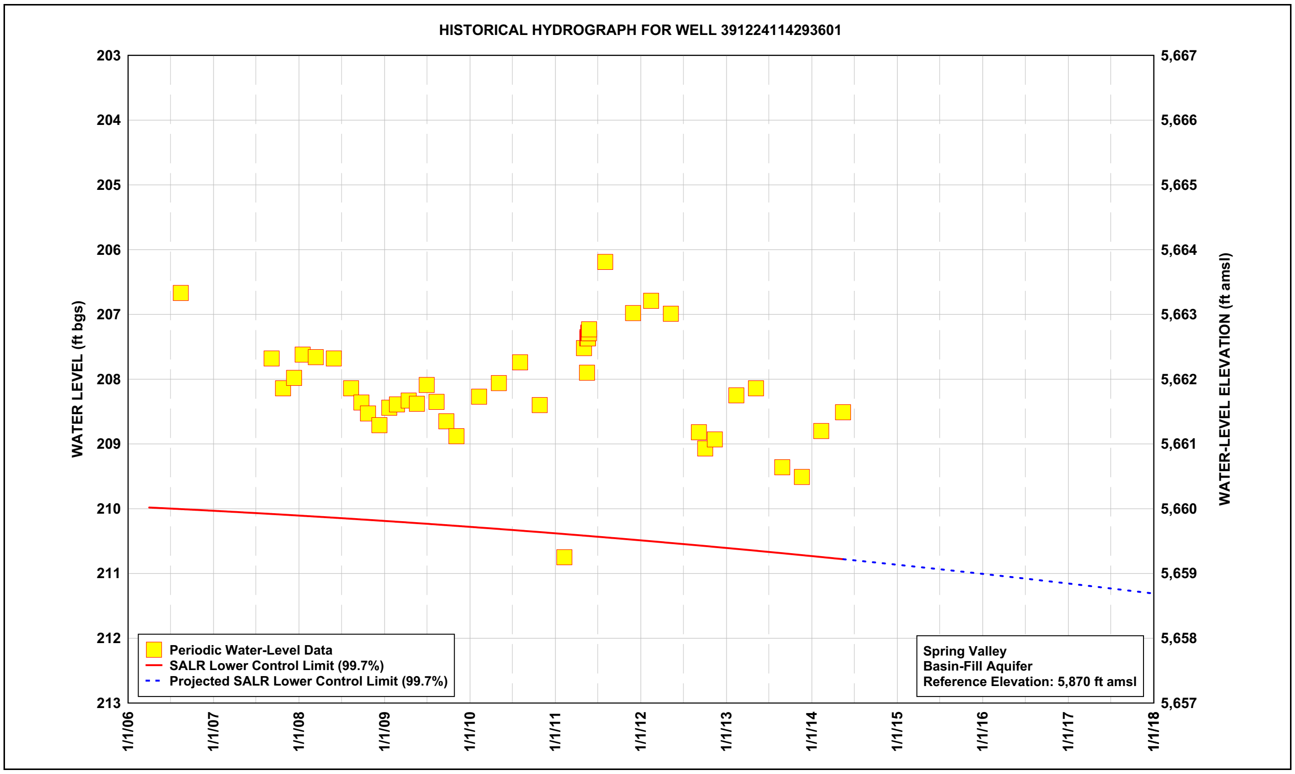


Figure C-25
Trigger, Well 391224114293601, Spring Valley Block 2

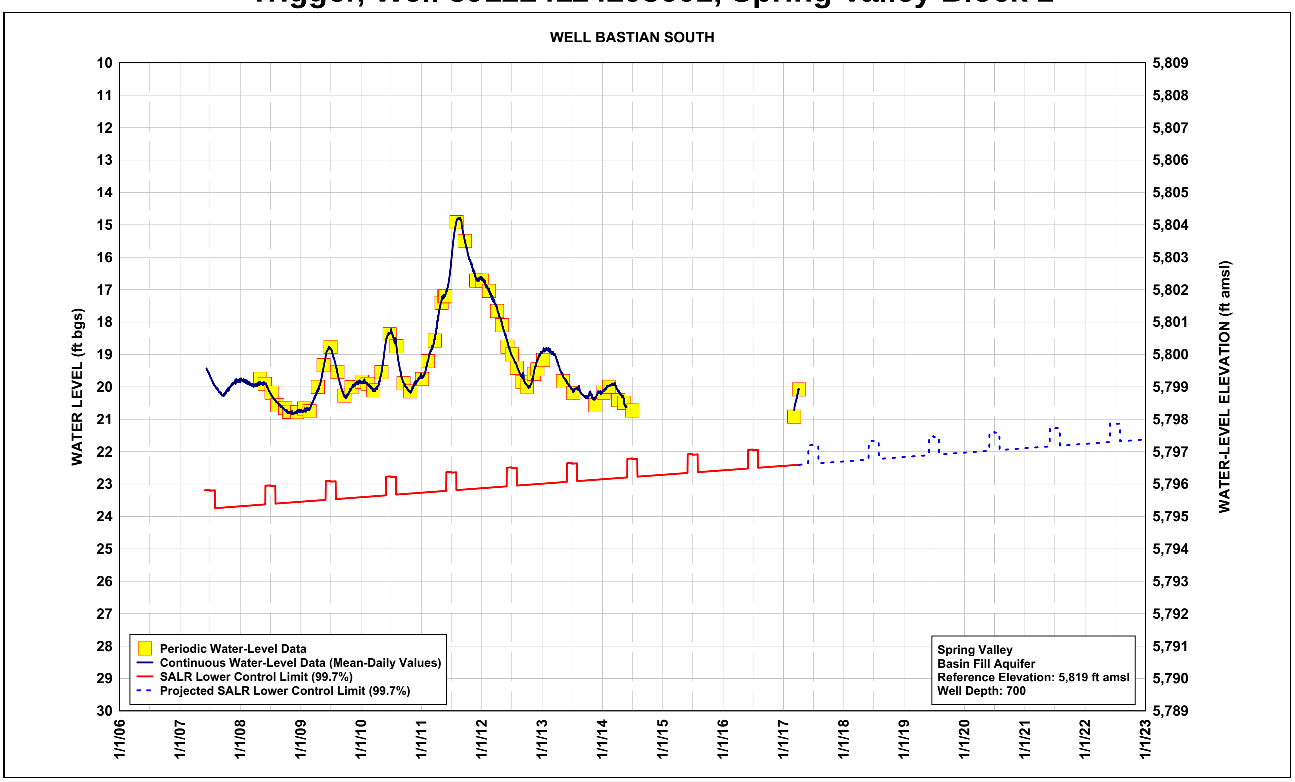


Figure C-26
Trigger, Bastian South Well, Spring Valley Block 2

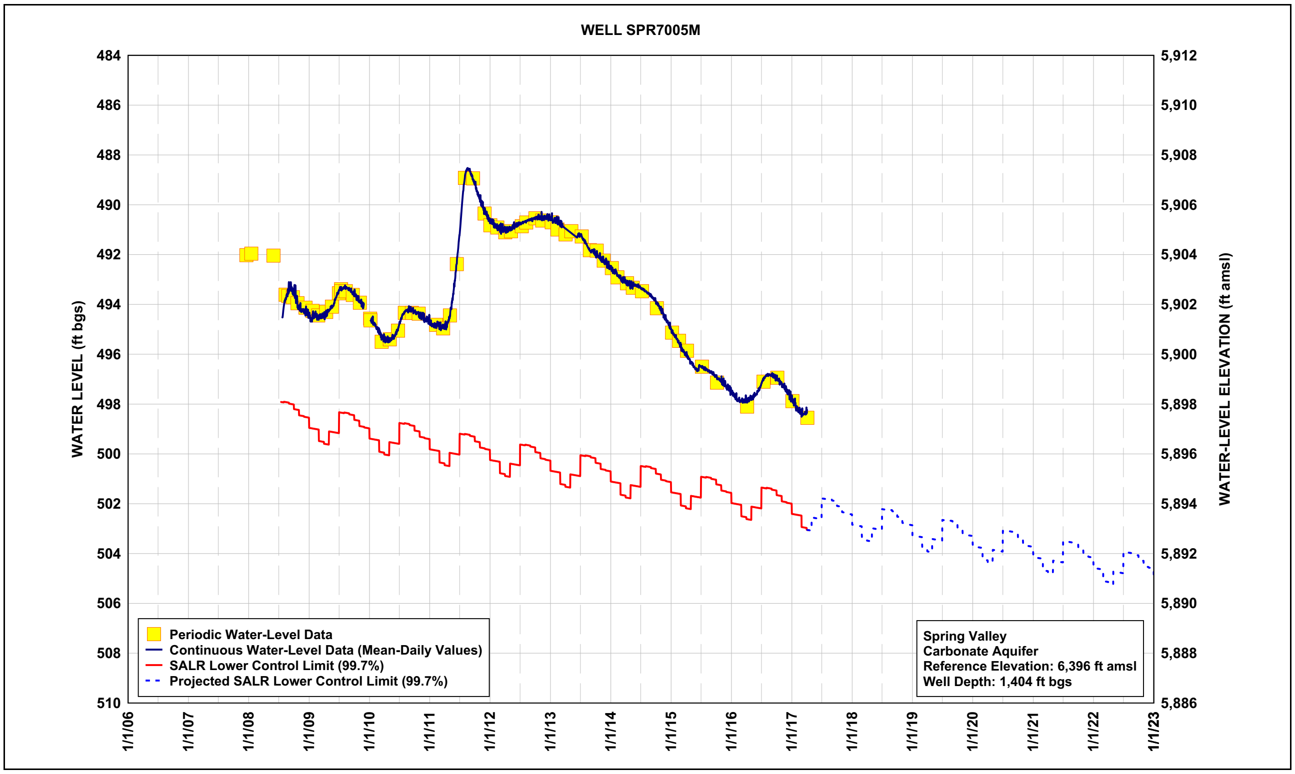


Figure C-27
Trigger, SPR7005M, Spring Valley Block 2

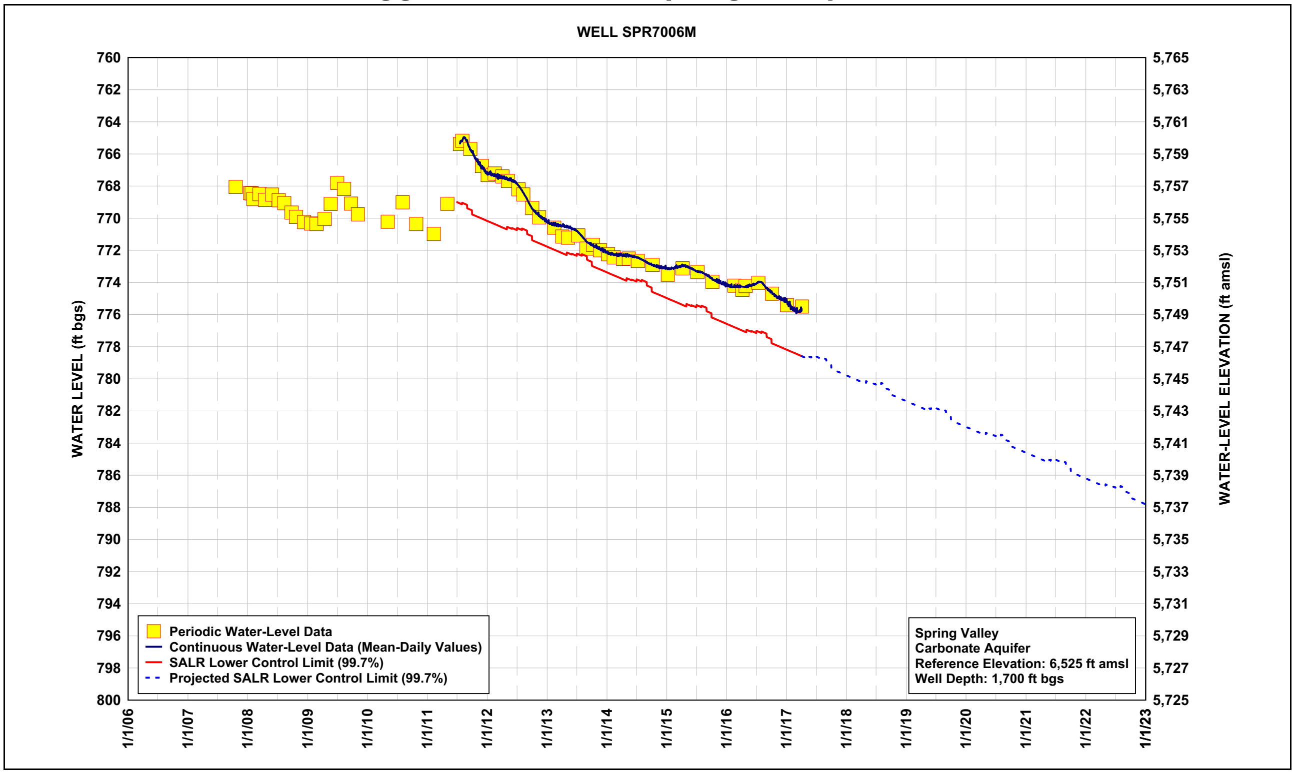


Figure C-28
Trigger, SPR7006M, Spring Valley Block 2

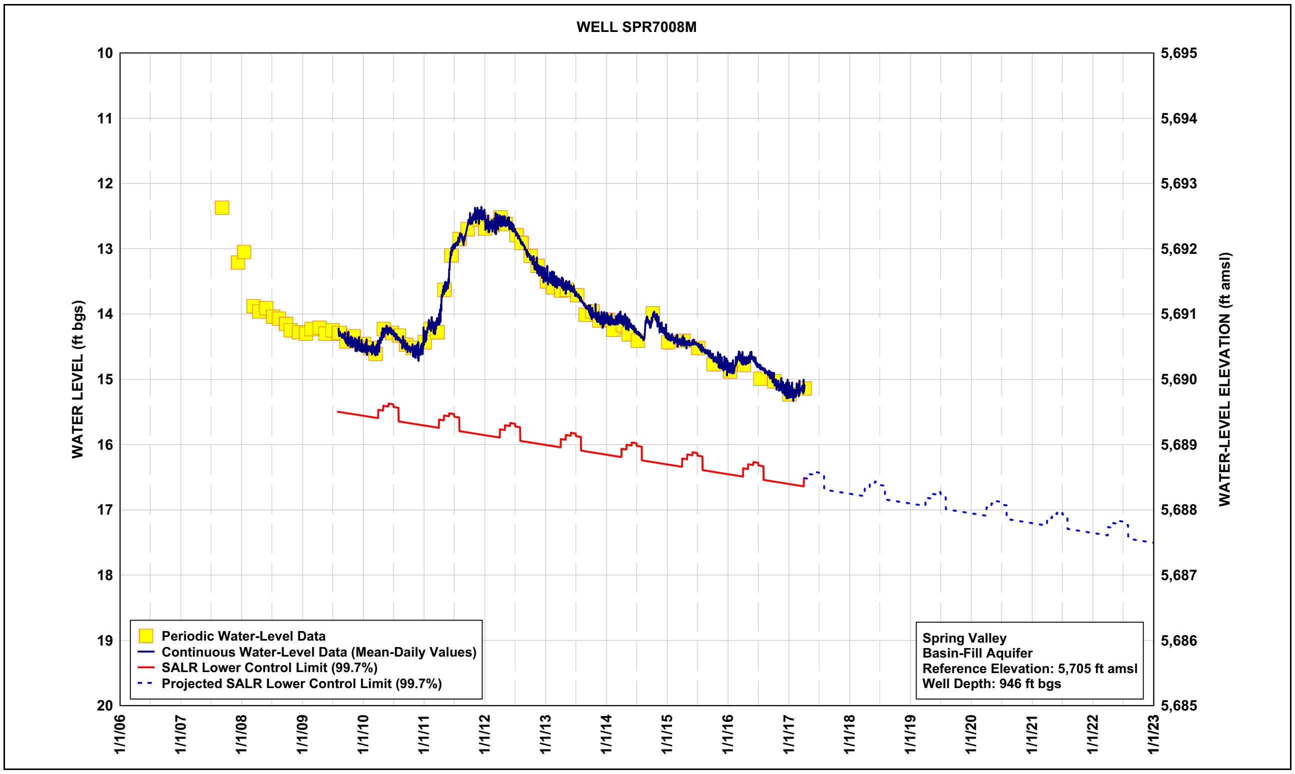


Figure C-29
Trigger, SPR7008M, Spring Valley Block 2

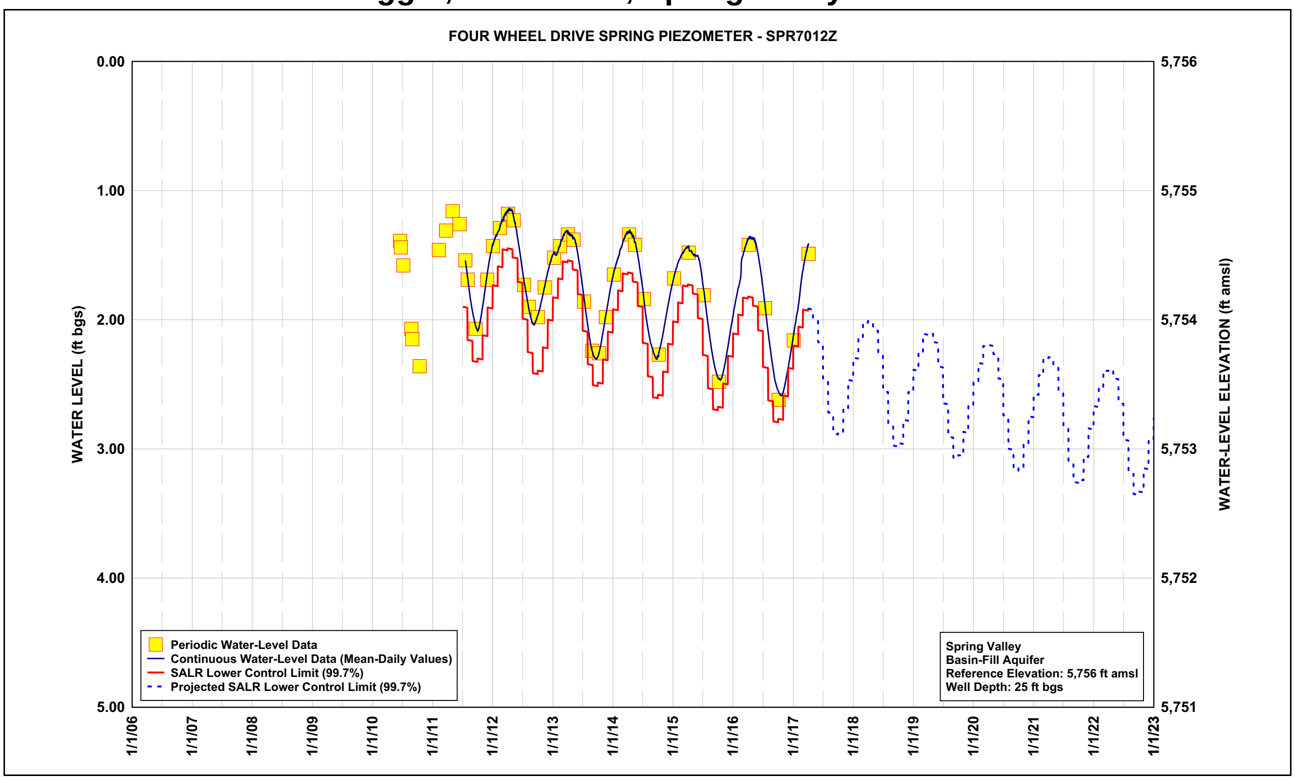


Figure C-30
Trigger, SPR7012Z, Spring Valley Block 2

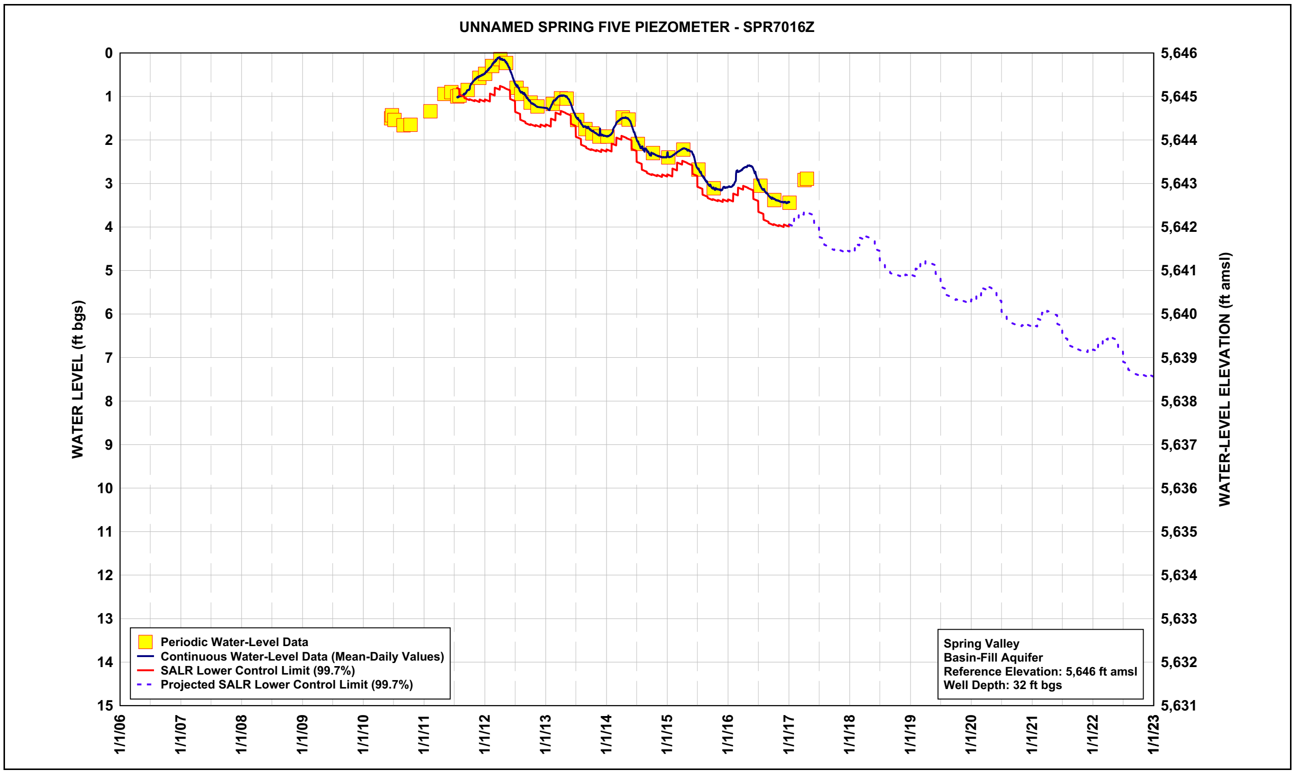


Figure C-31
Trigger, SPR7016Z, Spring Valley Block 2

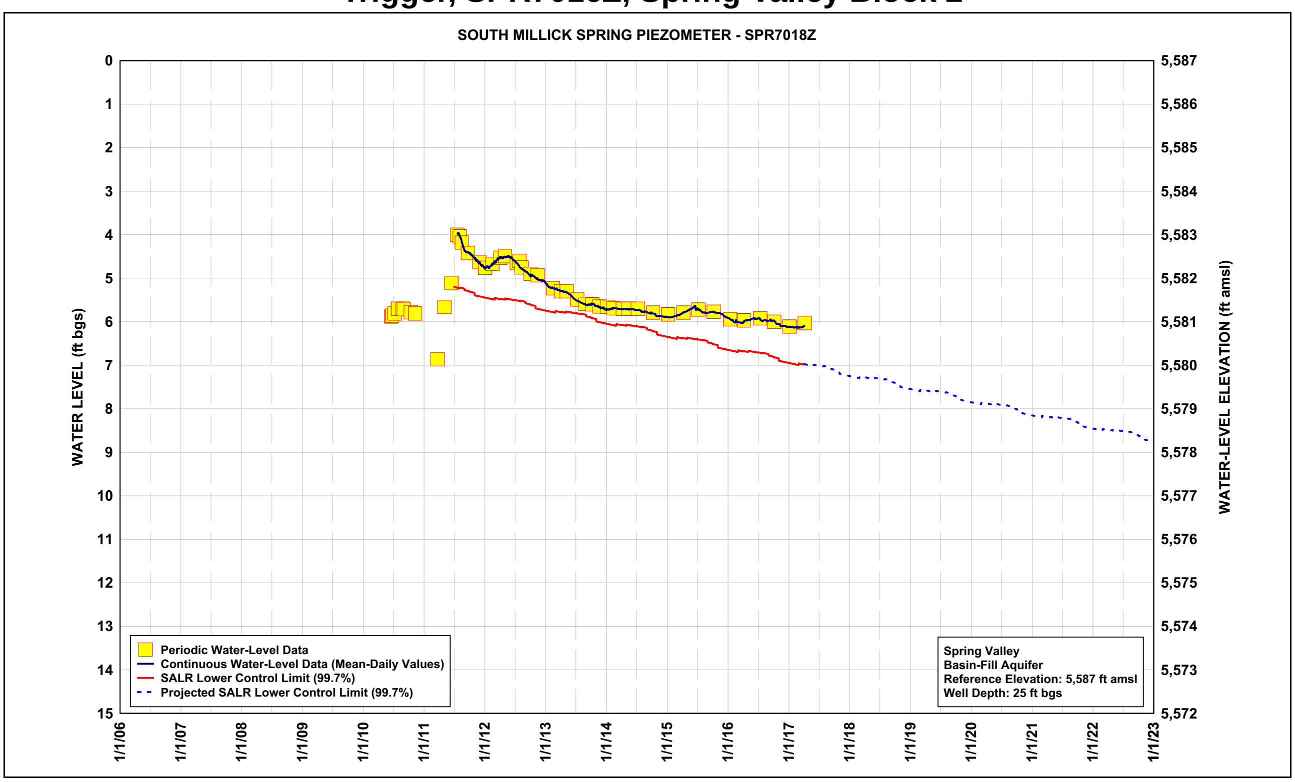


Figure C-32
Trigger, SPR7018Z, Spring Valley Block 2

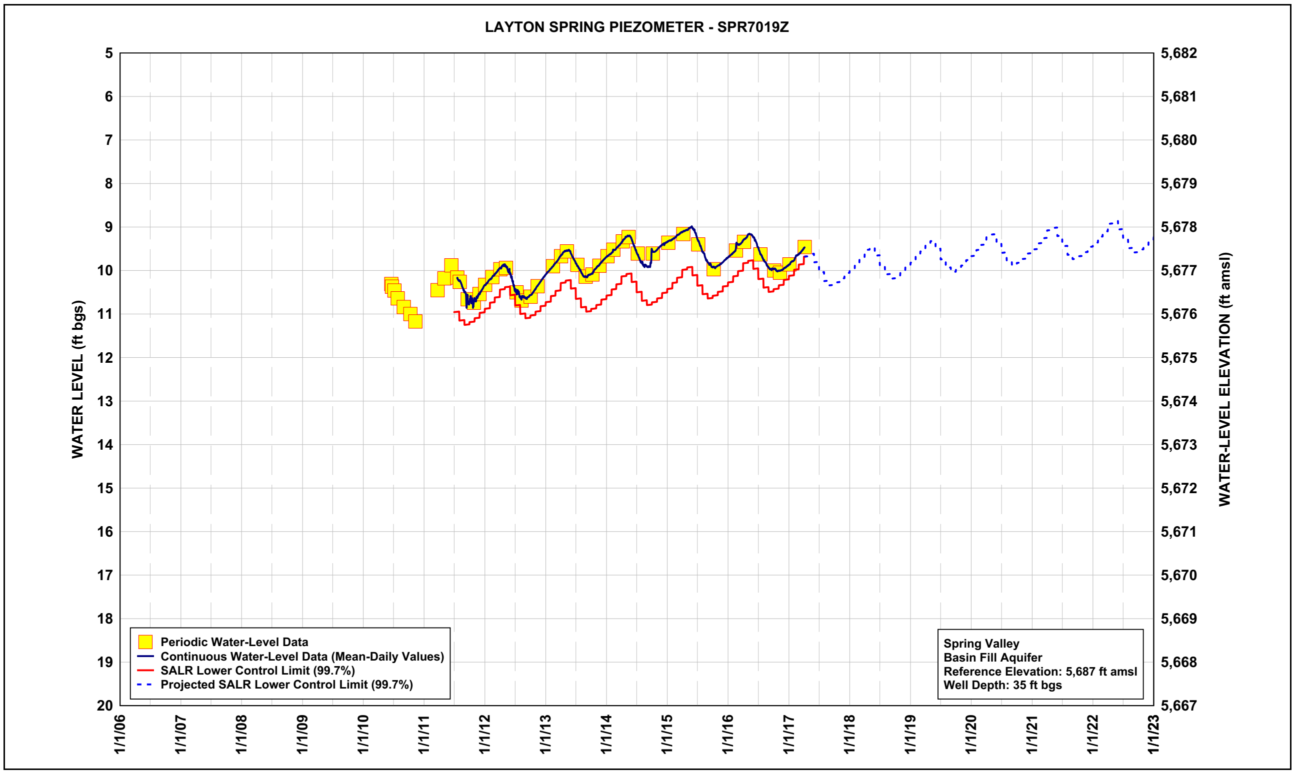


Figure C-33
Trigger, SPR7019Z, Spring Valley Block 2

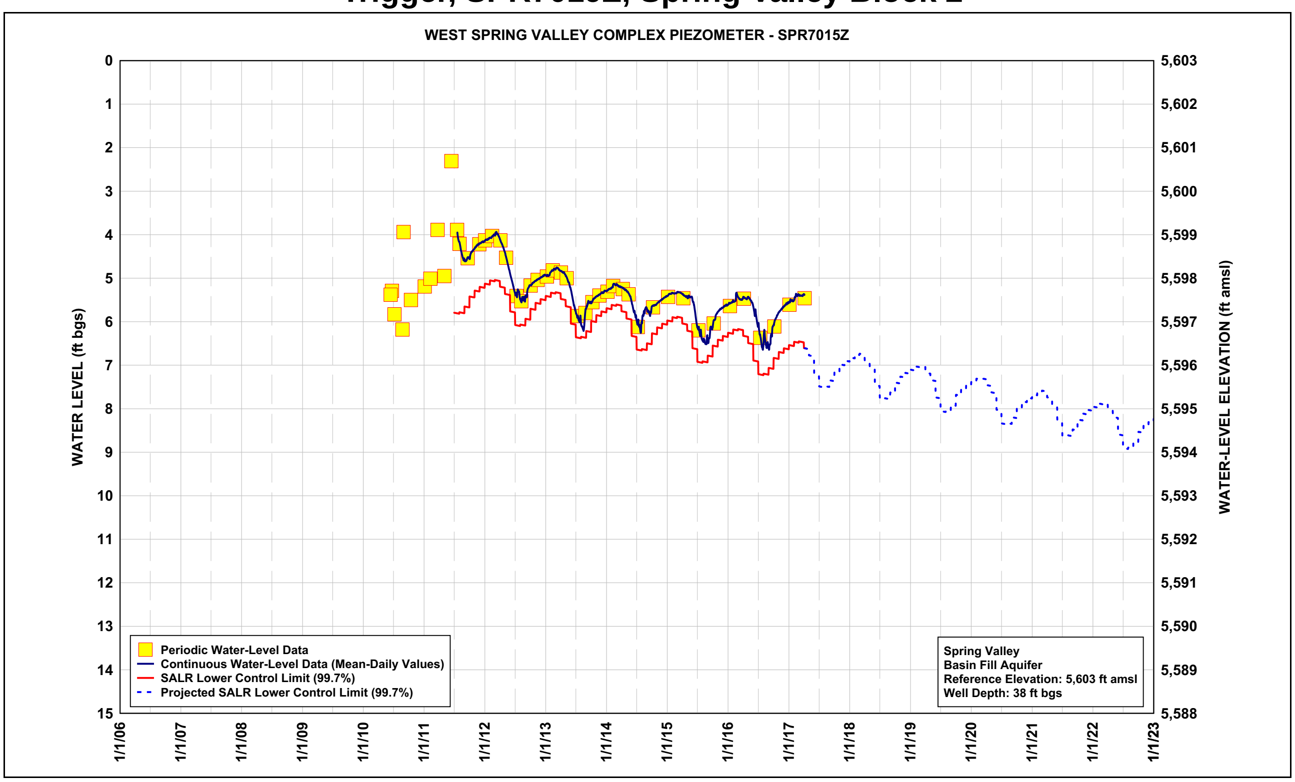


Figure C-34
Trigger, SPR7015Z, Spring Valley Block 3

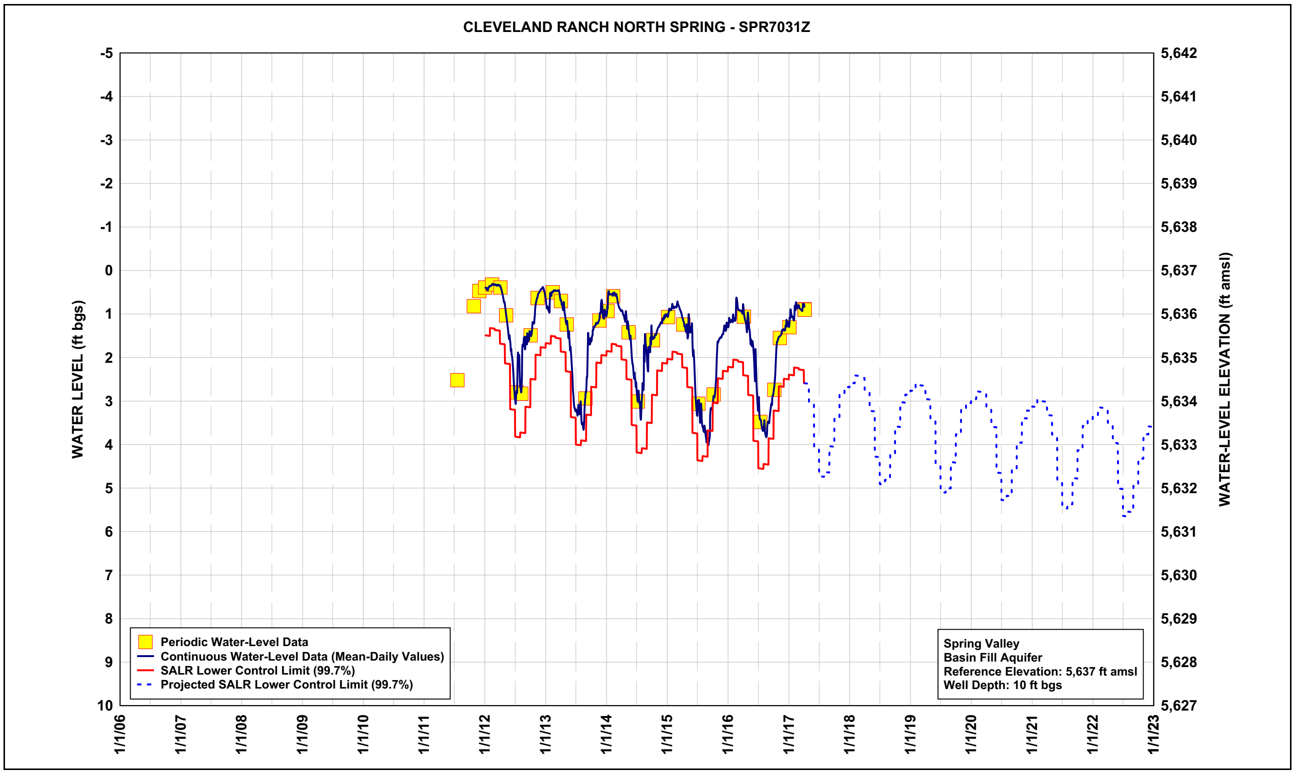


Figure C-35
Trigger, SPR7031Z, Spring Valley Block 3

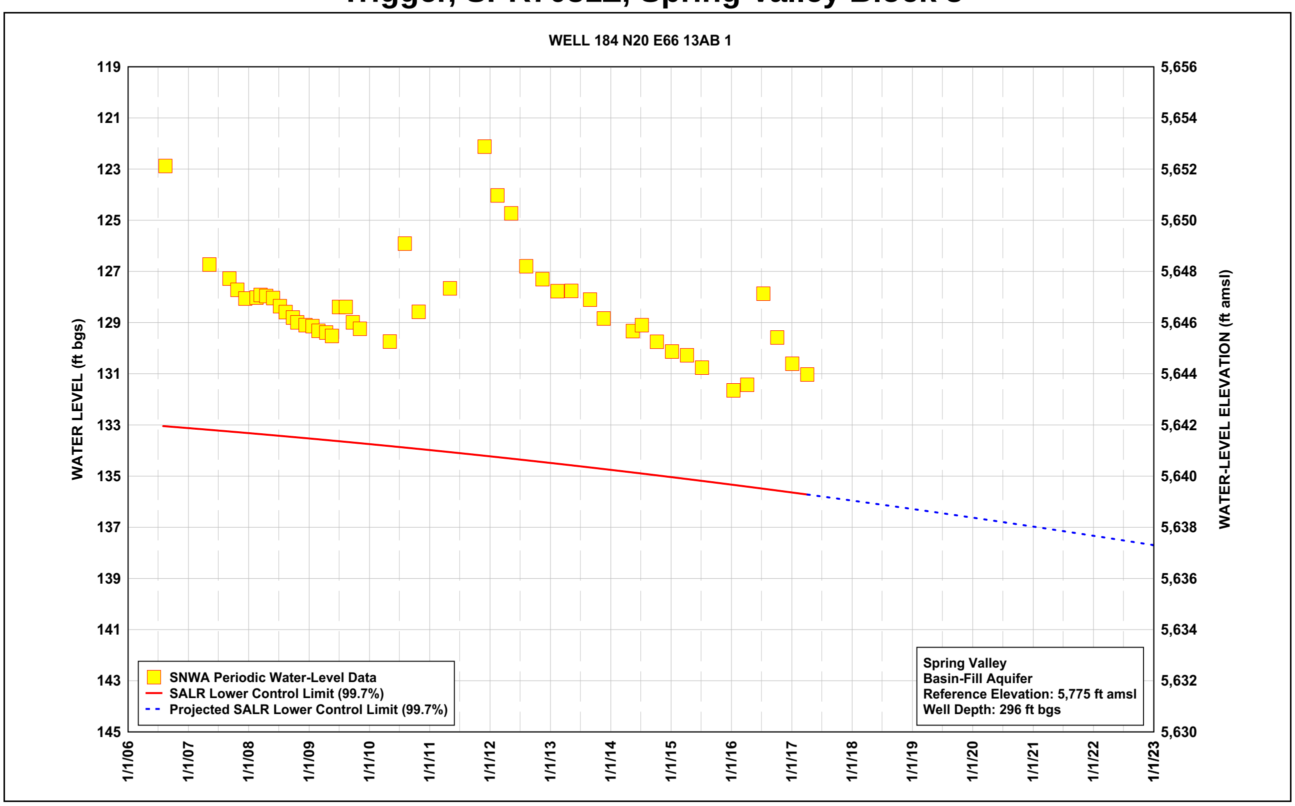


Figure C-36
Trigger, Well 184 N20 E66 13AB 1, Spring Valley Block 4

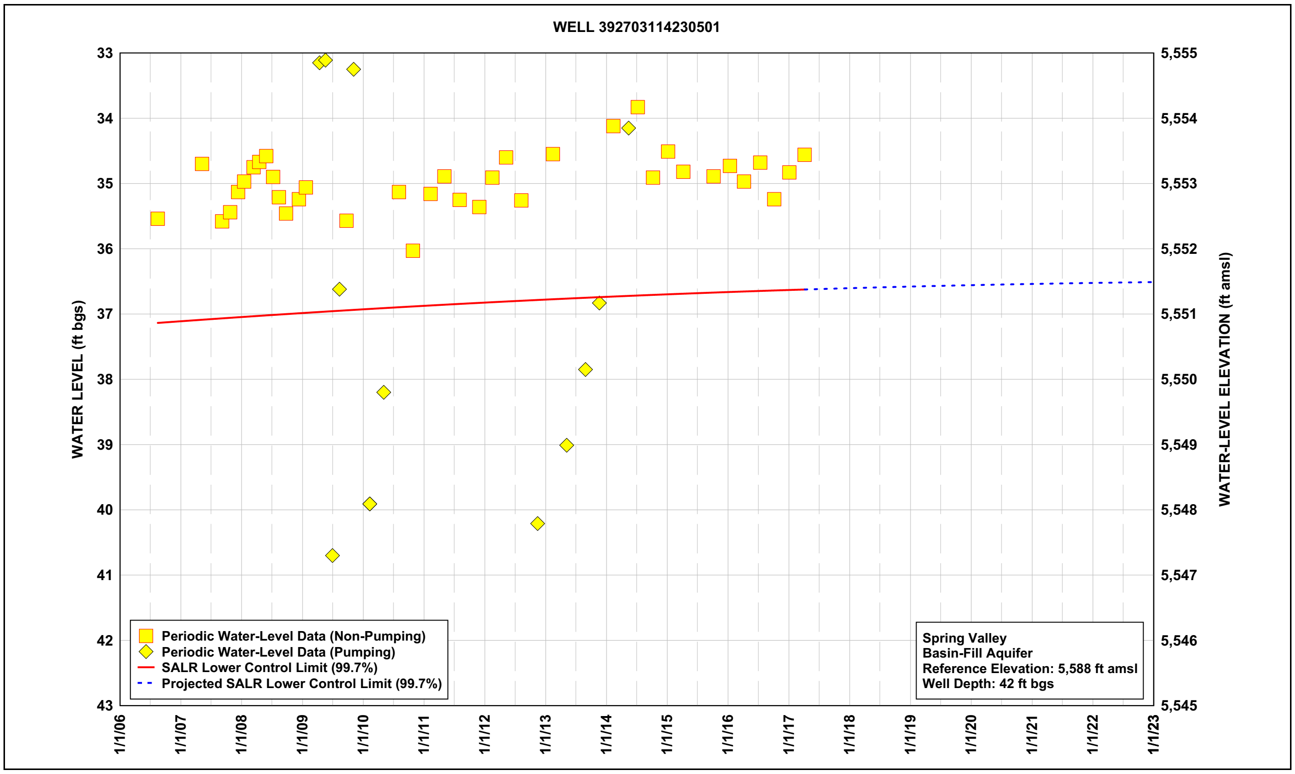


Figure C-37
Trigger, Well 392703114230501, Spring Valley Block 4

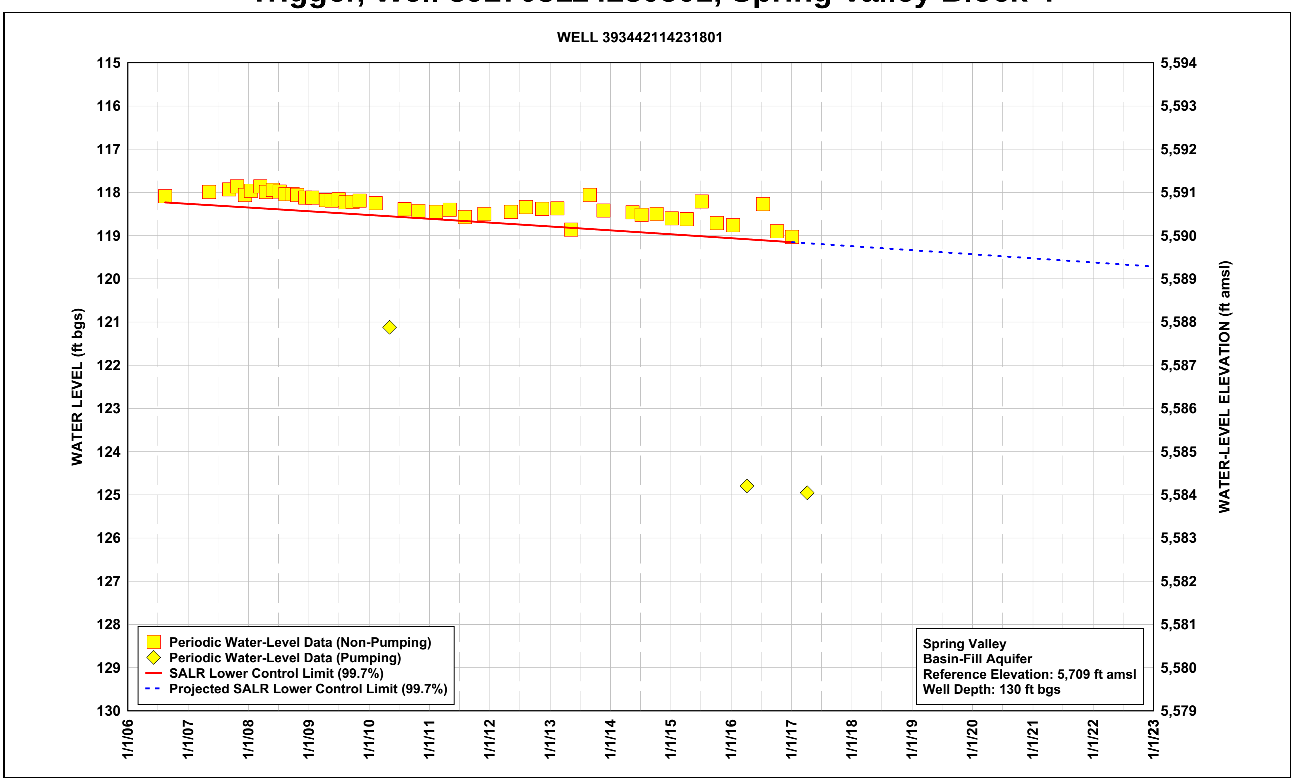


Figure C-38
Trigger, Well 393442114231801, Spring Valley Block 4

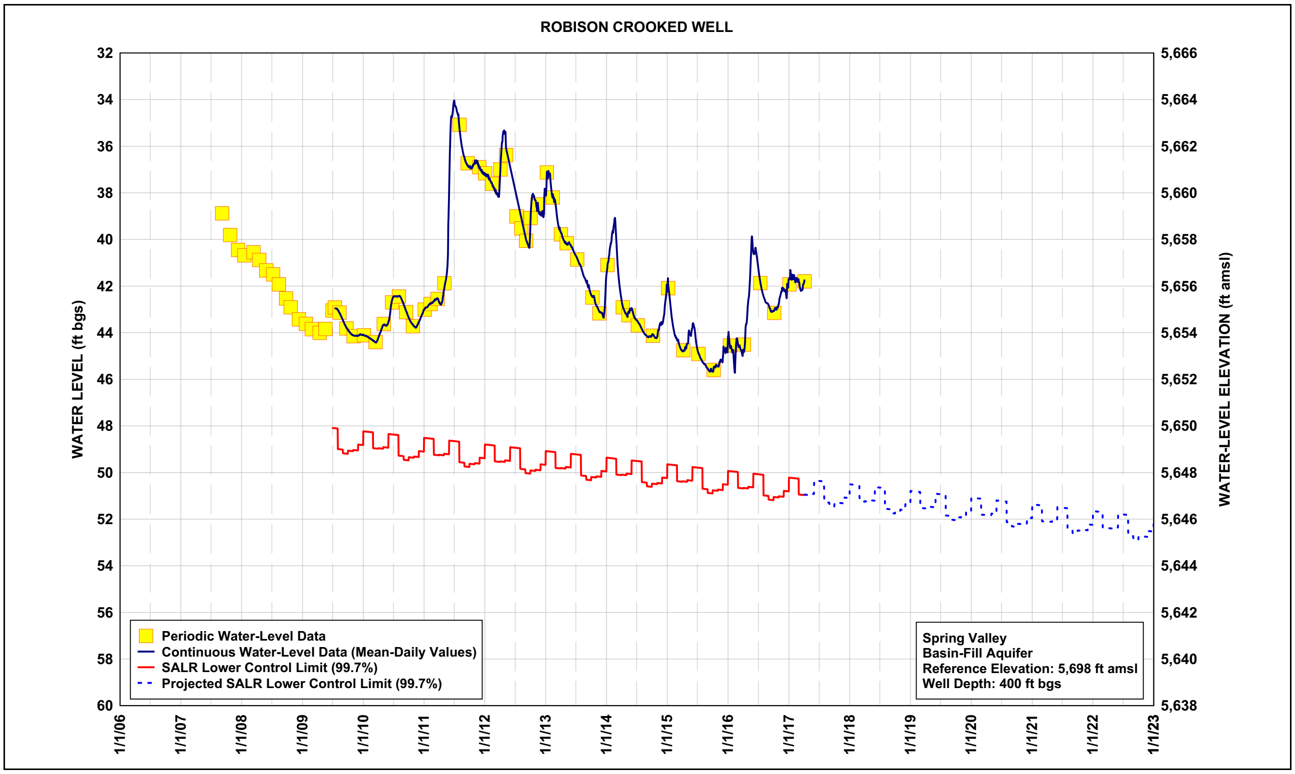


Figure C-39
Trigger, Robison Crooked Well, Spring Valley Block 4

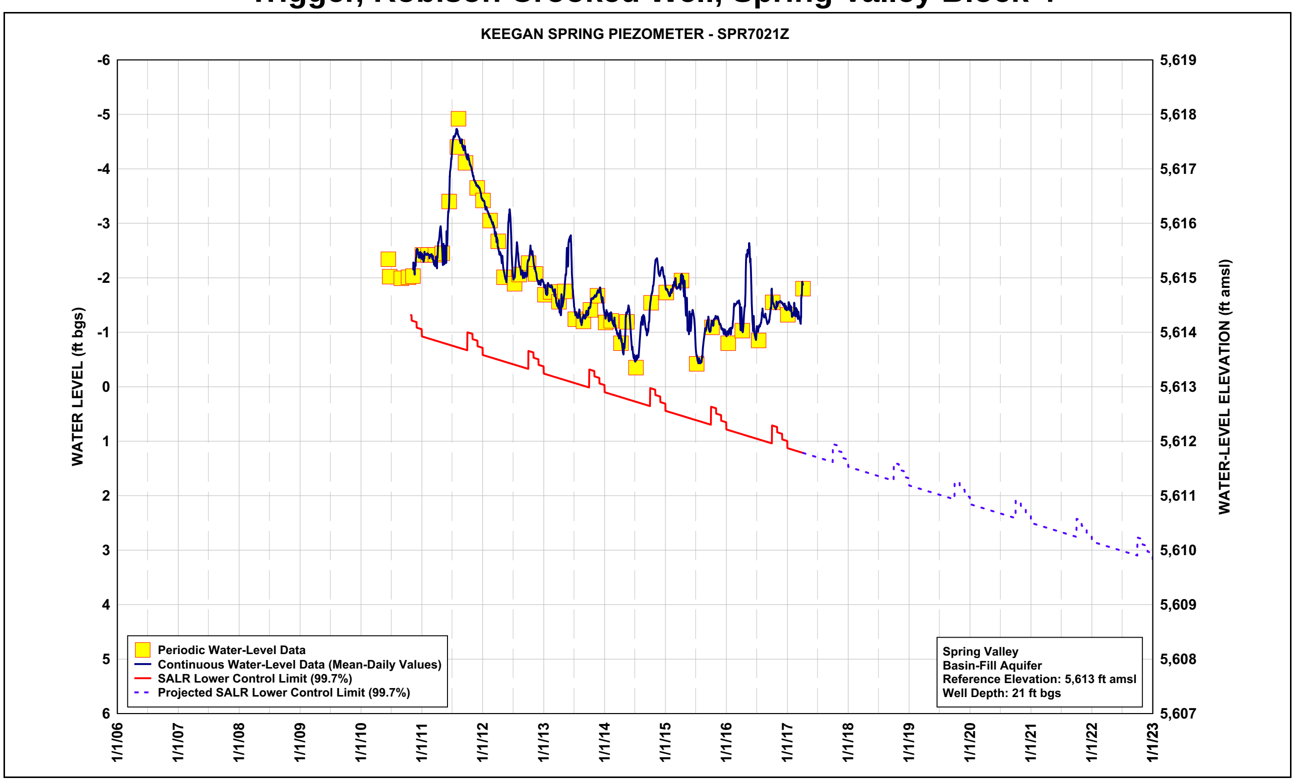


Figure C-40
Trigger, Well SPR7021Z, Spring Valley Block 4

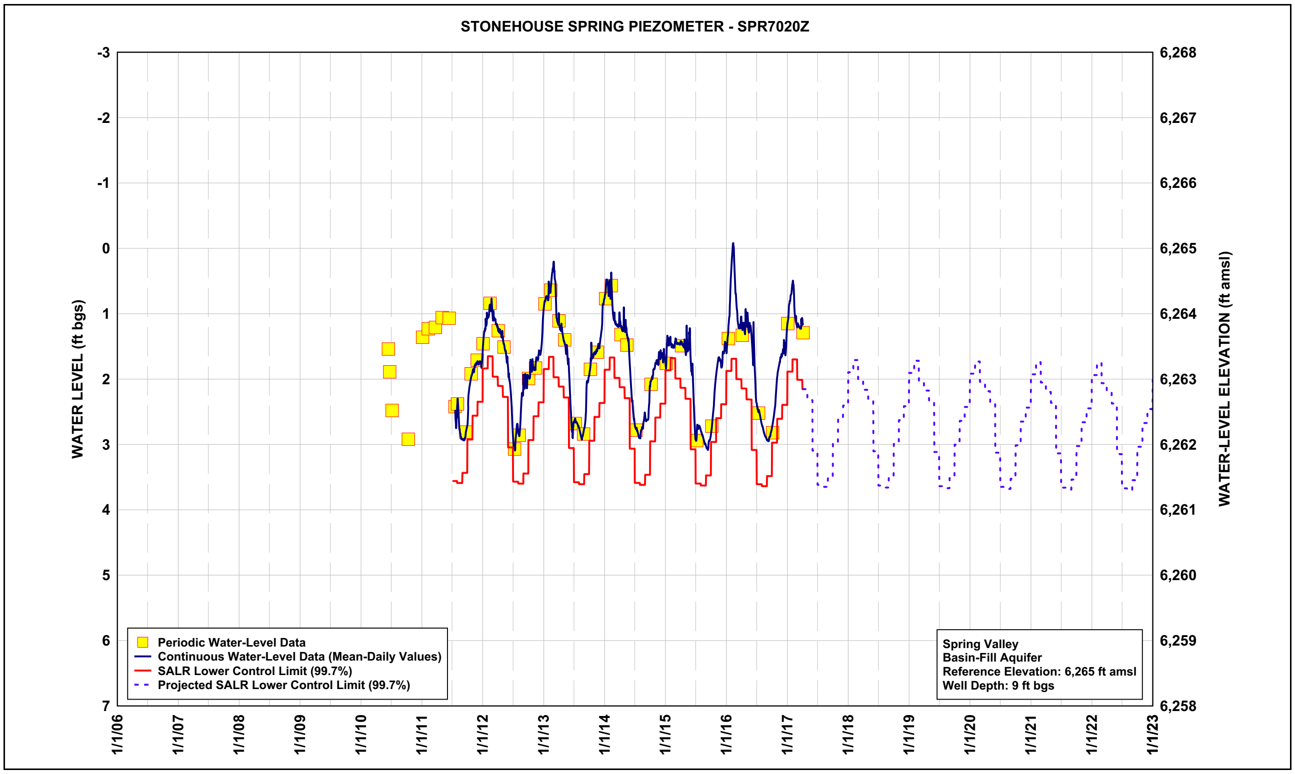


Figure C-41
Trigger, Well SPR7020Z, Spring Valley Block 5

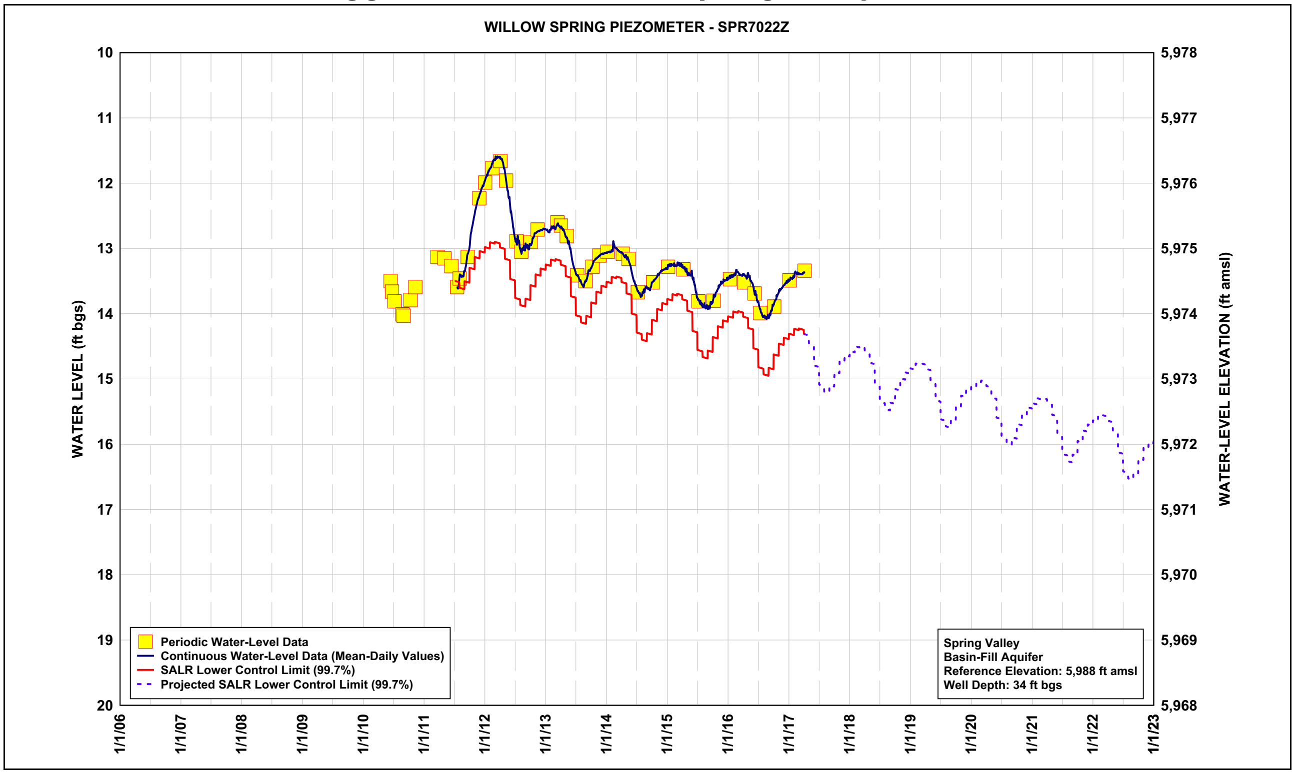


Figure C-42
Trigger, Well SPR7022Z, Spring Valley Block 5

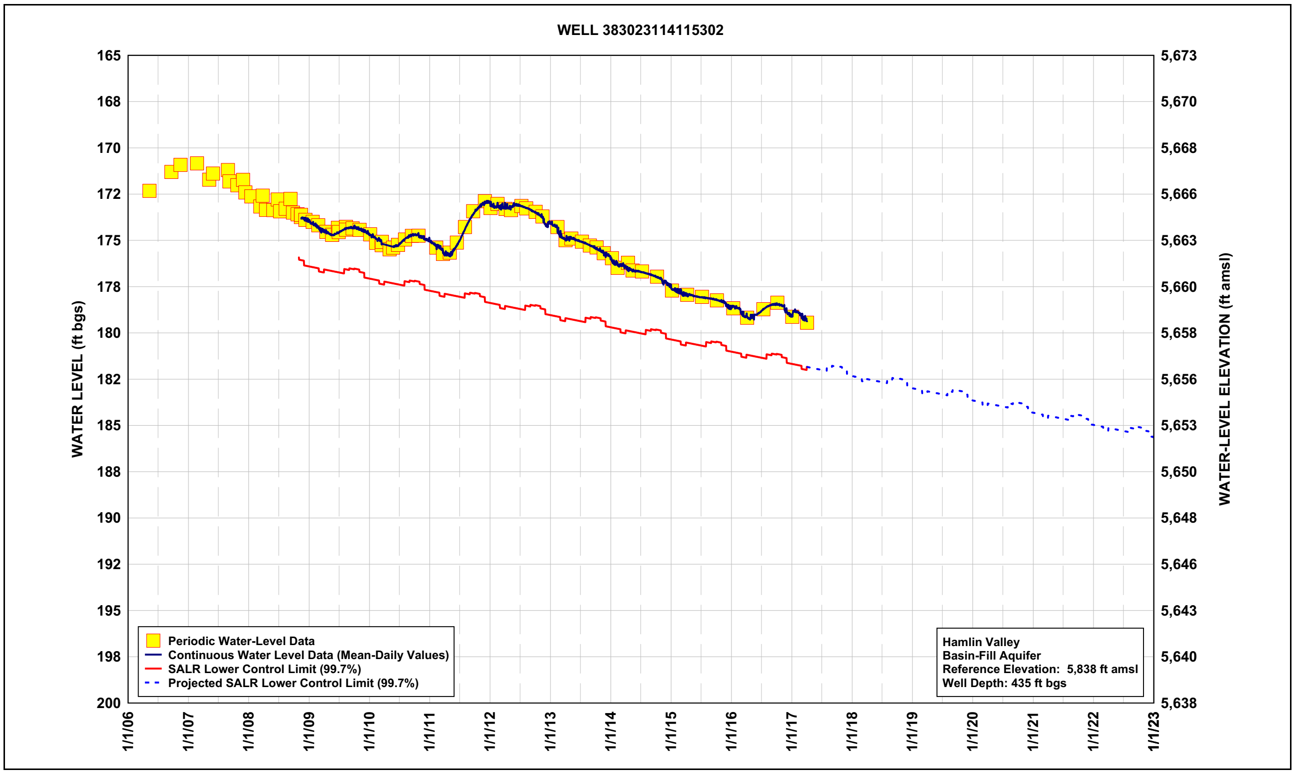


Figure C-43
Trigger, Well 383023114115302 (Hamlin MX), Hamlin Valley

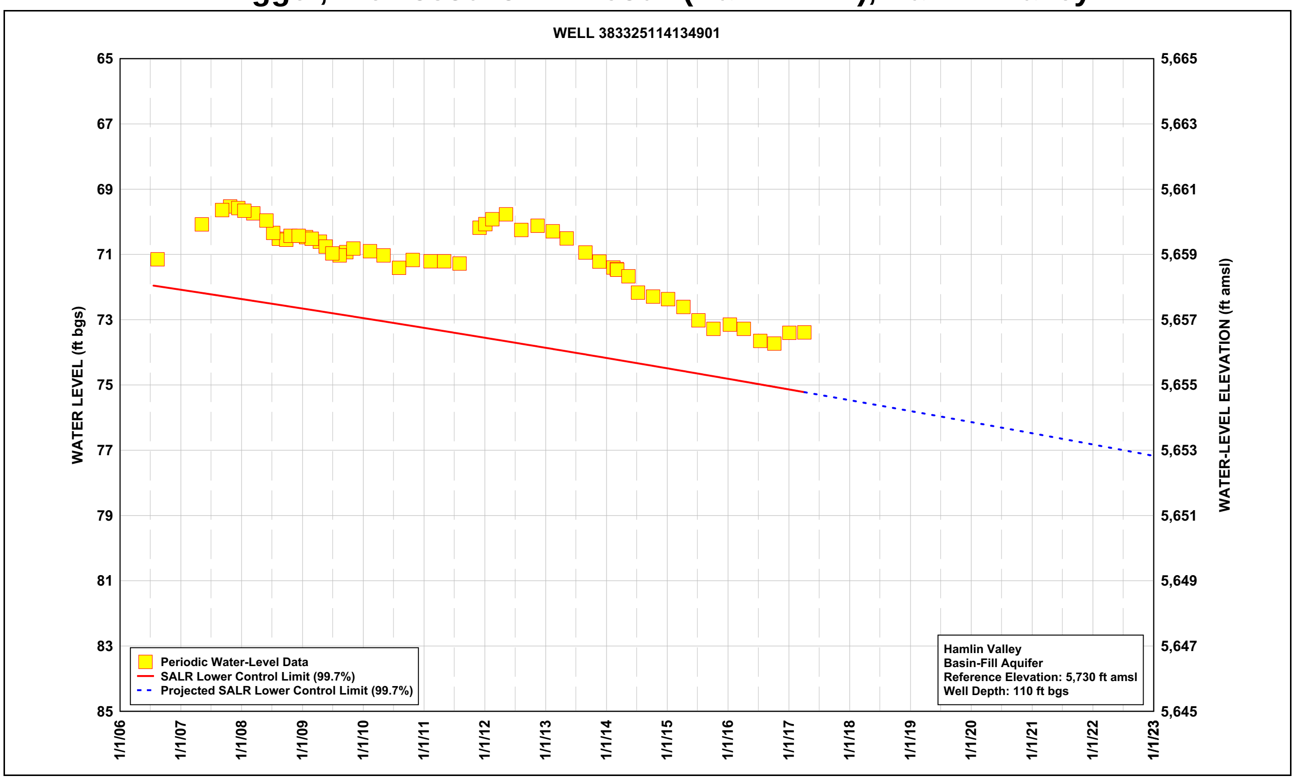


Figure C-44
Trigger, Well 383325114134901, Hamlin Valley

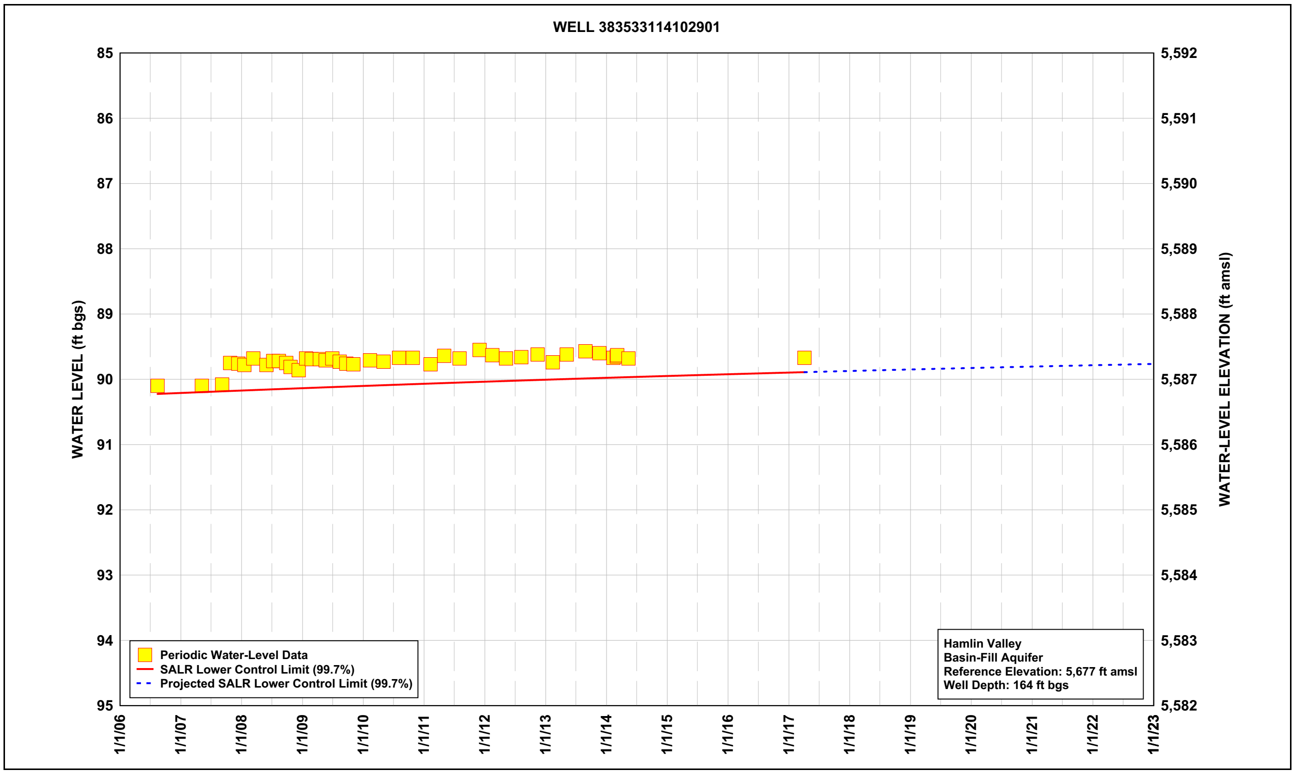


Figure C-45
Trigger, Well 383533114102901, Hamlin Valley

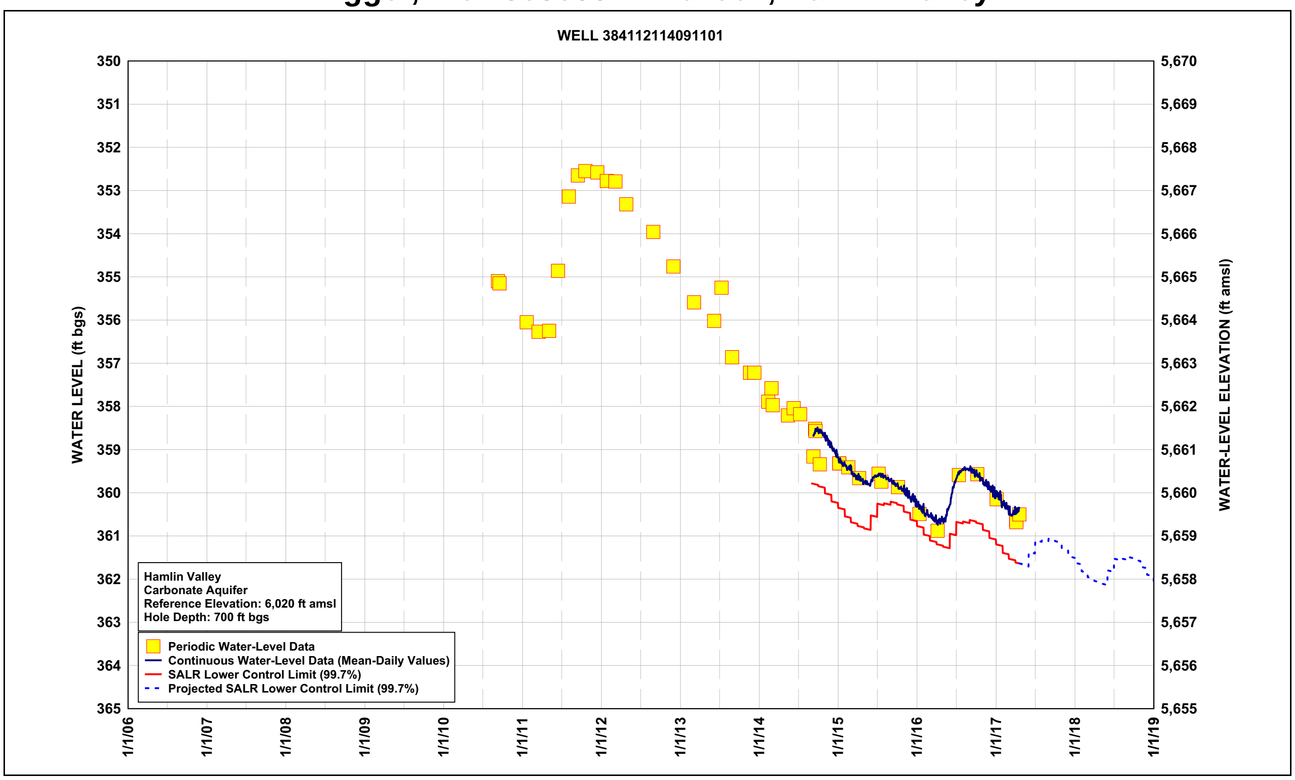


Figure C-46
Trigger, Well 384112114091101, Hamlin Valley

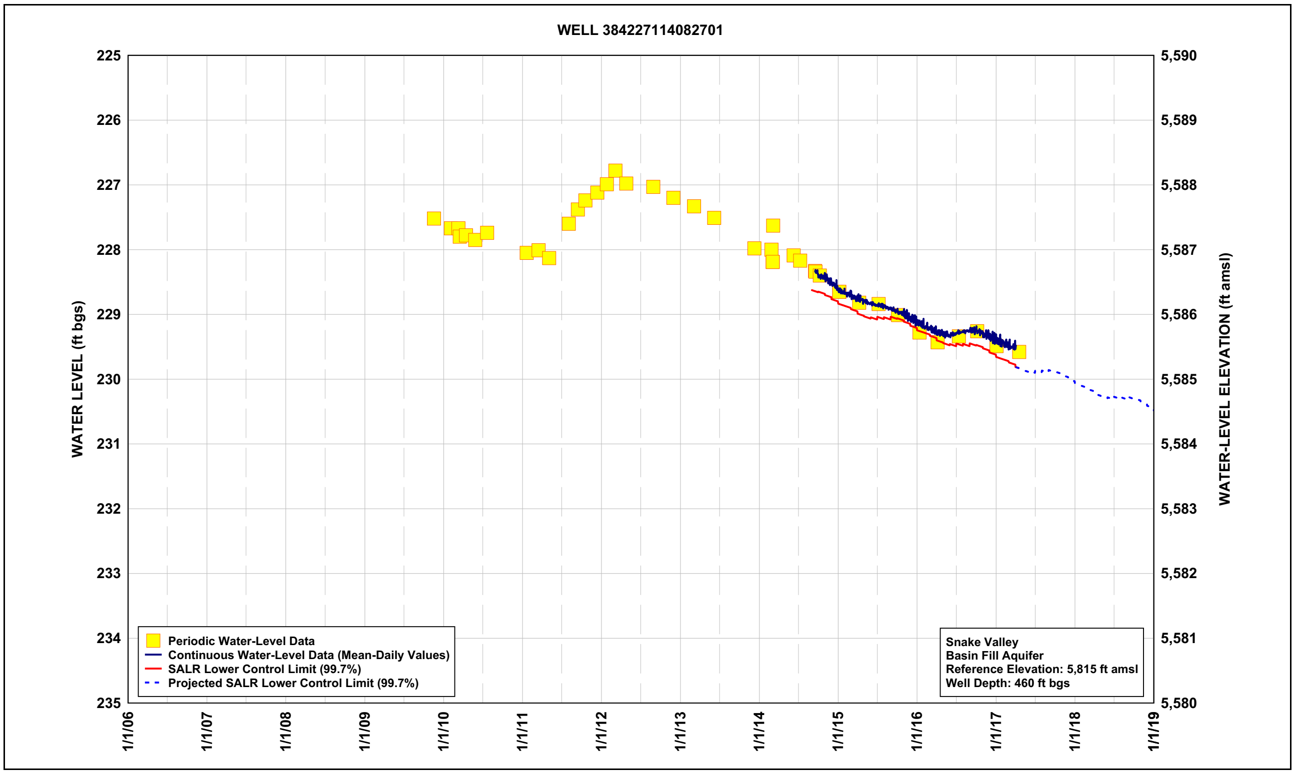


Figure C-47
Trigger, Well 384227114082701, Snake Valley

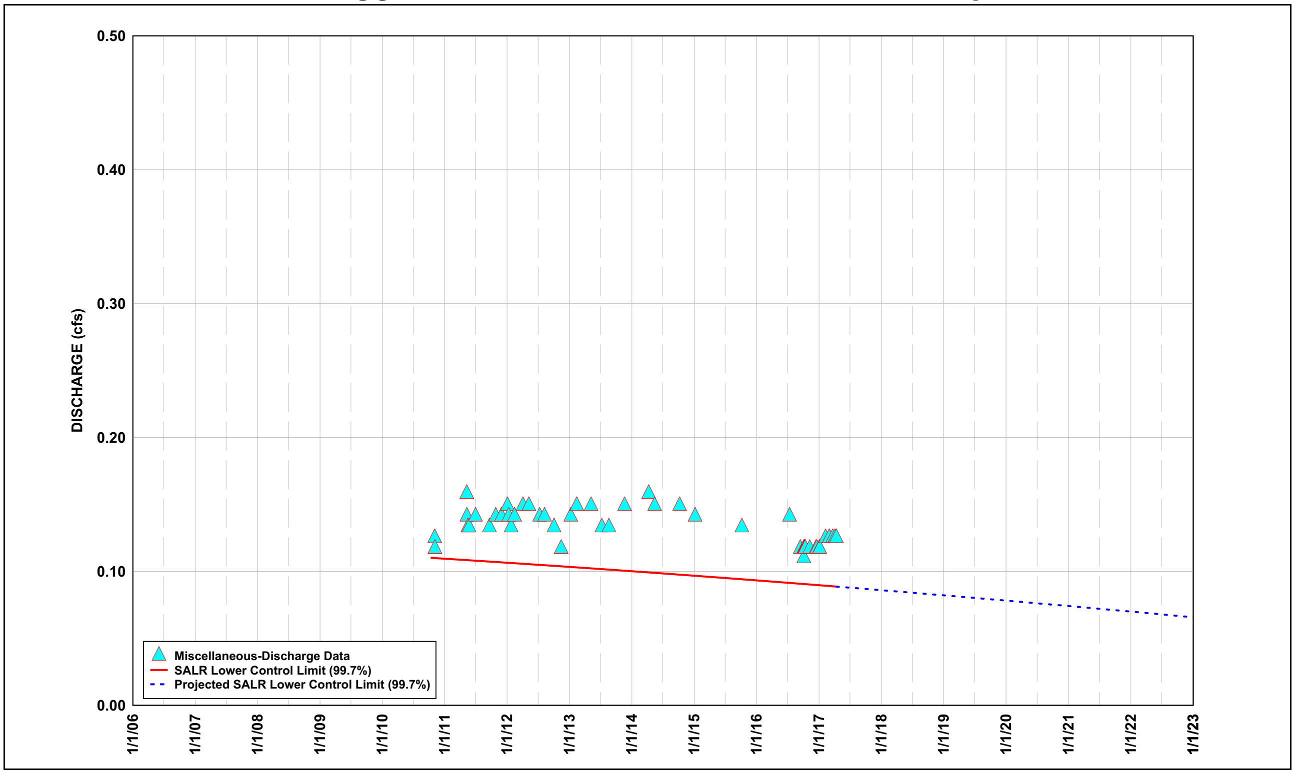


Figure C-48
Trigger, Well Cleveland Ranch Spring South - 1848501, Spring Valley Block 3

Table C-2
Triggers for DDC Sentinel and Select Monitor Wells

Well	Type	Basin
383307114471001	Sentinel Monitor Well	Cave Valley
180W501M	Sentinel Monitor Well	Cave Valley
209 S07 E62 20AA 1	Sentinel Monitor Well	Pahranagat Valley
209M-1	Sentinel Monitor Well	Pahranagat Valley
382807114521001	Select Monitor Well	Cave Valley
180W902M	Select Monitor Well	Cave Valley
383133115030201	Select Monitor Well	White River Valley
372639114520901	Select Monitor Well	Dry Lake Valley
181M-1	Select Monitor Well	Dry Lake Valley
181W909M	Select Monitor Well	Dry Lake Valley
380531114534201	Select Monitor Well	Delamar Valley
182M-1	Select Monitor Well	Delamar Valley
182W906M	Select Monitor Well	Delamar Valley
373405115090001	Select Monitor Well	Pahranagat Valley
373803115050501	Select Monitor Well	Pahranagat Valley
Flag Spring 2 - 2071302	Select Spring	White River Valley

Note: Planned Sentinel Monitor Wells that have not been constructed yet will be included after construction and data are available. These wells are: DEL4003X, WRV1012M, WRV1013M, and PAH1010M.

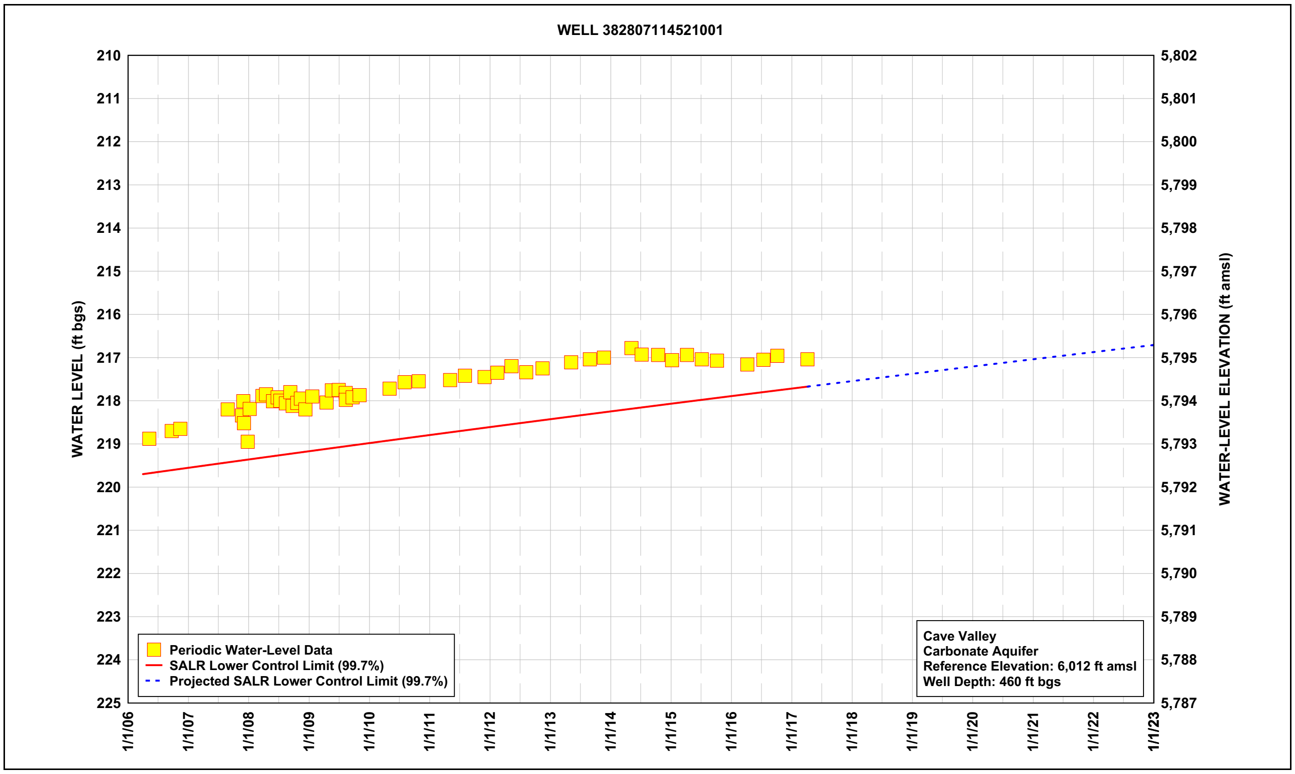


Figure C-49
Trigger, Well 382807114521001, Cave Valley

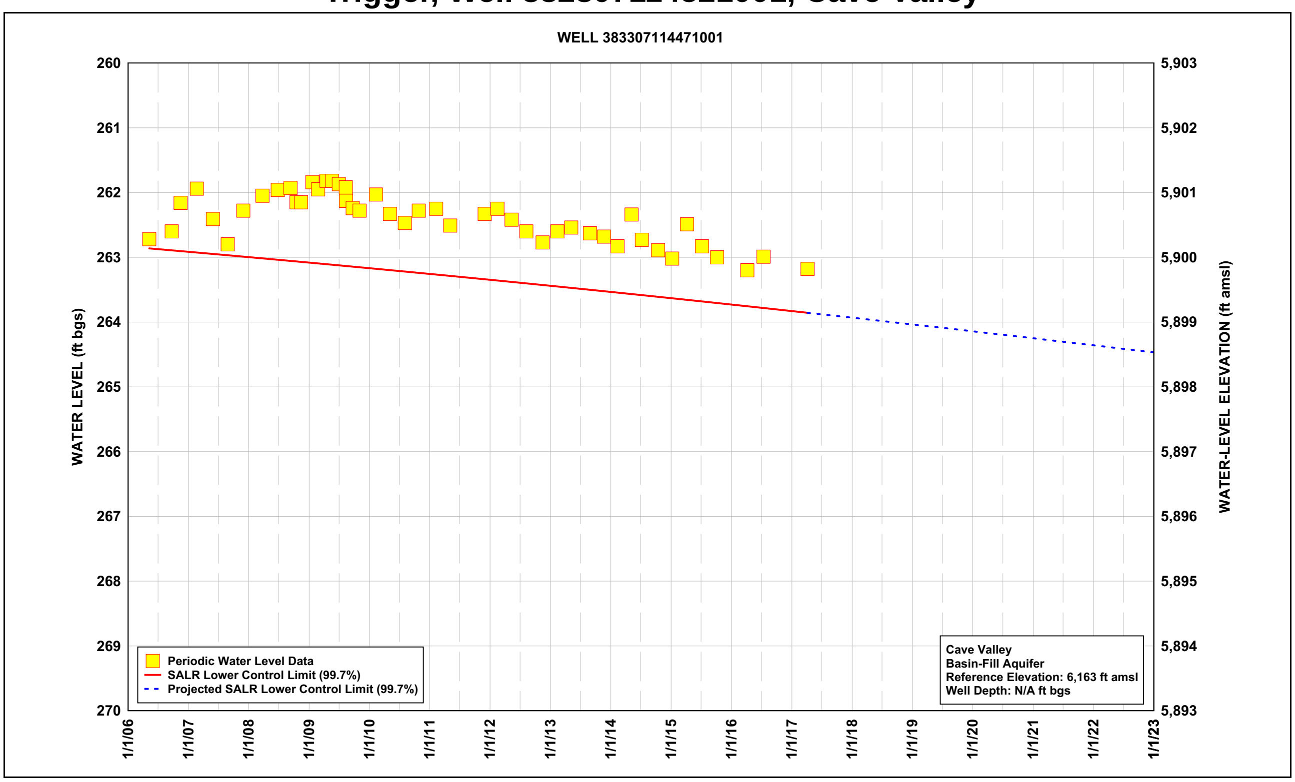


Figure C-50
Trigger, Well 383307114471001, Cave Valley

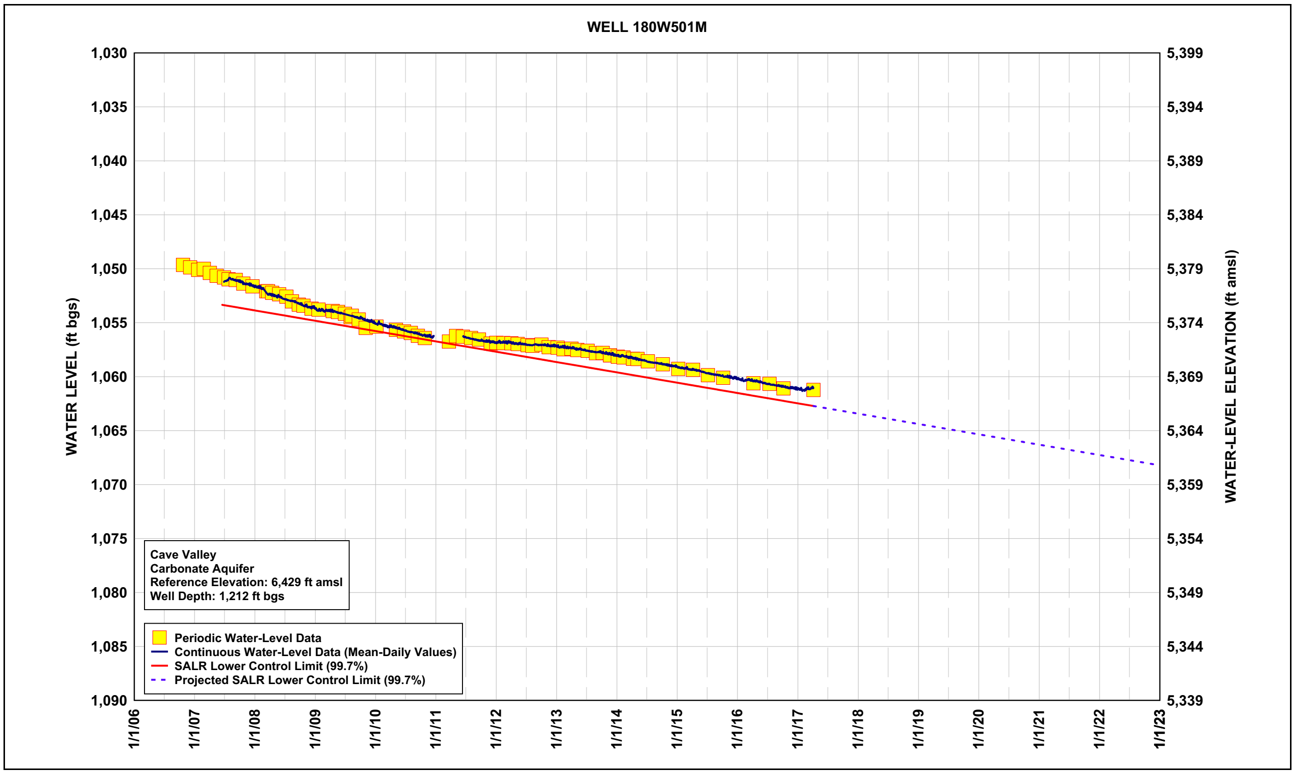


Figure C-51
Trigger, Well 180W501M, Cave Valley

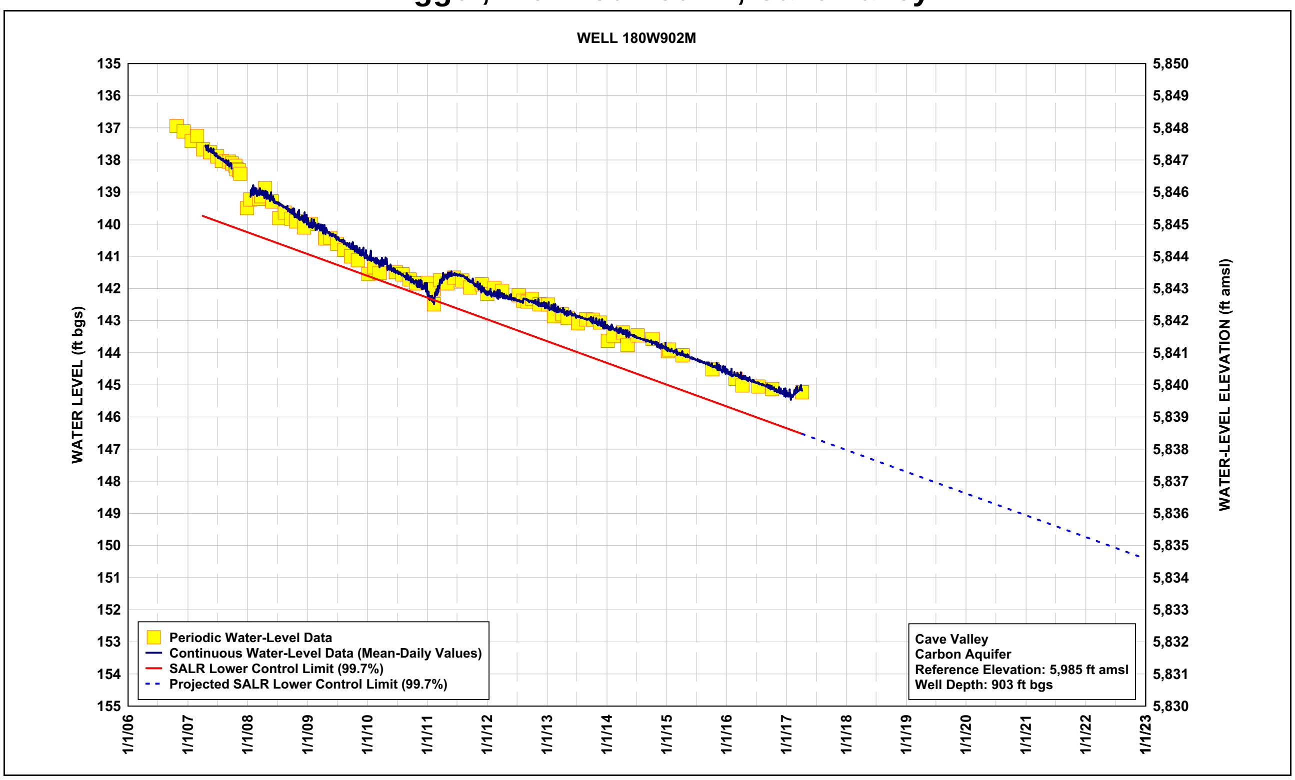


Figure C-52
Trigger, Well 180W902M, Cave Valley

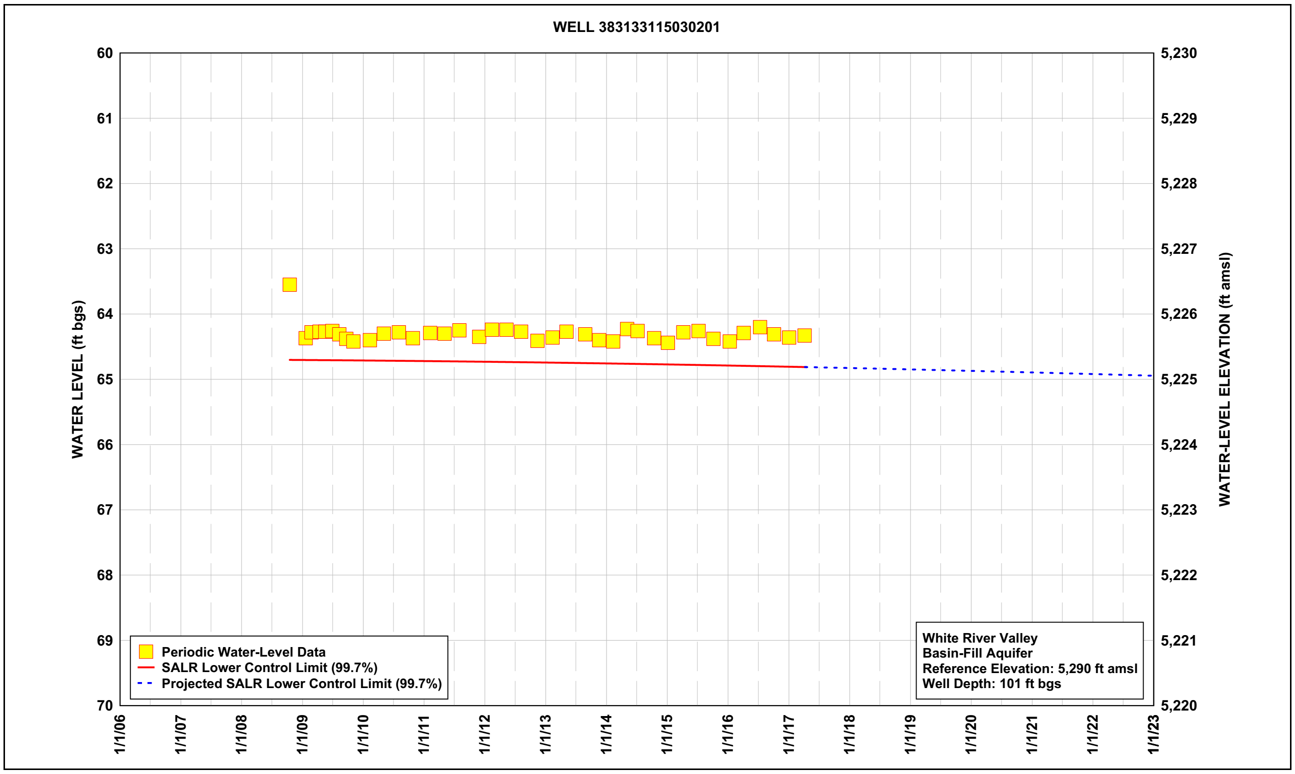


Figure C-53
Trigger, Well 383133115030201, White River Valley

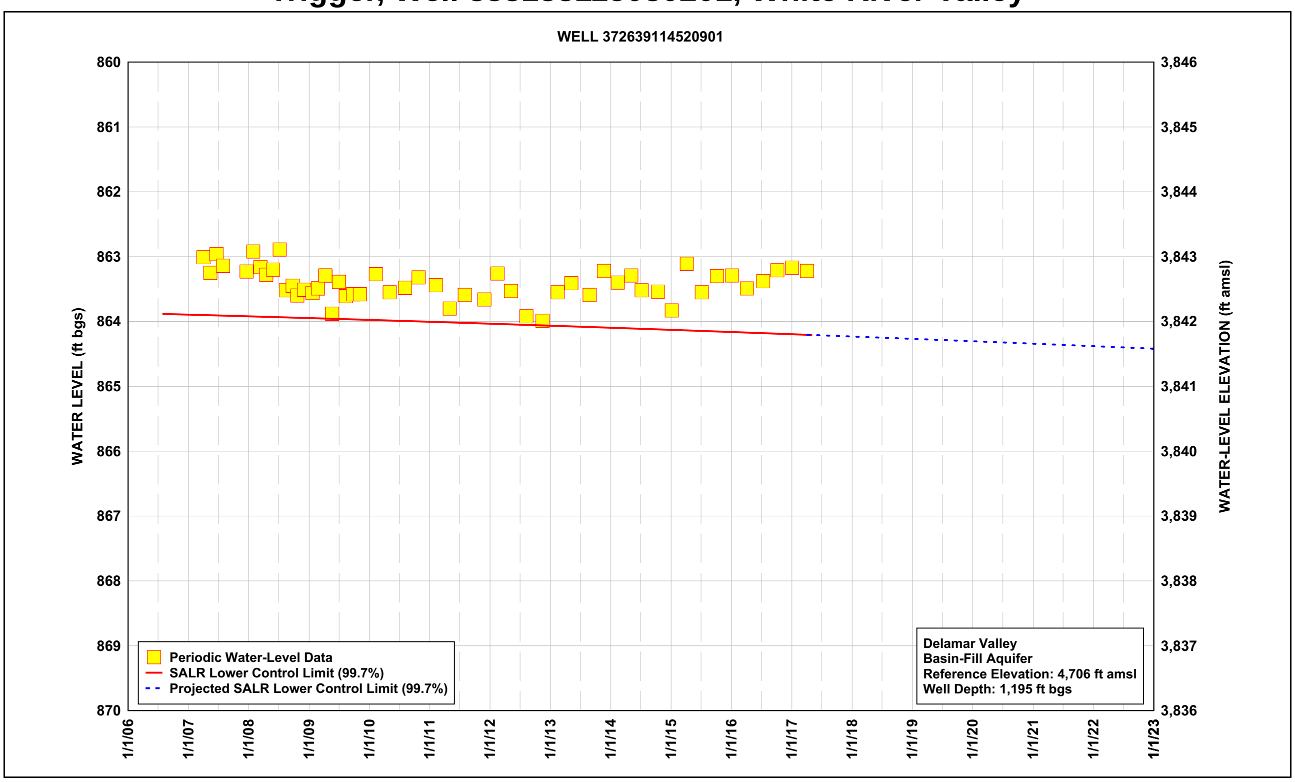


Figure C-54
Trigger, Well 372639114520901, Dry Lake Valley

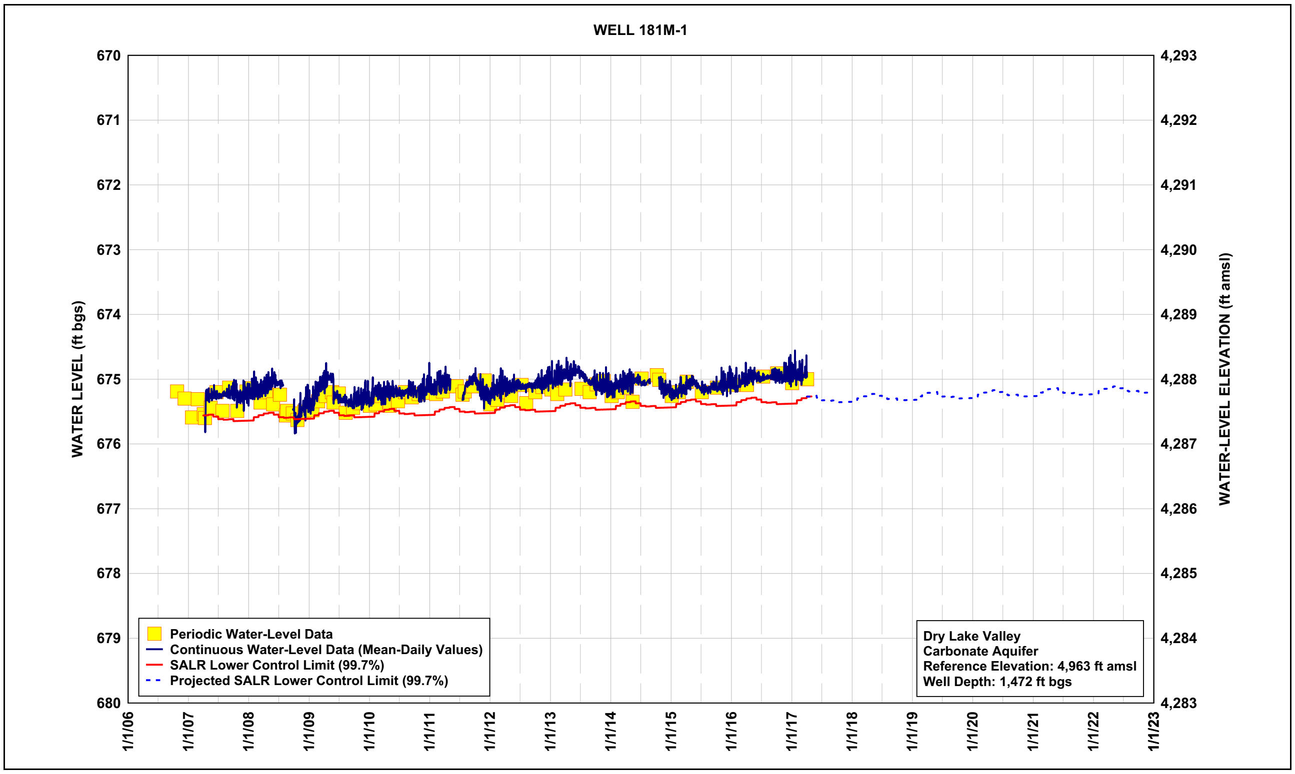


Figure C-55
Trigger, Well 181M-1, Dry Lake Valley

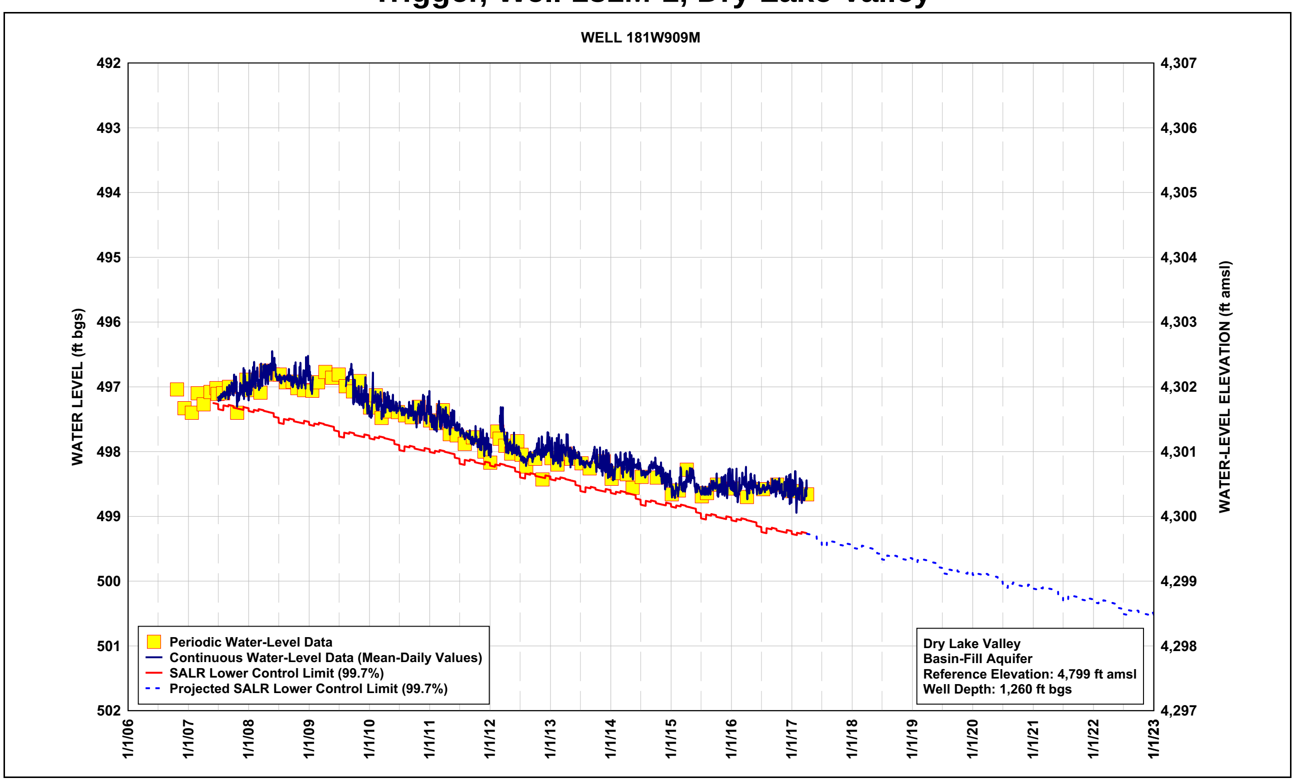


Figure C-56
Trigger, Well 181W909M, Dry Lake Valley

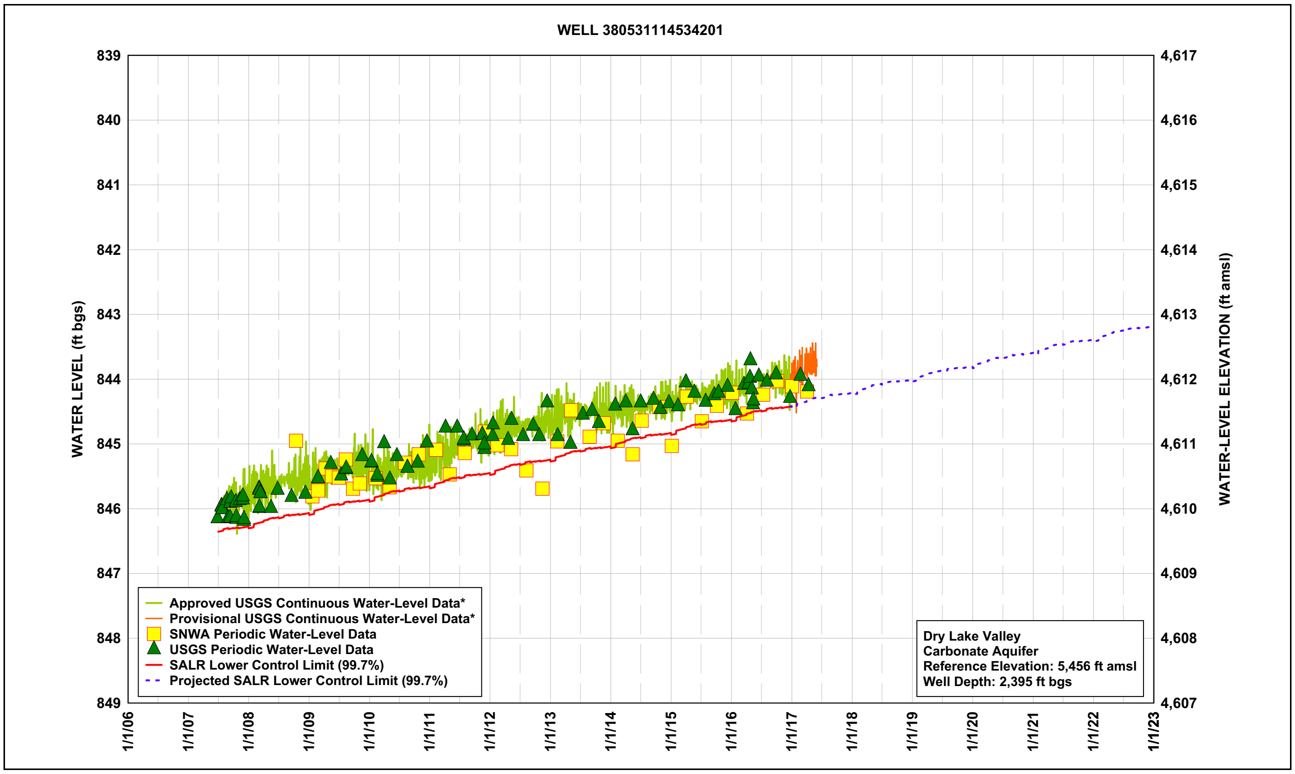


Figure C-57
Trigger, Well 380531114534201, Delamar Valley

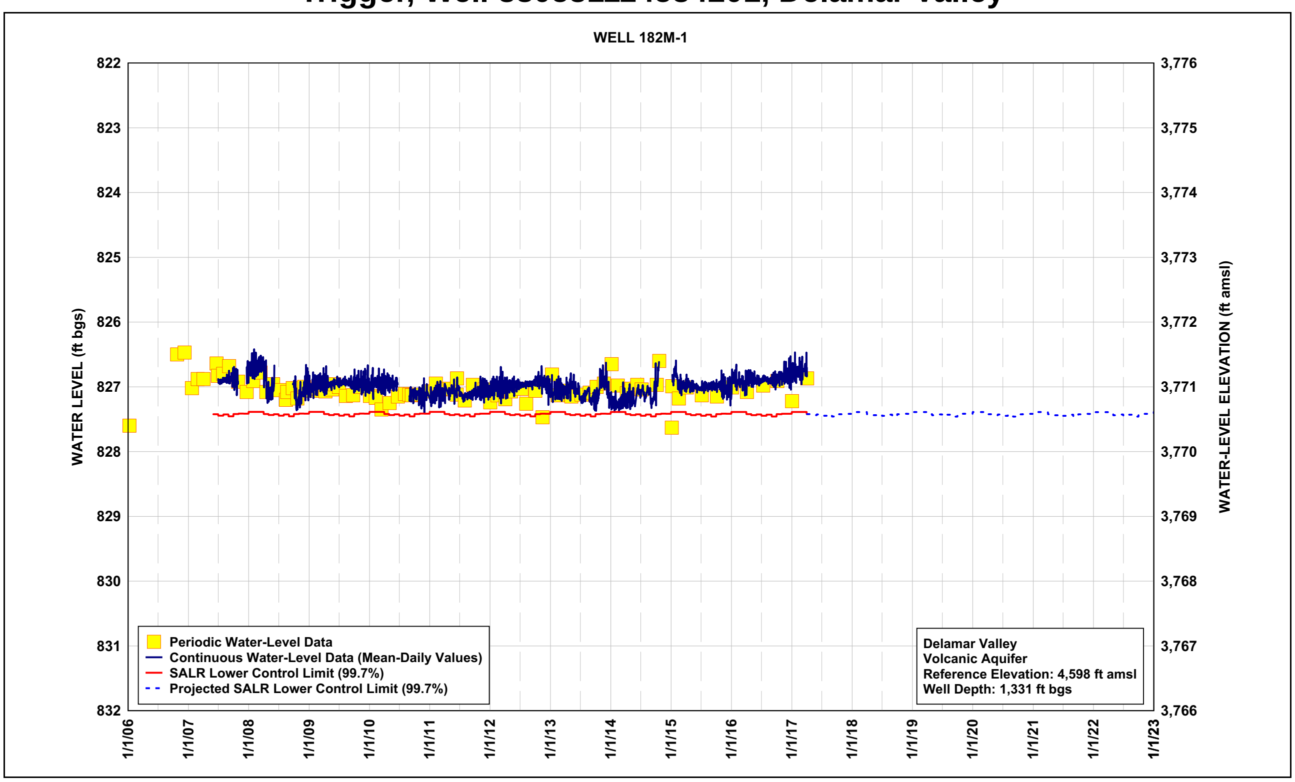


Figure C-58
Trigger, Well 182M-1, Delamar Valley

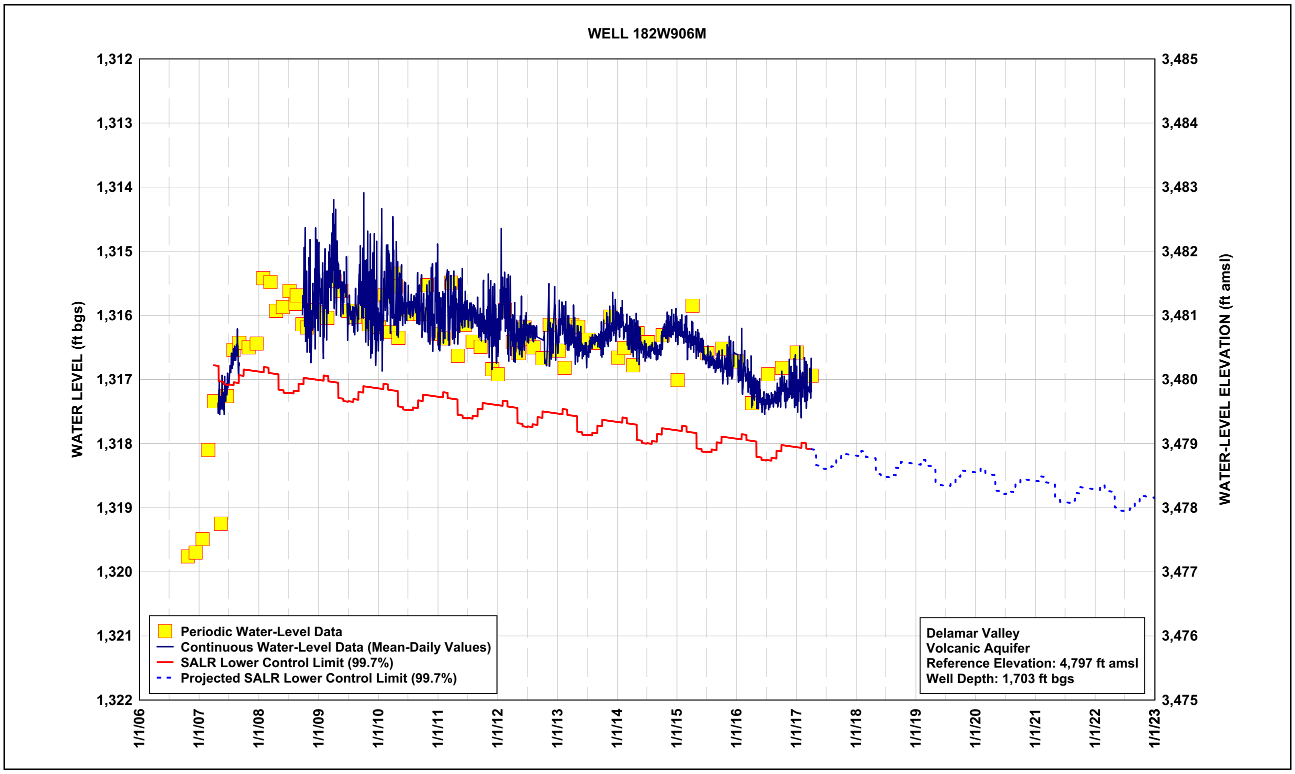


Figure C-59
Trigger, Well 182W906M, Delamar Valley

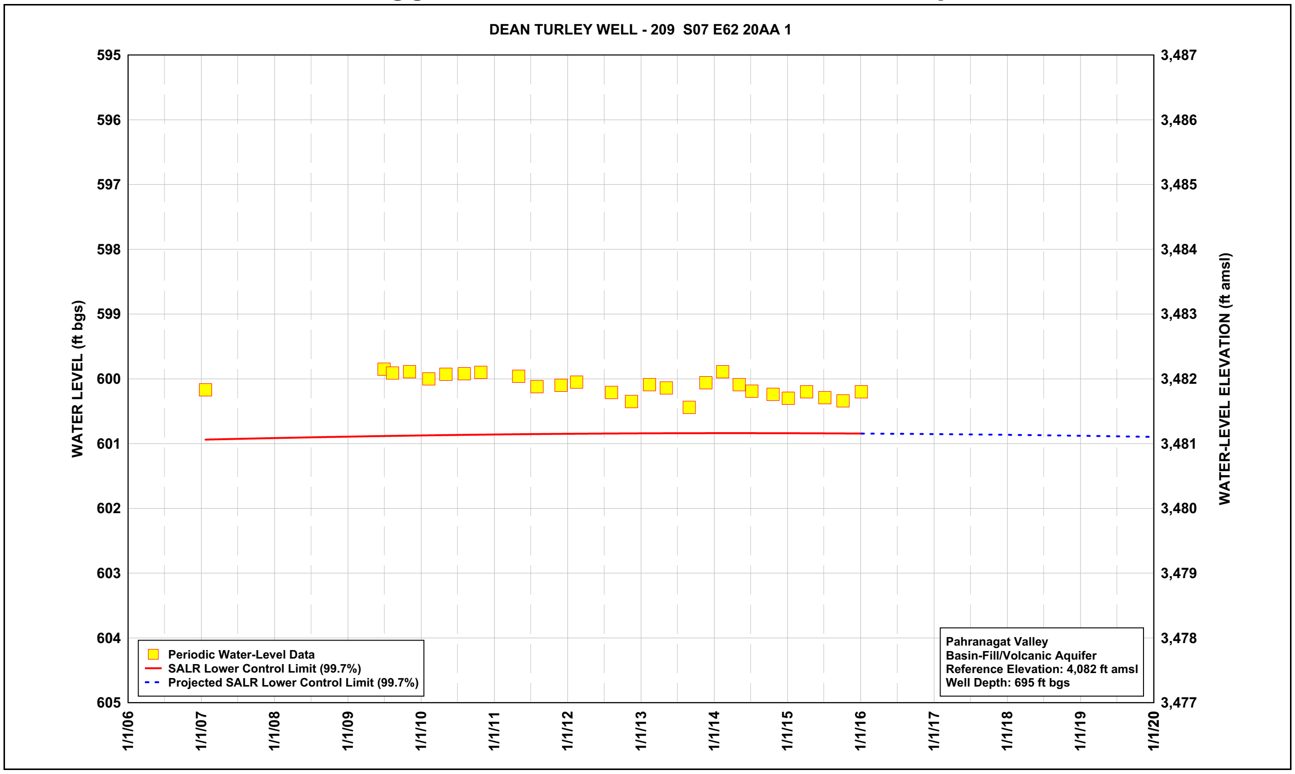


Figure C-60
Trigger, Well 209 S07 E62 20AA 1 (Dean Turley), Pahranagat Valley

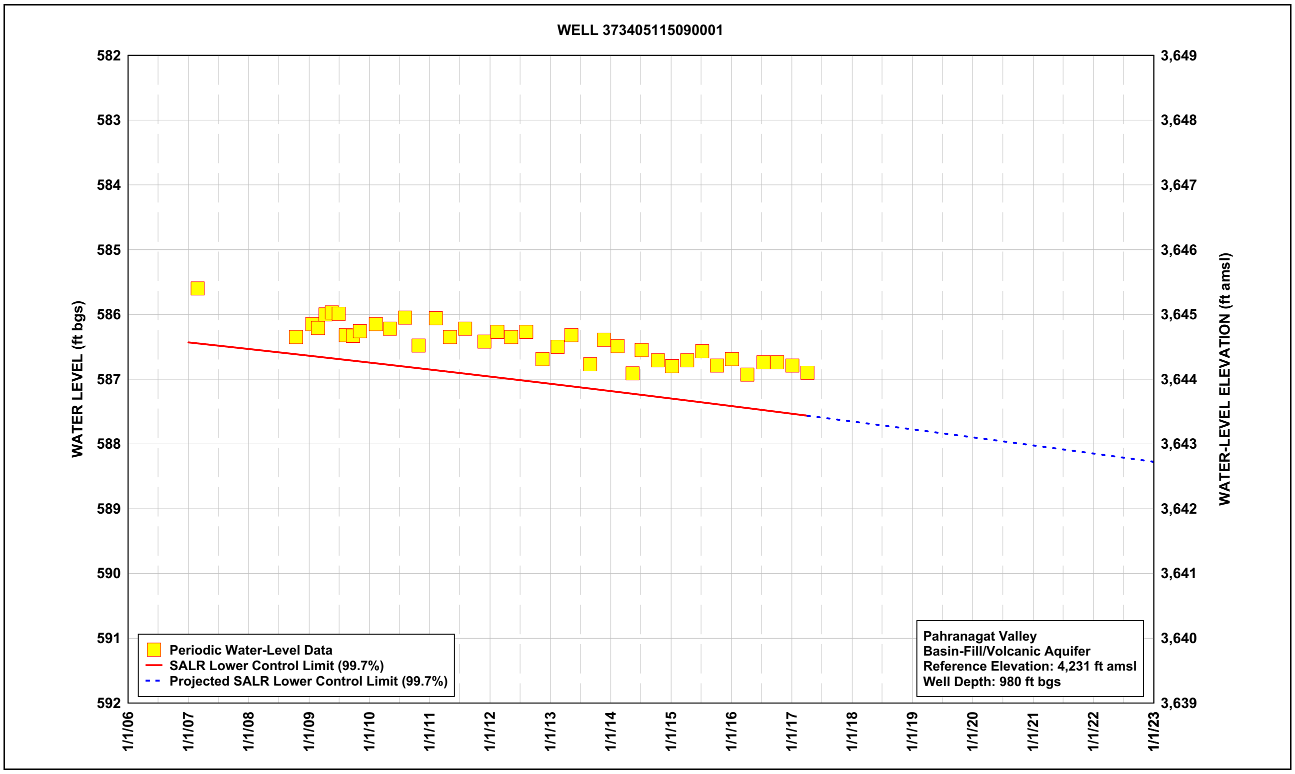


Figure C-61
Trigger, Well 373405115090001, Pahranagat Valley

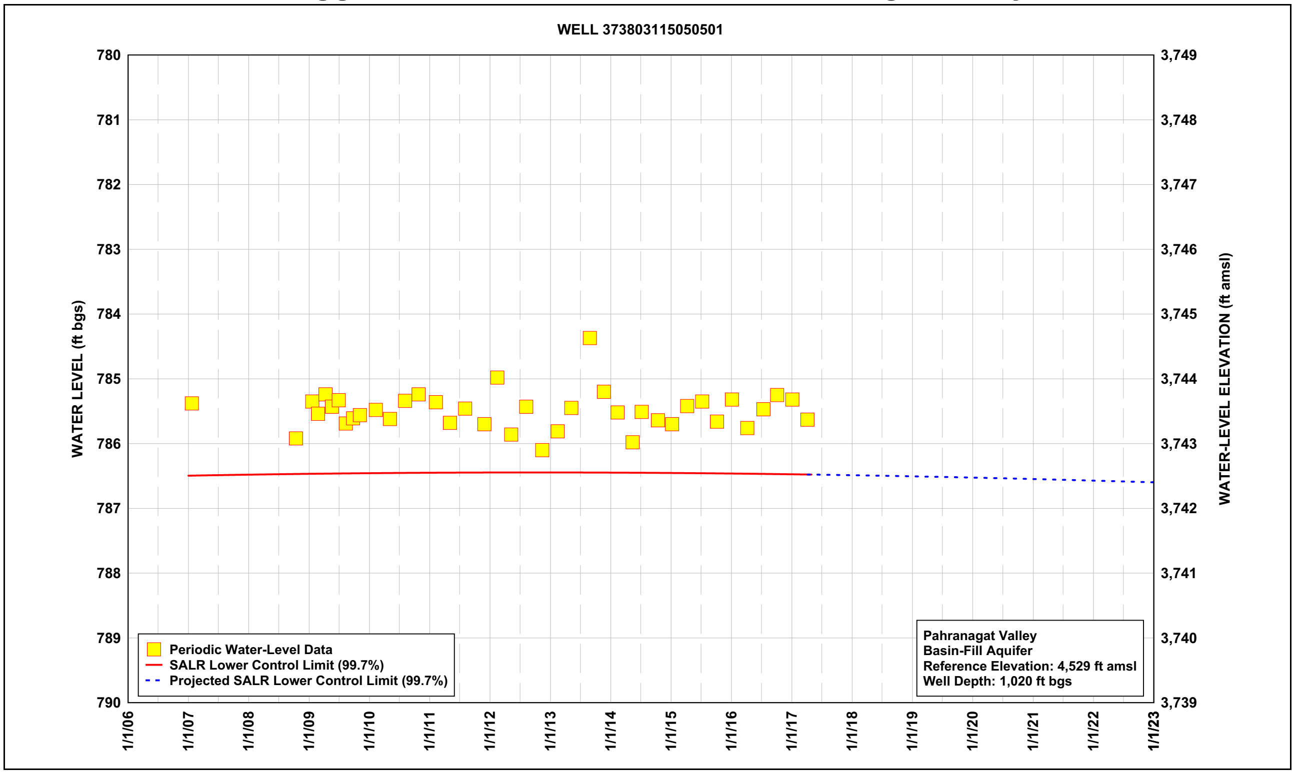


Figure C-62
Trigger, Well 373803115050501, Pahranagat Valley

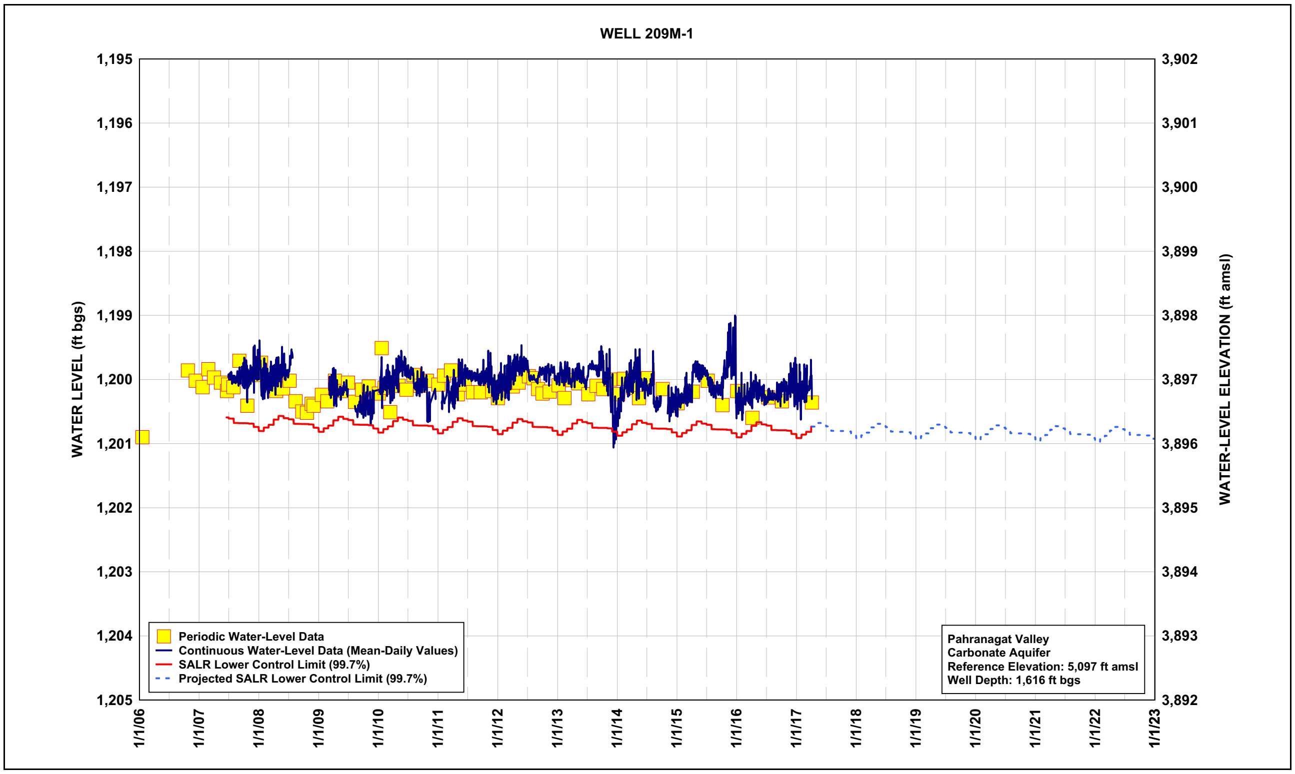


Figure C-63
Trigger, Well 209M-1, Pahranagat Valley

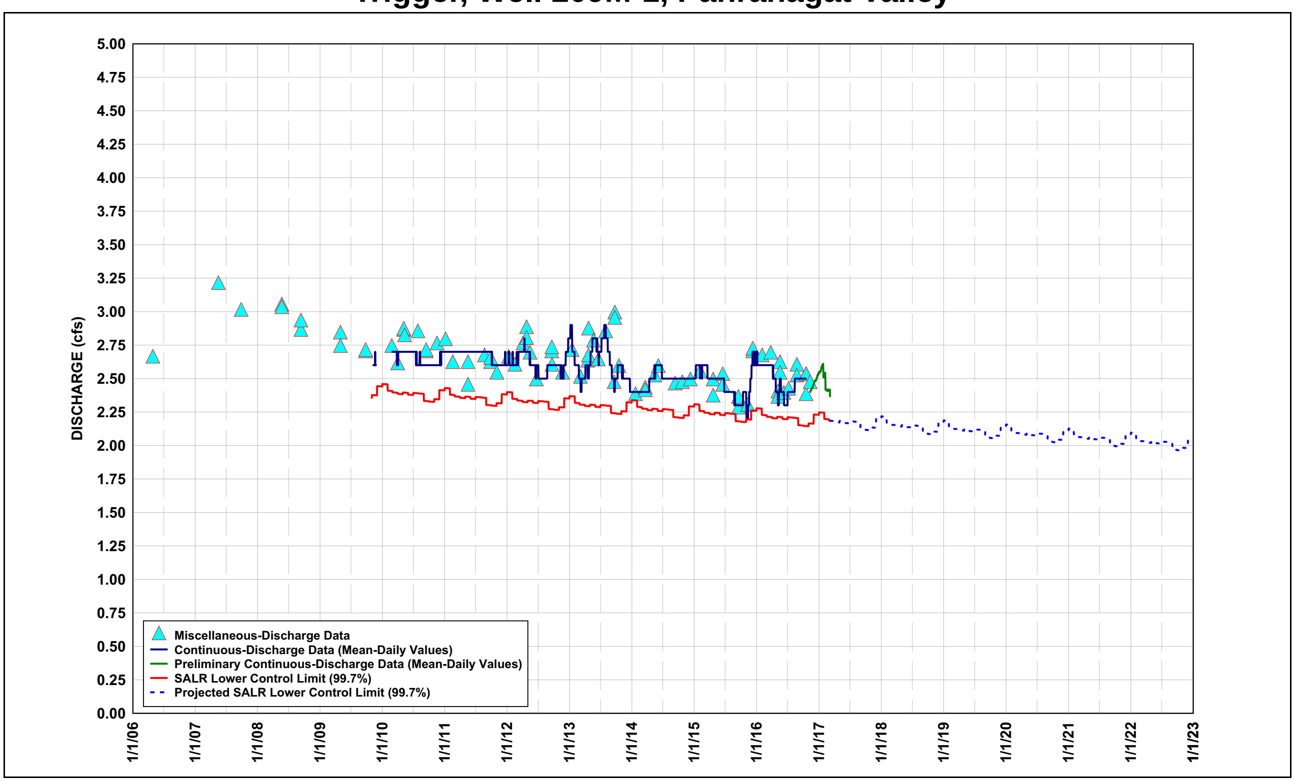


Figure C-64
Trigger, Flag Spring 2 - 2071302, White River Valley

Appendix D

Remote Sensing and Statistical Methods for Shrubland and Terrestrial Woodland Habitat Triggers

D.1.0 REMOTE SENSING FOR SHRUBLANDS

This section provides remote sensing and statistical methods used to establish the investigation and mitigation triggers for Spring Valley shrublands described in Section 6.3.3. These methods will also be used to establish investigation and mitigation triggers for northern Hamlin Valley and southern Snake Valley shrublands as needed (see Section 7.3).

D.1.1 Delineation of Shrubland Polygons and Plots

D.1.1.1 Shrubland Habitat and Remote Sensing Polygons

Shrubland polygons were delineated in southern and central Spring Valley (Management Blocks 1 and 2). The purpose of using polygons was two-fold: (1) to provide sample groups that characterized the shrubland habitat on a landscape scale, and (2) to enable a data-rich remote sensing analysis.

As described below, two groups of polygons were used for the remote sensing analysis: medium-density shrubland polygons and low-density shrubland polygons. Remotely sensed Normalized Difference Vegetation Index (NDVI) data derived from Landsat imagery data were used as a proxy for vegetation cover in these polygons from 1985-2015 (Section D.1.2). NDVI data influenced by clouds or cloud shadows were filtered from the dataset to ensure adequate representation of the vegetation cover on the ground (Section D.1.2.3). The use of polygons was instrumental in this process, as excluding data from polygons with cloud cover did not negate the use of data from cloud-free polygons in the same image. This process provided for extensive NDVI time series datasets and a robust remote sensing analysis.

The shrubland polygons were delineated based on an SNWA (2007) digital land cover map. This land cover map was originally developed for determining water budgets, and was presented in the 2011 water rights hearing (Burns and Drici 2011, at Figure 5-1). In this map, land cover was classified within groundwater discharge areas of 26 hydrographic basins in eastern Nevada and western Utah. A full discussion of methods and land cover descriptions are presented in Burns and Drici (2011, at Section 5), SNWA (2007), and SNWA (2009b, at Section 7.1.4.1). In summary:

- Remote sensing, global positioning systems, and geographical information systems (GIS) technologies were used to create the land cover map. Data incorporated included but were not limited to: USGS, SNWA, and Las Vegas Valley Water District phreatophytic area maps; USGS and Clark County aerial photographs; USGS topographic maps; a USGS national land cover analysis map; the USGS Southwest Regional GAP (ReGAP) land cover map; a USGS Digital Elevation Model dataset; and NDVI raster datasets derived from Landsat imagery data. Vegetation field data were also collected to produce percent cover and density estimates of vegetation communities at sample sites on the ground.

- The technologies and data were combined to devise six land cover classifications: “phreatophytic/medium density vegetation”, “bare ground/low density vegetation”, “wetland/meadow”, “agriculture”, “open water”, and “playa”. Each 30 m x 30 m raster image pixel was assigned a land cover class. An accuracy assessment, which compared land cover values in the map to land cover data collected at sample sites on the ground, returned a successful overall accuracy of 88%.[1]

- The two land cover classes defining shrublands were “phreatophytic/medium density vegetation” and “bare ground/low density vegetation”. “Phreatophytic/medium density vegetation” was defined as: “Shrubland with plant cover greater than 20% - Areas dominated by desert shrubland, including mixed stands of medium-density greasewood, rabbit brush, and other phreatophytic species”. “Bare ground/low density vegetation” was defined as: “Shrubland less than or equal to 20% plant cover - Areas dominated by bare soil and low- to moderate-density desert shrubland, including greasewood, rabbit brush, and other phreatophytic species”.

For the purposes of this report, the land cover classification values were converted to habitat values (for a complete description, see Section 5.1). All areas classified as “phreatophytic/medium density vegetation” or “bare ground/low density vegetation” were designated as shrubland habitat, with the exception of terrestrial woodland areas (see Section D.2.1). A few areas that were converted from shrubland to pivot agriculture after the land cover map was developed were excluded from the shrubland analysis.

The shrubland habitat was further designated into categories based on the density of cover. Shrubland habitat areas classified as “phreatophytic/medium density vegetation” were designated as medium-density shrubland. Shrubland habitat areas classified as “bare ground/low density vegetation” were designated as low-density or sparse shrubland. Sparse shrubland was then distinguished from low-density shrubland by visually examining habitat and shrubs with high-resolution digital imagery, including 1-m spatial resolution National Agricultural Imagery Program (NAIP) aerial imagery from 2006 and 2015, and 6-inch spatial resolution SNWA aerial imagery from 2007 and 2016. This process also included overlaying other data sources, such as USGS Basin and Range Carbonate-rock Aquifer System (BARCASS) and Southwest ReGAP digital land cover maps (Smith et al., 2007; and Lowry et al., 2007). Sparse shrubland areas were excluded from the shrubland analysis, as discussed below.

Medium-density and low-density shrubland polygons were delineated within the shrubland habitat using the following methods and criteria:

- Each polygon was delineated to predominantly represent one habitat type (medium-density shrubland or low-density shrubland). The purpose was to create clearly distinguishable

1. Phreatophytic / medium density vegetation class: producer's accuracy = 79%, user's accuracy = 89%. Bare ground / low density vegetation class: producer's accuracy = 88%, user's accuracy = 78% (SNWA 2007). Producer's accuracy = probability that a pixel value in the land cover map reflects the actual land cover class on the ground. User's accuracy = probability that the land cover class on the ground reflects the pixel value in the map.

sample groups for analysis. Approximately 80-95 percent of the pixels in each of the polygons were of the identified habitat type (mean = 90%).

- Polygon boundaries were refined by overlaying the initial polygons on 1-m resolution NAIP imagery and 6-inch resolution SNWA imagery. The imagery was used to visualize shrubs, mesic habitat, terrestrial woodland habitat, playa habitat, and agriculture. The purpose was to isolate and best capture medium-density and low-density shrubland at a finer resolution.

- Low-density shrubland polygons were not delineated in areas identified as sparse shrubland.[1] As discussed in Sections 6.3.3.2, sparse shrubland habitat already has extensive bare ground and thus was not included in the analysis. Therefore, the purpose of not delineating low-density shrubland polygons in sparse shrubland was to adequately represent low-density shrubland, and ensure consistency of the mitigation trigger with the low-density shrubland threshold.

- Major ephemeral washes, irrigation ditches, and roads apparent at a coarse scale on the imagery were omitted. The purpose was to maximize the vegetation signal and reduce the signal of non-vegetated areas.

These polygons, shown in Figure D-1, were used to quantify investigation and mitigation triggers for Spring Valley shrublands in this report (as discussed below). The shrubland habitat will change over time in response to natural factors (e.g., climate, succession) and anthropogenic factors (e.g., resource management). Therefore, prior to commencing shrubland monitoring in Spring Valley, a ground-truthing exercise and updated remote sensing analysis will be conducted to confirm the medium-density and low-density shrubland polygons in Management Blocks 1 and 2.

Three sparse shrubland polygons and two bare ground polygons were also delineated to provide context for the NDVI values. The sparse shrubland polygons were delineated in Spring Valley Management Block 2 in areas determined to be sparse during the polygon delineation process above. The bare ground polygons were approximately the size of a pixel, and were located at the edge of the central Spring Valley playa. The purpose of locating the polygons at the edge of the playa was to minimize NDVI reflectance from plants while avoiding high albedo and surface water that can accumulate during rain events (as these factors influence NDVI values). The bare ground polygons were examined with 6-inch resolution SNWA imagery to ensure that they had very low plant cover.[2] Twenty of the 365 NDVI values from the bare ground polygons were identified as outliers with box and whisker plots, all of which were from images with high albedo; these outliers were excluded from the bare ground mean NDVI calculation.

1. Because the polygons were delineated at a landscape scale (polygon mean area = 2,000 acres, 3 square miles), small inclusions of sparse shrubland that have little influence on mean polygon NDVI may be included in low-density polygons.
2. Pixels completely devoid of plant cover had too high of albedo for analysis.

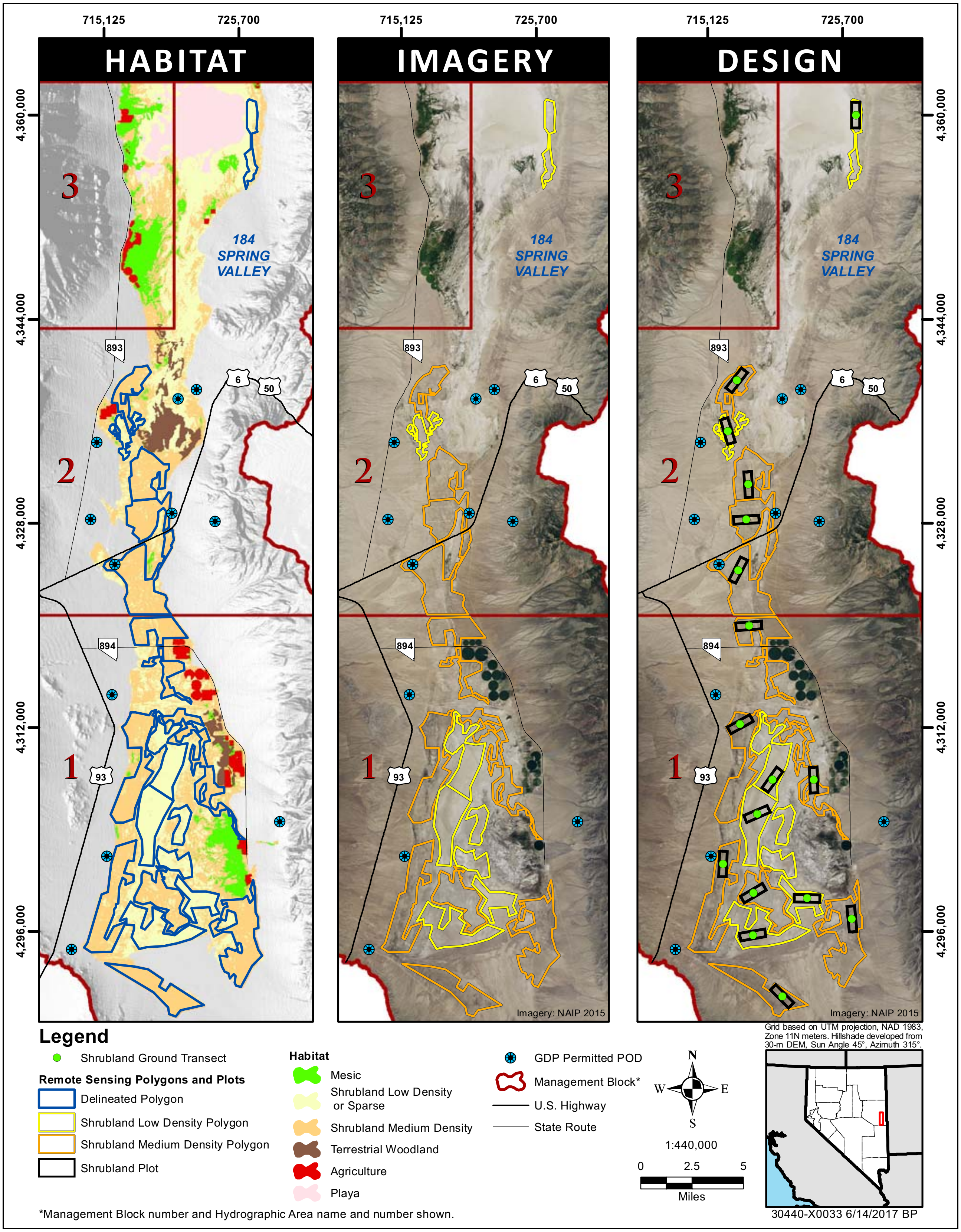


Figure D-1
Shrubland Remote Sensing Polygons and Plots and Ground Transects

D.1.1.2 Remote Sensing Plots

Remote sensing plots were placed within the medium-density and low-density shrubland polygons discussed in Section D.1.1.1. The purpose of using plots was two-fold: (1) to provide additional opportunities for statistical analysis, and (2) to provide a framework for the ground vegetation transect design.

The plots were located within the polygons using a proportionate stratified random design (Figure D-1). This common statistical sampling method minimizes sample selection bias, helps ensure that samples adequately represent the population and population segments (in this case, medium-density and low-density shrubland habitat), and prevents segments of the population from being over- or under-represented (Black, 2011; and Thompson, 2012).

The plots were digitized with a constant shape and size, using the maximum plot size that would fit within all of the polygons (2000x600m, approximately 300 acres). They were then stratified across the medium-density and low-density shrubland polygons. The number of plots were approximately proportional to the total area of the polygons within each habitat group. Medium-density polygons totaled approximately 28,000 acres (70% of the total polygon area), and the number of medium-density plots totaled 11 (65% of the total plot count). Low-density polygons totaled approximately 12,000 acres (30% of the total polygon area), and the number of low-density plots totaled 6 (35% of the total plot count).

The plots were randomly located within the polygons using the Environmental Systems Research Institute's (ESRI) ArcGIS 10.3 random point generator. The medium-density and low-density shrubland polygon feature classes were set as constraining feature classes. The “create feature” editing tool was used to create the plots with the specified length and width, and an on-line random compass generator program was used to determine the direction of each plot. If a plot could not be situated in a polygon with the first generated direction due to polygon shape, additional random compass directions were generated until a fit was possible. A vegetation transect was digitized in the center of each plot (Figure D-1).

As stated in Section D.1.1.1, prior to commencing shrubland monitoring, a ground-truthing exercise and updated remote sensing analysis will be conducted to confirm the polygons. The remote sensing plots and ground vegetation transects, which are dependent upon the polygons and additional on-the-ground factors (e.g., inclusions[1], dirt roads, and access), will also be confirmed at that time.

1. Relatively small area that is recognizably distinct from the area (e.g., soil type inclusion).

D.1.2 Remote Sensing Analysis

D.1.2.1 Remote Sensing Using Landsat Imagery and NDVI

Section D.1.2.1 by Justin Huntington, Principal Investigator, Huntington Hydrologic

Vegetation indices derived from satellite image data are commonly used to describe vegetation biomass and physiological status since they are directly related to the photosynthetic capacity and energy absorption of plant canopies (Rouse et al., 1974; Tucker, 1979). Vegetation indices are formulated to exploit the fact that vegetation absorbs red light and reflects near infrared (NIR) light. Specifically, chlorophyll pigments adsorb red light, while mesophyll (i.e. middle leaf) tissue reflects near infrared light. Various band-to-band ratios or differences using these two wavelengths (i.e. red and NIR) are common across most vegetation indices. Vegetation indices typically range from near 0 to 1 over land, where higher vegetation index values indicate higher vegetation vigor and/or cover.

Satellite derived vegetation indices such as NDVI have been extensively used in the Great Basin to quantify vegetation vigor, plant cover, evapotranspiration (Nichols, 2000; Devitt et al., 2011; Beamer et al., 2013; Garcia et al., 2015), and groundwater dependent ecosystem conditions over time (Huntington et al., 2016; Carroll et al., 2017). NDVI was selected for this study over other vegetation indices since it has been shown to better quantify sparse-to-moderate vegetation cover in arid environments (McGwire, et al., 2000; and Wu, 2014), has better statistical correlation with evapotranspiration from phreatophytic shrubs in Spring Valley (Devitt et al., 2011), is widely used across research and practitioner communities, and differences in NDVI across different Landsat satellites (i.e. Landsat 5, 7, and 8) have been assessed and calibration factors developed and applied in the Great Basin (Huntington et al., 2016).

Landsat satellite imagery is freely available, and has a native spatial (i.e., pixel) resolution of 30 m x 30 m for optical reflectance bands, and up to 120 m x 120 m for thermal radiance bands.[1] Landsat 5 Thematic Mapper (TM) images are available every 16 days from 1984-2012, however, this interval is reduced to 8 days when combined with the Landsat 7 Enhanced Thematic Mapper Plus (ETM+) (1999 - present), and when Landsat 7 is combined with Landsat 8 Optical Land Imager (OLI) (2013 - present). Landsat images are available every 7 days when the area of interest lies within an overlap of two Landsat paths, which is the case for the majority of Spring Valley shrubland areas analyzed.

D.1.2.2 NDVI and Weather Data Generation

Section D.1.2.2 by Justin Huntington, Principal Investigator, Huntington Hydrologic

Landsat 5, 7, and 8 archives, along with hourly and daily gridded weather data needed for atmospheric correction and correlation analysis, were used by Huntington Hydrologic to develop a complete historical time series of NDVI for Spring Valley from 1985-2015. Landsat satellites measure reflected shortwave and thermal infrared radiation in seven wavelength bands ranging from ~0.45 to 12.5 µm. Landsat top-of-atmosphere reflectance was transformed to at-surface reflectance

1. Landsat imagery is available on-line at https://landsat.usgs.gov/index.php. U.S. Geological Survey (USGS), Earth Resources and Observation Science Center.

using atmospheric correction algorithms according to Tasumi et al. (2008). Hourly vapor pressure from National Land Data Assimilation System (NLDAS) (Mitchell et al., 2004) gridded weather data sets were used to compute perceptible water and transmission coefficients following methods of Tasumi et al. (2008). Atmospheric pressure was estimated based on elevation derived from the 30 m National Elevation Dataset according to ASCE-EWRI (2005).

Landsat derived at-surface reflectance was used to compute NDVI as

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

where *NIR* is near infrared waveband from ~0.76 to 0.90 µm, and *Red* is waveband from ~0.63 to 0.69 µm. Due to differences in Landsat sensor bandwidths, cross-sensor calibration was needed for continuous time series analysis of at-surface reflectance and NDVI. Cross-sensor calibration between Landsat 5 and 7, and 8 bands of red and NIR at-surface reflectance was performed according to equations developed by Huntington et al. (2016), which were based on Landsat data acquired in the Great Basin. Automated cloud masks were computed following Irish et al. (2006) and Zhu and Woodcock (2012), and were used for data masking, filtering, and quality control during post-processing. These processing steps were implemented in the Google Earth Engine platform to create and download precipitation and cross-sensor calibrated at-surface reflectance derived NDVI and cloud mask raster datasets for all available Landsat imagery from 1985-2015.

Precipitation and reference evapotranspiration (ASCE-EWRI, 2005) was estimated using an ecological applications-focused gridded daily dataset, gridMET (Abatzoglou, 2013). GridMET is a hybrid of North American Land Data Assimilation System (NLDAS) hourly gridded weather data (Mitchell et al., 2004) and Parameter Regression on Independent Slopes Model (PRISM) monthly gridded weather data (Daly et al., 2008). The gridMET dataset has been shown be similar to or outperform other gridded precipitation datasets when compared to independent precipitation measurements collected in valley floor areas of Spring Valley and Snake Valley, Nevada (McEvoy et al., 2014).

D.1.2.3 NDVI and Weather Zonal Statistics

Section D.1.2.3 by Judith Brandt, Senior Remote Sensing Analyst, SNWA

Huntington Hydrologic processed and provided the following raster datasets to SNWA that were used for the shrubland analysis: Landsat TM, ETM+ and OLI data; Landsat-derived NDVI data; two Landsat-derived cloud detection products; thumbnail images of each Landsat scene; and gridMET monthly precipitation and reference evapotranspiration data. Each pixel in the Landsat raster dataset was 30 m x 30 m, and each pixel in the gridMET raster dataset was approximately 4 km x 4 km. All data spanned 1985-2015. Huntington Hydrologic also provided Python scripts for producing zonal statistics from the raster data.

SNWA used the Python scripts to produce NDVI, Cloud Mask, Cloud Score, and gridMET zonal statistics for the shrubland polygons and plots described in Section D.1.1 (hereafter referred to as "zones"). Zonal statistics are descriptive statistics (e.g., mean, minimum, maximum, count) calculated from pixel values in a zone, using only those pixels whose center points fall within the zone. The primary zonal statistics used in the shrubland analysis were mean at-surface reflectance derived NDVI (from each NDVI image, July through September, 1985-2015), and monthly precipitation (from each gridMET image, 1985-2015). The zonal data were compiled into ArcGIS file geodatabases, which are proprietary relational databases designed for use in ESRI's GIS. The zonal statistics datasets were then filtered using a multi-step process to include only valid, cloud-free NDVI data as described below.

First, NDVI data generated from incomplete Landsat ETM+ (7) images were filtered out of the zonal statistics datasets. On May 31, 2003, the Landsat 7 Scan Line Corrector (SLC) ceased functioning properly, and has been a permanent problem ever since (https://landsat.usgs.gov/slc-products-background). This problem visually appears as data striping, alternating bands of data and no-data. The alternating bands result in a loss of over 20% of the data in any Landsat 7 scene, and missing data in some of the pixels in the zones. NDVI zonal data generated from all affected Landsat 7 images were filtered out of the datasets, with the exception of data from 2012 when Landsat 7 data was all that was available.

Second, NDVI data generated from imagery where clouds or cloud shadows intersected the zones were filtered out of the zonal statistics datasets. Clouds and cloud shadows can produce NDVI zonal statistics that do not adequately represent vegetation cover on the ground. The process for filtering the data was as follows:

1. The first step was to visually examine every Landsat thumbnail image from July-September, 1985-2015 for cloud cover. If the entire thumbnail image was clear, NDVI zonal data were retained in the dataset. If the thumbnail image was cloudy, NDVI zonal data were filtered out of the dataset. If the thumbnail image was partly cloudy, the second step was implemented.

2. The second step was to examine the Cloud Score and Cloud Mask data. If the Cloud Score and Cloud Mask pixel count data for an image were relatively high in a specific zone, that image was considered too cloudy to use, and the NDVI zonal statistics data were filtered out of the dataset. If both the Cloud Score and Cloud Mask data for an image were relatively low in a specific zone, the third step was implemented.

3. The third step was to closely examine the original Landsat scenes to determine if clouds or cloud shadows intersected each zone. If any part of a zone was covered by a cloud or cloud shadow, the NDVI data for that zone were filtered out of the dataset. If the zone was cloud-free, the NDVI data for that zone were retained in the dataset.

The final NDVI zonal statistics data used in the shrubland analysis were produced from 2 - 16 NDVI images per zone per year, for the July - September time frame (mean = 6 images / zone / year). In 29 of the 31 years, NDVI zonal statistics data were produced from at least 3 images per zone per year. This was also true of all but 3 zones in 1990 and all but 5 zones in 1995, which were limited to 2 images each due to a preponderance of cloudy days. The final NDVI zonal statistics datasets thus provided extensive and representative data for each shrubland polygon and plot.

The NDVI and gridMET zonal statistics were exported from the ArcGIS geodatabases into Microsoft Excel spreadsheets. Statistical analyses of these data are described in Section D.1.3.

D.1.3 Statistical Analysis

Shrubland triggers were established using medium-density and low-density shrubland prediction intervals. A prediction interval is a statistical estimate of an interval in which future observations will fall, with a certain probability, given what has already been observed (Meeker et al., 2017; Hyndman and Athanasopoulos 2014). In this case, prediction intervals provided ranges of mean NDVI values expected from medium- and low-density shrubland habitat across a range of precipitation levels if no significant changes occur from baseline.

The methods used to produce the NDVI prediction intervals and statistical tests presented in Section 6.3.3.2 were as follows:

Step 1. July-September NDVI and monthly precipitation zonal statistics (as computed in Section D.1.2.3) were input into Systat 13. Descriptive statistics were used to average NDVI by zone by year (zone = polygon, plot; see Section D.1.2.3) and to sum precipitation by zone by water year (October-September) [NDVI_MEAN, PPT_SUM].[1]

Step 2. NDVI_MEAN and PPT_SUM were averaged across the zones within each habitat group by year (habitat groups = medium-density shrubland polygons, low-density shrubland polygons, sparse shrubland polygons, bare ground polygons, medium-density shrubland plots, low-density shrubland plots; see Sections D.1.1.1 and D.1.1.2).

Because polygons were different sizes, NDVI and precipitation were weighted. First, NDVI_MEAN and PPT_SUM were multiplied by polygon size (ACRES) [NDVIxACRE, PPTxACRE]. Next, descriptive statistics were used in Systat to sum NDVIxACRE, PPTxACRE, and ACRES across the polygons within each habitat group by year [NDVIxACRE_SUM, PPTxACRE_SUM, ACRES_SUM]. Last, these summed values were used to compute the weighted mean annual values for each habitat group [NDVIxACRE_SUM / ACRES_SUM = NDVI_WEIGHTED_MEAN, PPTxACRE_SUM / ACRES_SUM = PPT_WEIGHTED_MEAN].

Because the remote sensing plots were all the same size, they were not weighted. NDVI_MEAN and PPT_SUM were averaged across the plots within each habitat group by year [NDVI_MEAN2, PPT_MEAN].

The output data were used to produce time series line graphs and as input data for Steps 3-4.

1. For example, the water year for 1985 spanned October 1984 - September 1985.

Step 3. Linear mixed model Type III tests of fixed effects were performed in Systat to determine significant differences among the following habitat groups: (1) medium-density shrubland, low-density shrubland, sparse shrubland, and bare ground polygons; and (2) medium-density and low-density shrubland plots. The dependent variable was NDVI_WEIGHTED_MEAN (for polygons) and NDVI_MEAN2 (for plots), the fixed effects were the intercept and habitat, the random effect was year, and the estimation method was restricted maximum likelihood method. With these tests showing overall statistical differences, Tukey's honest significant difference tests were performed to compare the individual polygon habitat groups.

Descriptive statistics were used to average NDVI_WEIGHTED_MEAN (for polygons) and NDVI_MEAN2 (for plots) across years (1985-2015) by habitat group. The output data were used to produce a bar chart depicting the overall differences between the groups.

Step 4. Prediction intervals were calculated for the following four habitat groups: medium-density shrubland polygons, low-density shrubland polygons, medium-density shrubland plots, and low-density shrubland plots. The prediction intervals were calculated by performing a least squares linear regression in Systat. The dependent variable was NDVI_WEIGHTED_MEAN (for polygons) and NDVI_MEAN2 (for plots), the independent variable was PPT_WEIGHTED_MEAN (for polygons) and PPT_MEAN (for plots), a constant was included, the confidence level was 95 percent, and a Shapiro-Wilk normality test was included.

The mean annual NDVI and precipitation values and the upper and lower control limit output values were used to produce prediction interval graphs for each habitat group. For additional discussion on prediction intervals and confidence levels, see Appendix A.

Prior to SNWA GDP groundwater withdrawal from Spring Valley, prediction intervals for each habitat group will be re-calculated using the entire baseline period following the methods above.

Prediction intervals will also be calculated to provide percent live shrub cover triggers. As discussed in Section 6.3.3.3, percent live shrub cover will be recorded on ground vegetation transects located in the center of the medium- and low-density shrubland remote-sensing plots. Mean percent live shrub cover will be calculated for each habitat group every year (habitat groups = medium-density and low-density shrubland transects). The remote-sensing polygons where the transects are located will be used to calculate mean annual precipitation as described above. Prior to SNWA GDP groundwater withdrawal from Spring Valley, prediction intervals for each habitat group will be calculated by regressing mean annual percent live shrub cover against mean annual precipitation with a 95 percent confidence level using the methods above.

Once SNWA GDP groundwater withdrawal from Spring Valley begins, mean NDVI (July-September), mean precipitation (October-September), and mean percent live shrub cover (August) will be calculated for each habitat group every year. The mean annual NDVI and percent live shrub cover values will be plotted against the mean annual precipitation values for each habitat group. As discussed in Section 6.3.3.4, the data points will be compared to the 95 percent lower control limits of the prediction intervals to signal trigger activation.

D.2.0 Remote Sensing for Terrestrial Woodlands

This section provides remote sensing methods used to establish the investigation and mitigation triggers for Spring Valley terrestrial woodland habitat described in Section 6.3.4.

D.2.1 Delineation of Spring Valley Terrestrial Woodlands

A digital map of terrestrial woodland habitat in the groundwater discharge area of Spring Valley was created for this report. The woodland habitat co-occurs with shrubland habitat (where trees are intermixed with shrubs) and mesic habitat. Terrestrial woodland habitat areas that co-occur with shrubland habitats were classified in the SNWA (2007) land cover map as “phreatophytic/medium density vegetation” or “bare ground/low density vegetation” (see discussion on the land cover map in Section D.1.1.1). Woodland areas that co-occur with mesic habitat were classified in the land cover map as “wetland/meadow.” These areas were delineated as terrestrial woodland habitat for the purposes of this report.

The terrestrial woodland habitat was delineated by examining vegetation survey data and high-resolution imagery along with the SNWA (2007) land cover map. Portions of the terrestrial woodland habitat in Spring Valley were digitized in 2008-2009 as part of a detailed Spring Valley vegetation community map (SNWA et al., 2011). That vegetation map was produced by identifying plant communities in the field based on the three most dominant plant species in order of dominance, and mapping them on 6-inch resolution SNWA imagery (McLendon et al., 2011). Other portions of the habitat were digitized in 2012 as part of a juniper distribution survey in Spring Valley (SNWA, 2012c). These survey datasets were overlaid on 1-m resolution NAIP imagery from 2015, and in a few cases boundaries in the woodland map were refined to account for recent changes on the landscape. For terrestrial woodland habitat outside of the areas survey in 2008-2009 and 2012, trees and habitats were visually examined on 1-m resolution NAIP (2006 and 2015) imagery and 6-inch resolution SNWA (2007 and 2016) imagery. Sparse trees on the fringe of the woodlands were omitted so that the delineated area would best represent the terrestrial woodland habitat. The resultant digital map represents the current extent of the terrestrial woodland habitat in the Spring Valley groundwater discharge area.

D.2.2 Remote Sensing Analysis

D.2.2.1 Remote Sensing Using NAIP Imagery and NDVI

Section D.2.2.1 by Judith Brandt, Senior Remote Sensing Analyst, SNWA

A remote sensing analysis was conducted on the Swamp Cedar ACEC. Juniper trees in the ACEC were digitized using remote sensing methods and high resolution, digital aerial imagery. NAIP 1-meter spatial resolution aerial imagery collected in June 2015 was used to delineate the trees. SNWA 6-inch resolution imagery collected in June 2016 was used to check for quality of the one-meter analysis product.

The NAIP 2015 imagery tiles were mosaicked (merged) and clipped to the ACEC. None of the original data positions or values were altered in that process.[1] An NDVI raster image was calculated using the values of the Red and the NIR bands. The resulting NDVI pixel values reflected relative cover of vegetation across the ACEC. The imagery and NDVI data were brought into ESRI's ArcGIS v10.4.1 and visually examined for juniper trees. The high resolution of the image data enabled tree identification through visual image interpretation. For this visual image interpretation, the SNWA remote sensing analyst relied on past field experience which included spectral measurements, observations and identification of vegetation in shrublands of Spring Valley, as well as thousands of hours spent on high resolution photo interpretation of urban, sub-urban, riparian, and shrubland areas.

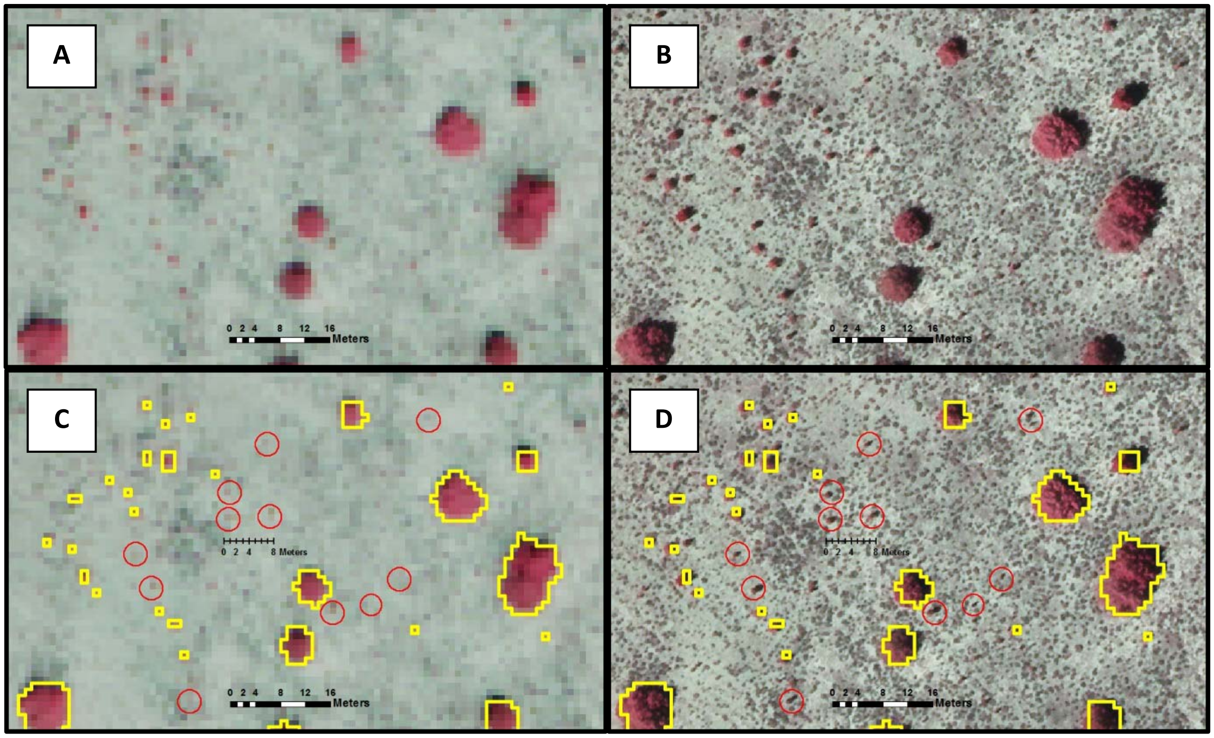
The NDVI values determined to be indicative of juniper trees in the Swamp Cedar ACEC ranged from 0.0733-0.6881. Other types of vegetation were also in this range, but were easily visually distinguished. The range of NDVI values representing juniper trees was converted to vector polygon data, and the data were manually “cleaned” of false positives (i.e., polygons void of trees were deleted) to provide a more accurate tree dataset. If an individual tree was distinguishable from the surrounding vegetation, the polygon encircled the tree. If individual trees were not distinguishable due to coincident tree canopies, the polygon encompassed the tree cluster. The tree polygons thus provide information on two-dimensional tree cover area, but not on tree density or count. Total tree cover area was calculated by summing the tree polygon areas.

The 6-inch resolution SNWA 2016 imagery, which covered the southeast quadrant of the ACEC, was used as a visual check on the quality of the tree polygons derived from the NAIP 2015 image data. Most of the tree cover area was detected by the selected range of NDVI values in the NAIP image data (Figure D-2). However, trees less than 1-1.5m in diameter were more difficult to discern from noise or background, especially in areas of dense shrubs (Figure D-2). The detection size was controlled partly by the resolution of the NAIP imagery, and partly by the lower end of the NDVI range chosen to determine tree pixels from non-tree pixels. The lower end of the NDVI range also resulted in “noise” (shrubs or other vegetation that were false positives for trees).

The NAIP 2015 imagery was captured using digital sensors that collect data in the red, green, blue and near-infrared (NIR) range of the color spectrum. Unlike Landsat satellite image data, the NAIP aerial image data did not include specific measurements of spectral radiance. Furthermore, during post-processing by the USDA, the data value was adjusted to produce natural-looking and seamless photographic tiles. Therefore, the pixel values were unique to the year and method in which the imagery is collected (i.e., they were not absolute). Additionally, the NAIP collection dates and frequency of data collection are not consistent. While NAIP imagery captured at a point in time can be used for an NDVI analysis, the utility of comparing those NDVI values over time is more limited.

This analysis demonstrated that tree cover area in the Swamp Cedar ACEC can be reliably quantified. For monitoring under the SNWA (2017e) Spring Valley 3M Plan, imagery of at least 0.5 m resolution that provides standardized measurements of spectral radiance will be collected and used to calculate tree cover area. High-resolution satellite imagery products by the Airbus Defence and Space Pleiades Constellation (http://www.intelligence-airbusds.com/en/3027-pleiades-50-cm-resolution-products)

1. NAIP imagery is available online at https://gdg.sc.egov.usda.gov/GDGHome_DirectDownLoad.aspx. USDA Farm Service Agency, Aerial Photography Field Office.



A. False color 1-m resolution NAIP 2015 image. The bright red color can be attributed to the juniper trees. Trees also have visible shadows, which help distinguish them from other vegetation.

B. False color 6-inch resolution SNWA 2016 image covering same area as **A**, showing resolution difference. Even small diameter trees have visible shadows,

C. NAIP 2015 tree polygon data in yellow overlaying NAIP 2015 imagery, showing that most trees were detected in the NAIP NDVI juniper tree range. Red circles show trees 1 meter or less in diameter that were not detected, but were visible in **D**.

D. NAIP 2015 tree polygon data in yellow overlaying SNWA 2016 imagery.

Figure D-2
Tree Polygons in the Swamp Cedar ACEC

and Digital Globe Worldview 2 (https://www.digitalglobe.com/about/our-constellation) are examples of this type of imagery.

Total tree cover area will be calculated each year by summing the tree polygon areas across the Swamp Cedar ACEC. Prior to SNWA GDP groundwater withdrawal from Spring Valley, the annual tree cover area values will be used to calculate the baseline maximum tree cover area. Once SNWA GDP pumping begins, the annual tree cover area will be compared to the baseline maximum tree cover area to signal trigger activation, as described in Section 6.3.4.3.

D.2.2.2 Baseline Percent Range in Cover

To determine the baseline percent range in cover within the Swamp Cedar ACEC, an analysis was conducted using NDVI derived from 1985-2015 Landsat satellite imagery. The NAIP imagery used to quantify tree cover area could not be used for this analysis due to the limitations in comparing NAIP data over time, as discussed in Section D.2.2.1. Therefore, NDVI was derived from Landsat imagery data to examine changes in cover over time. Given the long life span, slow growth rate and variable recruitment of the Rocky Mountain juniper species, the long record of data provided by Landsat imagery is optimal for this analysis.

To ensure that the NDVI data would reflect changes in tree cover and not simply changes in shrub cover, small sample areas (60 m x 60 m, or 2 x 2 Landsat pixels) were located where tree cover area was relatively high (as calculated in Section D.2.2.1). In case the percent range in cover differed in medium-density versus low-density vegetation areas, the sample areas were stratified across medium-density and low-density vegetation land cover polygons (as shown in Figure D-3). The land cover polygons were delineated based on the habitat map derived for this report using the methods in Section D.1.1.1. In the sample areas within the medium-density vegetation land cover polygons, the percent tree cover area ranged from 9-18% (mean = 14%) (percent tree cover area = total area of the tree polygons / sample area). In the sample areas within the low-density vegetation land cover polygons, percent tree cover area ranged from 4-14% (mean = 9%). To avoid sampling bias, the sample areas included areas with large trees or clumps of trees, as well as areas with a variety of tree sizes, which were visible on the NAIP 2015 imagery.

The NDVI analysis was conducted using the same methods as used for shrubland habitat (Section D.1.2.2 and Section D.1.2.3). Descriptive statistics were calculated in Systat to average NDVI by year by sample area group (medium-density and low-density vegetation). Because the two groups were similar, the data were combined to produce the final results. The mean annual NDVI was calculated by averaging across the sample areas. The mean annual NDVI values were then used to calculate the baseline percent range ((maximum - minimum) / maximum * 100).

The baseline percent range in cover will be recalculated prior to initiating SNWA GDP groundwater withdrawal from Spring Valley using the entire baseline period. Mean annual NDVI will be calculated by averaging across all of the sample areas in the Swamp Cedar ACEC each year of the baseline period. The annual values will then be used to calculate baseline percent range in cover ((maximum - minimum) / maximum * 100). Once SNWA GDP pumping begins, annual tree cover area will be compared to the baseline maximum tree cover area (as discussed in Section D.2.2.2) in relation to the baseline percent range in cover to signal trigger activation, as described in Section 6.3.4.3.

D.2.2.3 Tree Ground Monitoring Plots

To enhance understanding and tracking of tree population dynamics, five tree ground monitoring plots (100 m x 100 m) were designed within the Swamp Cedar ACEC. The monitoring plots were located in the medium-density and low-density vegetation polygons shown in Figure D-3 using a proportionate stratified random design (described in Section D.1.1.2). The tree monitoring plots are displayed in Figure 6-58 (Section 6.3.4.3).

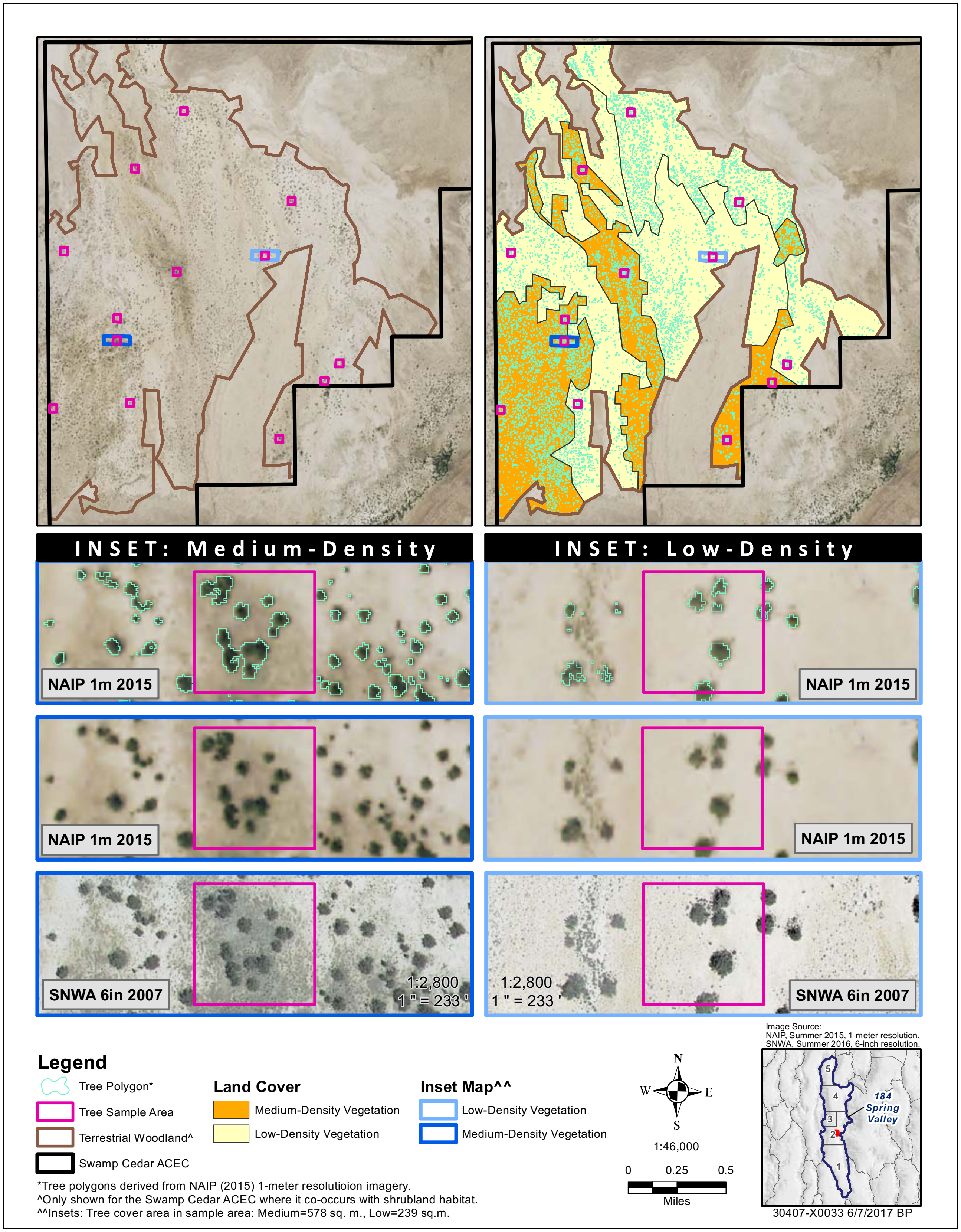


Figure D-3
Sample Areas and Tree Distribution in the Swamp Cedar ACEC

Appendix E

Environmental Sites Compiled within the Analysis Area

Table E-1
Environmental Sites Compiled within the Analysis Area
(Page 1 of 5)

Hydrographic Basin / Environmental Site	Source[a] 2011 Hearing	GDP EIS	GDP BA/BO	Geographic Location	Included in Analysis	Groundwater-Influenced Habitat[b]	Federally Listed and Aquatic-Dependent Special Status Animal Species[c]	Location[d] UTM Northing (m)	UTM Easting (m)	Elevation (ft)
Cave Valley (HB 180)										
Cave Spring	Y	Y	N	Alluvial Fan / Valley Floor (Perched)	Y	Spring, Cave		4279234	691760	6486
Cave Valley Meadow	Y	N	N	Alluvial Fan / Valley Floor (Perched)	Y	Spring, Wetland/Meadow		4280420	690235	6467
Parker Station Spring	Y	Y	N	Alluvial Fan / Valley Floor (Perched)	Y	Spring	Invertebrate (Hardy pyrg)	4282783	687749	6490
Delamar Valley (HB 182)										
Grassy Spring	Y	Y	N	Mountain Block	N	Spring		4157323	694969	5786
Dry Lake Valley (HB 181)										
Coyote Spring	Y	Y	N	Mountain Block	N	Spring		4211522	687636	5224
Meloy Spring	Y	Y	N	Mountain Block	N	Spring	Invertebrate (Flag pyrg)	4236240	700814	6178
Northern Hamlin Valley (HB 196)[e]										
South Little Spring	N	Y	N	Alluvial Fan	Y	Spring		4285394	751328	5578
Pahranagat Valley (HB 209)										
Ash Springs	Y	Y	Y	Valley Floor	Y	Spring	Fish (White River springfish); Invertebrate (Pahranagat pebblesnail, Grated tryonia, Ash Springs riffle beetle, Pahranagat naucorid bug)	4147658	659915	3603
Big Spring[f]	N	Y	N	Alluvial Fan / Valley Floor	Y	Spring	Fish (Pahranagat speckled dace)	4119046	672756	3156
Brownie/Deacon Springs	N	Y	N	Valley Floor	Y	Spring	Fish (Pahranagat speckled dace)	4149891	658155	3695
Cottonwood Spring[f]	Y	Y	N	Alluvial Fan / Valley Floor	Y	Spring	Fish (Pahranagat roundtail chub)	4123638	667261	3238
Crystal Springs	Y	Y	Y	Valley Floor	Y	Spring	Fish (Hiko White River springfish); Invertebrate (Hubbs pyrg)	4155375	656095	3803
Hiko Spring	Y	Y	Y	Valley Floor	Y	Spring	Fish (Hiko White River springfish)	4162750	657560	3878
Hoyt Spring[f]	N	Y	N	Alluvial Fan / Valley Floor	Y	Spring	Frog (Northern leopard frog)	4119766	672238	3180
Key Pittman WMA pond/lakes[g]	Y	Y	Y	Alluvial Fan / Valley Floor	Y	Well-fed: Lake (Reservoir), Pond	Fish (Pahranagat roundtail chub); Bird (Southwestern willow flycatcher, Western yellow-billed cuckoo)	4159787	656880	3834
L Spring[f]	Y	Y	N	Alluvial Fan / Valley Floor	Y	Spring	Fish (Pahranagat speckled dace); Frog (Northern leopard frog)	4119155	673202	3159

Table E-1
Environmental Sites Compiled within the Analysis Area
(Page 2 of 5)

Hydrographic Basin / Environmental Site	Source[a] 2011 Hearing	GDP EIS	GDP BA/BO	Geographic Location	Included in Analysis	Groundwater-Influenced Habitat[b]	Federally Listed and Aquatic-Dependent Special Status Animal Species[c]	Location[d] UTM Northing (m)	UTM Easting (m)	Elevation (ft)
Lone Tree Spring[f]	N	Y	N	Alluvial Fan / Valley Floor	Y	Spring		4119014	671456	3197
Maynard Spring	Y	Y	N	Alluvial Fan / Valley Floor	Y	Spring	Frog (Northern leopard frog)	4117909	674444	3107
Pahranagat Creek	Y	Y	Y	Valley Floor	Y	Stream, Riparian woodland gallery	Fish (Pahranagat roundtail chub); Bird (Southwestern willow flycatcher)	4145350	659798	3559
Pahranagat NWR lakes[f]	Y	Y	Y	Alluvial Fan / Valley Floor	Y	Spring, Lake (Reservoir), Marsh, Riparian woodland gallery	Bird (Southwestern willow flycatcher, Western yellow-billed cuckoo)	4129420	665817	3353
Southern Snake Valley (HB 195)[e]										
Big Springs	Y	Y	N	Alluvial Fan	Y	Spring	Invertebrate (Longitudinal gland pyrg)[l,m]	4287284	749419	5578
Big Springs Creek/Lake Creek	Y	Y	N	Alluvial Fan / Valley Floor	Y	Stream	None[m]	4293341	753805	5479
Big Wash (incl. S Fork Big Wash)	Y	Y	N	Originates in Mountain Block	N	Stream	Fish (Bonneville cutthroat trout [pure strain])[r]	4307392	747536	6187
Clay Spring North	Y	Y	N	Alluvial Fan	Y	Spring	Invertebrate (Longitudinal gland pyrg)	4306154	760853	5446
Dearden (Stateline) Springs	Y	Y	N	Alluvial Fan / Valley Floor	Y	Spring	Invertebrate (Longitudinal gland pyrg)	4295798	756730	5423
North Little Spring	Y	N	N	Alluvial Fan	Y	Spring		4286207	751009	5562
Pruess Lake[n]	N	Y	N	Alluvial Fan	Y	Lake (reservoir)	Invertebrate (California floater)	4308130	759066	5348
Unnamed 1 Spring North of Big	Y	Y	N	Alluvial Fan	Y	Spring	Invertebrate (Bifid duct pyrg)[l]	4289477	750196	5572
Spring Valley (HB 184)										
Bassett Creek	N	Y	N	Originates in Mountain Block	N	Stream		4367945	708774	7992
Bastian Creek	N	Y	N	Originates in Mountain Block	N	Stream		4336736	710650	6530
Blind Spring[j]	Y	Y	N	Valley Floor	Y	Wetland/Meadow	Frog (Northern leopard frog)	4298021	724721	5773
Cleve Creek	Y	Y	N	Originates in Mountain Block	N	Stream		4343870	710765	5964
Cleveland Ranch Complex[h]	N	Y	N	Alluvial Fan / Valley Floor	Y	Spring, Pond, Wetland/Meadow	Frog (Northern leopard frog)	4347511	717940	5597
Eight Mile Creek	N	Y	N	Originates in Mountain Block	N	Stream		4363394	733881	8133
Four Wheel Drive Spring	Y	N	N	Alluvial Fan / Valley Floor	Y	Spring		4335259	716246	5754
Home Ranch Property	N	N	N	Alluvial Fan / Valley Floor	Y	Pond, Wetland/Meadow[q]	Frog (Northern leopard frog)	4365486	715824	5585

Table E-1
Environmental Sites Compiled within the Analysis Area
(Page 3 of 5)

Hydrographic Basin	Source[a]							Location[d]		
Environmental Site	2011 Hearing	GDP EIS	GDP BA/BO	Geographic Location	Included in Analysis	Groundwater-Influenced Habitat[b]	Federally Listed and Aquatic-Dependent Special Status Animal Species[c]	UTM Northing (m)	UTM Easting (m)	Elevation (ft)
Indian Creek	N	Y	N	Originates in Mountain Block	N	Stream		4347301	714151	6304
Kalamazoo Creek	Y	Y	N	Originates in Mountain Block	N	Stream		4382169	710123	6233
Keegan Spring Complex	Y	Y	N	Alluvial Fan / Valley Floor	Y	Spring, Pond, Wetland/Meadow	Fish (Relict Dace); Frog (Northern leopard frog)	4369729	714947	5617
McCoy Creek	N	Y	N	Originates in Mountain Block	N	Stream		4361152	712804	6564
McCoy Creek Property	N	N	N	Alluvial Fan / Valley Floor	Y	Spring, Pond, Wetland/Meadow	Frog (Northern leopard frog)	4360707	716897	5592
Meadow Creek	N	Y	N	Originates in Mountain Block	N	Stream		4377422	711025	6142
Millick Spring Complex	N	Y	N	Valley Floor	Y	Spring, Wetland/Meadow	Frog (Northern leopard frog)	4353957	725673	5590
Minerva Spring Complex	Y	Y	N	Alluvial Fan / Valley Floor	Y	Spring, Pond, Wetland/Meadow	Frog (Northern leopard frog)[o]	4302423	725413	5825
Muncy Creek	N	Y	N	Originates in Mountain Block	N	Stream		4386314	709979	6187
Negro Creek	Y	Y	N	Originates in Mountain Block	N	Stream		4348593	727948	6032
Odgers Creek	N	Y	N	Originates in Mountain Block	N	Stream		4364305	713098	6275
O'Neil/Frog Pond	N	Y	N	Alluvial Fan / Valley Floor	Y	Spring, Pond, Wetland/Meadow	Frog (Northern leopard frog)	4372899	715403	5600
Osborne Spring	N	Y	N	Alluvial Fan / Valley Floor	Y	Spring	None[o]	4399091	711963	6127
Piermont Creek	N	Y	N	Originates in Mountain Block	N	Stream		4372851	707968	7543
Pine and Ridge Creeks[k]	Y	Y	N	Originates in Mountain Block	N	Stream	Fish (Bonneville cutthroat trout [pure strain])	4318879	727728	7345
Rock Spring	Y	Y	N	Mountain Block	N	Spring	Invertebrate (Bifid duct pyrg)	4340204	726798	6364
Shingle Creek	Y	Y	N	Originates in Mountain Block	N	Stream		4320388	727332	7309
Shoshone Ponds	Y	Y	Y	Alluvial Fan / Valley Floor	Y	Well-fed: Pond, Brook, Wetland/Meadow	Fish (Pahrump poolfish); Frog (Northern leopard frog)[p]	4312843	723711	5781
Siegel Creek	N	Y	N	Originates in Mountain Block	N	Stream		4400822	707782	6691
Spring Valley Creek	N	Y	N	Alluvial Fan / Valley Floor	Y	Stream	Fish (Relict Dace)	4411581	709337	6351

Table E-1
Environmental Sites Compiled within the Analysis Area
(Page 4 of 5)

Hydrographic Basin / Environmental Site	Source[a] 2011 Hearing	Source[a] GDP EIS	Source[a] GDP BA/BO	Geographic Location	Included in Analysis	Groundwater-Influenced Habitat[b]	Federally Listed and Aquatic-Dependent Special Status Animal Species[c]	Location[d] UTM Northing (m)	Location[d] UTM Easting (m)	Location[d] Elevation (ft)
Stonehouse Spring Complex	Y	Y	N	Alluvial Fan / Valley Floor	Y	Spring, Wetland/Meadow	Fish (Relict Dace)[o]	4406616	710222	6256
Swallow Spring	Y	Y	N	Alluvial Fan	Y	Spring		4302864	728689	6080
Swamp Cedar North	Y	Y	N	Valley Floor	Y	Woodland		4335053	719489	5645
Swamp Cedar South	Y	Y	N	Alluvial Fan / Valley Floor	Y	Woodland		4310128	724802	5813
Taft Creek (incl S Taft Creek)	N	Y	N	Originates in Mountain Block	N	Stream		4356856	714714	6213
Turnley/Woodsman Spring	N	Y	N	Mountain Block	N	Spring	None[s]	4338050	728695	6774
Unnamed 5 Spring	Y	Y	N	Valley Floor	Y	Spring	Frog (Northern leopard frog)[o]	4340639	718897	5645
Unnamed Springs East of Cleve Creek	N	Y	N	Valley Floor	Y	Spring	None[o]	4342419	719111	5652
Vipoint Creek	N	Y	N	Originates in Mountain Block	N	Stream		4352928	714952	6430
West Spring Valley Complex	Y	Y	N	Alluvial Fan / Valley Floor	Y	Spring	Frog (Northern leopard frog)[o]	4353810	717315	5603
Willard Creek	N	Y	N	Originates in Mountain Block	N	Stream		4323170	726693	7041
Williams Canyon Creek	N	Y	N	Originates in Mountain Block	N	Stream		4314021	728892	7325
Willow-NV Spring	Y	Y	N	Alluvial Fan / Valley Floor	Y	Spring	None[o]	4397069	713758	5987
Yelland Ranch Complex	N	N	N	Alluvial Fan / Valley Floor	Y	Spring, Pond, Wetland/Meadow	Frog (Northern leopard frog)	4357010	717336	5570
Southern White River Valley (HB 207)[e]										
Butterfield Spring	Y	Y	N	Alluvial Fan / Valley Floor	Y	Spring	Fish (White River speckled dace, White River sculpin); Invertebrate (Butterfield pyrg, Hardy pyrg)	4256498	673511	5324
Camp Spring	N	Y	N	Valley Floor	Y	Spring	Fish (White River speckled dace); Invertebrate (White River Valley pyrg)	4245192	658387	5181
Emigrant Springs	N	Y	N	Alluvial Fan / Valley Floor	Y	Spring	Fish (White River speckled dace); Invertebrate (Hardy pyrg, Emigrant pyrg)	4276964	669869	5464
Flag Springs	Y	Y	Y	Alluvial Fan / Valley Floor	Y	Spring	Fish (White River spinedace, White River speckled dace, White River desert sucker); Invertebrate (Flag pyrg, White River Valley pyrg)	4254223	672662	5294
Hardy Springs	Y	Y	N	Alluvial Fan / Valley Floor	Y	Spring	Invertebrate (Hardy pyrg)	4278175	667545	5354

Table E-1
Environmental Sites Compiled within the Analysis Area
(Page 5 of 5)

Hydrographic Basin	Source[a]							Location[d]		
Environmental Site	**2011 Hearing**	**GDP EIS**	**GDP BA/BO**	**Geographic Location**	**Included in Analysis**	**Groundwater-Influenced Habitat[b]**	**Federally Listed and Aquatic-Dependent Special Status Animal Species[c]**	**UTM Northing (m)**	**UTM Easting (m)**	**Elevation (ft)**
Hot Creek Spring	Y	Y	N	Valley Floor	Y	Spring	Fish (Moorman White River springfish); Invertebrate (Pahranagat pebblesnail, Grated tryonia)	4249920	661285	5229
Moon River Spring	N	Y	N	Valley Floor	Y	Spring	Fish (Moorman White River springfish); Invertebrate (Pahranagat pebblesnail, Grated tryonia[l])	4246389	658933	5223
Moorman Spring	Y	Y	N	Valley Floor	Y	Spring	Fish (Moorman White River springfish); Invertebrate (Pahranagat pebblesnail, Grated tryonia)	4273421	662057	5299
Silver Springs	N	Y	N	Alluvial Fan / Valley Floor	Y	Spring	Invertebrate (Hardy pyrg)	4268700	676190	5970
Sunnyside Creek[i]	Y	Y	Y	Alluvial Fan / Valley Floor	Y	Stream	Fish (White River spinedace, White River speckled dace, White River desert sucker)	4255021	672010	5230

[a] Environmental areas of interest identified by SNWA in the 2011 water rights hearing (Marshall and Luptowitz, 2011, at Section 2),and environmental resources identified in the SNWA Groundwater Development (GDP)
Environmental Impact Statement (EIS) (BLM, 2012a), Biological Assessment (BA) (BLM, 2012c), and Biological Opinion (BO) (USFWS, 2012).

[b] Mesic habitat includes spring, wetland/meadow, marsh, pond and stream habitat.

[c] Special status animal species are: Federally listed, proposed and candidate species under the ESA; Nevada (NV) state protected species, NV BLM sensitive species, and NV species of conservation priority; Utah sensitive species; and species ranked critically imperiled or imperiled across their entire range by NatureServe.

[d] NAD83, Zone 11N.

[e] Only sites in the portion of the basin included in the analysis area are listed.

[f] Pahranagat National Wildlife Refuge (PNWR) includes Big, Cottonwood, Hoyt, L, and Lone Tree springs, Upper Lake and Lower Lake, and marshes. Southwestern willow flycatchers breed and western yellow-billed cuckoo occur at Pahranagat NWR Upper Lake.

[g] Key Pittman Wildlife Management Area (WMA) includes a well-fed pond that flows into Nesbitt and Frenchy lakes. Pahranagat roundtail chub occur in the pond, southwestern willow flycatchers breed and western yellow- billed cuckoo have been documented at Nesbitt Lake.

[h] The EIS included a site named "North of Cleveland Ranch". Mesic habitat at that location (UTM N 4351695, E 719545) is a downstream continuation of mesic habitat in Cleveland Ranch. Thus, it was subsumed within the Cleveland Ranch Complex site.

[i] Flag Springs Complex has three main springheads (North, Middle, and South) that outflow into Sunnyside Creek. The endangered White River springfish occurs in all three springbrooks and down into the upper portion of Sunnyside Creek, inhabiting approx. 2.5 km (1.55 miles) of habitat (USFWS, 2012).

[j] Blind Spring is a dug-out retention area with wetland vegetation.

[k] Pine and Ridge creeks converge.

[l] Previously reports included both longitudinal gland pyrg and bifid duct pyrg in Big Springs, and longitudinal gland pyrg in Unnamed 1 Spring North of Big (Golden et al., 2007; BLM, 2012a; Marshall and Luptowitz, 2011).
Recent review of records suggest that only longitudinal gland pyrg is in Big Springs, and bifid duct pyrg is in Unnamed 1 Spring N of Big (Sada, 2017b); re-sampling and identification is suggested.
Also, the FEIS listed only Pahranagat pebblesnail at Moon River Spring, but surveys have also documented grated tryonia at the site (Sada, 2017a).

[m] Previously reports identified redside shiner, Utah chub, and Utah sucker as Utah State Protected species (BLM, 2012a; BWG, 2009; Marshall and Luptowitz, 2011. These species are no longer on the Utah Sensitive Species List (UDWR, 2015).

[n] In most years, Big Springs/Lake Creek becomes ephemeral near its terminus before reaching Pruess Reservoir.

[o] The invertebrate Toquerville pyrg (*Pyrgulopsis kolobensis*), which occurs at this site (Marshall and Luptowitz, 2011), does not have special status.

[p] The Nevada Department of Wildlife (NDOW) removed relict dace from Shoshone Ponds and transplanted them to their native Steptoe Valley.

[q] The habitat at Home Ranch Property was entirely created by irrigation water from Odgers Creek (piped from the mountain block).

[r] Lower limit of Bonneville cutthroat trout: Big Wash = end of native stream / upstream of canal ditches (approx. 6,400 ft elevation); Pine and Ridge Creeks = upstream of diversion pipeline (approx. 7,100 ft).

[s] Bifid duct pyrg presumed extirpated (Sada, 2017a).

Appendix F

Site Assessment of Springs with Vested Claims V10073 - V10085 in central Spring Valley conducted September, 2016

F.1.0 INTRODUCTION

This appendix documents several different types of supplementary data. First, the appendix documents site assessments that were performed by SNWA staff on selected springs in Spring Valley. Each of the visited springs has a vested water-right claim. In addition to the site assessments, the appendix documents well driller's reports for both senior, underground water rights and domestic water wells. The following sections discuss the supplementary data in greater detail.

F.1.1 Site Assessments

Table F-1 lists the 13 selected springs for which additional information is provided and were visited in September of 2016. The visits were conducted in order to document the spring locations and presence of water. The table also provides a summary of the conditions that were found at the springs. It can be seen from the table that four of the visited springs were dry in September of 2016. In addition to the table, photographs are provided for the 13 springs that were visited. The photographs can be seen in Figures F-1 through Figure F-13.

Table F-1
September 2016 Site Visit

App. No.	Spring Name	UTM Northing (m)	UTM Easting (m)	Alias	Duty (cfs)	Conditions during September 2016
V10073	Layton Spring	4,331,794	720,204	1845901	0.12	Dry
V10074	West Bastian Allotment Spring	4,335,154	716,285	1848413	0.12	Standing water, similar to 4WD spring.
V10075	West Bastian Allotment Spring 2	4,334,291	716,138	1848414	0.12	Dry
V10076	South Bastian Spring	4,334,865	718,388	1845801	0.12	Dry
V10077	South Bastian Spring 2	4,334,397	718,361	1845802	0.12	Dry
V10078	Triple Springs - North	4,341,814	719,479	1848415	0.12	Standing water, with boiling sands at orifice.
V10079	Triple Springs - Middle	4,341,690	719,459	1848416	0.12	Standing water, with boiling sands at orifice.
V10080	Triple Springs - South	4,341,564	719,459	1848417	0.12	Standing water, with boiling sands at orifice.
V10081	Big Water Spring	4,340,632	718,908	Unknown #5	0.12	Large pool of open water that discharges to the east.
V10082	Cleveland Ranch Allotment Spring - North	4,342,570	718,996	1848420	0.12	Four distinct orifice, small amount of standing water in tall grass, no open water. Lower pool area has numerous gopher mounds indicating it has been dry for some time.
V10083	Cleveland Ranch Allotment Spring - South	4,342,420	719,106	1848421	0.12	Standing water, with boiling sands at orifice. Some cattails in tall grass.
V10084	Fenceline Spring - North	4,342,102	719,351	1848419	0.12	Standing water, with boiling sands at orifice.
V10085	Fenceline Spring - South	4,342,014	719,450	1848418	0.12	Standing water, with boiling sands at orifice.

Figure F-1
Water- Right Application Number V10073 - Layton Spring, looking north

Figure F-2
Water- Right Application Number V10074 - West Bastian Allotment Spring, looking northwest

Figure F-3
Water- Right Application Number V10075 - West Bastian Allotment Spring 2, looking east

Figure F-4
Water- Right Application Number V10076 - South Bastian Spring, looking north

Figure F-5
Water- Right Application Number V10077 - South Bastian Spring 2, looking north

Figure F-6
Water- Right Application Number V10078 - Triple Springs - North, looking east

Figure F-7
Water- Right Application Number V10079 - Triple Springs - Middle, looking northeast

Figure F-8
Water- Right Application Number V10080 - Triple Springs - South, looking east

Figure F-9
Water- Right Application Number V10081 - Big Water Spring a.k.a Unknown #5, looking southeast

Figure F-10
Water- Right Application Number V10082 - Cleveland Ranch Allotment Spring - North, looking southeast

Figure F-11
Water- Right Application Number V10083 - Cleveland Ranch Allotment Spring - South, looking west

Figure F-12
Water- Right Application Number V10084 - Fenceline Spring - North, looking east

Figure F-13
Water- Right Application Number V10085 - Fenceline Spring - South, looking east