Biological Monitoring Plan for the Spring Valley Stipulation

February 2009

Biological Work Group

Stipulation Parties:	Bureau of Indian Affairs Bureau of Land Management National Park Service Southern Nevada Water Authority U.S. Fish and Wildlife Service
Invited Parties:	Nevada Department of Wildlife Utah Division of Wildlife Resources

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LIST OF ACRONYMS

ANOVA	Analysis of Variance
ANS	Aquatic Nuisance Species
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BWG	Biological Work Group
CAP	Conservation Action Planning
CCC	Civilian Conservation Corps
CPUE	Catch Per Unit Effort
DMP	Data Management Plan
DMS	Document Management Software
DOI	Department of the Interior
EC	Executive Committee
EPA	Environmental Protection Agency
EPT	Ephemeroptera Plecoptera Trichoptera
ESA	Endangered Species Act
FWS	Fish and Wildlife Service
GBNP	Great Basin National Park
GPS	Global Positioning System
HACCP	Hazardous Analysis and Critical Control Points
HB	Hydrographic Basin
IBMA	Initial Biological Monitoring Area
ICH	Ichthiopterius (fish bacteria)
LVVWD	Las Vegas Valley Water District
KEA	Key Ecological Attribute
MODFLOW	Modular Three-Dimensional Finite-Difference Groundwater Model
MS model	Mechanistic Simulation Model
NDOW	Nevada Department of Wildlife
NNHP	Nevada Natural Heritage Program
NPS	National Park Service
NSE	Nevada State Engineer
OSHA	Occupational Health and Safety Administration
POD	Points of Diversion
SGCN	Species of Greatest Conservation Need
SNWA	Southern Nevada Water Authority
SOCP	Species of Conservation Priority
ST	State-and-Transition Model
TNC	The Nature Conservancy
TRP	Technical Review Panel
UDWR	Utah Division of Wildlife Resources
UNHP	Utah Natural Heritage Program
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USOFR	United States Office of the Federal Register
WRCC	Western Region Climate Center

CONVERSION FACTORS

UNITS OF LENGTH

1 inch	=	2.54 centimeters (cm)	1 centimeter	=	0.39 inch (in)
1 foot	=	30.48 centimeters (cm)	1 meter	=	39.37 inches (in)
1 foot	=	0.305 meters (m)	1 meter	=	3.28 feet (ft)
1 yard	=	0.914 meters (m)	1 meter	=	1.09 yard (yd)
1 mile	=	1609 meters (m)	1 kilometer	=	3,281 feet (ft)
1 mile	=	1.609 kilometers (km)	1 kilometer	=	0.62 miles (mi)

UNITS OF AREA

1 square foot	=	929 square centimeters (cm^2)	1 square centimeter	=	0.155 square inches (in^2)
1 square foot	=	0.093 square meters (m^2)	1 square meter	=	10.76 square feet (ft^2)
1 square yard	=	0.837 square meters (m^2)	1 square meter	=	3.59 square yards (yd^2)
1 acre	=	4047 square meters (m^2)	1 hectare	=	2.47 acres (ac)
1 acre	=	0.405 hectares (ha)	1 square kilometer	=	247 acres (ac)
1 square mile	=	2.59 square kilometers (km^2)	1 square kilometer	=	0.386 square miles (mi^2)

UNITS OF VOLUME

1 cubic foot	=	7.48 gallons (gal)	1 gallon	=	0.134 cubic foot (ft^3)
1 acre foot	=	325,851 gallons (gal)	1 cubic meter	=	35.29 cubic feet (ft^3)
1 acre foot	=	43,560 cubic feet (ft^3)	1 cubic meter	=	263.9 gallons (gal)
1 acre foot	=	1233.6 cubic meters (m^3)			

UNITS OF WEIGHT

1 ounce	=	28.4 grams (g)			
1 pound	=	454 grams (g)			
1 pound	=	0.454 kilograms (kg)	1 kilogram	=	2.205 pounds (lbs)

TABLE OF CONTENTS

1.0 INTRODUCTION AND BACKGROUND.....1-1
1.1 STIPULATION REGARDING SNWA'S GROUNDWATER APPLICATIONS IN SPRING VALLEY HB.....1-2
1.1.1 Stipulation Requirements for Biological Monitoring.....1-2
1.1.2 Stipulation Requirements for Hydrologic Monitoring.....1-3
1.2 NEVADA STATE ENGINEER RULING.....1-3
1.3 STUDY AREA.....1-4
1.3.1 Areas of Potential Groundwater Development.....1-4
1.3.2 Initial Biological Monitoring Area (IBMA).....1-6
1.3.3 Biological Resources.....1-9
2.0 MONITORING GOALS AND OBJECTIVES.....2-1
2.1 MONITORING GOALS.....2-1
2.2 MONITORING OBJECTIVES.....2-1
3.0 BIOLOGICAL MONITORING PLAN METHODOLOGY.....3-1
3.1 CONSERVATION ACTION PLANNING (CAP) PROCESS.....3-1
3.1.1 Groundwater-Influenced Ecosystems and Nested Targets.....3-1
3.1.2 Key Ecological Attributes and Indicators.....3-2
3.2 RANGES OF VARIATION, UNREASONABLE ADVERSE EFFECT, AND CRITERIA FOR INITIATING BWG CONSULTATION.....3-2
3.3 PLAN DESIGN.....3-3
3.3.1 Adaptive Framework.....3-3
3.3.1.1 Pre-SNWA Groundwater Withdrawal Phase (Pre-Withdrawal).....3-4
3.3.1.2 Withdrawal Phase.....3-5
3.3.2 Supplemental Data Gathering.....3-5
3.3.3 Data Analysis, Review, Modification.....3-5
3.4 PEER REVIEW.....3-7
4.0 MONITORING FRAMEWORK.....4-1
4.1 GROUNDWATER-INFLUENCED ECOSYSTEMS.....4-2
4.1.1 Selection of Groundwater-Influenced Ecosystems.....4-2
4.1.2 Description of Groundwater-Influenced Ecosystems.....4-3
4.1.2.1 Springs.....4-3
4.1.2.2 Ponds (Shoshone).....4-4
4.1.2.3 Perennial Streams.....4-4
4.1.2.4 Wetlands.....4-5
4.1.2.5 Meadows.....4-5
4.1.2.6 Phreatophytic Shrublands.....4-6
4.1.2.7 Swamp Cedar Woodlands.....4-7
4.2 DESCRIPTION OF NESTED TARGETS.....4-8
4.3 NESTED TARGETS TO BE DIRECTLY MONITORED.....4-10
4.3.1 Springsnails.....4-11
4.3.2 Northern Leopard Frog.....4-11
4.3.3 Relict Dace.....4-12
4.3.4 Pahrump Poolfish.....4-13
4.3.5 Fishes Native to the Big Springs Complex.....4-14
4.3.6 Swamp Cedars.....4-14
4.4 MONITORING SITES.....4-15
4.4.1 Site Selection.....4-15
4.4.2 Sites.....4-24
4.4.2.1 Stonehouse Complex, West Spring Valley Complex.....4-25
4.4.2.2 Willow Spring.....4-25
4.4.2.3 Keegan Ranch Complex.....4-25
4.4.2.4 South Millick Spring, Unnamed Spring 5.....4-26
4.4.2.5 4WD Spring, Willard Spring.....4-26

4.4.2.6 Swallow Spring......4-26
4.4.2.7 Minerva Springs Complex......4-27
4.4.2.8 Clay Spring-North......4-27
4.4.2.9 Unnamed 1-North of Big Spring......4-27
4.4.2.10 North Little Spring......4-28
4.4.2.11 The Seep, Blind, and Burbank Meadows......4-28
4.4.2.12 Big Springs Complex......4-28
4.4.2.13 Shoshone Ponds......4-30
4.4.2.14 Swamp Cedar Woodland North and South......4-30
4.4.2.15 Phreatophytic Shrublands......4-31
4.5 KEY ECOLOGICAL ATTRIBUTES (KEAS) AND INDICATORS......4-31
4.5.1 Springs, Ponds (Shoshone), and Perennial Streams......4-33
4.5.1.1 KEAs and Indicators......4-33
4.5.1.2 Research and Information Needs......4-34
4.5.2 Wetlands......4-35
4.5.2.1 KEAs and Indicators......4-35
4.5.2.2 Research and Information Needs......4-36
4.5.3 Meadows......4-36
4.5.3.1 KEAs and Indicators......4-36
4.5.3.2 Research and Information Needs......4-37
4.5.4 Phreatophytic Shrublands......4-37
4.5.4.1 KEAs and Indicators......4-37
4.5.4.2 Research and Information Needs......4-38
4.5.5 Swamp Cedars......4-38
4.5.5.1 KEAs and Indicators......4-38
4.5.5.2 Research and Information Needs......4-40
5.0 MONITORING APPROACH......5-1
5.1 WATER SUPPLY AND WATER QUALITY......5-2
5.1.1 Specific, Measurable Sampling Objectives......5-3
5.1.2 Sampling Design......5-3
5.1.3 Monitoring Sites......5-4
5.1.4 Statistical Analysis......5-5
5.2 PHYSICAL HABITAT OF AQUATIC ECOSYSTEMS......5-5
5.2.1 Specific, Measurable Sampling Objectives......5-5
5.2.2 Sampling Design......5-5
5.2.3 Monitoring Sites......5-6
5.2.4 Statistical Analysis......5-7
5.3 OPEN WATER AND AQUATIC VEGETATION COVER......5-7
5.3.1 Specific, Measurable Sampling Objectives......5-8
5.3.2 Sampling Design......5-8
5.3.3 Monitoring Sites......5-8
5.3.4 Statistical Analysis......5-9
5.4 MACROINVERTEBRATE COMPOSITION AND RICHNESS......5-9
5.4.1 Specific, Measurable Sampling Objectives......5-10
5.4.2 Sampling Design......5-10
5.4.3 Monitoring Sites......5-10
5.4.4 Statistical Analysis......5-11
5.5 SPRINGSNAIL ABUNDANCE AND DISTRIBUTION......5-11
5.5.1 Specific, Measurable Sampling Objectives......5-11
5.5.2 Sampling Design......5-11
5.5.3 Monitoring Sites......5-12
5.5.4 Statistical Analysis......5-12
5.6 FISH AGE/SIZE CLASS STRUCTURE AND DISTRIBUTION......5-12
5.6.1 Specific, Measurable Sampling Objectives......5-13
5.6.2 Sampling Design......5-13

5.6.3 Monitoring Sites......*5-14*
5.6.4 Statistical Analysis......*5-14*
5.7 NORTHERN LEOPARD FROG EGG MASS COUNTS......5-15
5.7.1 Specific, Measurable Sampling Objectives......*5-15*
5.7.2 Sampling Design......*5-15*
5.7.3 Monitoring Sites......*5-16*
5.7.4 Statistical Analysis......*5-16*
5.8 COVER AND COMPOSITION OF AQUATIC VEGETATION......5-17
5.8.1 Specific, Measurable Sampling Objectives......*5-17*
5.8.2 Sampling Design......*5-17*
5.8.3 Monitoring Sites......*5-18*
5.8.4 Statistical Analysis......*5-18*
5.9 COVER AND COMPOSITION OF NON-AQUATIC VEGETATION......5-18
5.9.1 Specific, Measurable Sampling Objectives......*5-18*
5.9.2 Sampling Design......*5-19*
5.9.3 Monitoring Sites......*5-19*
5.9.4 Statistical Analysis......*5-21*
5.10 VEGETATION MEASUREMENTS IN SWAMP CEDAR COMMUNITIES......5-21
5.10.1 Specific, Measurable Sampling Objectives......*5-21*
5.10.2 Sampling Design......*5-21*
5.10.3 Monitoring Sites......*5-22*
5.10.4 Statistical Analysis......*5-22*
5.11 STEM ELONGATION IN SWAMP CEDAR COMMUNITIES......5-22
5.11.1 Specific, Measurable Sampling Objectives......*5-23*
5.11.2 Sampling Design......*5-23*
5.11.3 Monitoring Sites......*5-23*
5.11.4 Statistical Analysis......*5-23*
5.12 ADDITIONAL CONSIDERATIONS......5-24
5.12.1 Remote Sensing......*5-24*
5.13 SUMMARY OF SAMPLING SCHEDULE AND ACTIVITIES......5-24
6.0 PREDICTIVE ECOLOGICAL MODEL......6-1
6.1 PURPOSE......6-1
6.2 OBJECTIVES......6-1
6.3 TYPES OF MODELS......6-2
6.3.1 Statistical Models......*6-2*
6.3.2 State-and-Transition Models......*6-3*
6.3.3 Mechanistic Simulation Models......*6-4*
6.4 TIMELINE......6-5
7.0 DATA MANAGEMENT, ANALYSIS, AND REPORTING......7-1
7.1 GOALS AND OBJECTIVES OF DATA MANAGEMENT......7-1
7.1.1 Quality Maintenance......*7-1*
7.1.2 Interpretability......*7-1*
7.1.3 Security......*7-2*
7.1.4 Longevity......*7-2*
7.1.5 Availability......*7-2*
7.2 DATA STEWARDSHIP ROLES AND RESPONSIBILITIES OF PARTIES......7-2
7.3 DATA MANAGEMENT......7-2
7.3.1 Acquisition and Processing......*7-3*
7.3.2 Quality Assurance/Quality Control......*7-3*
7.3.3 Data Documentation (Metadata)......*7-4*
7.3.4 Data Dissemination......*7-4*
7.3.5 Data Maintenance, Storage, and Archiving......*7-5*
7.3.6 Data Ownership......*7-5*
7.4 DATA ANALYSIS......7-5
7.5 REPORTS......7-5
7.5.1 Expected Products......*7-5*

7.5.2 Intended Audiences.....*7-6*
7.6 RESOLVING CONFLICT REGARDING DATA ANALYSIS AND INTERPRETATION.....7-6
8.0 PLAN IMPLEMENTATION AND SCHEDULE.....8-1
8.1 ROLES AND RESPONSIBILITIES OF PARTIES.....8-1
8.2 SUMMARY OF SAMPLING SCHEDULE AND FREQUENCY.....8-1
8.3 TARGET COMPLETION DATES FOR OUTSTANDING PRODUCTS.....8-3
8.3.1 Protocol Review.....*8-3*
8.3.2 Withdrawal Phase.....*8-4*
8.3.3 Ecological Model.....*8-4*
8.3.4 Defining Unreasonable Adverse Effects.....*8-4*
8.3.5 Data Management Plan.....*8-5*
8.3.6 Statistical Protocols.....*8-5*
8.4 MITIGATION.....8-5
9.0 LITERATURE CITED.....9-1
10.0 GLOSSARY.....10-1

LIST OF APPENDICES

APPENDIX A STIPULATION FOR WITHDRAWAL OF PROTESTS, WITH EXHIBITS A AND B
APPENDIX B NEVADA STATE ENGINEER RULING 5726
APPENDIX C PROTOCOLS
APPENDIX D LIST OF SCIENTIFIC AND COMMON NAMES
APPENDIX E CONCEPTUAL MODELS

LIST OF TABLES

Table 4-1. Nested targets to be directly monitored in the IBMA.....4-10
Table 4-2. Monitoring sites, included ecosystems, and locations.....4-16
Table 4-3. Additional criteria evaluated for selection of monitoring sites for springs, ponds, and streams.....4-17
Table 4-4. KEAs and indicators to be monitored for each groundwater-influenced ecosystem.....4-32
Table 5-1. Water supply and water quality monitoring sites.....5-4
Table 5-2. Physical habitat characterization: spring and perennial stream monitoring sites.....5-7
Table 5-3. Aquatic macroinvertebrate monitoring sites.....5-10
Table 5-4. Springsnail monitoring sites.....5-12
Table 5-5. Fish monitoring sites.....5-14
Table 5-6. Northern Leopard Frog monitoring sites.....5-16
Table 5-7. Summary of activities at monitoring sites.....5-25
Table 8-1. Data Collection for the Pre-Withdrawal Phase.....8-2
Table 8-2. Schedule for Biological Monitoring Plan Development and Implementation.....8-3

LIST OF FIGURES

Fig. 1-1. SNWA groundwater exploratory areas and permitted points of diversion within Spring Valley.....1-5
Fig. 1-2. Land status within the Spring Valley Stipulation IBMA.....1-7
Fig. 3-1. Biological Monitoring Plan Adaptive Framework.....3-6
Fig. 4-1. TRP spring and stream hydrologic monitoring sites.....4-18
Fig. 4-2. TRP and SNWA groundwater monitoring sites.....4-20
Fig. 4-3. BWG monitoring sites: springs, ponds (Shoshone), and perennial streams.....4-21
Fig. 4-4. BWG monitoring sites: wetlands, meadows, and swamp cedars.....4-22
Fig. 4-5. BWG monitoring sites: phreatophytic shrublands.....4-23
Fig. 5-1. Illustration of location of transects in aquatic and adjacent plant communities at a hypothetical site.....5-20

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1.0 INTRODUCTION AND BACKGROUND

CONTENTS

1.1 Stipulation Regarding SNWA's Groundwater Applications in Spring Valley HB
- **1.1.1 Stipulation Requirements for Biological Monitoring**
- **1.1.2 Stipulation Requirements for Hydrologic Monitoring**

1.2 Nevada State Engineer Ruling

1.3 Study Area
- **1.3.1 Areas of Potential Groundwater Development**
- **1.3.2 Initial Biological Monitoring Area (IBMA)**
- **1.3.3 Biological Resources**

The Spring Valley Biological Monitoring Plan (Plan) is a component of a stipulated agreement between the Southern Nevada Water Authority (SNWA) and four U.S. Department of the Interior (DOI) Bureaus: Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (FWS), and National Park Service (NPS) (Stipulation; Appendix A). The purpose of the Plan is to establish a monitoring program that will further the understanding of groundwater-influenced ecosystem dynamics and track biotic community responses to SNWA's groundwater withdrawal from the Spring Valley Hydrographic Basin (Spring Valley HB) in east-central Nevada. This document focuses on monitoring baseline conditions prior to SNWA groundwater withdrawal (the Pre-Withdrawal Phase) from Spring Valley. A revised Plan for the Withdrawal monitoring phase will be in place before the end of the Pre-Withdrawal Phase.

The monitoring plan is designed to be consistent with the following goals of the Stipulation:

1. Manage the development of groundwater by SNWA in the Spring Valley HB in order to avoid unreasonable adverse effects to groundwater-influenced ecosystems[1] and maintain and/or enhance the baseline biological integrity and ecological health of the Area of Interest over the long term. The Area of Interest is the upper Great Salt Lake Desert Flow System and vicinity, including those valleys adjacent to and down-gradient of Spring Valley (Appendix A, Figure 1).

2. Avoid any effects to groundwater-influenced ecosystems within the boundaries of Great Basin National Park (GBNP) due to SNWA groundwater withdrawal from Spring Valley HB.

The Plan is a dynamic document to be reviewed and revised as needed to reflect increasing understanding of ecosystem dynamics and responses to SNWA's groundwater withdrawal, as well as refinement of monitoring, mitigation, and management questions and activities.

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[1] The Stipulation (Appendix A) used the term "water-dependent ecosystems." This Plan instead uses the term "groundwater-influenced ecosystems" because it is more biologically precise. While some of these ecosystems require groundwater to exist, others can exist without groundwater but at a lower level of productivity.

1.1 Stipulation Regarding SNWA's Groundwater Applications in Spring Valley HB

In October 1989, the Las Vegas Valley Water District (LVVWD) filed Applications 54003-54021 with the Nevada State Engineer (NSE) for a combined 126 cubic feet per second (cfs), or approximately 91,223 acre-feet per year (afy), of groundwater withdrawals in the Spring Valley HB. On December 2, 2003, SNWA assumed full interest by agreement with LVVWD in these applications. SNWA intends to develop and export groundwater from Spring Valley HB for municipal purposes and use in the Las Vegas area, subject to conditions set forth by the NSE. To protect their water rights and federal resources in the Area of Interest, the DOI Bureaus protested SNWA's applications. On September 8, 2006, prior to NSE's administrative hearing on SNWA's Spring Valley HB groundwater applications, SNWA and the DOI Bureaus entered into a Stipulation for Withdrawal of Protests (Stipulation) regarding these applications.

The Stipulation requires that SNWA implement hydrologic and biological monitoring, management, and mitigation plans (Exhibits A and B of the Stipulation; Appendix A). For development and implementation of the monitoring, management, and mitigation plans, the Stipulation requires the formation of a Biological Work Group (BWG) and hydrologic Technical Review Panel (TRP). The Stipulation also requires creation of an Executive Committee (EC) to review recommendations of the BWG and TRP, seek negotiated resolutions of issues, and implement actions as needed. Membership in each group (BWG, TRP, and EC) consists of one representative from SNWA and one representative from each of the DOI Bureaus, with designated agency backups.

To provide technical expertise to the BWG, the Stipulation allows for participation by the Nevada Department of Wildlife (NDOW) and the Utah Division of Wildlife Resources (UDWR), as well as other entities that may be identified that are not party to the Stipulation. The BWG invited NDOW and UDWR to participate in development of this Plan, as well as consultants to provide additional expertise (Great Basin Bird Observatory (GBBO), KS2 Ecological Field Services, and BIO-WEST). Following issuance of the ruling on Spring Valley, the NSE was also invited to observe the process of Plan development in an effort to reduce expenses and duplication of work.

1.1.1 Stipulation Requirements for Biological Monitoring

The Stipulation requires the BWG to:

- develop and oversee implementation of a biological monitoring plan that will assess baseline conditions as well as predict and assess impacts due to SNWA groundwater withdrawal from Spring Valley;
- identify indicators to monitor that can best predict effects to groundwater-influenced ecosystems;
- identify species of concern to monitor;
- identify sites to monitor and establish survey protocols;
- review and recommend modifications to the Plan as needed;
- identify research needs for investigating the response of indicators and groundwater-influenced ecosystems to groundwater withdrawal;

  - develop criteria and make recommendations to the EC on when a course of action shall be taken to avoid unreasonable adverse effects to groundwater-influenced ecosystems or any effect to GBNP; and
  - oversee implementation of management and migitation actions approved by the EC.

1.1.2 Stipulation Requirements for Hydrologic Monitoring

The Stipulation requires the TRP to:

- Establish and oversee implementation of a hydrologic monitoring network comprised of SNWA exploratory wells, SNWA production wells, new monitoring wells, select existing monitoring wells, and select springs and streams ;
- Monitor discharge and groundwater levels in all SNWA production wells on a continuous basis;
- Monitor groundwater levels in all SNWA exploratory wells at least quarterly, with a representative number to be identified for continuous measurement once groundwater withdrawal has commenced;
- Select 25 existing wells in Spring and Hamlin Valley HBs to monitor continuously or quarterly;
- Select new well sites adjacent to SNWA production wells, adjacent to federal water rights and federal resources, in the vicinity of Shoshone Ponds, and within the Interbasin Groundwater Monitoring Zone (zone of groundwater movement from Spring HB to Snake Valley HB via Hamlin Valley HB) to monitor continuously;
- With input from the BWG, select spring sites in Spring Valley HB for placement of piezometers for continuous groundwater elevation monitoring;
- Monitor stream discharge at Cleve Creek and Big Spring Creek / Lake Creek;
- Monitor synoptic-discharge measurements (gain/loss runs) at Big Springs Complex;
- Select springs, streams and wells at which to monitor water chemistry, and
- Cooperate with SNWA on maintaining, updating, and operating a well-calibrated regional groundwater flow system numerical model.

1.2 Nevada State Engineer Ruling

On April 16, 2007, the NSE issued Ruling 5726 in the matter of SNWA's applications to appropriate groundwater from Spring Valley HB (Appendix B). The NSE found that a reasonable and conservative estimate of the perennial yield (maximum amount of groundwater that can be salvaged each year over the long term without depleting the groundwater reservoir) for Spring Valley HB is 80,000 acre-feet/year (afy), of which 60,000 afy is available for appropriation and export. Fifteen of SNWA's nineteen applications were granted in part (54003-54015, 54019, and 54020), and four applications were denied (54016-54018 and 54021; northernmost applications near Cleve Creek). The granted applications are subject to the following conditions:

- A minimum of five years prior to groundwater export, SNWA must submit and the NSE must approve hydrologic and biological monitoring and mitigation programs;

- In addition to the monitoring and mitigation programs, SNWA must collect baseline hydrologic and biological data for a minimum of five years prior to SNWA groundwater export;
- Groundwater development must follow a staged development strategy laid out by the NSE;
- During the initial stage of phased development, SNWA may pump a maximum of 40,000 afy from Spring Valley HB for a minimum of ten years, with the pumping averaging at least 35,000 afy over ten consecutive years;
- At the initial stage of phased development, the NSE will make a determination as to whether the remaining permitted amount (i.e., 20,000 afy) may be pumped, or whether additional study is needed. As part of this decision, SNWA is to submit an updated groundwater flow model giving predictive results for 10, 25, and 100 years;
- SNWA must file annual reports with the NSE by March 15 of each year, detailing the findings of the approved monitoring and mitigation plans; and
- If SNWA groundwater pumping impacts existing rights, conflicts with protectible interests in existing domestic wells, threatens to prove detrimental to the public interest, or is found not to be environmentally sound, SNWA must curtail pumping and/or mitigate impacts to the satisfaction of the NSE.

The NSE found that by requiring the collection of biological and hydrological baseline data, requiring a monitoring and mitigation plan, and requiring staged development and associated studies, there are sufficient safeguards in place to ensure that the interbasin transfer of water from Spring Valley HB will be environmentally sound. It is SNWA's intent to submit this Plan to the NSE to partially satisfy the requirements set forth in Ruling 5726 regarding baseline monitoring and mitigation of pumping impacts on groundwater-influenced ecosystems.

1.3 Study Area

1.3.1 Areas of Potential Groundwater Development

SNWA holds rights to divert up to 60,000 afy from 15 Points of Diversion (POD) in Spring Valley (Fig. 1-1). SNWA may seek to change these points of diversion in the future, and has identified groundwater exploratory areas within which future groundwater production facilities may be proposed (Fig. 1-1). Geophysical surveys, detailed geologic mapping, exploratory well drilling, and hydrological modeling are being conducted as part of their groundwater exploratory program to determine potential locations of future groundwater development facilities. Selection of sites for production wells will consider hydrogeologic characteristics, well spacing requirements, site access, proximity to main or lateral pipelines, avoidance of Wilderness Areas, and minimizing impacts to sensitive environmental resources and sensitive areas to the extent practicable.

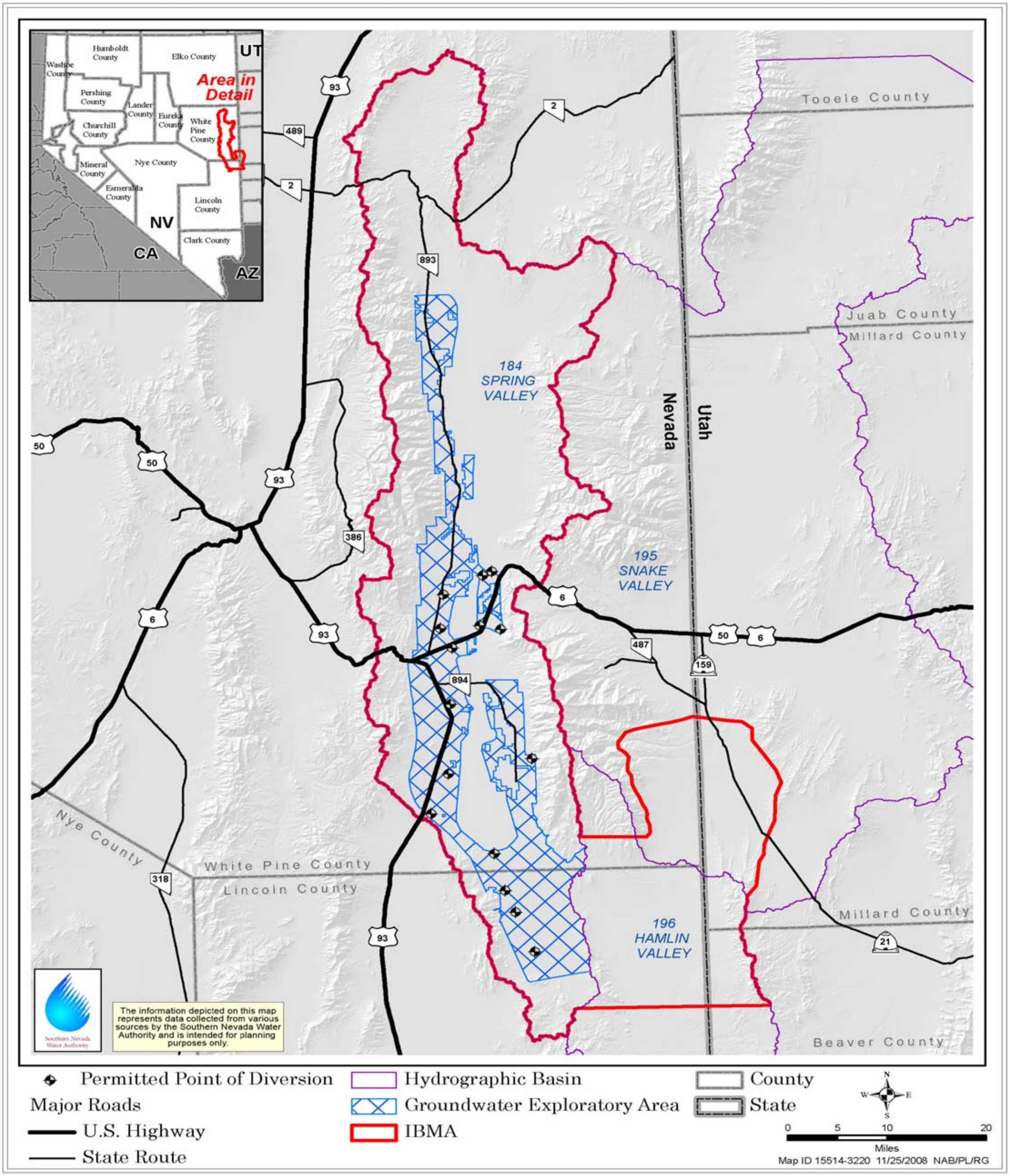

Fig. 1-1. SNWA groundwater exploratory areas and permitted points of diversion within Spring Valley.

1.3.2 Initial Biological Monitoring Area (IBMA)

The study area for this Plan, referred to as the Initial Biologic Monitoring Area (IBMA), encompasses Spring Valley HB (HB #184), the northern portion of Hamlin Valley HB (HB #196), and the Big Spring Creek sub-watershed in southern Snake Valley HB #195 (Fig. 1-1). The IBMA contains portions of Hamlin and Snake Valley because of potential inter-basin groundwater flow from Spring Valley, as identified in the Stipulation. The IBMA comprises approximately 1,388,000 acres consisting of 4% private land, 1% Utah state land, and 95% federal land (82% managed by the BLM, 12% by the U.S. Forest Service, and 1% by NPS) (Fig. 1-2). A portion of the GBNP that straddles the Spring Valley and Snake Valley HBs falls within the IBMA. Tribal areas located closest to the IBMA are the Ely Shoshone Indian Reservation in Steptoe Valley HB (west of Spring Valley HB), and the Goshute Reservation in Tippet and Deep Creek Valley HBs (approximately 40 miles north of the IBMA). In accordance with the Stipulation, future modifications to the Plan may require monitoring outside of the IBMA if the BWG anticipates that effects associated with SNWA's groundwater withdrawal from Spring Valley will extend outside these boundaries.

Spring Valley HB is a topographically closed valley in east-central Nevada, approximately 115 miles long north-to-south and maximum 25 miles wide east-to-west, covering 1,660 square miles. The valley floor averages about 5,700 feet above mean sea level (msl) and ranges in elevation from more than 6,500 feet msl on the alluvial fans to about 5,550 msl at Yelland Dry Lake. The principal mountain ranges are the Snake Range, Schell Creek Range, Fortification Range, and Wilson Creek Range.

The Hamlin Valley portion of IBMA begins at the Spring Valley HB north of the White Pine and Lincoln county lines, extends southeast below Big Springs to follow the crest of the Mountain Home Range as its eastern boundary, and crosses from the Mountain Home Range to the Wilson Creek Range south of Atlanta. Hamlin Valley is bounded by mountains on three sides and open to Snake Valley on the north.

The Snake Valley portion of IBMA includes the Big Spring Creek sub-watershed, and extends north along the foothills of the southern portion of the Snake Range, crossing the valley from Snake Creek Canyon to the town of Garrison, Utah. The eastern edge of the IBMA is bordered by the western edge of Burbank Hills, the western edge by the Snake Range, and the southern edge by the Mountain Home Range, where it meets with the Hamlin Valley portion of the IBMA.

The IBMA is located within the Great Salt Lake Desert flow system in the Basin and Range geologic province. During the Cenozoic Era, the Earth's crust in this area began to stretch in an east-west direction, forming the mountain ranges of relatively impermeable bedrock that are oriented in a north-south direction. Erosion of these mountains has carried sediments down to the valleys and created alluvial fans, which are classic geologic features of basin and range topography. Sediments carried to the floor of the valleys have accumulated in layers thousands of feet thick.

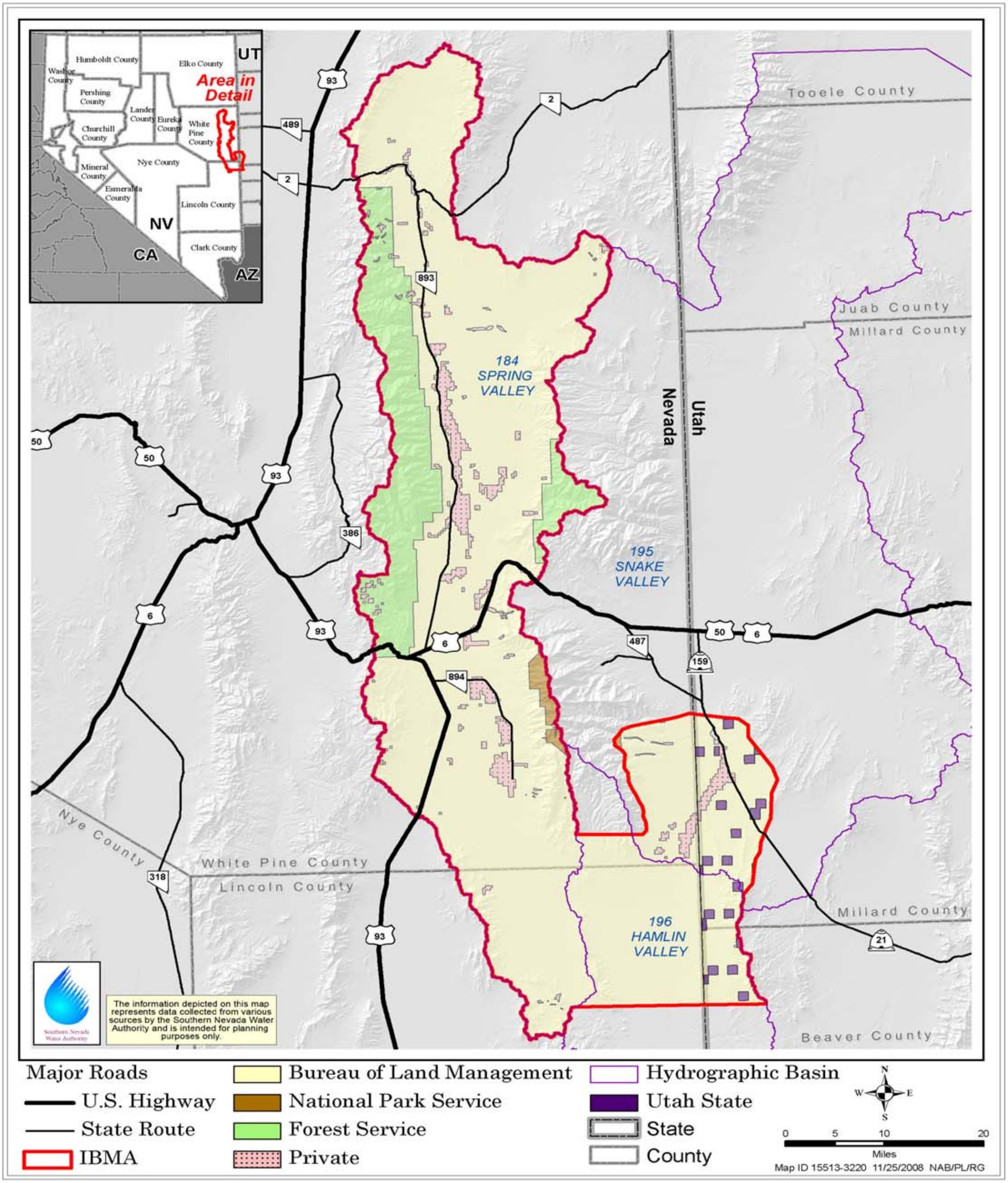

Fig. 1-2. Land status within the Spring Valley Stipulation IBMA.

Groundwater moves constantly from points of recharge (primarily from precipitation in the mountains), through the subsurface hydrologic system, and exits back to the surface at points of discharge. These flowpaths are determined by geologic structure, lithology, land-surface topography, and the arrangement of water-bearing aquifers (basin-fill, carbonate, and volcanic) and less permeable aquitard units. Groundwater within shallow alluvial (basin fill) aquifers travels intermediate distances through the shallow subsurface, while groundwater within deeper carbonate-rock aquifers travels further through regional discharge/recharge points. Discharge from the aquifers primarily occurs through evapotranspiration, but also involves subsurface inter-basin flow, withdrawal by wells, and discharge into streams and springs.

Springs in the IBMA occur from the valley floor to the mountain top. Most springs in the IBMA occur in relatively high elevation areas in the mountains. These mountain-block springs generally are controlled by discharge from localized or perched groundwater systems that are not hydraulically connected to the regional groundwater system (Prudic et at. 1995). Small springs also occur along the valley margin and in the valley floor. The occurrence and discharge of these springs generally is controlled by flow along intermediate flow paths that originate in the adjacent mountain ranges or alluvial fans (Welch et al. 2007). Adjacent to some of these spring areas are wetlands and meadows, where higher groundwater tables are often supported by irrigation/diversions.

The climate of the IBMA is characterized by cold winters, hot summers, and a wide diurnal temperature range due to low atmospheric humidity and abundant sunshine. Average annual precipitation for 1988-2006 was 9.7 inches in south Spring Valley (5,798 feet msl), with the majority falling in the spring, summer, and fall. The average minimum January temperature was 15° F, while the average maximum July temperature was approximately 88° F (WRCC 2007a). South Snake Valley (5,273 feet msl) is drier and warmer than south Spring Valley. The average annual precipitation for 1951-1990 was 7.6 inches, with the majority falling in the spring and fall. The average minimum January temperature was 15° F, while the average maximum July temperature was 93° F (WRCC 2007a). A USGS bulk precipitation station on Mt. Washington in GBNP (10,440 feet msl) has recorded an average annual precipitation of 28 inches per year since 1983 (Bob Bostic, USGS, pers. comm.). These data indicate that much of the water in Spring and Snake Valleys comes from precipitation from the surrounding mountains.

Agriculture currently represents the largest single water use in the IBMA. The primary form of agriculture is livestock grazing, and pastureland dominates the landscape. Smaller irrigated acreage is dedicated largely to alfalfa hay production, with the primary source of irrigation water being groundwater. Of the approximately 1,063,000 acres in the Spring Valley hydrographic basin, 4% (43,500 acres) is private land, 92% of which is agricultural land. The other 96% is public land (1,020,500 acres), including active grazing allotments. There are no housing communities in Spring Valley, but several ranches and single family homes dot the landscape. In Snake Valley, although the community of Baker and most of the GBNP are not within the IBMA, recreational access to these areas occurs through the IBMA.

1.3.3 Biological Resources

Examples of fauna that occur in the IBMA valley bottoms are big game species (e.g., pronghorn antelope, *Antilocapra americana*), small mammals (e.g., meadow vole, *Microtus pennsylvanicus*, and Brazilian free-tailed bat, *Tadarida brasiliensis*), birds (e.g., northern harrier, *Circus cyanus*, and greater sage-grouse, *Centrocercus urophasianus*), reptiles (e.g., common side-blotched lizard, *Uta stansburiana*), amphibians (e.g., northern leopard frog, *Rana pipiens*), fish (e.g., speckled dace, *Rhinichthys osculus*), and invertebrates (e.g., springsnails, *Pyrgulopsis* spp.). Flora communities in the IBMA valley floor are largely composed of Great Basin Xeric Mixed Sagebrush Shrubland, Inter-Mountain Basins Mixed Salt Desert Scrub, Inter-Mountain Basins Greasewood Flat, Inter-Mountain Basins Playa, and Agriculture (Lowry et al. 2005). Aside from phreatophytic shrublands, groundwater-influenced habitats are relatively sporadic in the IBMA.

Groundwater-influenced ecosystems in the IBMA include springs, creek, ponds, wetlands, meadows, playas, swamp cedar woodlands, and phreatophytic shrublands. Those systems with standing water support a variety of submerged aquatic vegetation (e.g., watercress, *Rorippa nasturtium-aquaticum*) and emergent vegetation (e.g., baltic rush, *Juncus balticus*) and provide habitat for fish, frogs, macroinvertebrates, and springsnails (including rare, endemic, and sensitive species). The springs, ponds, and creek especially provide water for animals traversing the Great Basin Desert (e.g., big game, migratory waterfowl, bats), and their associated riparian, wetland, and meadow vegetation provide habitat for resident and migratory animals (e.g., breeding birds). These valley floor groundwater-influenced ecosystems and their associated biological resources of interest are more fully discussed in Chapter 4.

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2.0 MONITORING GOALS AND OBJECTIVES

CONTENTS

2.1 Monitoring goals
2.2 Monitoring objectives

This chapter provides an overview of the monitoring goals and objectives that form the basis of the Plan. These goals and objectives are specific to the IBMA, which is the area of focus for biological monitoring due to proximity to pumping and potential impacts from SNWA's groundwater withdrawal in Spring Valley, Nevada. Specific, measurable objectives are also presented in Chapter 5 (Monitoring Approach).

2.1 MONITORING GOALS

The purpose of the Plan is to establish a monitoring program that will enhance the understanding of groundwater-influenced ecosystem dynamics in the IBMA and track biotic community responses to SNWA's groundwater withdrawal from Spring Valley. The specific goals of the Plan are to provide data and develop tools to:

1. Establish current ("baseline") condition of groundwater-influenced ecosystems within the IBMA and identify trends in indicators of the condition of these biotic communities prior to groundwater withdrawal by SNWA (hereafter referred to as "pre-withdrawal");
2. Establish the range of variability for indicators of the condition of groundwater-influenced ecosystems in the IBMA prior to groundwater withdrawal by SNWA;
3. Assess the response of groundwater-influenced ecosystems to groundwater withdrawal by SNWA;
4. Give early warning of unreasonable adverse effects to groundwater-influenced ecosystems in the IBMA and/or any adverse effect to GBNP due to groundwater withdrawal by SNWA;
5. Determine if an observed or predicted response is likely attributable to SNWA's groundwater withdrawal; and
6. Direct and evaluate management actions for the purpose of maintaining or enhancing the baseline biological integrity and ecological health of the IBMA over the long term.

2.2 MONITORING OBJECTIVES

Achievement of the following twelve objectives will help the BWG meet the purpose and goals of the Plan.

1. Develop a conceptual model for each of the groundwater-influenced ecosystems in the IBMA.

Conceptual models identify processes and factors that maintain and/or shape groundwater-influenced ecosystems within the IBMA, as well as system disturbances ("stressors"), both natural and anthropogenic. These models will help the BWG to understand the potential effects of stressors on groundwater-influenced ecosystems. These models will be updated as additional information is acquired and the systems are better understood and will form the conceptual basis of any future numerical modeling efforts.

2. Identify indicators of the condition of groundwater-influenced ecosystems in the IBMA, including those that may provide early warning of adverse effects to specific resources from groundwater withdrawal.

The ecological attributes that will be monitored are those thought to be good indicators of ecosystem health, including those that may provide early warning of adverse impacts from SNWA groundwater withdrawal. The Plan focuses on variables and communities that are expected to show earlier impacts from groundwater withdrawal by SNWA for the purpose of initiating BWG consultation in a timely manner. The Plan also emphasizes aquatic species that are intimately tied to groundwater-influenced ecosystems for the purpose of correlating species responses with ecosystem changes due to groundwater withdrawal.

3. Collect seven years of baseline data on selected biological indicators prior to SNWA’s groundwater withdrawal in Spring Valley, Nevada. (Note: A minimum of five years of data must be collected prior to groundwater withdrawal per the NSE Ruling #5726.)

4. Gather relevant current and historical data to supplement BWG baseline data collection and analysis.

Objectives 2 through 4 will help the BWG assess the current condition of groundwater-influenced ecosystems within the IBMA, as well as establish trends in indicators of the condition of these biotic communities. Selecting appropriate monitoring indicators to understand how these systems, and their respective floral and faunal components, respond to groundwater levels and surface flows will be vital to the success of the Plan. Baseline data will help the BWG understand the status and function of these ecosystems, such as whether the key processes that create and maintain them are intact and the current impact to these biotic systems from natural and human stressors, which will in turn aid with refinement of the conceptual models. Baseline data, supplemented with current and historical data from other sources, will also help the BWG to better understand the range of variability of indicators of the condition of these biotic systems prior to SNWA's groundwater withdrawal. This will form the basis for understanding the response of these systems to groundwater withdrawal. Monitoring indicators are described in detail in Chapter 4 (Monitoring Framework).

5. Prior to the end of the baseline data collection period, develop and recommend to the EC a refined biological monitoring plan for the period commencing with SNWA’s groundwater withdrawal.

As described in Chapter 3 (Plan Methodology), the BWG will analyze baseline data and report results at regular intervals, evaluate and revise the Plan as needed, and upon completion of the seven-year baseline period, recommend to the EC a refined plan. Pursuant to the refined plan, data will be collected and evaluated on select indicators of condition of groundwater-influenced ecosystems in the IBMA once groundwater withdrawal by SNWA commences. These data will help the BWG understand and assess the response of groundwater-influenced ecosystems to groundwater withdrawal.

6. During the Pre-Withdrawal Phase, establish the range of variation for each indicator (or suite of indicators) that will be considered acceptable.

7. Define what constitutes an "unreasonable adverse effect" during the Pre-Withdrawal Phase.

8. In coordination with TRP, during the Pre-Withdrawal Phase, establish criteria that will initiate the BWG consultation process as outlined in the Stipulation.

The Stipulation directs that there be no "unreasonable adverse effect" to groundwater-influenced ecosystems in the IBMA and no adverse effect to GBNP as a result of SNWA's groundwater withdrawal in Spring Valley. In order to meet these requirements, it is imperative that impacts are detected and assessed, and appropriate management actions are initiated, prior to such an effect occurring. If monitoring data suggest possible negative impacts to GBNP or unreasonable adverse effects to groundwater-influenced ecosystems, BWG consultation will be initiated. Objectives 6, 7, and 8 address this need by establishing how and when effects will be determined.

The process will include: 1) establishing threshold values for maintenance of groundwater-influenced ecosystems; 2) establishing acceptable ranges of variation for each indicator or suites of indicators; 3) defining "unreasonable adverse effect"; and 4) establishing criteria that initiate the BWG consultation process as described in the Stipulation (Appendix A). These values will be established during the Pre-Withdrawal Phase in Spring Valley, and will be included as recommendations to the EC in the refined Plan. After pumping is initiated, these criteria can be revisited and revised if appropriate as system responses are better understood.

9. Identify indicators to monitor that may help differentiate between impacts due to groundwater withdrawal by SNWA and other stressors.

If the BWG determines that an adverse impact is likely to occur or has occurred to a groundwater-influenced ecosystem, the BWG will determine if this response is likely attributable to SNWA's groundwater withdrawal. Determining the cause of impacts will be done in coordination with the TRP.

10. Develop and recommend to the EC an approach for ecological modeling.

Ecological models are tools that can be used to further understand ecological systems by simulating complex ecological interactions; identifying and describing specific ecological responses (including establishing potential threshold levels for maintenance of ecosystems); and quantifying, predicting, and projecting impacts. Chapter 6 (Predictive Ecological Model) describes the objectives of modeling, types of models that could be developed and employed, and the BWG's recommended approach for an IBMA ecological model. This potential tool could help the BWG meet all of the monitoring goals, and its utility will be explored further through the process outlined in Chapter 6.

11. Identify information and research needs and implement special studies as appropriate.

Much is not known about the groundwater-influenced ecosystems in the IBMA (e.g., relationship between groundwater levels and spring flow; relative dependence of certain vegetation on groundwater versus other sources of water), and the response of these systems to groundwater withdrawal by SNWA. Thus, specific research projects may be needed to obtain data that will inform monitoring and management decisions. Chapter 4 provides an initial assessment of research and information needs for each groundwater-influenced ecosystem in the IBMA. Applied research could help the BWG meet all of the monitoring goals. Thus, research needs will continually be evaluated, recommended to the EC, and implemented as described in Chapter 3 (Plan Methodology).

12. Evaluate mitigation opportunities.

Mitigation planning is not a part of this Plan but will be handled separately when impact location and magnitude are better understood. However, in the course of monitoring, the BWG can evaluate potential opportunities for mitigation (e.g., habitat enhancement and/or use as translocation sites for certain species to help direct future management and mitigation efforts).

3.0 BIOLOGICAL MONITORING PLAN METHODOLOGY

CONTENTS

3.1 Conservation Action Planning (CAP) process
- **3.1.1 Groundwater-influenced ecosystems and nested targets**
- **3.1.2 Key ecological attributes and indicators**

3.2 Ranges of Variation, Unreasonable Adverse Effect, and Criteria for Initiating BWG Consultation

3.3 Plan design
- **3.3.1 Adaptive framework**
  - **3.3.1.1 Pre-SNWA Groundwater Withdrawal Phase (Pre-Withdrawal)**
  - **3.3.1.2 Withdrawal Phase**
- **3.3.2 Supplemental data gathering**
- **3.3.3 Data analysis, review, modification**

3.4 Peer review

Development of the biological monitoring plan methodology was aided by The Nature Conservancy's (TNC) Conservation Action Planning (CAP) process. An overview of the CAP process is provided in Section 3.1. The remaining sections in this Chapter focus on the Plan design and a proposed peer review process.

3.1 CONSERVATION ACTION PLANNING (CAP) PROCESS

The BWG applied several components of the CAP process, an iterative and science-based approach to conservation planning, to develop the Plan. With TNC facilitation, the BWG applied the CAP process to: 1) identify ecosystems and species that will be the targets of BWG conservation efforts; 2) identify key ecological attributes (KEAs) essential to the long-term viability of those targets; and 3) identify indicators to assess each KEA, including those that may be used to predict potential adverse effects and/or show early warning of effects from SNWA's groundwater pumping. Other components of the CAP process include an assessment of the current status and determination of an acceptable range of variation for attributes and indicators (TNC 2007). Comprehensive information on the CAP process can be found in the CAP Handbook and an online toolbox at http://conserveonline.org/workspaces/cbdgateway/cap.

3.1.1 Groundwater-Influenced Ecosystems and Nested Targets

The first step of the CAP process was to select groundwater-influenced ecosystems that may be affected by SNWA groundwater withdrawal. Within each groundwater-influenced ecosystem the BWG identified nested targets, which are biota of special interest that are dependent on one or more groundwater-influenced ecosystems. Conservation of groundwater-influenced ecosystems in the IBMA will help ensure conservation of the biota that relies on these ecosystems. Therefore, most nested targets are not directly monitored. The groundwater-influenced ecosystems and nested targets selected for monitoring are described in detail in Chapter 4 (Monitoring Framework).

The BWG established the following criteria for nested targets:

1. Dependent upon a groundwater-influenced ecosystem that may be affected by SNWA groundwater withdrawal; and
2. Known to occur or may potentially occur in the IBMA where they rely on a groundwater-influenced ecosystem for one or more life stages;

and either

3a. Federally-listed threatened or endangered species, Nevada BLM sensitive species, or Nevada- or Utah-listed species; or
3b. Designated by the BWG based on their ecological role in the IBMA.

For each groundwater-influenced ecosystem, the BWG chose monitoring sites based on spatial coverage of the IBMA (including consideration of potential locations for groundwater withdrawal by SNWA, i.e., points of diversion and exploratory areas), proximity to hydrologic monitoring sites, presence of nested targets and indicators, coverage of different vegetation communities and levels of anthropogenic or natural disturbance, mitigation potential, and possible use as a reference site. Lack of a nested target did not preclude a site from being monitored as this was just one consideration in site selection. Criteria development is described in Chapter 4 (Monitoring Framework).

3.1.2 Key Ecological Attributes and Indicators

The next step in the CAP process was to identify key ecological attributes (KEAs) and indicators of condition for each groundwater-influenced ecosystem. KEAs are characteristics that describe groundwater-influenced ecosystems and potentially are critical to their long-term viability or integrity, including biological composition, interactions, and processes (Parrish et al. 2003). Indicators are measures to assess the KEAs.

The BWG selected KEAs and indicators based on the following criteria: 1) strongly related to the status of the groundwater-influenced ecosystem and possibly essential to its viability; 2) good indicator of ecosystem health, including those that may provide early warning of adverse impacts due to SNWA groundwater withdrawal; and 3) reasonably feasible and efficient to measure.

3.2 RANGES OF VARIATION, UNREASONABLE ADVERSE EFFECT, AND CRITERIA FOR INITIATING BWG CONSULTATION

Ecosystems do not remain stable, but naturally vary over time. Thus, determining the range of variation of the indicators during the pre-withdrawal period is an objective of the Plan. This range will encompass the effects of human-induced alterations (e.g., grazing, water diversions, roads). Determining the acceptable range of variation for indicators or suites of indicators is also an objective of the Plan. The acceptable range of variation is that range in values, rates of change, and frequency of change associated with ecosystem integrity and long-term viability (Parrish et al. 2003). The BWG recognizes that some indicator values may already fall outside of the acceptable range of variation. In defining acceptable range of variation, the BWG will seek to determine thresholds, which are indicator levels associated with shifts in condition of KEAs. Using the baseline and other available data, the BWG will determine thresholds and define acceptable range of variation before groundwater withdrawal by SNWA is initiated (except pump tests).

The BWG will also determine what constitutes an unreasonable adverse effect due to SNWA's groundwater withdrawal, which are to be avoided per Stipulation. An adverse effect occurs if an indicator or suite of indicators falls outside the acceptable range of variation. During the Pre-Withdrawal Phase, the BWG will define unreasonable adverse effects. What constitutes an unreasonable adverse effect may vary among sites, and the BWG may set higher standards for some sites than for others. To avoid unreasonable adverse effects, the BWG will establish criteria during the Pre-Withdrawal Phase that will initiate BWG consultation , as described in detail in Exhibit B of the Spring Valley Stipulation and summarized in Chapter 9. During consultation, the BWG will consider whether the response was attributable to SNWA groundwater withdrawal. If the BWG agrees the change in an indicator or suite of indicators is not attributable to SNWA groundwater withdrawal from Spring Valley, no further management actions shall be taken; however, the BWG may conduct further investigation into the cause of such change (Appendix A). If any member of the BWG is concerned that a change in an indicator or suite of indicators is attributable to SNWA groundwater withdrawal from Spring Valley, and is causing or has the potential to cause an unreasonable adverse effect, the BWG shall work to develop consensus-based courses of action to address the concern and/or manage or mitigate as appropriate. The BWG shall convey all recommended courses of action to the EC (Appendix A).

3.3 PLAN DESIGN

The focus of the BWG was to design a monitoring plan to address the monitoring requirements of the Spring Valley Stipulation and meet the goals and objectives described in Chapter 2. As outlined in Exhibit B of the Stipulation, the monitoring requirements are three-fold: 1) develop a baseline condition for comparison; 2) implement a monitoring plan to assess impacts from groundwater pumping by SNWA, and 3) monitor the success of mitigation activities.

3.3.1 Adaptive Framework

The BWG will use an adaptive framework (i.e., setting goals and priorities, developing monitoring and conservation strategies, taking needed action, measuring results, and refining the plan) for conservation planning for groundwater-influenced ecosystems in the IBMA. An adaptive framework provides for phased implementation of the monitoring plan with designated review, modification, and future development periods. The prescribed monitoring plan approach follows the classic design for ecological long-term monitoring programs. It focuses on sampling before versus after initiation of SNWA groundwater withdrawal (hereafter referred to as "Pre-Withdrawal" versus "Withdrawal" phases) and, where applicable, incorporates reference versus impact sites. The Pre-Withdrawal Phase involves developing and refining the monitoring plan, developing and refining conceptual models (and potentially predictive models), collecting baseline data, gathering historical data, identifying and implementing research projects, determining acceptable ranges of variation and threshold levels, defining unreasonable adverse effects, and setting criteria for BWG consultation. The Withdrawal Phase includes continued monitoring, assessing and refining the monitoring plan, assessing impacts, applying and refining conceptual models (and potentially predictive models), identifying and implementing research projects, and developing and implementing mitigation measures. The data collected and predictive tools employed during each of these phases will be designed to address the goals and objectives of the monitoring plan, yet allow flexibility for modification as information is gained, reviews are conducted, and improvements are identified. Fig. 3-1 presents an overview of the Biological Monitoring Plan Adaptive Framework.

3.3.1.1 Pre-SNWA Groundwater Withdrawal Phase (Pre-Withdrawal)

The Pre-Withdrawal Phase involves all activities that occur prior to SNWA's groundwater withdrawal (except pump tests), including development and implementation of this monitoring plan. A key step in development was for the BWG to understand the various biological processes occurring in the IBMA, how they relate, and how they might be influenced by anthropogenic activities. Thus, conceptual models were developed to provide a framework of the known physical and biological processes in the IBMA. These models will be used to guide the BWG's decisions and allow for ease of description and interpretation of this plan. Models are subject to revision both via simplification and enhancement as information is acquired and understanding of the system is enhanced.

Concurrent with model development, known information on biological resources within the IBMA was assembled. Spring system inventories conducted for SNWA in 2004-2006 (BIO-WEST 2007), earlier spring investigations (Sada 2005), and on-going or special studies conducted by resource agency professionals provided an overview of the biological resources within the IBMA. These efforts, coupled with information provided by BWG members, have been used to identify data gaps and structure the pre-withdrawal monitoring plan. The BWG will continue to gather additional data to supplement their baseline data collection effort.

A major objective of Pre-Withdrawal is to establish a data set consisting of existing resources and BWG baseline data collection. Therefore, the seven-year baseline data collection effort is the key initial component of the monitoring plan, with much of the detail about the Plan (groundwater-influenced ecosystems, nested targets, KEAs, and indicators) presented in following chapters. Baseline data collection lays the foundation for assessing the response of groundwater-influenced ecosystems in the IBMA to hydrological changes resulting from SNWA's withdrawal of groundwater from the Spring Valley HB. The BWG will collect baseline data and gather historical and outside data in order to describe biotic and abiotic relationships, determine ranges of variation and thresholds, define unreasonable adverse effects, and set criteria for BWG consultation as described in Section 3.2. Prior to SNWA groundwater withdrawal, the BWG will submit a refined monitoring plan to the EC.

An additional activity being conducted by the BWG during Pre-Withdrawal is the identification of research and information needs. Studies may be needed to: 1) refine the Plan (e.g., determine best indicators), and 2) assess the response of biological resources/specific indicators to groundwater drawdown and reduced surface flows. While the BWG has identified potential research and information needs, specific studies have yet to be developed and recommended as of publication of this Plan. The development of predictive ecological models (discussed in Chapter 6) may also be conducted during Pre-Withdrawal, with the understanding that continued refinement of such models would be performed during Pre-Withdrawal and Withdrawal.

3.3.1.2 Withdrawal Phase

The Withdrawal Phase will focus on continued monitoring, assessing ecosystem response to groundwater withdrawal, assessing project impacts and, if necessary, developing and implementing mitigation measures. Seven years of baseline data collection coupled with existing information and targeted research should provide a starting point for identifying potential SNWA groundwater development impacts. Withdrawal monitoring will focus on indicators that provide a high level of confidence in detecting biological changes in the groundwater-influenced ecosystems in the IBMA due to SNWA groundwater withdrawal. If biological responses resulting from SNWA groundwater withdrawal are detected or predicted, consultation between the BWG, TRP, and EC may be initiated.

The BWG anticipates that the components of Withdrawal monitoring will follow closely with the biological communities, sites, and indicators selected for Pre-Withdrawal monitoring. As the BWG collects data during the Withdrawal Phase, biotic and abiotic relationships, ranges of variation, and the definition of unreasonable adverse effect will continue to be refined. The BWG will use an adaptive framework to assess the Plan and implement changes as needed.

Additional components of the Withdrawal monitoring plan include continued modifications to the conceptual (and potentially predictive) models. Research may be required to evaluate whether ecosystem responses to SNWA groundwater withdrawal are within the acceptable range of variation. When specific research projects are identified, the BWG will present proposals to the EC for approval. Development, implementation, and assessment of mitigation measures will also be addressed during the Withdrawal Phase.

3.3.2 Supplemental Data Gathering

The BWG anticipates that supplemental data gathering may be necessary to understand responses of groundwater-influenced ecosystems to other influences and stressors such as precipitation, drought, fire events, insect outbreaks, invasives, livestock grazing, climate change, and changes in patterns of water diversion. Measurement and documentation of these other factors are not part of the data collection proposed in this Plan. However, the BWG will compile historic and current data from existing sources that will be used to evaluate and distinguish impacts on the groundwater-influenced ecosystems.

3.3.3 Data Analysis, Review, Modification

An integral part of Pre-Withdrawal activities will be data analysis, review, and monitoring plan adjustments (Fig. 3-1). The NSE decision on SNWA's Spring Valley water rights stated that biological monitoring must be conducted for a period of five years prior to any pumping activity. The EC decided that a minimum of seven years of baseline data will be collected. The BWG

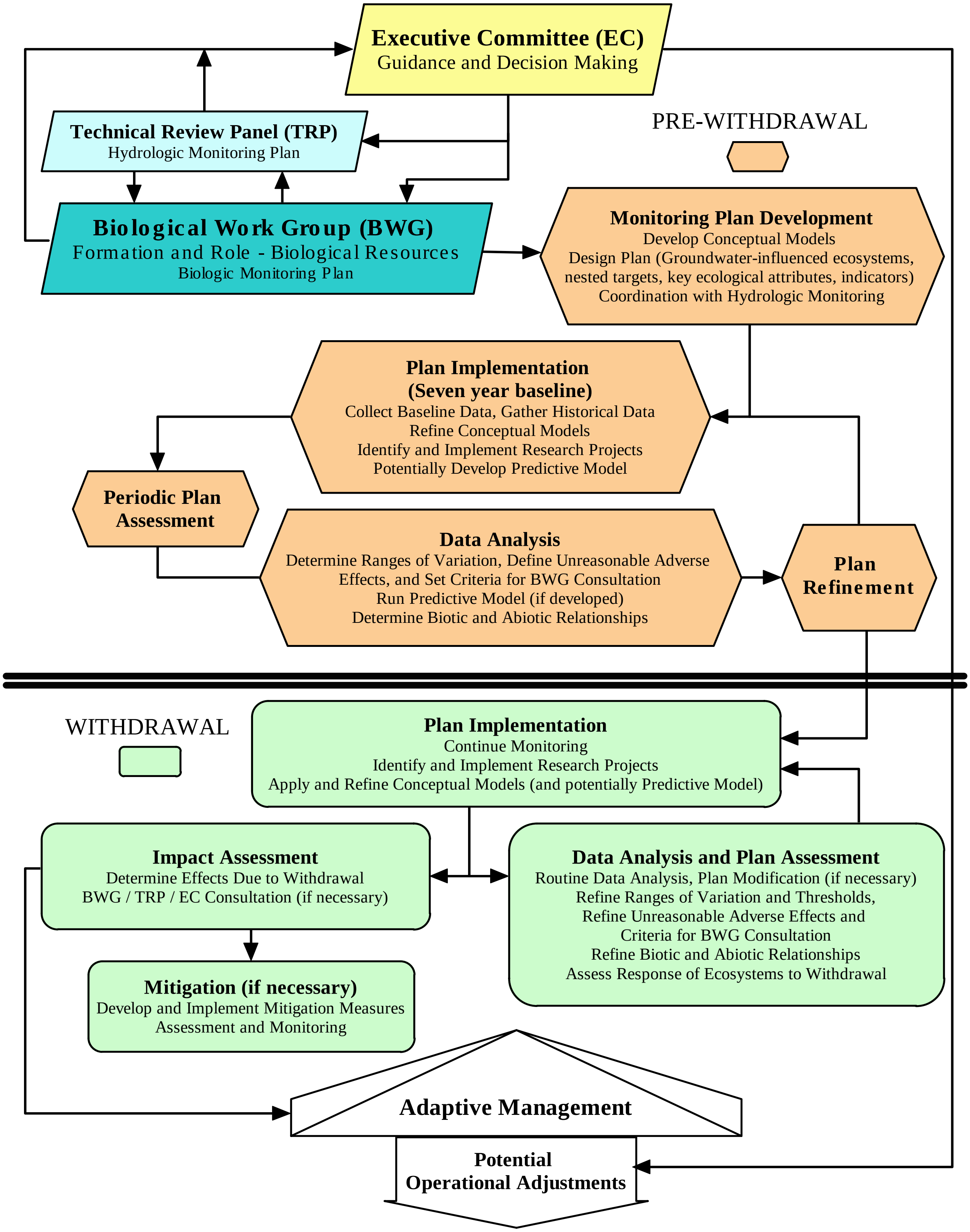

Fig. 3-1. Biological Monitoring Plan Adaptive Framework.

designed the baseline data collection to be comprehensive upfront. The intensive level of effort described in this Plan will be conducted for a period of no less than two years from initiation. During this two-year period, data will be evaluated by the BWG with a focus on continually assessing the effectiveness of the Plan. At the completion of the second year, a comprehensive report will be submitted by the BWG which may include recommendations on monitoring plan modification and adjustments. Additionally, research needs will be identified at that time and peer review will occur (see Section 3.4).

The BWG will assess and potentially recommend monitoring plan modifications annually for Years 3-7 of the baseline period. Starting in Year 5, discussions on the Withdrawal Phase will commence. During the final year of Pre-Withdrawal monitoring, the BWG will finalize details for monitoring during the Withdrawal Phase. Upon completion of the seven-year baseline monitoring effort, a final report will be submitted to the EC. In addition, a separate document (Withdrawal Monitoring Plan) outlining the Withdrawal monitoring activities and reporting protocol will be prepared and submitted to the EC. Chapter 7 discusses data management, analysis, and reporting in more detail.

3.4 PEER REVIEW

Scientific credibility is imperative to both 1) biological monitoring plan design and implementation and 2) interpretation of Plan results. Scientific credibility refers to general acceptance by the scientific community of the approach used in the monitoring plan, the data collected, and the interpretation of the data. One way to achieve this credibility is by the process of scientific peer review, whereby qualified scientists in the appropriate disciplines who are not directly involved in a program have the opportunity to critically review work products.

The BWG recommends that peer review be considered at three stages in the process: 1) after refinement of the Plan based on two years of baseline data collection, 2) one year prior to Withdrawal Phase, and 3) periodically during the Withdrawal Phase. The first stage has been approved by the EC.

The BWG recommends peer review through the use of a professional society. The Ecological Society of America (ESA) is recommended and would be given the responsibility to organize and direct a panel under its auspices. It is anticipated that ESA would review the Plan and the report following Year 2 of baseline data collection and prior to the Withdrawal Phase.

In addition to a peer-review panel, scientific credibility would be enhanced by publication of results in scientific journals. Journal publication provides for dissemination of the results and their interpretations to the widest possible scientific audience, thereby encouraging the highest level of critical review.

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4.0 MONITORING FRAMEWORK

CONTENTS

4.1 Groundwater-influenced ecosystems
- **4.1.1 Selection of groundwater-influenced ecosystems**
- **4.1.2 Description of groundwater-influenced ecosystems**
  - **4.1.2.1 Springs**
  - **4.1.2.2 Ponds (Shoshone)**
  - **4.1.2.3 Perennial streams**
  - **4.1.2.4 Wetlands**
  - **4.1.2.5 Meadows**
  - **4.1.2.6 Phreatophytic shrublands**
  - **4.1.2.7 Swamp cedar woodlands**

4.2 Description of nested targets

4.3 Nested targets to be directly monitored
- **4.3.1 Springsnails**
- **4.3.2 Northern Leopard Frog**
- **4.3.3 Relict Dace**
- **4.3.4 Pahrump Poolfish**
- **4.3.5 Fishes native to the Big Springs Complex**
- **4.3.6 Swamp cedars**

4.4 Monitoring sites
- **4.4.1 Site selection**
- **4.4.2 Sites**
  - **4.4.2.1 Stonehouse Complex, West Spring Valley Complex**
  - **4.4.2.2 Willow Spring**
  - **4.4.2.3 Keegan Ranch Complex**
  - **4.4.2.4 South Millick Spring, Unnamed Spring 5**
  - **4.4.2.5 4WD Spring, Willard Spring**
  - **4.4.2.6 Swallow Spring**
  - **4.4.2.7 Minerva Springs Complex**
  - **4.4.2.8 Clay Spring-North**
  - **4.4.2.9 Unnamed 1-North of Big Spring**
  - **4.4.2.10 North Little Spring**
  - **4.4.2.11 The Seep, Blind, and Burbank Meadows**
  - **4.4.2.12 Big Springs Complex**
  - **4.4.2.13 Shoshone Ponds**
  - **4.4.2.14 Swamp Cedar Woodland North and South**
  - **4.4.2.15 Phreatophytic Shrublands**

4.5 Key ecological attributes (KEAs) and indicators
- **4.5.1 Springs, Ponds (Shoshone), and Perennial Streams**
- **4.5.2 Wetlands**
- **4.5.3 Meadows**
- **4.5.4 Phreatophytic Shrublands**
- **4.5.5 Swamp Cedars**

As discussed in Chapter 2, the purpose of the Plan is to establish a monitoring program that will enhance the understanding of groundwater-influenced ecosystem dynamics in the IBMA and track biotic community responses to SNWA's groundwater withdrawal from Spring Valley. Using the CAP process, the BWG developed a list of groundwater-influenced ecosystems, nested targets (biota of special interest dependent on those systems), and sites within the IBMA to monitor. The BWG then selected Key Ecological Attributes (KEAs, characteristics that describe the systems and potentially are critical to their viability or integrity) and indicators (measures to assess the KEAs) to focus on for the Plan. Although sites, nested targets, KEAs, and indicators are directly used to guide the process, the goal remains to protect the ecosystems, not just individual components. As the monitoring plan moves forward, careful examination of the data collected may lead the BWG to focus more directly on certain indicators, specific nested targets, or particular groundwater-influenced ecosystems and monitoring sites. This additional focus may be necessary to increase confidence that the Plan is being implemented effectively and impacts are being detected early.

4.1 GROUNDWATER-INFLUENCED ECOSYSTEMS

4.1.1 Selection of Groundwater-Influenced Ecosystems

The CAP process (described in Section 3.1) allowed a broad-based approach for evaluating groundwater-influenced ecosystems and biological resources within the IBMA. Each groundwater-influenced ecosystem within the IBMA was identified and characterized. The BWG then selected only those groundwater-influenced ecosystems which, with reasonable judgment, could be directly or indirectly impacted by SNWA withdrawal of groundwater within Spring Valley. The rationale for this selection is documented in general ecosystem descriptions laid out in conceptual models and is specifically explained throughout this chapter. Specific to the IBMA, these seven ecosystems are:

- Springs
- Ponds (Shoshone; artificial ponds fed by artesian wells)
- Perennial streams (Big Spring Creek / Lake Creek)
- Wetlands
- Meadows
- Swamp cedar woodlands
- Phreatophytic shrublands

Ecosystems considered and subsequently dismissed from inclusion in the monitoring plan were mountain block springs, mountain block originating streams, ephemeral streams, and playas. In coordination with the TRP, the BWG based dismissal of these ecosystems due to no or low likelihood of direct or indirect impacts by SNWA withdrawal of groundwater within Spring Valley. For mountain block springs, the TRP does not anticipate SNWA groundwater withdrawal will impact the perched water tables supplying these systems because of the apparent lack of hydrologic connectivity. Mountain block springs (including those in GBNP) will be re-evaluated by the TRP as more information is obtained during test well drilling and as pumping locations are established. Mountain block originating streams are fed by mountain block springs and/or snowmelt and, in the cases where the potential exists to extend into the valley floor, these streams are typically diverted for agricultural purposes. Ephemeral streams were not included because flow pattern limits their use for impact determination. Additionally, these streams are predominantly driven by surface water runoff and precipitation related events. The TRP confirmed that while there is groundwater discharge in the form of evaporation in the playas, the majority of water present in the Spring Valley playas is due to surface water runoff. Furthermore, the soil properties of playas make for limited permeability.

4.1.2 Description of Groundwater-Influenced Ecosystems

The seven groundwater-influenced ecosystems identified by the CAP process for inclusion in the Plan are discussed below.

4.1.2.1 Springs

Springs are highly important in maintaining the biodiversity of the Great Basin, the driest physiographic province in North America (Sada and Vinyard 2002, Sada 2003). The hydrologic history of the Great Basin has left many of the spring systems fragmented and isolated from each other, giving rise to a host of endemic aquatic organisms (Sada and Vinyard 2002). Spring systems provide a major source of reliable water in the region, making them critical to the persistence of many plant and animal species (Hershler 1998, Sada and Vinyard 2002, Sada 2003). Aquifer geology, morphology, discharge rates, regional precipitation, and vegetation all control the complex environmental characteristics of springs (Garside and Schilling 1979).

Springs are often classified by morphology into several distinct type categories including rheocrene (spring that discharges into a defined channel), limnocrene (spring that discharges into an open pool before a defined channel), and helocrene (spring without an open pool and discharges into a marshy and relatively shallow wetland). Within the IBMA all three morphological spring types are represented, but rheocrene and limnocrene are more prevalent. Morphology influences aquatic biota, as species that inhabit rheocrenes prefer flowing water, species in limnocrenes are more closely related to species that occupy lakes and ponds, and species in helocrenes are more similar to species that occupy marshy bogs (Sada 2000).

Physical and chemical characteristics are major factors influencing spring-fed riparian and aquatic plant and animal communities (van der Kamp 1995, Sada and Pohlmann 2006). Most spring environments at or near the spring head are less variable in their physical and chemical characteristics than other aquatic habitats (e.g., streams, rivers, lakes, etc.), causing comparatively low within-spring variability in population sizes and assemblage structures (van der Kamp 1995). Typically, environmental variation is greater downstream than at the spring head, causing the composition of spring head and downstream communities to be quite different (Hayford et al. 1995, Herschler 1998). Crenobiontics (species that live only in springs [e.g., springsnails]) appear to be specifically adapted to the spring head environments (Sada and Pohlman 2006). Many additional factors such as food availability, temperature, reproduction, and migration of species along a spring brook can influence the diversity and abundance of aquatic organisms (Varza and Covich 1995).

Springs in the Great Basin have been subjected to many stressors – physical, chemical, and biological – since settlers entered the region. Surface water and groundwater diversion and withdrawal, recreation, development, pollution, and introduced species all have played roles over time. Most of the IBMA springs within the valley floor or range front have been or are disturbed by diversion or livestock use, and several springs have substantial amounts of livestock trampling, as well as piped, ponded, or excavated spring heads (BIO-WEST 2007).

4.1.2.2 Ponds (Shoshone)

The classic definition of a pond is a small, shallow, body of standing water with abundant rooted and floating macrophytic vegetation (Welch 1952). For this Plan, however, there are no traditional ponds proposed for monitoring within the IBMA. Shoshone Ponds is a unique ecosystem due to its creation history and purpose. While Shoshone Ponds consists of multiple "ponded" environments, it was artificially created and is maintained by a number of artesian wells.

4.1.2.3 Perennial Streams

Streams are small flowing-water systems of a wide range of types. The flow can be year-round ("perennial" or permanent), seasonal ("ephemeral"), or "intermittent" (Minshall et al. 1989). Source water for all streams will almost always include some surface runoff from precipitation events in the nearby watershed. Other water sources can include springs or seeps, snow melt, or outflow from ponds or lakes. Perennial streams in arid lands usually have springs in the headwaters, outflows from spring-fed ponds, and/or groundwater seeps along the channel as their primary water source. The portion of total stream flow arising from groundwater in any form is called "base flow". Base flow can be relatively constant year-round, but can vary seasonally as recharge rates vary with seasonal precipitation and snow melt (Elliott et al. 2006).

One important feature of streams is the transition among habitat features along the course. Streams have a variety of segment types, including pools, riffles, runs, glides, and others (Hawkins et al. 1993). Many plant and animal species tend to occupy specific segment types. However, all segments share common water quality and overall stream flow attributes, so that disturbances in one segment are likely to have impact in that and all lower segments.

Another important physical factor determining stream type is gradient. High-gradient streams in arid lands may have little water-associated vegetation. This is because the water moves too rapidly to allow significant infiltration, and the water can scour out fine sediments and organic materials potentially utilized by both plants and stream animals. Low gradient streams, on the other hand, are almost ideal for plant growth because of infiltration into sediments below and alongside the stream into the riparian zone.

Perennial streams usually support numerous small invertebrates which are important in the food chain as grazers on periphyton and decomposing vegetation, as well as providing food for vertebrates. Perennial streams in the Great Basin are not usually large, so the associated animals are usually small, including forage fishes (minnow-like) and amphibians. Where appropriate emergent and riparian vegetation are present, perennial streams can provide habitat for a wide range of birds and mammals.

4.1.2.4 Wetlands

Wetlands are a type of ecosystem characterized by wet hydrology, hydric (saturated) soils, and hydrophytic vegetation (plants adapted to saturated soils) for some period of the growing season. Hydrology is the major factor determining the presence and location of wetlands, since the presence of water has an overriding influence on characteristics of vegetation and soils. Water may originate from a number of sources, including direct precipitation, ground water, and runoff. The frequency and duration of inundation of wetlands varies, though wetland areas of lower elevation in a floodplain tend to have more frequent periods of inundation and/or greater duration than wetland areas at higher elevations. Soil permeability also influences duration and inundation and soil saturation of wetlands. For example, clay soils absorb and release water more slowly than sandy or loamy soils, and therefore have slower permeability and remain saturated much longer. Type and amount of plant cover also affect the degree of inundation and the duration of saturated soil conditions. In areas of abundant plant cover, excess water drains more slowly and evaporation rates are lower than in unvegetated areas, but transpiration rates are higher in areas of abundant plant cover, which may reduce the duration of soil saturation.

Wetlands in the IBMA require saturated soils during most of the growing season. These saturated soils can be the result of 1) a water table that reaches the surface of soil, 2) prolonged, substantial amounts of surface flooding, or 3) flooding of low permeability or impermeable soils. Wetland areas may form around the perimeter of bodies of flowing or ponded water, or may be present by themselves in depressions in the landscape. The largest extent of wetlands within the IBMA is in valley bottoms, often hydrologically linked to springs and streams through seasonal flooding and groundwater movement.

Wetland plant communities are substantially different from most other associated plant communities in the region. Because wetlands have restricted water flow-through, sediments and nutrients can accumulate to produce highly productive ecosystems. In productive wetlands in the Great Basin, there is often abundant emergent rooted vegetation, such as cattail (*Typha* spp.), common reed (*Phragmites australis*), Baltic rush, common threesquare (*Scirpus pungens*), Nebraska sedge (*Carex nebraskensis*), creeping spikerush (*Eleocharis palustris*), and cordgrasses (*Spartina* spp.). Due to the high productivity of these plants, wetlands are able to support diverse communities of macroinvertebrates. In turn, wetland plants and macroinvertebrates may provide an important habitat as well as food source for other animals such as amphibians, migratory birds, and bats.

Wetlands in the IBMA have been subjected to a number of anthropogenic disturbances. The most common disturbances to these wetlands are diversions for irrigation and grazing and trampling by livestock. Some of the wetlands are artificially maintained by irrigation or water diversion activities, or as water sources for livestock.

4.1.2.5 Meadows

Meadows are grasslands (communities dominated by grasses or grass-like plants) that have saturated soil within the rooting zone in most or all months of the year. If standing water occurs, it is for only part of the growing season. Meadows tend to have relatively high cover values and in the IBMA are typically dominated by saltgrass (*Distichlis spicata*), Baltic rush, alkali sacaton (*Sporobolus airoides*), or wildrye (*Leymus* spp.), either singularly or in combination.

Low elevation meadows, such as in the IBMA, require high soil moisture during most of the growing season. High soil moisture can result from either 1) a shallow water table (i.e., groundwater within 1-3 m of the soil surface) or 2) substantial amounts of surface flooding, either from outflow from adjacent wetlands or from surface runoff following spring snowmelt. These meadows also require perturbations sufficiently frequent to exclude dominance by shrubs. Common types of perturbation are high groundwater for at least six months of the year or frequent fires. The most effective high groundwater produces surface flooding in most years, and fire frequency should be frequent enough to effectively reduce shrub establishment. Haying operations can replace fire as an effective perturbation in relation to reducing shrub establishment.

Meadows are located throughout Spring Valley. They occur downslope from springs and wetlands where slope is relatively gentle and overflow water spreads out onto the landscape rather than into a channelized system. They also occur where groundwater rises to within 3 m of the soil surface, phreatophytic shrubs are not abundant, and irrigation has been practiced. The largest extent of meadows in IBMA occurs along a strip in the lower elevation of the valley floor.

In addition to the naturally occurring meadows in Spring Valley, some meadows are, in part, artificially-maintained because of agricultural practices. These exist because of surface and sub-surface water movement from water diversion ditches. When ditches occur on slopes, some of the water moving through the ditches percolates down slope. In cases where this sub-surface water collects near the surface down slope from the ditch (e.g., where the slope substantially decreases), the increased water supply can create a meadow. Similarly, irrigation of upslope sites can result in meadows forming down slope from the irrigated site because of subsurface movement of water (i.e., tail-water).

Meadows are substantially different from most of the associated plant communities in the region. Species composition is different than in surrounding predominately shrub-dominated communities. Meadows are also structurally different and more productive than shrublands. These ecological differences result in meadows providing unique habitats to both flora and fauna in the regions.

Meadows in Spring Valley have been exposed to numerous disturbances. Common disturbances include grazing by livestock, modification of hydrology because of water diversions or irrigation, haying operations, and fire. Each of these factors has had, and may continue to have, substantial effects on the composition, productivity, and structure of these plant communities.

4.1.2.6 Phreatophytic Shrublands

Phreatophytic shrublands are plant communities dominated by shrubs and deriving a relatively large portion (more than 50%) of their water from groundwater. Shrub communities of similar species composition may also exist on sites where groundwater is unavailable to the shrubs, but in such cases the cover values are substantially less than when groundwater is available to the plant communities. Phreatophytic shrublands typically have cover values twice those typical of the same types of shrublands occurring on sites where groundwater is not a substantial portion of the water use by the community. The most common type of phreatophytic shrubland in the IBMA and throughout the Great Basin is greasewood (*Sarcobatus vermiculatus*) communities.

Greasewood communities generally occur along a toposequence between meadow communities (typically saltgrass) where groundwater nears the surface and upland shrub communities, typically dominated by shadscale (*Atriplex confertifolia*), rabbitbrush (*Chrysothamnus* spp.), or sagebrush (*Artemisia* spp.). In the IBMA, they occur at lower elevations throughout the valley floor. Greasewood can occur in near-monoculture stands, but often occurs as the dominant species in mixed stands that also include shadscale, rabbitbrush, alkali sacaton, and saltgrass.

Greasewood communities require higher amounts of soil moisture than are supplied directly by precipitation in the region. The two primary sources of this supplemental water are shallow groundwater and surface runoff (overland flow). Unlike meadows, greasewood communities cannot tolerate prolonged (six months or more) flooding of the surface soil layers. Greasewood requires a minimum of 25-30 cm of unsaturated soil for most of the year (Ganskopp 1986; Nichols 1994). Greasewood is relatively tolerant of saline and sodic conditions.

Phreatophytic shrublands can utilize groundwater at deeper depths than most meadow communities. Greasewood communities can access some groundwater, either directly or by capillary rise, from depths to about 9 m (29 ft). However, canopy cover decreases substantially when depth to groundwater increases to 4 m or more.

Phreatophytic shrublands have higher cover and productivity rates than most upland shrublands. These higher values are the result of water availability to the phreatophytic communities. Most species found in the phreatophytic shrublands in the IBMA also occur in non-phreatophytic communities, but often at lower levels of cover and productivity. This is especially true for greasewood. The phreatophytic shrublands are different in both structure and composition from the associated meadow and wetland communities and therefore increase the habitat heterogeneity of the lower elevation vegetation mosaic in the IBMA.

4.1.2.7 Swamp Cedar Woodlands

Swamp cedar woodlands are low-elevation plant communities dominated by Rocky Mountain juniper (*Juniperus scopulorum*), a major conifer of the surrounding higher-elevation pinyon-juniper woodlands. There are two low-elevation populations in the IBMA. Little research has been conducted on these local populations of Rocky Mountain juniper relative to the ecological factors that allow them to exist at these low-elevation sites. It can be speculated that the occurrence of these juniper woodlands at low-elevation sites is the result of additional water being available to the trees than is available solely from precipitation. A likely source of additional water is a perched water table, probably resulting from a relatively impervious hardpan beneath the woodland communities. The primary source of water maintaining the perched water table is probably subsurface flow from a higher-elevation source along the alluvial fan. An alternative source of water could be a localized area of high groundwater caused by deeper groundwater being forced upward (but not to the surface) by hydrologic pressure.

Low-elevation populations of Rocky Mountain juniper provide a unique ecosystem to the low-elevation landscape in the IBMA. Understory vegetation is similar to that of some other lowland and upland plant communities, but the existence of trees along the valley floor provides both structural and compositional diversity to the landscape. Fauna associated with these communities is likely to be different from that of the surrounding shrublands and meadows, and may be unique to the low-elevation portions of the valley. This may be particularly true for invertebrate and avian species.

4.2 Description of Nested Targets

Nested targets are biota of special interest that are dependent on a groundwater-influenced ecosystem within the IBMA. As described in Chapter 3, the BWG established the following criteria for nested targets:

1. Dependent upon a groundwater-influenced ecosystem that may be affected by SNWA groundwater withdrawal; and
2. Known to occur or may potentially occur in the IBMA where they rely on a groundwater-influenced ecosystem for one or more life stages;

and either

3a. Federally-listed threatened or endangered species, Nevada BLM sensitive species, or Nevada- or Utah-listed species; or
3b. Designated by the BWG based on their ecological role in the IBMA.

Nested targets that will be directly monitored are springsnails, northern leopard frog, relict dace, Pahrump poolfish (*Empetrichthys latos*), fishes native to the IBMA, and swamp cedars. These species were chosen for direct monitoring because of their intimate tie to groundwater-influenced ecosystems in the IBMA, which provides an opportunity for correlating species responses with ecosystem changes due to SNWA groundwater withdrawal.

Species that meet the criteria for nested target but are migratory or have large ranges will be monitored using a habitat-based approach. The rationale for this approach is that wide-ranging or migratory species that rely on groundwater-influenced ecosystems in the IBMA are affected by many other factors across their range. Therefore, they are not ideal indicators of change resulting from SNWA groundwater withdrawal. However, maintaining habitat for these species within the groundwater-influenced ecosystems will presumably allow the species to persist within the IBMA. The BWG considered habitat requirements for some breeding birds and bats when determining appropriate KEAs and indicators to monitor, including physical components (e.g., vegetation cover, areal extent of open water, etc.), chemical components (e.g. water quality), and biological components (e.g., macroinvertebrates as a food source).

Based upon the criteria, not all species of conservation interest that occur in the IBMA are nested targets. For example, small mammals (e.g. meadow vole), other birds (e.g. waterfowl and raptors), and large mammals (e.g. pronghorn antelope) use groundwater-influenced ecosystems in the IBMA and are important components of the landscape. Small mammals use these groundwater-influenced ecosystems and perform important ecological functions such as seed dispersal and soil aeration, and serve as the primary prey species for larger mammals and raptors. Birds are influenced by seasonal site-specific environmental conditions (which can include open water, wetlands, foraging habitat, etc.) that can influence their abundance and distribution. Large mammals use these groundwater-influenced ecosystems as a water source and forage on the vegetation supported by these systems. However, as these species are not federally-listed threatened or endangered species, Nevada BLM sensitive species, or Nevada- or Utah-listed species, and were not designated by the BWG, they do not meet the criteria for nested target. The habitat-based approach is also applicable for monitoring these species. Habitat monitoring is intended as a surrogate to evaluate potential impacts to these species resulting from SNWA groundwater withdrawal. Therefore, the BWG anticipates that monitoring ecological attributes that are good indicators of integrity and viability, and that provide early warning of adverse impacts from SNWA groundwater withdrawal, will best maintain the groundwater-influenced ecosystems used by these species.

4.3 NESTED TARGETS TO BE DIRECTLY MONITORED

The BWG selected 11 nested targets to directly monitor (Table 4-1).

Table 4-1. Nested targets to be directly monitored in the IBMA[1]

Common Name	Scientific Name	Status[2]
Fish		
Mottled sculpin	*Cottus bairdi*	BWG (one of five native Bonneville Basin fish species found in Big Springs Complex).
Pahrump poolfish	*Empetrichthys latos*	FWS: Endangered; NV: Protected/Endangered, SOCP.
Redside shiner	*Richardsonius balteatus*	BWG (one of five native Bonneville Basin fish species found in Big Springs Complex); UT: Protected, SGCN.
Relict dace	*Relictus solitaries*	BLM: Sensitive; NV: Protected/Sensitive, Stewardship Species.
Speckled dace	*Rhinichthys osculus*	BWG (one of five native Bonneville Basin fish species found in Big Springs Complex); UT:SGCN.
Utah chub	*Gila atraria*	BWG (one of five native Bonneville Basin fish species found in Big Springs Complex); UT: Protected, SGCN.
Utah sucker	*Catostomus ardens*	BWG (one of five native Bonneville Basin fish species found in Big Springs Complex); UT: Protected, SGCN.
Invertebrates		
Bifid duct pyrg	*Pyrgulopsis peculiaris*	BLM: Sensitive; NV: SOCP; UT: Protected/Sensitive, SGCN.
Longitudinal gland pyrg	*Pyrgulopsis anguina*	BWG (endemic to Snake Valley where it is known from 3 locales including Big Springs); NV:SOCP; UT: Protected/Sensitive, SGCN.
Amphibian		
Northern leopard frog	*Rana pipiens*	BLM: Sensitive; NV: Protected, SOCP; UT: SGCN.
Plant		
Swamp cedar	*Juniperus scopulorum*	BWG (unique populations of Rocky Mountain juniper that occur in seasonally flooded valley bottoms; 2 of Nevada's 3 populations of swamp cedar are found in Spring Valley).

[1] Nested targets include those: 1) dependent upon a groundwater-influenced ecosystem that may be affected by SNWA groundwater withdrawal and 2) known to occur or may potentially occur in the IBMA where they rely on a groundwater-influenced ecosystem for one or more life stages; and are either 3a) federally-listed threatened or endangered species, Nevada BLM sensitive species, or Nevada- or Utah-listed species; or 3b) designated by the BWG based on their ecological role in the IBMA.

[2] BWG = Species of concern by the BWG (based on rationale presented in parentheses)
SOCP = Species of Conservation Priority, Nevada Wildlife Action Plan.
SGCN = Species of Greatest Conservation Need, Utah Comprehensive Wildlife Conservation Strategy.

4.3.1 Springsnails

Springsnails (family Hydrobiidae), are small (1-8 mm), sexually reproducing aquatic mollusks (Sada 2001). They are oviparous, with reproduction occurring several times a year, and feed on algae present on submerged vegetation and substrate (Sada 2001). Springsnails are generally most abundant near spring sources, with species within the genus *Pyrgulopsis* being especially abundant in areas with watercress (Sada 2001). Within valley-floor springs in the IBMA, three species of springsnails have been identified: Toquerville springsnail (*P. Kolobensis*; Spring and Snake Valleys), longitudinal gland springsnail (*P. anguina*; Snake Valley), and bifid duct springsnail (*P. peculiaris*; Snake Valley) (Sada 2005, BIO-WEST 2007). The presence of springsnails varies from spring to spring within the IBMA, with the maximum number of species observed at any spring not exceeding two.

Springsnails were chosen as nested targets to directly monitor because they are truly aquatic species that are restricted to persistent (perennial) springs that have suitable water quality and that are minimally affected by drought (Sada 2000). Of the three springsnail species that occur in the IBMA, two are considered nested targets because of their limited distribution and BLM sensitive and/or Utah state-listed status. Longitudinal gland springsnail, endemic to Snake Valley (Hershler 1998), was petitioned for federal listing under the Endangered Species Act in 2007 and FWS is currently reviewing the petition to determine if listing may be warranted. The third species, Toquerville springsnail (as currently taxonomically defined) is a wide-ranging species, and is therefore not a nested target. However, it will serve as an indicator species for the reasons described below.

Because springsnails require persistent water of suitable quality, they are excellent indicators of the health of spring systems and are well-suited for long-term monitoring. For these reasons, as well as those outlined by Sada (2000) and listed below, BWG chose to specifically monitor springsnails as part of this Plan):

- Springsnail demography in unaltered habitats indicates that population variation may be predictable;
- Springsnails occur in small habitats that can be easily sampled; and
- Springsnail populations are susceptible to comparatively rapid changes in abundance and distribution in response to changes in habitat conditions (e.g. both surface water diversions and excessive groundwater withdrawal).

Sada (2001) described the main threats to springsnails as habitat alteration from surface water diversion, livestock grazing, groundwater depletion, and nonnative macroinvertebrates. These threats are present at spring sites within the IBMA to varying degrees.

4.3.2 Northern Leopard Frog

Northern leopard frog (*Rana pipiens*) historically had one of the largest ranges of any amphibian in North America (Stebbins 1985; Conant and Collins 1991). However, as early as the 1960s, the species began to decline in abundance throughout a large portion of its range (Smith 2003).

In Nevada, Spring Valley has been described as having one of the largest remaining northern leopard frog populations (Hitchcock 2001), and BIO-WEST (2007) recently confirmed their presence there. However, northern leopard frog has not been documented in the Snake Valley portion of the IBMA (BIO-WEST 2007).

Northern leopard frog was chosen as a nested target to directly monitor because it is a truly aquatic species that relies on the spatial and temporal distribution of water along the valley floor; is sensitive to changes in water quality; and is experiencing population declines throughout much of its range, particularly in the western United States (Rorabaugh 2005). In June 2006, the western states population of the northern leopard frog was petitioned for listing under the Endangered Species Act, and FWS is currently conducting a status review of the species to determine if listing is warranted.

Each developmental stage of the northern leopard frog (egg masses, tadpoles, metamorphs, and adults) requires different habitats that are influenced by the quantity and quality of water. Their habitat can be categorized as over wintering habitat (generally larger, deeper water that does not freeze solid), breeding and tadpole habitat (shallow ponds, generally with abundant aquatic and emergent vegetation), and summer habitat (wet meadows and upland areas surrounding aquatic habitat which is used for feeding) (Smith 2003). The species is a typical pond-breeding amphibian that over winters underwater, emerging relatively early in the spring to breed (Smith 2003). Eggs and sperm are shed into the water and egg masses can be found floating near the surface in clumps (Smith 2003), typically attached to emergent or aquatic vegetation (Kendell 2002). Breeding and hatching are strongly influenced by water and ambient temperature (K. Wilson, UDWR, pers. comm.). Tadpoles spend two to three months developing in small, shallow water bodies that are heated by the sun to temperatures suitable for rapid development and then metamorphose into young frogs (Smith 2003; Smith and Keinath 2007)).

Threats to northern leopard frog within the IBMA include habitat alteration resulting from groundwater withdrawal, surface water diversions, livestock grazing, and road construction. Pollutants such as pesticides, herbicides, and fertilizers also pose direct threats to the northern leopard frog population. Water quality is extremely important to the northern leopard frog: the complex life cycle of amphibians and the permeability of their skin make them highly susceptible to water quality alterations, especially ecotoxicological agents (Cooke 1981; Bishop 1992; Hall and Henry 1992). Nonnative aquatic species, in particular bullfrogs and crayfish also pose a threat. Natural disturbances that can affect the species include insect epidemics, disease outbreaks, wildfire, weather, and succession (Smith 2003).

4.3.3 Relict Dace

Relict dace (*Relictus solitarius*) is a ray-finned fish in the Cyprinidae family. The species was native to pluvial lakes outside of the IBMA in northeastern Nevada. As these lakes desiccated in the Pleistocene epoch approximately 10,000 years ago, the species became restricted to isolated springs and spring-fed systems (Hubbs et al. 1974). Throughout the 1900s, relict dace was transplanted to four locations in Spring Valley: Spring Valley Creek, Stonehouse Ranch, Keegan Ranch, and Shoshone Ponds. In recent surveys, BIO-WEST (2007) documented the presence of relict dace at Stonehouse, Keegan Ranch, and Shoshone Ponds (South Pond). A population still exists in Spring Valley Creek (C. Crookshanks, NDOW, pers. comm.).

Although translocated to Spring Valley, relict dace meet the nested target criteria because it is one of the few fish species now in Spring Valley, is endemic to Nevada, and is a BLM sensitive species. Relict dace are good indicators because they are aquatic species that directly rely upon the quantity and quality of water for their continued existence.

Relict dace is a relatively small fish, is an opportunistic feeder, and inhabits primarily small thermal springs, creeks, and wetland areas (Sigler and Sigler 1987). Morphological adaptations are likely related to their isolation in these small aquatic systems and lack of competition and predation by other fish species (Crookshanks 2006). Relict dace is an extremely prolific species with a long breeding season and reproductive strategies that vary with respect to environment, especially thermal regime (Crookshanks 2006). Aquatic vegetation is a key habitat component, including *Chara*, *Nasturtium*, *Potamogeton*, *Utricularia*, filamentous algae, rush (bull and spike), moss, and *Carex* (Crookshanks 2006). Threats to relict dace include but are not limited to habitat alteration from surface water diversion, livestock grazing, groundwater depletion; impacts from nonnative species; and disease.

4.3.4 Pahrump Poolfish

Pahrump poolfish is a small fish rarely exceeding two inches in length. Previously described by Miller (1948) as Pahrump killifish (*Empetrichthys latos latos*), the common name has since been changed to Pahrump poolfish and the scientific name to *E. latos* following extirpation of two of the three subspecies that had comprised the species. Pahrump poolfish historically occupied an isolated spring (Manse Spring) on private property in the Pahrump Valley of southern Nye County, Nevada. After the extirpation of the two other subspecies from different springs in Nye County, individuals from the Manse Spring population were relocated to three different sites, including Shoshone Ponds Natural Area, a BLM native fish refuge. Subsequently, the Manse Spring population was extirpated; hence, the three refuge locations contain the only known populations of Pahrump poolfish.

The Pahrump poolfish was listed as endangered by the FWS in 1967 under the Endangered Species Preservation Act, the precursor to the Endangered Species Act of 1973. As a federally listed endangered species, it was automatically chosen as a nested target and will be monitored where it occurs at Shoshone Ponds: the North, Middle, and Stock Ponds (Morrell et al. 2007). Pahrump poolfish are good indicators because they are aquatic species that directly rely upon the quantity and quality of water for their continued existence.

NDOW has conducted annual surveys for Pahrump poolfish for over a decade, which provides the BWG with a wealth of information for evaluating ranges of variability in this refuge population. Recent population estimates using minnow trap based mark-recapture techniques put numbers at 3,816 (3,521-4,137) in the Stock Pond, 113 (85-154) in the North Pond, and 368 (292-464) in the Middle Pond (Morrell et al. 2007). Threats to Pahrump poolfish include but are not limited to habitat alteration from surface water diversion and groundwater depletion; impacts from nonnative species and vandalism; and disease.

4.3.5 Fishes Native to the Big Springs Complex

Five native fish species are known to occur in the Big Springs Complex, Snake Valley in the IBMA: Utah chub (*Gila atraria*), speckled dace (*Rhinichthys ocsculus*), redside shiner (*Richardsonius balteatus*), mottled sculpin (*Cottus bairdi*), and Utah sucker (*Catostomus ardens*). A 2005 collaborative sampling effort by NDOW and BIO-WEST between the various Big Springs spring heads downstream to the Nevada-Utah state line found all five species to be present (Tallerico and Crookshanks 2005; BIO-WEST 2007).

These five species constitute the most diverse assemblage of fishes recently collected from any system within Spring Valley or Snake Valley (BIO-WEST 2007). Additionally, they represent the most comprehensive suite of Bonneville Basin native, non-game fish species within the IBMA. Thus, the BWG designated these fish as nested targets based on their ecological role in the IBMA. As previously discussed, fish are good indicators because they are aquatic species that directly rely upon the quantity and quality of water for their continued existence.

Four of the five native fish in the Big Springs Complex are generalists. Speckled dace is small (less than four inches), short lived, feeds primarily on benthic invertebrates, and occupies a wide variety of habitats including desert springs (Sigler and Sigler 1996). Redside shiner can grow up to seven inches, is omnivorous, and can occupy a wide variety of habitats (Sigler and Sigler 1996). Utah sucker is relatively large species with an elongate body and, from a habitat perspective, a very adaptable species (Sigler and Sigler 1996). Utah chub typically reaches ten to twelve inches in length, is omnivorous, and thrives in a wide range of habitats and water temperature (Sigler and Sigler 1996). Of the five native fish species in the Big Springs Complex, mottled sculpin has the most stringent habitat requirements – clear, cold, well-oxygenated water and an abundance of cover – and it prefers flowing water over coarse substrates including gravel, small loose rocks, or rubble (Sigler and Sigler 1996). Mottled sculpin is found in such habitats in Big Springs (BIO-WEST 2007) and Stateline Springs (G. Baker, GBNP, pers. comm.). Threats to these native fish species include but are not limited to habitat alteration from surface water diversion, livestock grazing, groundwater depletion, road construction; impacts from nonnative species; and pollutants and disease.

4.3.6 Swamp Cedars

Swamp cedar woodlands are low-elevation plant communities dominated by Rocky Mountain juniper, a major conifer of the surrounding higher-elevation pinyon-juniper woodlands. There are two low-elevation populations in the IBMA. The north population is located near South Bastian Spring and covers about 3.5 mi^2. The south population is located in the south-central portion of Spring Valley and covers about 1.5 mi^2.

Swamp cedars in Spring Valley were included as a nested target because the BWG considered them to provide an important ecological role in the IBMA by providing a substantial increase in the structural heterogeneity of the landscape. Swamp cedars are good indicators because they are dependent on higher levels of moisture than supplied directly by the precipitation received at the lower elevations and thus, react more quickly to changes in groundwater levels or surface water patterns. Threats to swamp cedars include but are not limited to direct impact from surface water diversion, livestock grazing, groundwater depletion, fire, and road construction.

4.4 MONITORING SITES

After identifying the locations of groundwater-influenced ecosystems in the IBMA, the BWG initiated the site selection process as described in Section 4.4.1. Selection of monitoring sites was facilitated by BWG-TRP coordination to cover both hydrologic and biological monitoring needs.

4.4.1 Site Selection

The BWG considered the following factors when selecting monitoring sites within groundwater-influenced ecosystems: presence of nested targets and indicator species, level of disturbance, location relative to hydrologic monitoring, spatial coverage of the IBMA, mitigation potential, and access. Also considered during site selection were habitat requirements of nested targets not being directly monitored, such as breeding birds and bats. A list of monitoring sites and associated groundwater-influenced ecosystems is presented in Table 4-2, and a summary of site selection criteria is presented in Table 4-3.

One of the first steps in the site selection process was to describe the occurrence of nested targets and indicator species at each potential monitoring site. This was aided by BIO-WEST's survey of 23 springs or spring complexes (including associated wetlands and wet meadows) within the IBMA between 2004 and 2006 (BIO-WEST 2007). BIO-WEST (2007) also summarized the findings of earlier spring surveys conducted by researchers and resource agencies, providing valuable baseline information to use for site selection. Of the sites chosen for biological monitoring, eight have documented springsnail populations, six have documented northern leopard frog populations, four have fish that are nested targets, and two have swamp cedars (BIO-WEST 2007; Table 4-3).

The biological diversity of the spring sites range from systems that are moderately disturbed and contain springsnails, fish, and northern leopard frogs (e.g. Minerva Complex), to those that are highly disturbed and contain only macroinvertebrate communities (e.g. Willard, North Little Spring) (Table 4-3). This diversity in spring type will allow for comparisons of the level of potential impact over time by providing a glimpse of springs currently at differing levels of ecological productivity and integrity. A shift from a highly diverse to a less diverse aquatic community may signal potential impacts if proximal to ground water pumping. On the other hand, springs farther away from groundwater pumping that demonstrate such a shift may simply be exhibiting natural variability. Because it is too early to make such predictions, the BWG focused on selecting a range of ecological conditions within sites in order to fully evaluate conditions over the baseline period.

Table 4-2. Monitoring sites, included ecosystems, and locations

#	Monitoring Site	Groundwater-Influenced Ecosystem	Location
1	Stonehouse Springs Complex	Valley Floor Spring / Wetland / Meadow	Spring Valley (North)
2	Willow Spring	Valley Floor Spring	Spring Valley (North)
3	Keegan Ranch Springs Complex	Valley Floor Spring / Wetland / Meadow	Spring Valley (Middle)
4	West Spring Valley Complex	Valley Floor Spring / Wetland / Meadow	Spring Valley (Middle)
5	South Millick Spring	Valley Floor Spring	Spring Valley (Middle)
6	Unnamed 5 Spring	Valley Floor Spring	Spring Valley (Middle)
7	4WD Spring	Valley Floor Spring	Spring Valley (Middle)
8	Willard Spring	Valley Floor Spring	Spring Valley (South)
9	Swallow Spring	Range front Spring	Spring Valley (South)
10	Minerva Spring Complex	Valley Floor Spring / Wetland / Meadow	Spring Valley (South)
11	Clay Spring-North	Valley Floor Spring	Snake Valley
12	Unnamed 1 Spring	Valley Floor Spring	Snake Valley
13	North Little Spring	Valley Floor Spring	Snake Valley
14	Shoshone Ponds	Ponds / Wetland / Meadow	Spring Valley (South)
15	Big Spring Complex		Snake Valley
	Big Spring Creek / Lake Creek	Perennial Stream	
	Big Springs	Valley Floor Spring	
	Stateline Springs	Valley Floor Spring	
16	The Seep	Wetland / Meadow	Spring Valley (South)
17	Blind	Wetland / Meadow	Spring Valley (South)
18	Burbank	Wetland / Meadow	Snake Valley
19	Swamp Cedar Woodland (Middle)	Swamp Cedar Woodland	Spring Valley (Middle)
20	Swamp Cedar Woodland (South)	Swamp Cedar Woodland	Spring Valley (South)
21	Greasewood / Rabbitbrush	Phreatophytic Shrublands	Spring Valley (North)
22	Greasewood / Rabbitbrush	Phreatophytic Shrublands	Spring Valley (Middle)
23	Greasewood / Rabbitbrush	Phreatophytic Shrublands	Spring Valley (South)
24	Greasewood / Rabbitbrush	Phreatophytic Shrublands	Hamlin Valley
25	Greasewood / Rabbitbrush	Phreatophytic Shrublands	Snake Valley

Table 4-3. Additional criteria evaluated for selection of monitoring sites for springs, ponds, and streams.

Monitoring Site	Valley	Owner	Hydrological monitoring Location	P/A of Springsnails[1]	P/A of Fish[2]	P/A of Amphibians[3]	Disturbance Level[4]
Stonehouse Complex	Spring	SNWA	Yes	P-pk	P-rd	A	Moderate
Willow	Spring	BLM	Yes	P-pk	A	A	Moderate
Keegan Ranch Complex	Spring	SNWA	Yes	A	P-rd	P	Moderate/High
West Valley Complex	Spring	Private/BLM	Yes	P-pk	A	P	Moderate/High
South Millick	Spring	BLM	Yes	A	A	P	Moderate
Unnamed Spring 5[5]	Spring	SNWA	Yes	P-sp	A	P	Low/Moderate
4WD[5]	Spring	BLM	Yes	A	A	A	Moderate/High
Willard	Spring	SNWA	No	A	A	A	Moderate
Swallow Spring	Spring	SNWA	Yes	A	A	A	Moderate
Minerva Complex	Spring	SNWA	Yes	P-pk	P-uc*	P	Moderate/High
Clay	Snake	Private/BLM	No	P-pa	A	A	High
Unnamed 1 – North of Big	Snake	Private	No	P-pa	A	A	Moderate
North Little Spring	Snake	Private	No	A	A	A	Moderate
Shoshone Ponds	Spring	BLM	Yes	A	P-pp, rd	P	Moderate
Big Springs Complex	Snake	Private/BLM	Yes	P-pa,pp	P-5	A	High
The Seep[5]	Spring	BLM	Yes	A	A	A	High
Blind	Spring	BLM	Yes	A	A	P[5]	High

A = absent; P = present
[1] Springsnails: -pp = Pyrgulopsis peculiaris; -pk = Pyrgulopsis kolobensis; -pa = Pyrgulopsis anguina; sp = species not confirmed
[2] Fish: -rd = Relict dace; -pp = Pahrump poolfish; -uc* = Utah chub – not a nested target in Spring Valley; -5 = Five Species;
[3] Amphibians: Northern Leopard Frog
[4] BIO-WEST (2007)
[5] Supplemental 2008 surveys (BIO-WEST unpublished data)

Early in the process, the TRP selected 13 springs in Spring Valley to conduct hydrologic monitoring (one range front, one mountain block, and 11 valley floor springs; Fig. 4-1; SNWA 2008). This selection process was coordinated with the BWG to address both hydrologic and biological considerations. Only one range front spring was selected due to the limited occurrence of such springs within the IBMA. The TRP's hydrologic monitoring plan currently includes continuous groundwater elevation measurements at 12 of the 13 sites (one range front and 11 valley floor springs, using piezometers); and continuous spring discharge measurements at one of the sites (mountain block Rock Spring, using a weir; Fig. 4-1; SNWA 2008). Depending on site condition and technical feasibility, SNWA may also measure spring discharge (method dependent on site) or spring pool elevation (using staff gages) at TRP spring sites.

For the biological monitoring plan, the BWG has included 11 of the 13 TRP spring sites. Two of the 13 sites were eliminated as biological monitoring sites for the following reasons: (1) Rock Spring, the only mountain block spring in the TRP hydrologic monitoring plan, was excluded because impacts from SNWA groundwater withdrawal in Spring Valley are currently considered unlikely; and (2) Layton Spring was excluded because it is highly modified (water is diverted into a cattle trough). All 11 of the joint TRP-BWG spring sites have been surveyed for aquatic biota (BIO-WEST 2007, and unpublished data).

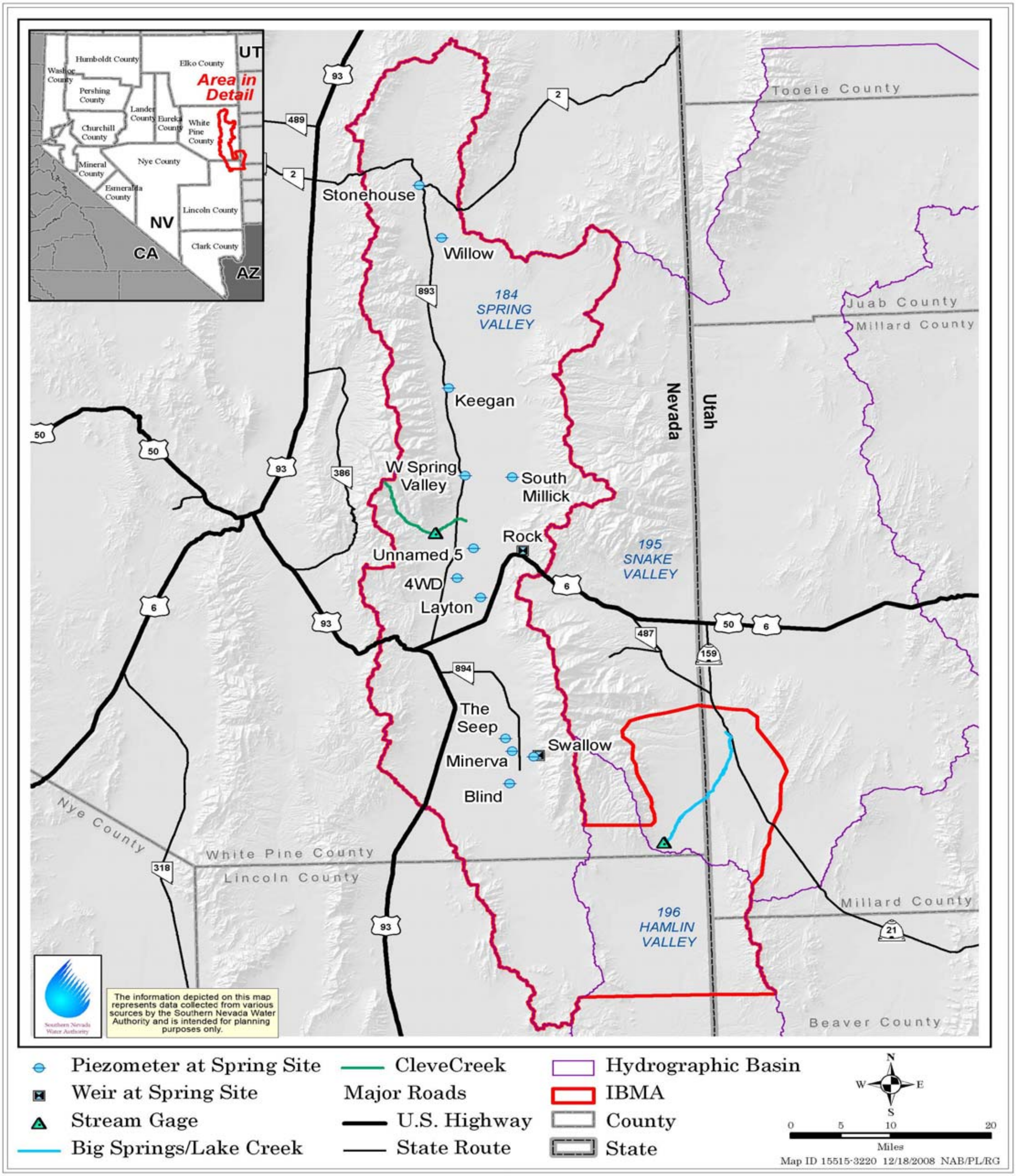

Fig. 4-1. TRP spring and stream hydrologic monitoring sites.

In addition to monitoring spring hydrology, the TRP will monitor groundwater elevation in existing and new wells spatially distributed across the IBMA in basin fill, carbonate, and volcanics (Fig.4-2; SNWA 2008). Future SNWA exploratory and production wells will be added to this monitoring network as they are developed, and monitoring will occur between SNWA's future production wells and existing water rights and federal resources. The TRP hydrologic monitoring plan also includes water chemistry samples from 40 spring, stream, and monitoring well sites in Spring Valley, the locations of which will be selected with BWG input (parameters presented in Exhibit A of Appendix A). Lastly, the TRP's plan includes continuous discharge measurements using stream gages at Cleve Creek and Big Springs channels leading to Big Spring Creek / Lake Creek, as well as a gain/loss study at the Big Springs Complex in Snake Valley (Big Spring Creek / Lake Creek surface water system from the Big Springs orifice to Pruess Lake; SNWA 2008). While the Big Springs Complex is included in this biological monitoring plan, Cleve Creek was not selected for biological monitoring because it is a mountain block-originating stream diverted for agriculture before reaching the valley floor, and SNWA's applications for points of diversion near Cleve Creek were denied.

The BWG used TRP hydrologic monitoring sites, as well as spatial coverage throughout the IBMA, to inform biological site selection. The IBMA was divided into five areas based on hydrogeology and direction of groundwater flow, as well as the location of permitted points of diversion and groundwater exploratory areas: southern Snake Valley, northern Hamlin Valley, southern Spring Valley (south of Hwy 6 where a hydrogeological divide has been identified; Sweetkind et al. 2007), middle Spring Valley, and northern Spring Valley (north of SNWA's groundwater exploratory area). While site selection was constrained by limited occurrence of particular groundwater-influenced ecosystems, monitoring sites (springs, wetlands, meadows, swamp cedar woodlands, and phreatophytic shrubland locations) were distributed to provide as broad coverage of the IBMA as possible (Figs. 4-3, 4-4, and 4-5).

Reference sites and sample size were also considered during site selection. The BWG selected sites located at differing distances from proposed pumping so that those located farthest from pumping might provide reference conditions. For instance, based on discussions with the TRP, it is unlikely that sites in the northernmost portion of Spring Valley (e.g., Stonehouse, Willow) will be impacted by groundwater pumping south in the valley. As data collection progresses and data gaps are potentially identified, additional reference sites may be added if necessary (possibly including regional reference sites located outside the IBMA). Selecting replicate valley floor springs proved difficult as many of the individual spring systems have unique characteristics. Thus, the BWG considered spatial distribution (related to hydrologic monitoring sites, permitted points of diversion, and groundwater exploratory areas), presence of nested targets and indicator species, and levels of site disturbance to ensure a design that would allow for detection of patterns, trends, and relationships within and across sites.

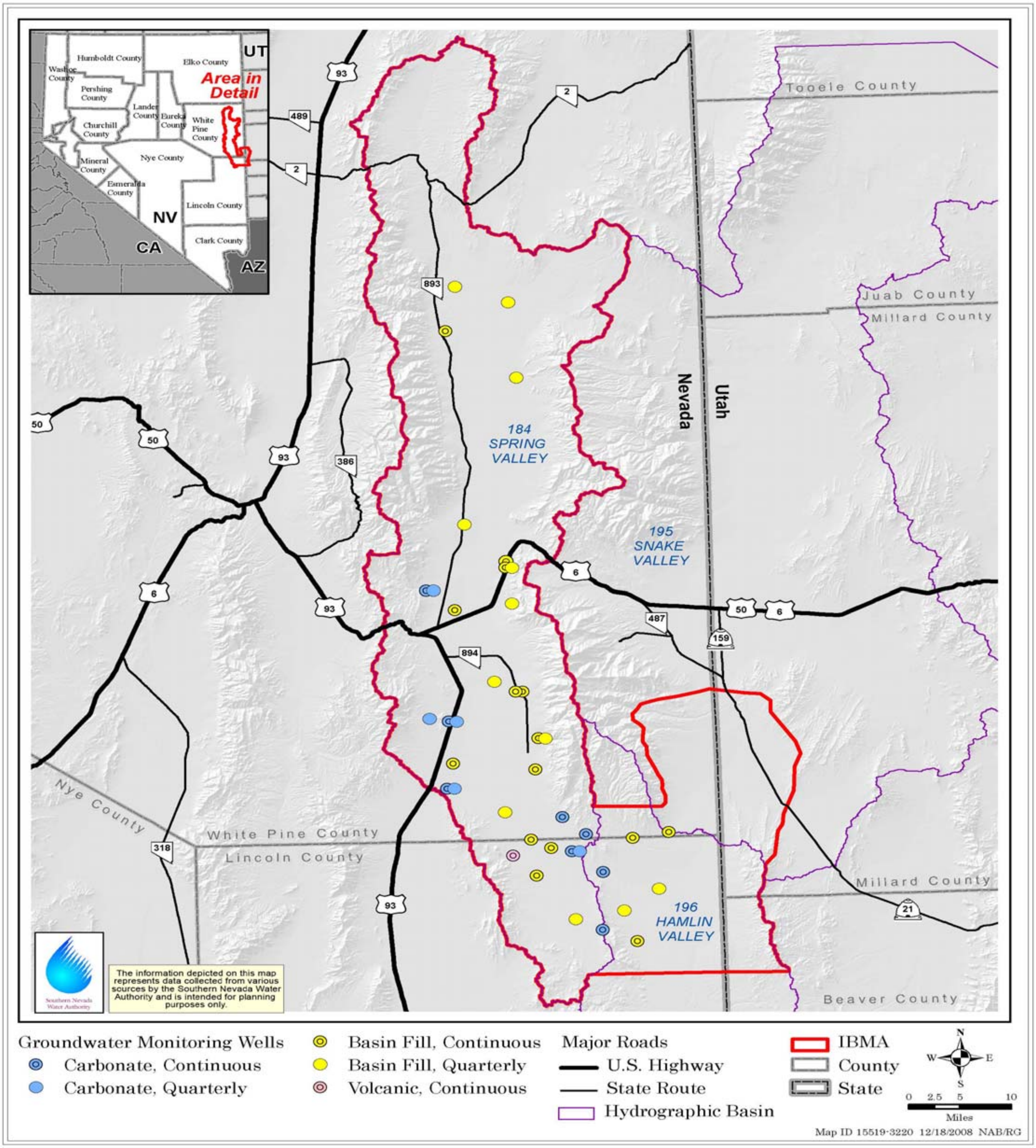

Fig. 4-2. TRP and SNWA groundwater monitoring sites (see Fig. 4-1 for piezometers at spring sites). Some well locations are subject to change, and additional wells may be added to the network.

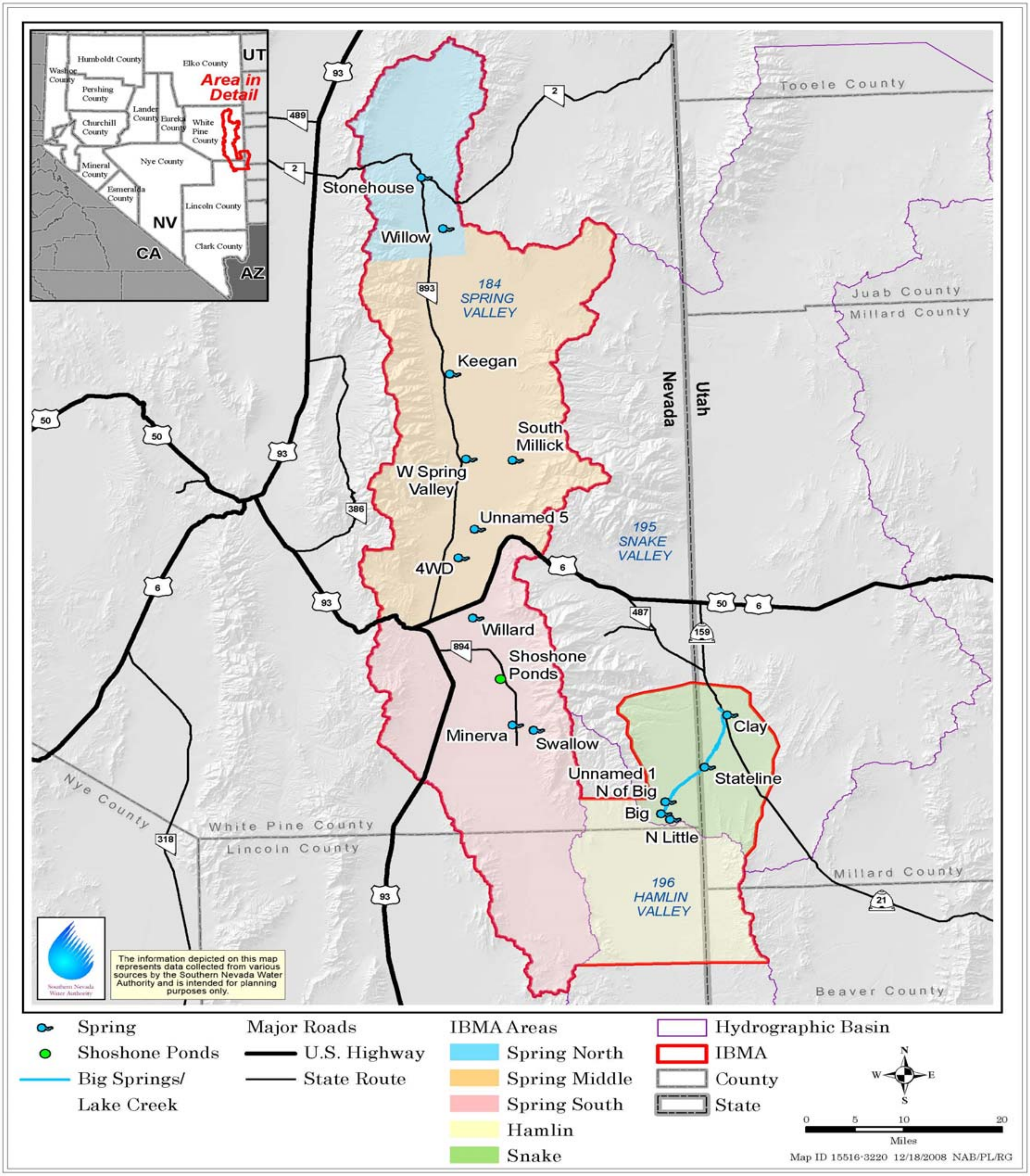

Fig. 4-3. BWG monitoring sites: springs, ponds (Shoshone) and perennial streams.

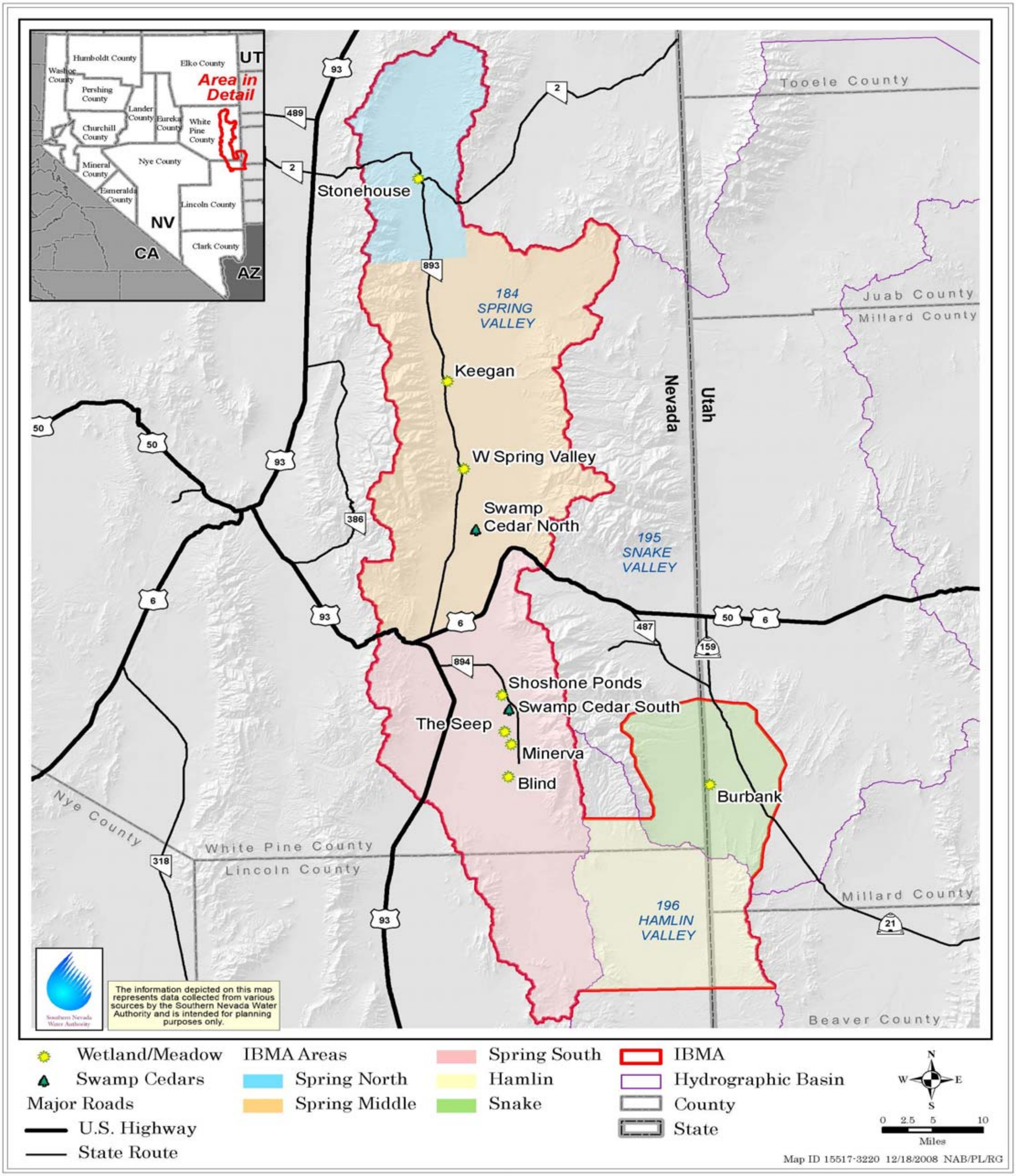

Fig. 4-4. BWG monitoring sites: wetlands, meadows, and swamp cedars.

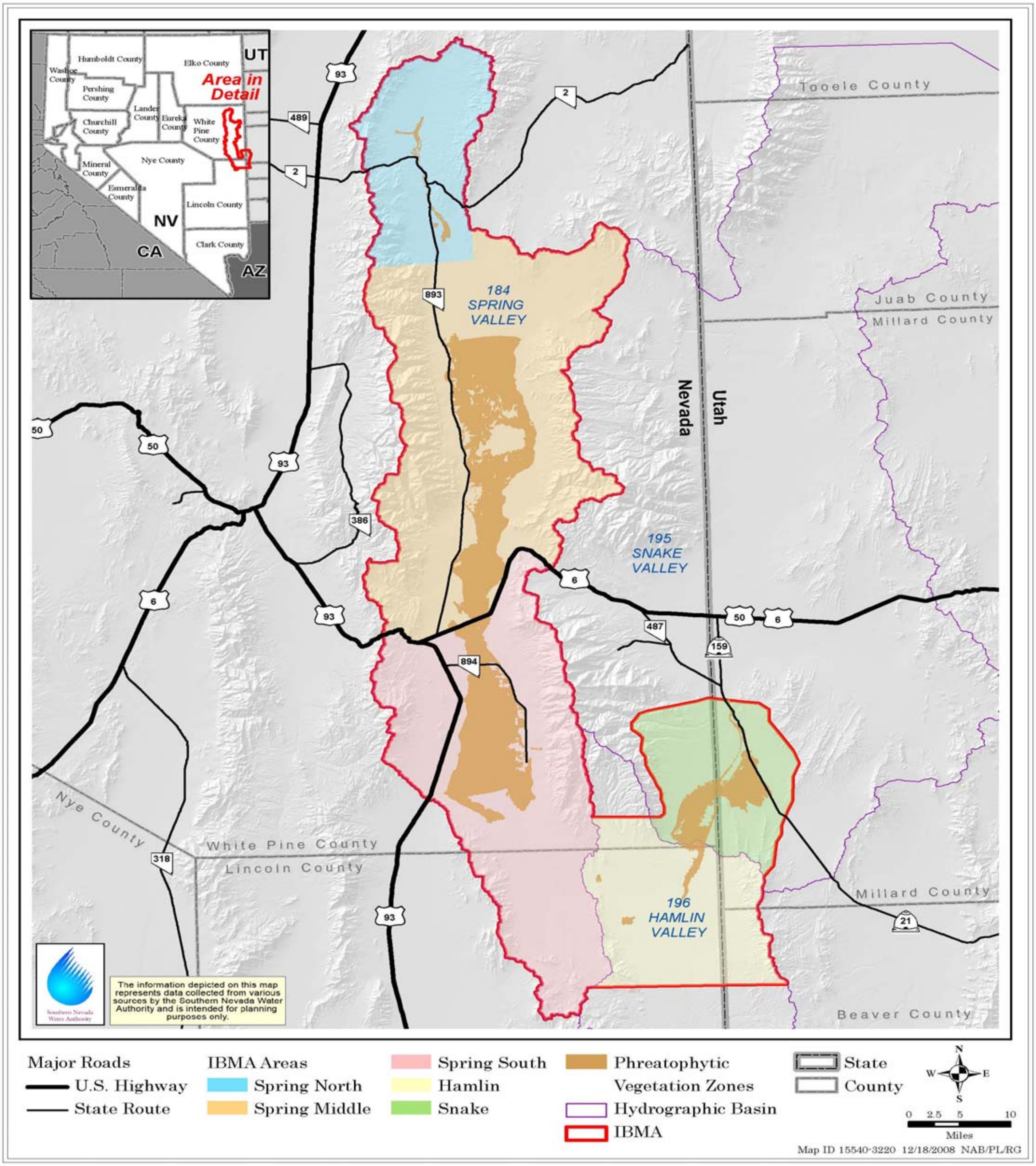

Fig. 4-5. BWG monitoring sites: phreatophytic shrublands. The coarse vegetation zones depicted in this figure encompass phreatophytic shrublands as well as non-phreatophytic plants (SNWA 2007).

Translocation/refuge potential (i.e. potential mitigation opportunities) was another factor considered when selecting monitoring sites, but to a lesser extent. Translocation/refuge potential is defined as a site having the potential to support sensitive species that could be translocated within or between valleys. A positive translocation/refuge designation in BIO-WEST (2007) simply represented possible areas that may be suitable for range expansions or refuge populations. However, as stated in BIO-WEST (2007), "Serious consideration of translocation or refugia populations would require additional data collection to determine seasonal fluctuation in productivity and water quality, as well as a detailed examination of the agreements and compliance documents needed for such activities." This was a preliminary judgment made by BIO-WEST and not determined by the BWG. However, this preliminary information was informative to site selection because of the importance of acquiring information with the foresight of potential mitigation opportunities.

Access to the proposed monitoring sites is a key component to the success of the Plan. A large number of the sites for monitoring are located on public land. This public land is managed by the BLM, and the BLM is a member to the Stipulation. Of the monitoring sites on private land, a large number of these sites are owned by SNWA, which the BWG has access to. The BWG will be consulting with landowners to discuss access potential for the remaining sites. Additionally, public outreach efforts will be jointly coordinated with the TRP to provide information to the public and allow the opportunity for specific questions regarding landowner access and specifics of the Plan. Should access not be granted at specific sites, the BWG will attempt to find alternative sites.

In summary, twenty-five locations were selected for monitoring that include all seven groundwater-influenced ecosystems. Of these, 14 are associated with valley floor springs and one with range front springs. Although Shoshone Ponds is an artificially created system, it will be monitored because it contains a federally endangered species. The Big Springs complex is a focal point of both the hydrological (TRP – gain/loss study) and biological (BWG – five individual reaches) monitoring. There are eight wetland/meadow complexes for monitoring with four directly associated with springs being monitored, one being associated with Shoshone Ponds, and the remaining three being individual complexes. Five phreatophytic shrubland communities will be monitored to be representative of the five regions described in Fig.4-5. Finally, the two populations of lowland swamp cedars in Spring Valley will be monitored because of their ecological role within the IBMA. At these sites (or subsets of sites), numerous specific parameters will be sampled as outlined in Section 4.5.

4.4.2 Sites

The following sites have been selected for biological monitoring within the IBMA. At each site, one or more groundwater-influenced ecosystems will be monitored, as indicated in the site descriptions below.

4.4.2.1 Stonehouse Complex, West Spring Valley Complex

Systems to be monitored: Springs, Wetlands, Meadows

Stonehouse and West Spring Valley complexes, located in the northern and middle portion of Spring Valley respectively, are similar in that they both are classified as limnocrene (BIO-WEST 2007), and they are labeled complexes because of the multiple spring orifices present. The springs are predominantly limnocrene because they flow from deeper pool areas with no defined spring brook. However, portions of Stonehouse are also considered helocrene because of shallow water depth and wetland conditions at several of the pool areas. Both systems flow for several hundred meters. Since the flow is not confined, both systems flow outward and create a myriad of habitat types characteristic of springs, wetlands, and meadows. Springsnails are present in both systems, and water quality parameters are similar (BIO-WEST 2007). Northern leopard frog has been confirmed at West Spring Valley complex, but not at Stonehouse although extensive potential frog habitat exists. Conversely, relict dace is present at Stonehouse (via translocation), but no fish has been collected at West Spring Valley complex although potential habitat is abundant.

4.4.2.2 Willow Spring

System to be monitored: Spring

Willow Spring is located in the middle portion of Spring Valley and classified as rheocrene, flowing into a confined channel. It is the site closest to the Stonehouse Springs complex, and water quality results were similar to those at Stonehouse (BIO-WEST 2007). Willow Spring maintains springsnails and abundant watercress near the spring orifices, but is only a fraction of the size of the Stonehouse Springs complex.

4.4.2.3 Keegan Ranch Complex

Systems to be monitored: Spring, Wetland, Meadow

Keegan Ranch complex is located in middle Spring Valley between the Stonehouse and West SpringValley complexes. Keegan Ranch is also considered a complex because of multiple spring orifices and the vast size of the overall springs, wetlands, and meadow. Unlike Stonehouse and West Spring Valley, Keegan Ranch has three well-defined main spring orifices that flow into confined channels, thus classifying this system as a series of rheocrenes. These confined channels flow for several hundred meters creating an expansive and diverse community. The northernmost spring channel has the most defined spring brook, which extends over 200 meters before entering a series of human-modified wetlands/pools. Past the pools is an extensive channel flowing to the south then east which is utilized by relict dace. It is likely that the other spring heads also contribute to these wetlands and downstream channel. The larger water bodies at Keegan Ranch provide different habitat structure than at the aforementioned complexes. Keegan Ranch maintains a translocated population of relict dace, as well as northern leopard frog.

4.4.2.4 South Millick Spring, Unnamed Spring 5

Systems to be monitored: Springs

South Millick Spring and Unnamed Spring 5 are located in middle Spring Valley towards the center of the valley floor. They are classified as rheocrene with similar spring morphology. Both have extensive spring brooks that extend hundreds of meters downstream, and are well-defined with a narrow band of herbaceous vegetation compared to the previously described complexes. Near the spring orifices, fine sand in the immediate area of upwelling springs can be observed as rolling or bubbling. Both springs contain extensive amounts of northern leopard frog habitat with confirmation of several adult frogs noted during previous surveys and site visits (BIO-WEST 2007 and unpublished data). Springsnails have been documented at Unnamed Spring 5, but not at South Millick spring. No fish has been documented in either spring system. Both springs have moderate disturbance due to livestock, but relative to other valley floor springs appear less impacted.

4.4.2.5 4WD Spring, Willard Spring

Systems to be monitored: Springs

4WD Spring is located in middle Spring Valley, and Willard Spring is in south Spring Valley (based on current knowledge of the nearby hydrogeological divide). Geographically these springs are relatively close and are described together because they are both limnocrene, highly disturbed, support relatively small water bodies with limited wetland or meadow areas, do not support fish or springsnails, and have no documented occurrence of northern leopard frog. A notable difference between them is the associated riparian community. 4WD Spring is one of the few valley floor springs in Spring Valley that has woody riparian vegetation, and may provide important habitat for breeding birds. Willard Spring is more similar to other valley floor springs in the IBMA with typical wetland and meadow vegetation.

4.4.2.6 Swallow Spring

System to be monitored: Spring

Swallow Spring is located in southern Spring Valley and is the one range front spring selected for hydrological and biological sampling. The TRP and BWG recommended Swallow Spring for hydrological monitoring because of the anticipated close proximity to future groundwater withdrawal locations. It is a rheocrene spring, but the higher elevation and different geologic situation contributes to slightly different water quality conditions than valley floor springs. During surveys conducted by BIO-WEST (2007), Swallow Spring had some of the coolest water temperatures and, in general, lower conductivity and higher pH than the majority of springs surveyed. Swallow Spring has a unique invertebrate community with a high number (5) of EPT taxa, including the stonefly, *Hesperoperla pacifica*. The riffle beetle (*Heterlimnius* sp.) and *H. pacifica* were not collected at any other of the aquatic systems of interest throughout the valleys surveyed by BIO-WEST (2007). No springsnails or frogs have been documented at Swallow Spring. Swallow Spring does support a small population of rainbow trout, which are introduced.

It is also one of the few spring systems with woody riparian vegetation which may provide important habitat for breeding birds.

4.4.2.7 Minerva Springs Complex

Systems to be monitored: Spring, Wetland, Meadow

Minerva Springs complex is located in southern Spring Valley and consists of a combination of rheocrene and limnocrene springs, and a human-modified pond/reservoir. Minerva Springs complex is not as confined as the previously described complexes, as it is entirely interconnected either naturally or via irrigation ditches. The northernmost springs consist of four defined spring orifices (smaller spring heads are also present) that flow into three confined channels. These channels are immediately dammed with managed culverts, which allows for flow down both the original channel and a separate irrigation channel. All four spring orifices maintain springsnails, and northern leopard frog has been documented in this area (BIO-WEST unpublished data). The middle Minerva springs area consists of multiple spring orifices flowing into mostly-confined channels, with water captured at varying distances downstream by a large irrigation ditch. Large expanses of wetlands and meadows are created by these multiple channels providing vast areas of northern leopard frog habitat. This middle springs area also supports well-established woody riparian vegetation. The southernmost area at Minerva includes a human-modified pond/ reservoir that is managed for irrigation.

The northern and middle springs at Minerva exhibit similar water quality whereas the reservoir has more varying temperature and double the conductivity (BIO-WEST 2007). Utah chub has been documented in the northern-most springs and southern-most reservoir (BIO-WEST 2007); however, as Spring Valley was historically a fishless valley, this occurrence is likely due to stocking. As Utah chub was introduced to Spring Valley and is not a species of concern in Nevada, monitoring of this species at Minerva Springs is not proposed.

4.4.2.8 Clay Spring - North

System to be monitored: Spring

Clay Spring-North is located in southern Snake Valley and is classified as limnocrene. It is the type location for longitudinal gland springsnail (Hershler 1998). Sada (2005) and BIO-WEST (2007) found longitudinal gland springsnail to be common in Clay Spring-North. No frog or fish has been documented at this location, and BIO-WEST (2007) ranked the level of disturbance as high due to livestock and diversions. Although highly disturbed, five EPT taxa were collected by BIO-WEST (2007) at Clay Spring-North, the highest number of EPT taxa they found at any of the valley floor springs (excluding Big Springs) proposed for this Plan.

4.4.2.9 Unnamed 1 – North of Big Spring

System to be monitored: Spring

Unnamed 1- North of Big Spring is located in southern Snake Valley just north of the Big Springs Complex. It is a small rheocrene with shallow water depth and a short, confined spring brook, which creates a limited wetland area at the terminus. Springsnails have been collected at this site indicating perennial flow; thus, this spring serves as a representative rheocrene within the IBMA in Snake Valley. Two EPT taxa have also been documented at this site (BIO-WEST 2007).

4.4.2.10 North Little Spring

System to be monitored: Spring

North Little Spring is located in southern Snake Valley south of the Big Springs Complex. It is a valley floor spring that exhibits classic limnocrene characteristics. A deep, wide pool is located at the source. No fish, springsnail, or frog has been documented at North Little Spring.

4.4.2.11 The Seep, Blind, and Burbank Meadows

Systems to be monitored: Wetlands, Meadows

Wetlands and meadows will be monitored at The Seep, Blind, and Burbank Meadows. The Seep, located in south Spring Valley just north of the Minerva Springs complex, includes wetland and meadow areas. Blind Spring, also in south Spring Valley, is actually a small seep consisting of a shallow, open pool with fringing wetland vegetation. Burbank Meadows, located in Snake Valley adjacent to the Big Springs Complex near the Nevada/Utah State line, includes extensive wetlands and meadows. These three sites were selected for monitoring because of their potential importance as habitat for breeding birds and bats.

4.4.2.12 Big Springs Complex (includes Big Spring Creek / Lake Creek, Big Springs, and Stateline Springs)

Systems to be monitored: Springs, Perennial Stream

Big Springs Complex was designated a stand-alone category due to its location within Snake Valley, complexity in terms of the amount and types of aquatic habitat contained within the greater complex, overall size, and the number of native aquatic species found within the system. Big Springs Creek / Lake Creek originates at Big Springs and the creek proper is supported by additional springs (including Stateline Springs) as it progresses towards Pruess Lake.

Big Spring Creek is unique in the fact that it is one of only two waters in Nevada (the other is Thousand Springs Creek – Elko County) that contain a suite of Bonneville Basin-requisite native non-game fish species. The first documented collection of fish from the stream was conducted in 1938 by the University of Michigan and found redside shiners (*Richardsonius balteatus*), speckled dace (*Rhinichthys osculus*), Utah chub (*Gila atraria*), Utah suckers (*Catostomus ardens*), and mottled sculpin (*Cottus bairdi*). In the following 70 years, a number of sampling efforts of the stream have been conducted by both academic institutions and agency personnel with varying results. The most recent survey effort, conducted in 2005, documented the presence of Utah chub, speckled dace, redside shiner, mottled sculpin, and Utah sucker in various reaches from the Big Springs spring source to the Nevada-Utah state line (Tallerico and Crookshanks 2005). At this time, it was concluded that the fish populations in Big Springs

Creek were stable and it was noted that this was the first time since 1968 that all five native species had been collected during the same survey.

A number of non-native game fish species have been introduced into Big Springs Creek / Lake Creek over the course of the past 60 years in an attempt to establish a sport fishery. Beginning in 1945 and 1948 respectively, rainbow trout (*Onchorynchus mykiss*) and brown trout (*Salmo trutta*) were released into the stream. From 1953 to 1968, rainbow trout, brown trout, largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), black crappie (*Pomoxis nigromaculatus*), and channel catfish (*Ictalurus punctatus*) were introduced. The stream was treated with rotenone in 1968 in an effort to reduce numbers of Utah chub and Utah sucker that were judged to be at nuisance levels. One year subsequent to its eradication, Utah chub and redside shiners were found in the stream. Smallmouth bass were stocked again in 1971. The last non-native introduction conducted at the stream was in 1980 when 152 brown trout were stocked. Although rainbow trout and brown trout were occasionally found in survey work completed in 1960s and 1970s, all other non-native sport fish species failed to become established in Big Springs Creek / Lake Creek.

Longitudinal gland springsnail (*Pyrgulopsis anguina*) and bifid duct springsnail (*Pyrgulopsis peculiaris*) are present in Big Springs Complex springs. Both are on the State of Utah Sensitive Species List and the State of Nevada Rare (At-risk) Species List (NNHP 2004, Gorrell et al. 2005, UNHP 2005, UDWR 2007). Longitudinal gland springsnail is endemic to Snake Valley (Hershler 1998). Of all the springs in Spring and Snake Valleys surveyed by BIO-WEST (2007), the Big Springs Complex maintained the largest number of intolerant macroinvertebrate taxa. Tolerance refers to an organism's ability to tolerate various forms of stress such as low dissolved oxygen levels, high amounts of siltation, or varying amounts of toxic chemicals. Intolerant species are more sensitive to perturbations and thus, make good early indicators of change.

The Big Springs Complex also provides habitat for a variety of terrestrial biota including bats and breeding birds. Riparian woodlands and shrublands are examples of obligate phreatophytic vegetation. Riparian woodlands are tree-dominated communities that are very rare throughout the Big Springs Complex. Riparian shrublands are dominated by shrubs such as willow (*Salix* spp.) and are slightly more prevalent in this system. Riparian herbaceous species are the most dominant in this complex and also require the presence of groundwater (or high soil moisture from the surface stream).

The hydrological connectivity of the Big Springs Complex to Spring Valley is a major question being addressed by the TRP. Exhibit A of the Stipulation specifies that a discharge monitoring site be maintained on Big Spring Creek, and a gain/loss study be conducted on the Big Spring Creek / Lake Creek surface water system from the spring orifice to Pruess Lake. The Big Springs Complex extending from the spring orifice through a major portion of Big Spring Creek / Lake Creek is highly altered. The major disturbances are livestock, diversions, development, and nonnative aquatic species.

4.4.2.13 Shoshone Ponds

Systems to be monitored: Ponds, Wetlands, Meadows

Shoshone Ponds is a unique ecosystem due to its creation history and purpose. Shoshone Ponds consists of multiple "ponded" environments, however it was artificially created and water is maintained by a number of artesian wells. Historically, the area was used as a camp for the Civilian Conservation Corps (CCC) in the early-1900s. In 1970, the BLM designated Shoshone Ponds as part of the Shoshone Ponds Natural Area. The area is characterized by a series of six artesian wells and is currently managed by the BLM as a native fish refuge. Currently, one artesian well feeds a series of three man-made ponds within a fenced enclosure while an additional well feeds another pond to the north. The three ponds within the enclosure are commonly referred to as the North, Middle, and South Ponds and the remaining pond is known as the Stock Pond.

Various species of fish including Pahrump killifish (now Pahrump poolfish), Moapa dace (*Moapa coriacea*), and Pahranagat bonytail (now Pahranagat roundtail chub, *Gila robusta jordani*) were transplanted to Shoshone Ponds when construction of the three ponds within the enclosure was completed in 1972. However, due to vandalism, Pahrump killifish and Moapa dace were extirpated in 1974. Pahranagat bonytail were extirpated from the area in 1979. An additional 50 Pahrump killifish were transplanted from Corn Creek in 1976 while a total of 42 relict dace were transplanted from Steptoe Valley in 1977. Currently, the federally endangered Pahrump poolfish reside in the North, Middle and Stock Ponds while the South Pond is home to a population of relict dace (USFWS 2004, Hobbs et al. 2005). Since their last introductions, both species at Shoshone Ponds have experienced only natural fluctuations.

In addition to Pahrump poolfish and relict dace, Shoshone Ponds Natural Area (including all six artesian wells) is home to northern leopard frogs, breeding birds, and bats. Additionally, overflow from Shoshone ponds flows into the valley floor and supports wetland and meadow communities.

4.4.2.14 Swamp Cedar Woodland North and South

Systems to be monitored: Swamp Cedar Woodlands

As discussed in Section 4.3.6, swamp cedar woodlands are low-elevation plant communities dominated by Rocky Mountain juniper, a major conifer of the surrounding higher-elevation pinyon-juniper woodlands. Swamp cedars in Spring Valley are small coniferous trees, generally 5-15 m (16-49 ft) in height. There are two low-elevation populations in the IBMA. The north population is located near South Bastian Spring and covers about 3.5 mi^2. The south population is located in the south-central portion of Spring Valley and covers about 1.5 mi^2.

4.4.2.15 Phreatophytic Shrublands

Systems to be monitored: Phreatophytic Shrublands

Phreatophytic shrublands are shrub-dominated plant communities that require more moisture than is supplied by the average precipitation received in the lowland areas of the IBMA to maintain their characteristic productivity and/or species composition. The typical example in the IBMA is greasewood. Phreatophytic shrublands can also be dominated by other shrubs, such as big sagebrush (*Artemisia tridentata*) and rabbitbrush. In such cases, the shrubs are larger and have greater canopy coverage than big sagebrush or rabbitbrush communities on upland sites. Phreatophytic shrubland monitoring sites will be located in each of the 5 IBMA areas (Fig. 4.5) and be placed relative to hydrological monitoring well locations to the extent practicable.

4.5 KEY ECOLOGICAL ATTRIBUTES (KEAs) AND INDICATORS

As described in Chapter 3, KEAs are characteristics that describe groundwater-influenced ecosystems and potentially are critical to their long-term viability or integrity, including biological composition, interactions, and processes (Parrish et al. 2003). Indicators are measures to assess the KEAs; they are what are actually measured in order to quantify impacts associated with groundwater withdrawals by SNWA. The BWG selected KEAs and indicators based on the following criteria: 1) strongly related to the status of the groundwater-influenced ecosystem and possibly essential to its viability; 2) good indicator of ecosystem health, including those that may provide early warning of adverse impacts due to SNWA groundwater withdrawal; and 3) reasonably feasible and efficient to measure.

The following subsections describe the KEAs and indicators, and discuss why they were selected for monitoring for each groundwater-influenced ecosystem. Chapter 5 generally describes protocols and sampling design for monitoring indicators, and Appendix C presents the detailed protocols. For each groundwater-influenced ecosystem, KEAs and indicators are not always monitored at every site due to unique site characteristics or existing monitoring programs.

The following five KEAs were chosen to represent various groundwater-influenced ecosystems:

- **Water supply**. Water supply describes potential water availability for ecosystem processes.
- **Water quality**. Water quality describes the physical and chemical characteristics of water that can influence biota.
- **Physical habitat**. Physical habitat provides a link between groundwater discharge and biota, and can serve as an early warning indicator of potential adverse effects.
- **Aquatic animals**. Aquatic animals are characteristic fauna that have an intimate tie to the aquatic systems, making them ideal indicators of change from groundwater withdrawal.
- **Vegetation**. Vegetation describes characteristic plant species, communities, and distributions that differ in their sensitivities to groundwater change.

Indicators chosen for monitoring provide quantifiable measures of short-term responses to systemic change, as well as long term viability and integrity of the groundwater-influenced ecosystems within the IBMA. The indicators provide a means to monitor how each system expands or contracts over time, how water availability and quality changes over time, and how the vegetation and animal communities change over time. KEAs and indicators for each groundwater-influenced ecosystem are presented in Table 4-4.

Table 4-4. KEAs and indicators to be monitored for each groundwater-influenced ecosystem.

KEA Indicator	**Spring**	**Ponds (Shoshone)**	**Perennial stream**	**Wetland**	**Meadow**	**Phreat Shrub**	**Swamp cedar**
Water Supply							
Depth to groundwater[1]	x	x	x	x	x	x	x
Discharge	x	x[2]	x[2]				
Water Quality							
Dissolved oxygen	x	x	x	x[3]			
Temperature	x	x	x	x[3]			
pH	x	x	x	x[3]			
Conductivity	x	x	x	x[3]			
Turbidity	x		x				
Total nitrogen	x		x	x[3]			
Total phosphorus	x		x	x[3]			
Physical Habitat							
Qualitative (photos, condition)	x		x				
Maps	x		x				
Substrate composition	x		x				
Areal extent	x			x	x		x
Open water and aquatic vegetation cover	x		x	x			
Water depth	x		x	x			x
Water width	x		x				
Water length	x						
Aquatic Animals							
Macroinvertebrate composition and abundance	x		x				
Springsnail abundance and distribution	x						
Fish age class structure and distribution	x	x	x				
Northern leopard frog egg masses	x	x	x[4]	x[5]			
Northern leopard frog breeding habitat	x	x	x[4]	x[5]			
Vegetation							
Cover and composition	x			x	x	x	x
Pattern of internal heterogeneity					x	x	x
Size and density of mature trees							x
Size and density of saplings and juveniles							x
Stem elongation							x

[1] In cases where direct measurements will not be taken (i.e., other than the piezometers at the spring sites), regional patterns in depth to groundwater will be inferred from the nearest monitoring wells (Fig.4-2).
[2] The TRP will be conducting stream discharge measurements during a gain/loss study on Big Spring Creek / Lake Creek, and will be collecting continuous discharge measurements in Big Springs channels leading to Big Spring Creek. The BLM plans to set the discharge rate for the alluvial wells that create Shoshone ponds.
[3] Water quality measurements will be taken in wetlands only at northern leopard frog breeding habitat transects.
[4] Only if northern leopard frogs are found at the Big Springs Complex during Phase 1 surveys.
[5] Egg mass surveys will be conducted in wetlands where there is standing water adjacent to springs, streams and ponds.

4.5.1 Springs, Ponds (Shoshone), and Perennial Streams

4.5.1.1 KEAs and Indicators

KEAs and indicators chosen for spring, ponds (Shoshone), and perennial stream monitoring are presented in Table 4-4. Due to similarities in their KEAs and indicators, justifications for the selected KEAs (**in bold**) and associated indicators (*in italics*) for the three systems are presented together below.

Water supply. Indicators of water supply are direct and effective measures for quantitatively documenting changes over time. *Depth to groundwater* is a major factor influencing biological composition and productivity as it relates to the potential availability of groundwater to these systems. Local depth to groundwater will serve as an indicator for select springs, while regional patterns in depth to groundwater will be inferred from the nearest monitoring wells for remaining sites. Relationships will be drawn between depth to groundwater and discharge in these systems. *Discharge* quantifies the actual amount of water issuing from springs, from alluvial wells, or along the creek, which is absolutely necessary for the persistence of these systems.

Water quality. Water quality can reveal changing groundwater conditions for the springs, ponds (Shoshone), and perennial streams. Water quality indicators (*temperature, pH, conductivity, turbidity, dissolved oxygen concentration, nitrogen and phosphorus*) are important to plants and animals in these habitats, and can influence the biological integrity of the systems (see Table 4-4 for specific indicators to be monitored in each system). It will be important to understand how their values naturally fluctuate in response to precipitation, weather, and/or other present disturbances, in order to detect meaningful changes due to future SNWA groundwater withdrawal.

Physical habitat. The response time of the physical habitat indicators are often quicker than that of the biotic communities, making them good early warning indicators of potential adverse effects. *Qualitative data (fixed photography, site condition), physical habitat maps, substrate composition, areal extent, open water and aquatic vegetation cover, water depth, water width, and water length* will characterize site conditions in springs and perennial streams (see Table 4-4 for specific indicators to be monitored in each system). These indicators also play important roles for biota. For example, substrate conditions below spring orifices influence the distribution of springsnails and mottled sculpin, and shallow standing water is necessary for northern leopard frog egg laying. These data can be used to establish linkages and develop predictive relationships between abiotic and biotic factors. It may then become possible to use some of the physical measures as surrogates for plant and animal data, if in fact linkages can be quantified and established.

Aquatic animals. The aquatic animal indicators to be monitored in these aquatic systems are *macroinvertebrate composition and abundance* (in springs and perennial streams), *springsnail abundance and distribution* (in springs), *fish size class structure and distribution, and northern leopard frog egg masses and breeding habitat*. These measures have been applied to groundwater-influenced ecosystems in the Great Basin for many years. Macroinvertebrate indices have been used for decades as a measure of water quality (Barbour et al. 1999); Sada (2000, 2005) monitored springsnails and macroinvertebrate communities; and NDOW and

UDWR continue to monitor fish and frog population dynamics and habitat conditions within their respective agencies. Collecting northern leopard frog breeding habitat data where northern leopard frog eggs are lain will provide additional information about site condition, allowing the BWG to potentially establish linkages and develop predictive relationships between breeding habitat and northern leopard frog egg mass occurrence and status.

Vegetation. Monitoring changes in *cover and composition of vegetation* (in springs) will provide insight into ecological responses to changes in groundwater level and outflow, and provide early indication of potential impacts from SNWA groundwater withdrawal. Measuring cover and composition also provides a non-destructive measure that can be used to estimate change in relative importance of individual species and dynamics of the communities overall. These vegetation measurements will also be used to describe and track changes in springsnail, fish, and frog habitat, which can be used to establish linkages and develop predictive relationships between habitat and wildlife. It may then become possible to use some of the physical measures as surrogates for wildlife data, if in fact linkages can be quantified and established.

4.5.1.2 Research and Information Needs

BIO-WEST (2007) indicated that aquatic spring ecosystems without State- or Federal-status species remain under-sampled and, in some cases, un-sampled. Although the surveys conducted by BIO-WEST (2007) provide an inventory of the biological resources in Spring and southern Snake Valleys, even BIO-WEST (2007) acknowledged that this data only represents a single “snapshot” of a spring’s condition at the time the surveys were conducted. Although there is considerable information regarding the general life histories of proposed fish for monitoring and northern leopard frog, in general, actual thresholds for adverse effects are poorly understood. Even less is known regarding springsnail life histories, although recent work by Sada and others has greatly enhanced the knowledge base. In either case, thresholds for physical habitat indicators and the linkages of physical habitat to biotic response have not been established or studied to any degree within the IBMA. Springsnails would be an ideal candidate for specific research activities. Recent work has shown that spring brook length and springsnail distribution and abundance are correlated in springs in Death Valley (Sada and Herbst 2006). Understanding the linkage between available habitat during constricting and expanding conditions and how that affects springsnail populations would provide extremely valuable information to guide decisions relative to adverse effects and threshold conditions. A laboratory setting or possibly an *in situ* experiment within the IBMA (several springs are currently set up with management flexibility) are potential options for consideration. Another potential research effort may be to evaluate how habitat conditions in the fall potentially influence northern leopard frog egg masses during the breeding season. This would evaluate whether seasonal fluctuations in water level affect the breeding success of northern leopard frog.

At this time, our understanding is complicated further by the level of anthropogenic disturbance within the IBMA and thus, the pre-withdrawal monitoring period is necessary to describe ranges of conditions for the various indicators. As the monitoring efforts get started, this IBMA-specific data along with existing data from the Great Basin will be used to develop initial estimates for threshold responses. However, it is likely that several years of data specific to the IBMA will be needed to test the appropriateness and completeness of any preliminary estimates.

Lastly, the extent of natural variation has yet to be determined for all of the sites in question and species of interest. This information will only become available through sampling the various components of a given spring ecosystem multiple times in a highly repeatable manner.

4.5.2 Wetlands

4.5.2.1 KEAs and Indicators

KEAs and indicators chosen for wetland monitoring are presented in Table 4-4. Justifications for the selected KEAs (**in bold**) and associated indicators (*in italics*) are presented below:

Water supply. Wetlands require saturated soils during the growing season. The amount of groundwater available to a wetland system can determine what floral and faunal species it can support, along with the relative abundance of each. *Depth to groundwater* is a major factor influencing vegetation composition and productivity as it relates to the availability of groundwater to various plant species. Regional patterns in depth to groundwater will be inferred from the nearest monitoring wells.

Physical habitat. Changes in *open water and aquatic vegetation cover* in a wetland could signify a change in the supply of and/or depth to groundwater. Furthermore, the *depth of that standing water* influences water temperature regimes, light penetration, types of vegetation present, and habitat zonation for many faunal species. *Areal extent* of the wetland plant communities provides a measure of wetland viability and persistence. Changes in the edges of the meadow community, where it merges with other habitats (i.e., ecotones), can provide an early indicator of the effects of environmental stress. This is because it is on the edges that environmental conditions are marginal and, therefore, changes in tolerance conditions for species are more likely to appear in these ecotones before they affect a response in the community proper (Daubenmire 1968:21). If the areal extent of wetlands change once pumping begins, it will be important to distinguish natural dynamism from potential groundwater withdrawal impacts.

Aquatic biota. *Northern leopard frog egg masses* will provide a good indication of whether a wetland is functioning in a manner that supports organisms dependent on wetlands. Collecting *breeding habitat data where northern leopard frog eggs are lain* will provide information about site condition, allowing the BWG to establish linkages and develop predictive relationships between breeding habitat and northern leopard frog egg mass occurrence and status.

Vegetation. Monitoring changes in *cover and composition of the wetland vegetation* will provide an insight into the ecological responses to changes in water supply and, around springs in particular, to changes in groundwater level and outflow. Because wetland plant species have different water requirements, different root architectures, and different water uptake patterns, changes in water supply affect individual species differently. Measuring cover and composition of the wetland vegetation provides a non-destructive measure that can be used to estimate change in relative importance of individual species and dynamics of the community overall. Monitoring change in cover and composition over time provides a relatively short-term response indicator to environmental stress.

4.5.2.2 Research and Information Needs

The natural variability and the dynamics of these communities are not well understood. Specifically, the extent to which breeding birds and bats depend on the wetland ecosystems of Spring Valley is not known. BIO-WEST (2007) collected information on the presence of northern leopard frog in wetland areas around various springs in Spring Valley, but a complete inventory of leopard frog habitat in Spring Valley has not been performed.

Collection of plant species composition, depth to groundwater, and precipitation data in these wetland ecosystems will provide information to enhance understanding of the ecological responses of these communities over time, and reveal whether additional studies are warranted. Threshold values for each of these indicators are poorly known. Limited data exist from studies in other areas in the Great Basin. While these data can be used to develop initial estimates for threshold responses, data specific to the IBMA is required to test the appropriateness and completeness of these estimates.

4.5.3 Meadows

4.5.3.1 KEAs and Indicators

KEAs and indicators chosen for meadow monitoring are presented in Table 4-4. Justifications for the selected KEAs (**in bold**) and associated indicators (*in italics*) are presented below:

Water supply. Meadows require high water content within their rooting zones. *Depth to groundwater* is a primary variable affecting the productivity and diversity of the meadow communities. Because different plant species have different rooting depths, water requirements, and potential productivities, changes in depth to groundwater can have a profound effect on species composition and productivity. Regional patterns in depth to groundwater will be inferred from the nearest monitoring wells.

Physical habitat. The *areal extent* of the meadow community is influenced, in part, by the amount of water supplied to the community. Because water supplied to the meadows is often partly outflow from the wetland communities, changes in water supply and their areal extent, may occur sooner than changes to the adjacent wetland . Hence, changes in areal extent of the meadows should serve as an early indicator that changes in water supply to the wetland complexes are occurring.

Vegetation. Monitoring change in *vegetation cover and composition* over time provides a relatively short-term response indicator to environmental stress. Because meadow plant species have different water requirements, different root architectures, and different water uptake patterns, changes in water supply affect individual species differently. Therefore, species cover and composition can be altered through changes in depth to groundwater, as can the diversity and persistence of micro-communities and the meadow community as a whole. *Pattern of internal heterogeneity* refers to the distribution patterns of the micro-communities that are included in the larger meadow community. These micro-communities (communities of very limited spatial extent within the matrix of the larger community) exist because environmental conditions change sufficiently within the spatial extent of the larger community that their respective indicator species become locally dominant. The first indicator of depth to groundwater-induced change in the vegetation is likely to be manifested in some of these micro-communities, rather the larger community as a whole.

4.5.3.2 Research and Information Needs

The relationship between depth to groundwater and productivity of meadow communities has been studied at other sites in the Great Basin. Results of these studies can be applied to the IBMA sites. However, results of these studies also indicate that there may be site-specific differences in response patterns. Therefore, data on depth to groundwater, amount of precipitation received, and changes in vegetation cover (by species) should be collected at the IBMA sites. From these data, relationships among these three variables can be better understood and management programs can be developed.

There is a strong relationship between soils and vegetation in many meadow ecosystems and little is known about the specifics of the soil characteristics at the meadow sites to be monitored. Data on the following soil parameters, by horizon, would be helpful in understanding their effects on vegetation at these meadow sites: depth (thickness), texture, bulk density, water-holding capacity, organic matter content, pH, and content of major nutrients (e.g., nitrogen, phosphorus, potassium).

The natural variability in the dynamics of these communities is not well understood. Collection of species composition, depth to groundwater, and precipitation data will provide information necessary to better understand the ecological responses of these communities over time. Threshold values for each of these indicators are poorly known. Limited data exist from studies in other areas in the Great Basin. While these data can be used to develop initial estimates for threshold responses, data specific to the IBMA is required to test the appropriateness and completeness of these estimates.

4.5.4 Phreatophytic Shrublands

4.5.4.1 KEAs and Indicators

KEAs and indicators chosen for phreatophytic shrubland monitoring are presented in Table 4-4. Justifications for the selected KEAs (**in bold**) and associated indicators (*in italics*) are presented below:

Water supply. Phreatophytic shrublands are dependent on the supply of water in excess of what is directly supplied by precipitation. This supplemental water is generally supplied as groundwater, surface runoff, or a combination of the two. If the supply of supplemental water is reduced, the productivity of these communities is likely to decrease, potentially followed by a change in species composition. Regional patterns in *depth to groundwater* will be inferred from the nearest monitoring wells.

Vegetation. Monitoring change in *cover and composition of the phreatophytic shrubs and their understory* over time provides a relatively short-term response indicator to environmental stress. Because phreatophytic shrubland plant species have different water requirements, different root architectures, and different water uptake patterns, changes in water supply affect individual species differently. Therefore, species cover and composition can be altered through changes in depth to groundwater, as can the diversity and persistence of micro-communities and the phreatophytic shrubland community as a whole. *Pattern of internal heterogeneity* refers to the distribution patterns of the micro-communities that are included in the larger phreatophytic shrubland community. These micro-communities (communities of very limited spatial extent within the matrix of the larger community) exist because environmental conditions change sufficiently within the spatial extent of the larger community that their respective indicator species become locally dominant. The first indicator of depth to groundwater-induced change in the vegetation is likely to be manifested in some of these micro-communities, rather the larger community as a whole.

4.5.4.2 Research and Information Needs

The relationship between depth to groundwater and the productivity of greasewood communities has been studied at other sites in the Great Basin. Results of these studies can be applied to the sites in the IBMA. However, results of these studies also indicate that there may be site specific differences in these response patterns. Therefore, data should be collected at these sites in the IBMA on depth to groundwater, amount of precipitation received, and changes in vegetation cover. From these data, relationships among these three variables can be better understood and management programs based on these data can be developed.

The natural variability in the dynamics of these communities is not well understood. Collection of species composition, depth to groundwater, and precipitation data will provide information necessary to better understand the ecological responses of these communities over time. Threshold values for each of these indicators are currently poorly known. Limited data exist from studies in other areas in the Great Basin. While these data can be used to develop initial estimates for threshold responses, data specific to the IBMA is required to test the appropriateness and completeness of these estimates.

4.5.5 Swamp Cedars

4.5.5.1 KEAs and Indicators

KEAs and indicators chosen for swamp cedar monitoring are presented in Table 4-4. Justifications for the selected KEAs (**in bold**) and associated indicators (*in italics*) are presented below:

Water supply. Swamp cedar communities are dependent on a supply of water in excess of what is directly supplied by precipitation. This supplemental water may be supplied by groundwater, subsurface flow from adjacent wetlands, subsurface flow from adjacent wetlands, or some combination. If the supply of supplemental water is reduced, the productivity of these communities is likely to decrease. Regional patterns in *depth to groundwater* will be inferred from the nearest monitoring wells.

Physical habitat. The presence and *depth of standing water* likely influences the dynamics of the understory vegetation of the swamp cedar woodlands, and perhaps the dynamics of seedling, juvenile, and mature cedars. *Areal extent* of the swamp cedar woodlands provides a measure of viability and persistence. If the areal extent of swamp cedar woodlands change once pumping begins, it will be important to distinguish natural dynamism from potential groundwater withdrawal impacts.

Vegetation. A change in depth to groundwater, or a change in amount of surface or subsurface water flow from adjacent areas, is likely to result in a change in species *cover and composition* in the swamp cedar woodlands. Deeper-rooted species (e.g., shrubs and trees) are likely to respond more to changes in deeper soil moisture, while shallower-rooted understory species (e.g., grasses) are more likely to respond to changes in soil moisture contents in the upper soil profile. The understory of the swamp cedar woodlands forms a gradient from upland species to species characteristic of wetlands and meadows, likely the result of a corresponding gradient in depth to groundwater or surface or subsurface flow. While the shorter-lived shrubs and grasses may respond more rapidly to short-term changes in environmental conditions, canopy cover of both the cedars and associated understory species can be relatively rapidly affected by moisture stress.

As species cover and composition can be altered through changes in depth to groundwater, so can the diversity and persistence of micro-communities. *Pattern of internal heterogeneity* refers to the distribution patterns of the micro-communities that are included in the larger swamp cedar woodlands. These micro-communities (communities of very limited spatial extent within the matrix of the larger community) exist because environmental conditions change sufficiently within the spatial extent of the larger community that their respective indicator species become locally dominant. The first indicator of depth to groundwater-induced change in the vegetation is likely to be manifested in some of the understory micro-communities, rather the larger community as a whole.

Tree numbers and densities determine in part the pattern of internal heterogeneity and, thus, structural integrity of the swamp cedar woodlands. For example, a few large trees does not provide the same structural basis for the ecosystem as does a larger number of smaller trees even if the total canopy cover is the same. *Density of mature trees* is a measure of the status of the cedar populations.

Density of saplings and juveniles is ecologically important for two reasons. Firstly, sapling and juvenile individuals of a species are generally more susceptible to environmental stressors than are mature individuals. Secondly, for a population to remain viable, it must successfully reproduce. For these two reasons, change in density of saplings and juveniles should provide an indicator of potential adverse impacts from groundwater withdrawal by SNWA at both medium-term and long-term scales.

Stem elongation can be closely associated with relatively short-term shifts in physiological response in the cedars. Stem elongation is a function of short-term growth and as such is sensitive to short-term fluctuations in resource supply, especially supply of water. Changes in water supply are more likely to be manifested in stem growth rates than in changes in sapling or mature tree density or canopy cover. Therefore, stem elongation is much more of an early indicator of stress on the trees and is either density or canopy cover.

4.5.5.2 Research and Information Needs

The amount of groundwater utilized by the cedars and the source of this water is important to the management of this plant community and to the prediction of potential impacts of groundwater withdrawal on the community. It is assumed that the cedars access substantial amounts of groundwater with the most likely source a perched water table. Both assumptions are logical but unproven. A critical research need is to determine the importance of groundwater, both amount and source, to this plant community.

Source of groundwater used by the cedars can be determined by an isotope study. A shallow monitoring well can be established within the spatial footprint of each population. Soil water samples can be collected from these wells and analyzed for stable isotopes of oxygen and hydrogen. This will provide isotopic signatures of shallow soil moisture, deep soil moisture, perched groundwater (if it exists), and groundwater if it is within the rooting depth of the cedars. Isotopic signatures can also be collected from other nearby water sources, such as springs, streams, and seasonal precipitation. These signatures can be compared to isotopic signatures of the xylem water in the plants to determine likely sources of water being transpired by the cedars.

If a perched water table is detected, its depth and spatial extent can also be determined. Isotopic signatures of its water and the surrounding potential water sources can be compared to determine the likely source of water in the perched water table.

Root architectures should be determined for the cedars in order to determine maximum potential rooting volume and potential water supply pool. Extensive root trenching studies can be conducted on nearby upland populations of Rocky Mountain juniper and these results compared to more limited and less intrusive studies from the lowland populations.

Data from the pre-operation monitoring period can be used to estimate some natural range in values for the indicator variables. It is unlikely that the natural range in these values encountered during the 7-year pre-withdrawal monitoring period will be sufficient to determine thresholds for these indicators. However, these data combined with simulation modeling (Chapter 6) may provide a useful tool to estimate these threshold values.

5.0 MONITORING APPROACH

CONTENTS

5.1 Water Supply and Water Quality
5.2 Physical Habitat of Aquatic Ecosystems
5.3 Open Water and Aquatic Vegetation Cover
5.4 Macroinvertebrate Composition and Richness
5.5 Springsnail Abundance and Distribution
5.6 Fish Age/Size Class Structure and Distribution
5.7 Northern Leopard Frog Egg Mass Counts
5.8 Species Cover and Composition of Aquatic Vegetation
5.9 Cover and Composition of Non-Aquatic Vegetation
5.10 Vegetation Measurements in Swamp Cedar Communities
5.11 Stem Elongation in Swamp Cedar Communities
5.12 Additional Considerations
5.13 Summary of Sampling Schedule and Activities

As discussed in Chapter 3, the development of KEAs and indicators for groundwater-influenced ecosystems was aided by the CAP process. The selection process and rationale for determining sites, nested targets, KEAs, and indicators are described in Chapter 4. Subsequently, monitoring protocols (protocols) were developed by the BWG to measure each indicator or suite of indicators. Chapter 5 describes the target population, sampling design, monitoring sites, and statistical analysis for data collection for each indicator. Detailed monitoring protocols for each indicator, and protocols for training, safety, and avoidance of transfer of nuisance species are presented in Appendix C.

The goal of protocol development and implementation is to establish a highly repeatable methodology that allows a quantifiable assessment of the indicators. The value of a protocol is largely dependent upon repetitive sampling over many sampling events. Repetitive sampling allows the accumulation of trend data associated with many of the species and habitat types directly dependent upon the target systems. The accumulated data gives perspective and will assist the BWG to understand and distinguish both natural and anthropogenic changes in groundwater-influenced ecosystems. All in all, this protocol should facilitate the collection of unbiased information regarding natural fluctuations of the physical, chemical, and biological aspects of chosen groundwater-influenced ecosystems in a cost-effective manner and should facilitate ascertainment of future impacts to those ecosystems.

During protocol development, focus was placed on building upon existing monitoring programs and evaluating established methods that have been conducted recently by various BWG entities within the IBMA. In each case, presently-employed protocols were evaluated and assessed as to whether or not the type and level of effort associated with existing monitoring programs were sufficient to meet the biological monitoring goals and objectives (Chapter 2) of the Stipulation. The aim of this Plan is not to replace existing monitoring programs, but rather to supplement them where deemed necessary. State and federal scientific collection permits will be required for many of the biological collections associated with the Plan.

The following sections describe the components listed below for each indicator proposed for monitoring within the IBMA:

- sampling objectives
- sample design
  - sampling unit
  - sample size
  - sampling frequency
- monitoring sites, and
- statistical analysis.

As described in Chapter 4, several indicators overlap between groundwater-influenced ecosystems and will be noted as such in the following discussion. A summary of proposed sampling activities, sites, and schedules is provided at the end of this chapter.

Access to private property will be coordinated with the property owner. Sampling on private property will be dependent on the granting of access by the property owner. If access is denied, the BWG will attempt to locate alternative sites.

5.1 WATER SUPPLY AND WATER QUALITY

The target population is comprised of all groundwater-influenced ecosystems within the IBMA that have been selected for monitoring. There is a need to obtain regular, long-term depth to groundwater, discharge, and water quality parameter information at springs, ponds (Shoshone), and perennial streams within the IBMA, as well as regional depth-to-groundwater information for wetlands, meadows, phreatophytic shrublands, and swamp cedar woodlands. The BWG will monitor water quality (and discharge if feasible) during site visits, and the TRP will monitor depth to groundwater, corresponding spring head level (if feasible), discharge, and water quality on a continual or periodic basis.

The TRP has a specific responsibility to measure depth to groundwater, discharge, and water quality at certain sites, which will provide a strong link between TRP and BWG proposed activities. Of the sites where biological monitoring will take place, the TRP will monitor local depth to groundwater using piezometers at 11 spring sites (Fig. 4-1). Depending on site condition and feasibility, SNWA may also take additional spring discharge (method dependent on site) or spring pool elevation (using staff gages) measurements at TRP spring sites. Additional hydrological studies will be conducted by the TRP at Cleve Creek (stream discharge, Spring Valley) and the Big Springs Complex (spring and stream discharge, gain/loss study, Snake Valley). Exhibit A of the Stipulation also specifies that the TRP will monitor groundwater elevation in existing and new wells spatially distributed across the valley, as well as between future pumping wells and existing water rights and federal resources, and in future SNWA exploratory and production wells (Fig. 4-2). Additionally, the TRP will be developing a water chemistry sampling program for 40 spring, stream, and monitoring well sites within the hydrological monitoring network. This program is described in Exhibit A of the Stipulation and includes a suite of field parameters, major ions, isotopes, and metals.

The BWG has designed protocols to supplement the information already being collected by the TRP and will coordinate closely with the TRP to ensure the availability of all pertinent water quantity and quality data during biological data interpretation. The following sections describe the objectives and sample design for collecting this supplemental information as part of the Plan.

5.1.1 Specific, Measurable Sampling Objectives

General sampling objectives include consistently measuring water supply and water quality in the groundwater-influenced ecosystems. Within each of these broad sampling objectives, specific objectives have been identified. These include measuring depth to groundwater, corresponding spring head level (if feasible), the amount of water issuing from springs, and discharge in spring brooks and perennial streams. Water quality parameters to be measured are: dissolved oxygen (DO), conductivity, pH, temperature, turbidity, total nitrogen, and total phosphorus.

5.1.2 Sampling Design

For this effort, each water body selected for monitoring is a sample unit. For terrestrial communities (i.e., wetlands, meadows, phreatophytic shrublands, swamp cedars), the specific plant community designated for monitoring is the sample unit. Measurements at these sampling units may include depth to groundwater, flow, corresponding spring head level (if feasible), and water quality parameters (Table 5-1). Depth to groundwater will be measured locally with piezometers or regionally with nearby groundwater monitoring wells; discharge will be measured with flow meters, flumes, USGS gages, or some other method to be determined; and corresponding spring head level may be measured with staff gauges (depending on site condition and feasibility). Standard water quality parameters will be measured with a water quality multi-probe (i.e. Hydrolab or similar device) and fixed station temperature loggers. Additional water quality parameters (nitrogen and phosphorus) will be measured with composite grab samples at the spring orifices. Each individual measurement will constitute its own data point that provides its own information – all of which will be tracked over time on an individual parameter by parameter basis.

The sample size and schedule for water supply and water quality measures will vary based on sampling method. Piezometers at spring sites and discharge monitoring equipment on Big Springs channels leading to Big Spring Creek (implemented by the TRP) will allow continuous recording of the sites, yielding a large sample size over time. For spring and perennial stream sites that have flowing water, discharge measurements will be taken each time a site is visited for biological sampling (to the degree possible—this measurement is not practical at certain sites).

For water quality, temperature loggers will be placed at BWG spring sites for continuous measurement (Table 5-1). The remaining standard water quality parameters will be monitored by the BWG during each biological sampling effort. Standard water quality parameters as proposed for biological monitoring will consist of one sample in time per spring, pond, and stream per visit. However, this one sample may consist of multiple sample locations within that spring, pond, or stream (detailed description in Appendix C.1). For example, in a defined rheocrene, a minimum of one standard water quality suite of measurements will be taken at the spring orifice, midpoint of the spring brook, and terminus of the spring brook. Big Spring

Creek/Lake Creek, measurements will be conducted within the defined reaches discussed in the fish sampling section (Section 5.6). The sample size for total nitrogen and total phosphorus measurements will be two composite grab samples per site visit, one taken at the spring orifice and one taken near the terminus. The sample size for all other water chemistry samples will be dependent on the TRP implementation and interpretation of Exhibit A of the Stipulation.

5.1.3 Monitoring Sites

Water supply data will be collected for all groundwater-influenced ecosystems, and water quality data will be collected at springs, ponds (Shoshone), and perennial streams (and at northern leopard frog breeding transects in wetlands). Data collection will be conducted at sites selected for monitoring within the IBMA as described in Table 5-1.

Table 5-1. Water supply and water quality monitoring sites.

Monitoring Site	Depth to Groundwater[1]	Discharge[2]	Water Quality[3]
Stonehouse Spring Complex	Piezometer		BWG
Willow Spring	Piezometer	Flow meter	BWG
Keegan Ranch Spring Complex	Piezometer	Flow meter	BWG
West Spring Valley Complex	Piezometer		BWG
South Millick Spring	Piezometer	Flow meter	BWG
Unnamed Spring 5	Piezometer	Flow meter	BWG
4WD Spring	Piezometer		BWG
Willard Spring	Nearby well		BWG
Swallow Spring	Piezometer	Flume[4]	BWG
Minerva Spring Complex	Piezometer	Flow meter	BWG
Clay Spring - North	Nearby well		BWG
Unnamed 1 – North of Big	Nearby well		BWG
North Little Spring	Nearby well		BWG
Shoshone Ponds	Nearby well	Set discharge rate[4]	NDOW[5]
Big Springs Complex Big Spring Creek / Lake Creek Big Springs Stateline Springs	 Nearby well Nearby well	 USGS gage[4], flow meter[6] USGS gage[4] Flow meter	 BWG, TRP[6]
The Seep	Piezometer		
Blind	Piezometer		
Burbank			
Swamp Cedar Woodland (Middle)	Nearby well		
Swamp Cedar Woodland (South)	Nearby well		
Greasewood/Rabbitbrush	Nearby well (if possible)		

[1] To correlate groundwater elevation in piezometers,to spring head level, staff gauges may be placed in springs depending on site condition and feasibility.
[2] Measured where and when practical.
[3] BWG water quality parameters: dissolved oxygen, temperature, pH, conductivity, turbidity, total nitrogen, total phosphorus, and water temperature. TRP will also be collecting water chemistry measurements at 40 still-to-be determined sites per Exhibit A of the Spring Valley Stipulation.
[4] TRP continuous measurements at Swallow Spring and at Big Springs channels leading to Big Spring Creek / Lake Creek. The BLM plans to set the discharge rate for the alluvial wells that create Shoshone ponds.
[5] Standard water quality sampling conducted by NDOW during fish sampling in the ponds.
[6] TRP gain/loss study on Big Spring Creek / Lake Creek.(BWG will also be collecting stream discharge measurements during biological surveys).

5.1.4 Statistical Analysis

The three objectives of the statistical analysis of water supply and water quality data are: 1) delineating and tracking water supply and water quality throughout the IBMA, in order to monitor those variables that influence the biology of each groundwater-influenced ecosystem; 2) monitoring any alterations in water supply and water quality that may be attributed to anthropogenic activities; and 3) evaluating consistency with historical water supply and water quality information as well as potential effects of climate change. Due to sample size and frequency, sampling activities that occur only during biological monitoring site visits will provide informational data at first, then progress to trend data over time. Over time, differences between seasons (seasons refers to periods sampled, typically spring and fall) for these parameters will be evaluated by comparing data from combined sampling events by season across multiple sampling years. There will likely be differences by season, so an assessment of annual differences will be conducted by looking across annual sampling events within each of the seasons when sampling occurs. Statistical analysis to test differences between the seasons and sites tested for the continuous data collection parameters (depth to groundwater, discharge, and water temperature) will be conducted. The continuous data collection and larger data sets will allow for more robust statistical analysis.

5.2 PHYSICAL HABITAT OF AQUATIC ECOSYSTEMS

The target population is comprised of five of the groundwater-influenced ecosystems (springs, perennial streams, wetlands, meadows and swamp cedar woodlands), with particular emphasis on springs and perennial streams. Physical habitat measurements of the latter ecosystems are of particular importance to nested targets. As discussed in Chapter 4, physical habitat is the link between discharge and biota that is often overlooked in monitoring programs, yet the response time of physical habitat is often less than that of animal communities, making physical habitat a good early warning indicator of potential adverse effects. The described physical habitat measurements provide an actual, direct measure of condition at a given aquatic ecosystem. This condition can be compared over time to assess potential impacts from SNWA groundwater withdrawal. The physical habitat data can also be used to evaluate correlations to the biological monitoring indicator data in order to establish linkages and develop predictive relationships between habitat and biota. Once these relationships are established, it may be possible to use some of the physical habitat measures as surrogates for biological data, thereby improving monitoring efficiency. The physical habitat measurements will also guide sampling protocols for other indicators.

5.2.1 Specific, Measurable Sampling Objectives

The general sampling objective for physical habitat measurements is to quantitatively describe each ecosystem proposed for monitoring over time. Specific objectives include:

- general physical habitat description;
- comprehensive physical habitat characterization adequate to characterize aquatic nested target (or indicator species in the case of Toquerville springsnail) habitat use and selection, to be conducted

- o within the spring orifice and spring brook extent that supports springsnails per given sampling effort,
- o within the designated sampling areas (Appendix C.6) for relict dace observed at Stonehouse and Keegan Ranch springs complexes, and
- o within the selected reaches in Big Springs Complex selected for fish sampling.

5.2.2 Sampling Design

Various physical habitat measures (substrate composition, areal extent, open water and aquatic vegetation cover (discussed in Section 5.3), water depth, water width, and water length) will be collected at groundwater-influenced ecosystems as described in Chapter 4 (see Table 4-4 for specific indicators to be monitored in each system). Each individual measurement will constitute its own data point that provides its own information and has the potential to be individually tracked over time. These physical habitat indicators will also be combined for analysis purposes to examine biota responses to sets of variables.

For springs and perennial streams, additional physical habitat measures (fixed photography, spring brook length, and site condition) will be used to describe the general habitat condition during each sampling event. The level of characterization increases at those sites that support springsnails and fish. Physical habitat delineations will be based on hydro-morphological unit, depth, flow, vegetation, and possibly substrate as described in Appendix C.2. From this information, physical habitat maps will be created for the purpose of designing sampling points and transects related to nested targets, and to create spatial images that may be analyzed over time.

At springs with springsnails, the longitudinal extent of springsnails will be determined per sampling event. Once determined, a comprehensive physical habitat characterization will be completed for the entire extent of the springsnail distribution with the downstream limit extended by 10 meters, or within the designated sample area (Appendix C.2). At springs and streams with fish (Stonehouse and Keegan Ranch Springs complexes and Big Springs Complex) a comprehensive habitat assessment will also be performed. For Stonehouse and Keegan Ranch Springs, the extent of the area for this comprehensive mapping will consist of the designated sample areas shown in Appendix C.2 (Figures C-2 and C-3, respectively). The designated sample areas include a diversity of habitat types that are representative of the larger complexes and are areas where fish have historically been collected. For Big Springs Complex, each selected reach as described in Section 5.6.2 will be mapped.

5.2.3 Monitoring Sites

Physical habitat measures will be collected in all groundwater-influenced ecosystems except for the ponds at Shoshone Ponds (to diminish disturbance to the site) and phreatophytic shrublands. Spring and perennial stream monitoring sites will be characterized by additional suites of physical habitat measures, as described in Table 5-2.

Table 5-2. Physical habitat characterization: spring and perennial stream monitoring sites.

Monitoring Site	General Characterization	Comprehensive (Nested Target Habitat) Characterization
Stonehouse Spring Complex	√	Springsnails, Fish
Willow Spring	√	Springsnails
Keegan Ranch Spring Complex	√	Fish
West Spring Valley Complex	√	Springsnails
South Millick Spring	√	
Unnamed Spring 5	√	Springsnails
4WD Spring	√	
Willard Spring	√	
Swallow Spring	√	
Minerva Spring Complex	√	Springsnails
Clay Spring-North	√	Springsnails
Unnamed 1 – North of Big	√	Springsnails
North Little Spring	√	
Big Springs Complex		
Big Spring Creek / Lake Creek	√	Fish
Big Springs	√	Springsnails, Fish
Stateline Springs	√	Springsnails, Fish

5.2.4 Statistical Analysis

The BWG proposes bi-annual (twice per year) sampling for these parameters in order to minimize disturbance in these sensitive ecosystems. Thus, the limited sample size and frequency will provide informational data at first, then later progress to trend data. Over time, seasonal differences for these parameters will be evaluated by comparing data from combined sampling events by season across multiple sampling years. There will likely be differences by season so an assessment of annual differences will be conducted by looking across annual sampling events within each of the seasons when sampling occurs. Statistical analysis for independently relating habitat types to discharge, water quality, and aquatic biota will consist of repeated measures analysis of variance (ANOVA) or similar method to test for differences. Interactions among variables may be examined using multivariate statistics.

5.3 OPEN WATER AND AQUATIC VEGETATION COVER

There are three target populations at each monitoring site that has permanent water: 1) emergent aquatic vegetation, 2) submerged aquatic vegetation, and 3) open water. Open water is defined as that portion of the aquatic system where standing water is present but no vegetation extends above the water surface. Emergent aquatic vegetation is vegetation with some stems or leaves above the water surface. Submerged aquatic vegetation is vegetation with all stems and leaves below the water surface. The amounts of all three populations will be dynamic for a number of reasons: supply of water to the aquatic system, water loss from the system (outflow and evapotranspiration), changes in cover (amount) of emergent vegetation, growth dynamics and life cycles of the various species, water level, season of the year, use of the vegetation by fauna, and impacts from other stressors such as disease and climatic extremes.

5.3.1 Specific, Measurable Sampling Objectives

The objectives for this indicator are to 1) sample the amount of vegetation and the amount of open water in each monitored spring, stream, and permanent wetland, and 2) monitor changes in the relative amounts (i.e., proportion of emergent and submergent or proportion of emergent and open water) of each of these components.

5.3.2 Sampling Design

The sampling units will be line-point transects. Each line-point transect will be permanently marked by placing metal stakes at both ends of the transect, and will extend across the entire width of the aquatic system plus 2 meters past the water edge at both ends of the transect. Should the aquatic system expand past the 2-m extensions during the monitoring period, the affected transects will be extended to a point at least 2-m past the new high-water mark. These will be the same transects as those used to measure Cover and Composition of Aquatic Vegetation (Section 5.8). If possible and appropriate, these transects will be continuous with those used to measure Cover and Composition of Non-Aquatic Vegetation in adjacent groundwater-influenced ecosystems (Section 5.9).

A tape measure, marked at 1-cm intervals, will be placed between the starting and ending stakes as close to the water surface as possible. At each 1-cm mark on the tape, ocular counts will be made for 1) presence of emergent vegetation at that point, 2) presence of submerged vegetation at that point, or 3) absence of vegetation at that point. Data will be collected at 1-cm intervals and summed at 1-m intervals along the tape, beginning at the water edge and extending across the aquatic system. Amount of aquatic vegetation will be expressed as a proportion of the surface of the aquatic system and will be calculated as the total number of hits (1-cm marks) at which vegetation was present divided by the total length (in centimeters) of the transect. Amount of open water will be calculated as the total number of hits (1-cm marks) at which standing water was present but where emergent vegetation was not present, divided by the total length (in centimeters) of the transect.

Sample size (i.e., number of transects per aquatic system being monitored) will depend on the spatial extent and the heterogeneity of the aquatic system. There will be a minimum of five permanent line-point transects per aquatic site, if appropriate. The transects will be stratified-randomly located in the following manner. The spatial footprint of the aquatic system will be divided into approximately equal segments. One transect will be randomly located in each of the segments. Each transect will extend across the aquatic system perpendicular to the longest axis of the aquatic system.

Each transect will be monitored once per year during the Pre-Withdrawal Phase. Sampling will be conducted during the summer season, which is expected to correspond to the peak of the growing season of the vegetation and the period of lowest surface water level.

5.3.3 Monitoring Sites

This indicator will be sampled at all springs, perennial streams and wetlands proposed for biological monitoring.

5.3.4 Statistical Analysis

All data will be summarized for each variable (emergent vegetation, submerged vegetation, total aquatic vegetation, open water) by transect and by monitoring site. Three statistics (mean, standard deviation, and 95% confidence interval of the mean) will be calculated for each variable and will be compared among years to detect patterns of change over time.

Multivariate statistical analysis (stepwise discriminant analysis) will be used to test the statistical significance of differences over periods of greater than two years. At each monitoring site, data for all three variables will be entered into the analysis and grouping initially by transect (observation) and by year (group). The discriminant analysis will then be used to determine statistically-significant changes among years, and which variables and transects (spatial locations) are associated with the changes if such changes are significant.

Recording data at 1-m intervals will allow patterns of change to be detected and monitored. The values for each of the three variables at each 1-m interval will be compared among years to detect changes over time. Statistical significance of these changes will be determined using a second discriminant analysis. In this analysis, each 1-m segment will be considered an observation. Segments with similar water depths will be grouped together within years. The discriminant analysis will then be used to determine which groups and which observations within groups are statistically different among years.

5.4 MACROINVERTEBRATE COMPOSITION AND RICHNESS

The target population will be the macroinvertebrate communities at all sites that maintain springsnails, fish, or northern leopard frog, with the exclusion of the ponds at Shoshone Ponds (to diminish disturbance to the site), and the additional inclusion of Swallow Spring (because of its diverse macroinvertebrate community with several intolerant species). Among the sites selected for monitoring, springs that do not maintain aquatic nested targets support low macroinvertebrate diversity and highly tolerant species (excepting Swallow Spring). When further stressed, these systems often continue to maintain communities of highly tolerant species and, in some cases, chironimid abundance actually increases. As a shift to a more diverse or intolerant assemblage is not anticipated at these sites, the use of macroinvertebrates as indicators is more limited. Thus, macroinvertebrate sampling will not be conducted at 4WD Spring, Willard Spring, or North Little Spring.

At the sites with diverse communities that support several intolerant species, monitoring the macroinvertebrate community can provide information on changes in water quality and habitat, as well as serve as an index for the quantity and quality of resources available for other aquatic biota. Such information can then be used to determine if there are any impact-related changes to aquatic ecosystems and can help identify what types of adaptive management and/or mitigation activities are needed to maintain or enhance existing aquatic conditions. Monitoring the health of the macroinvertebrate community can also help to ensure that spring habitat conditions maintain biological integrity over time.

5.4.1 Specific, Measurable Sampling Objectives

The sampling objective for macroinvertebrate monitoring is to ascertain the seasonal and annual variation in macroinvertebrate assemblage composition and richness over time. More specifically, there exists a need to monitor the assemblages of aquatic macroinvertebrates throughout the various spring's ecosystems within the IBMA to determine seasonal baseline richness and relative abundance values of the aquatic macroinvertebrate communities at each spring. Potential changes in macroinvertebrate abundance and species composition would allow for the assessment of linkages between changes in habitat and water quality conditions.

5.4.2 Sampling Design

The sample design for benthic macroinvertebrates will follow the EPA rapid bioassessment approach for multi-habitat assessments (Barbour et al. 1999). The sampling unit is the macroinvertebrate community collected with a small modified aquarium net in small springs or a D-frame net in larger springs or streams. Regardless of the length or complexity of the spring, a single composite sample will be taken from each spring or stream reach selected for monitoring. Therefore, the sample size will consist of one composite sample per spring or stream reach per sampling event. For valley floor and range front springs there will be two sample events per year (spring and fall). The five reaches of the Big Springs Complex will be sampled on an annual basis in conjunction with fish sampling. Whether within a spring system or stream reach, all available habitats will be sampled in a systematic procedure based on the proportion of available habitat as described in Appendix C.4.

5.4.3 Monitoring Sites

Aquatic macroinvertebrates will be collected at the springs and perennial streams selected for monitoring within the IBMA as described in Table 5-3. Identification will be made at the lowest taxon practical.

Table 5-3. Aquatic macroinvertebrate monitoring sites.

Monitoring Site	Sample Location
Stonehouse Spring Complex	Designated sample area
Willow Spring	Entire area
Keegan Ranch Spring Complex	Designated sample area
West Spring Valley Complex	Designated sample area
South Millick Spring	Entire area
Unnamed Spring 5	Entire area
Swallow Spring	Entire area
Minerva Spring Complex	Designated sample area
Clay Spring-North	Entire area
Unnamed 1 – North of Big	Entire area
Big Springs Complex	
Big Spring Creek / Lake Creek	In each of the five reaches
Big Springs	Designated sample area
Stateline Springs	Designated sample area

5.4.4 Statistical Analysis

Statistical analysis will focus on the macroinvertebrate taxa and estimates of taxonomic richness and relative abundance of dominant taxa. Several commonly used metrics will be selected to look for differences within and between sites sampled. Repeated measures ANOVA or a similar method will be used to test for differences within and among sites as needed and, where appropriate, Tukey's multiple comparison tests may also be used to compare all differences between means. Multivariate techniques (e.g., stepwise discriminant analysis) will be used to analyze differences in the selected metrics within and among sites over seasons and years.

5.5 SPRINGSNAIL ABUNDANCE AND DISTRIBUTION

The target population will be the springsnail communities at the proposed monitoring sites in the IBMA that have been found to contain springsnails. Springsnails should be closely monitored during the Pre-withdrawal and Withdrawal Phases for the following reasons provided by Sada (2000): 1) they are unable to live outside of the aquatic environment; 2) they are restricted to persistent springs with good water quality that are minimally affected by drought; 3) their demography in unaltered habitats indicates that population variation may be predicable; 4) they occur in small habitats that can be easily sampled; and 5) their populations are susceptible to comparatively rapid changes in abundance and distribution in response to changes in habitat conditions (e.g. both surface water diversions and groundwater use).

Springsnails are found throughout the IBMA. They are found in north and central Spring Valley and southern Snake Valley. One species is found throughout Spring Valley and two species are present in southern Snake Valley. Although no two springs are identical, their spatial distribution and species representation should prove a valid means of replication or reference over time. As Pre-Withdrawal data are collected and analyzed, the BWG will investigate whether additional applied research on springsnails may provide valuable information during plan implementation.

5.5.1 Specific, Measurable Sampling Objectives

There are three sampling objectives for springsnails: 1) to monitor the seasonal and annual variation in springsnail abundance; 2) to monitor the spatial distribution of springsnails within each spring of interest; and 3) to describe any habitat associations or variables that may be governing springsnail abundance and/or distribution within springs.

5.5.2 Sampling Design

The sampling unit is the springsnail population occurring within each spring identified for sampling. Collection of springsnails along equally spaced transects (covering the extent of springsnail distribution or designated sample area) will allow for the estimation of their abundance per unit of area (see Appendix C.5 for details). Up to twenty equidistant transects will be established for the extent of the springsnail distribution when feasible. Springsnail searches and detailed habitat characterization will be conducted at five samples across each transect. Springsnail sampling will be conducted twice per year (spring and fall) during the initial two years of monitoring after which, the data collected up to that point will be evaluated to determine if monitoring may be reduced to annual sampling.

5.5.3 Monitoring Sites

Springsnails will be collected at springs selected for monitoring within the IBMA as described in Table 5-4.

Table 5-4. Springsnail monitoring sites.

Monitoring Site	Sample Area
Stonehouse Spring Complex	Extent of springsnails in designated sample area
Willow Spring	Extent of springsnails
West Valley Spring Complex	Extent of springsnails in designated sample area
Unnamed Spring 5	Extent of springsnails
Minerva Spring Complex	Extent of springsnails in designated sample area
Clay Spring-North	Extent of springsnails
Unnamed 1 – North of Big	Extent of springsnails
Big Springs Complex	
Big Springs	Extent of springsnails in designated sample area
Stateline Springs	Extent of springsnails in designated sample area

5.5.4 Statistical Analysis

The number of springsnails observed within each habitat type and at each transect will be recorded. It will then be possible to determine how the distribution and spatial extent of springsnails within a given spring contracts and expands over time. A maximum-likelihood analysis may be used to estimate abundance (Van Deventer and Platts 1985). Because multiple samples will be conducted within each habitat type and at each transect during each of the sampling events, repeated measures ANOVA or a similar method may be used to evaluate differences in catch. In addition, regression analysis may also be used to assess how potential changes in water quality and physical habitat influence springsnail populations. Over time, the collection of this site-specific habitat, water quality and velocity information should lend itself to the development of suitability criteria for the respective springsnail species. Future activities could include modeling discharge changes to predict springsnail response within a given spring system.

5.6 FISH AGE/SIZE CLASS STRUCTURE AND DISTRIBUTION

The target population is the fish community at all sites containing fish within the IBMA. BIO-WEST (2007) did not sample Shoshone Ponds because NDOW conducts regular monitoring within the Shoshone Ponds complex (NDOW protocols for Shoshone Ponds are included below). NDOW has confirmed that annual sampling will continue, so no additional sampling is proposed under the Plan for either relict dace or Pahrump poolfish at Shoshone Ponds. NDOW data will be incorporated in the annual reports. Utah chub present at the Minerva Complex will not be included as a nested target for this Plan because it is an introduced species to Spring Valley and it does not have special status in Nevada. Therefore, the target populations for this indicator are 1) relict dace populations at Stonehouse, Keegan Ranch, and Shoshone Ponds (NDOW sampling only), 2) Pahrump poolfish at Shoshone Ponds, and 3) Utah chub, speckled dace, redside shiner, mottled sculpin, and Utah sucker in the Big Springs Complex.

5.6.1 Specific, Measurable Sampling Objectives

There are three sampling objectives related to fish age class structure and distribution: 1) to provide information regarding the recruitment patterns of fish within a given spring or stream, 2) to evaluate annual, seasonal, and habitat conditions conducive to recruitment and growth of the fish population within a given spring or stream, and 3) to assess the spatial extent and habitat use of fishes present within a given system over time. Additionally, population estimates for relict dace and Pahrump poolfish will continue to be provided through NDOW annual monitoring.

5.6.2 Sampling Design

The sample unit will be each fish population occurring within the springs or stream reaches that have been selected for sampling. Five representative reaches 100 meters long will be selected in the Big Springs Complex: one reach originating from the Big Springs spring head(s), two reaches positioned between Big Springs and the state line, one reach originating from the Stateline Springs head(s), and a reach positioned between Stateline Springs and Pruess Lake.

The sampling gear type chosen for each site was determined based on past experience and current sampling activities at each of the different springs, the ease of use within the available habitat, and reducing disturbance to the available habitat. Standard Gee-Brand minnow traps will be the gear utilized at all but the Big Springs Complex. The number of individual fish captured per trap will be recorded. When seines are used, the number of fish (by species) captured per seine haul area will be recorded. When backpack electrofishing gear is used, the number of fish (by species) captured per habitat type will be recorded. Catch per unit effort (CPUE) will be calculated for each method.

The sample size will depend on the spatial extent of each spring complex. When minnow traps are used, there will be a minimum of three traps set per defined habitat type (Section 5.2, Appendix C.6). As these habitat types will be measured and determined during an individual sampling event, it is not possible to provide exact examples of these habitats at this time. However, at a minimum, coverage will likely include deeper areas associated with spring heads and terminus ponded areas (depending on spring type); shallower, near-shore areas of the spring head/ponded head; and connector channels between spring heads, or in other interface locations as needed. Electrofishing gear will be employed at the Big Springs Complex. The duration of electrofishing will depend upon the complexity of habitat to be sampled. Three pass electrofishing efforts within identified reaches will not only provide CPUE information, but will also enable depletion estimates to be made. Seines may be used at the Big Springs Complex to complement electrofishing data. Seine hauls will typically be allocated to shallow habitat types. If seines are used, three replicates will be taken for statistical comparison purposes.

At Shoshone Ponds, NDOW sampling for Pahrump poolfish and relict dace consists of a 2 field-day effort (Morrell et al. 2007). On the first day, Gee Minnow 1/4” mesh traps and modified 1/8” mesh traps, without bait, are set around the perimeter of the north, middle, and stock pond for Pahrump poolfish and around the perimeter of the south pond for relict dace. The traps are allowed to fish 3-4 hours before being pulled. All fish in the modified traps are measured before being marked. Each fish greater than 30 millimeters is marked with an oblique clip on the caudal fin before each fish is released. Approximately one week later, Gee Minnow 1/4” mesh traps are set, without bait, along the perimeters of north, middle, south, and stock ponds. Traps are again allowed to fish for 3-4 hours before being pulled. Each fish caught is examined for marks, tallied, and released. Dissolved oxygen, percent saturation and temperature are measured using a YSI Model 55 Dissolved Oxygen Probe. These water quality measurements are made at one location each within the north, middle, and south ponds, and at the inflow and outflow of the stock pond.

In summary, fish sampling will be conducted twice per year (spring and fall) during the initial two years of monitoring at Stonehouse and Keegan Ranch spring. After the initial two years, the data collected up to that point will be evaluated to determine if monitoring may be reduced to annual sampling. Shoshone Ponds (NDOW) and the Big Springs Complex will be sampled on an annual basis during late summer or early fall.

5.6.3 Monitoring Sites

Fish will be collected at the springs, ponds (Shoshone), and perennial streams selected for monitoring within the IBMA as described in Table 5-5.

Table 5-5. Fish monitoring sites.

Monitoring Site	Sampled Location
Stonehouse Spring Complex	Designated sample areas
Keegan Ranch Spring Complex	Designated sample area
Shoshone Ponds	Sampled by NDOW
Big Springs Complex	
Big Spring Creek / Lake Creek	Five reaches
Big Springs	Designated sample area
Stateline Springs	Designated sample area

5.6.4 Statistical Analysis

CPUE will be calculated for all sampling efforts. Also, length-frequency histograms will be constructed to identify recruitment patterns. Because replicates will be taken in triplicate for each of the gear types and during each of the sampling events, ANOVA or similar method will be used to evaluate differences in catches. In the case of electrofishing, data will also be available to perform a population estimate using linear three pass depletion estimation techniques. Regression analyses or multivariate analysis may also be used to assess how potential changes in water quality and physical habitat characteristics influence fish populations. At Shoshone Ponds, NDOW calculates a population estimate using Peterson’s estimator: MC/R. Where M=number of individuals marked, C=number of individuals captured and R=number of individuals recaptured. Approximate 95% confidence intervals are determined using a table appropriate to the Poisson distribution, after the method described in Ricker (1975).

5.7 NORTHERN LEOPARD FROG EGG MASS COUNTS

The target population is the individual egg masses produced at the proposed groundwater-influenced ecosystems. Egg masses were specifically chosen for monitoring because egg masses are stationary versus the other life stages of the northern leopard frog that are mobile and often difficult to observe because of their secretive behavior. Additionally, each individual egg mass is laid by a single female which allows counting the egg masses to provide an estimate of the breeding population at a given location. At this time, northern leopard frog has been documented at the following sites within the IBMA: Keegan Ranch complex; West Valley Spring complex; Unnamed Spring 5; South Millick Spring; Minerva Spring complex; and Shoshone Ponds. As Hitchcock (2001) described Spring Valley as having one of the largest remaining northern leopard frog populations in Nevada, all aquatic ecosystems in the Plan will initially be surveyed for northern leopard frog.

5.7.1 Specific, Measurable Sampling Objectives

There are two sampling objectives related to northern leopard frogs within the IBMA: 1) to monitor the spatial distribution of northern leopard frogs and 2) to monitor the breeding population size at representative springs.

5.7.2 Sampling Design

Individual egg masses will be treated as sample units for measurement. Initially, the sample size will vary because of the proposed phased approach. The first phase involves documenting use of the groundwater-influenced ecosystem by northern leopard frog. This requires the confirmation of an adult, juvenile, tadpole, or egg mass. Currently, six sites (mentioned in the introductory paragraph to this section) have confirmed usage by northern leopard frog. For other sites, it is not productive to conduct detailed egg mass surveys before use of the site is documented; therefore, the initial phase of the monitoring will be to confirm use. During the first two years, after egg masses have been documented at a site where northern leopard frog are known to occur, confirmation of use surveys (for adult frogs and egg masses) will occur at aquatic sites once during the spring. A single confirmation is sufficient to move a site into the second phase. However, it will take two consecutive years with no adult frog or egg mass to officially classify a site as not being used by northern leopard frog. Limited effort will be expended in the fall on visual encounter surveys for adults, as they can be difficult to locate during this time. However, since field crews will be conducting biological sampling in the fall, they will be observant any of adult frog activity. If during any fall survey northern leopard frog activity is incidentally documented at a previously undocumented site, that site will be monitored for frogs the following spring.

The second phase involves collecting data on egg masses and breeding habitat. Once a site has confirmed frog use, it will be monitored using the egg mass protocol described in Appendix C.7. During this phase, searches for adult frogs will cease and the focus will be on egg mass counts (every other week for up to three visits). During the final egg mass survey visit, extent of open water and water quality data will be collected at a breeding habitat line-point transect placed at or near egg mass locations. Vegetation cover and composition data will be collected at this same breeding habitat transect in the summer. Following the initial two years of egg mass counts, the goal is to shift to the breeding survey protocols currently implemented by UDWR for Columbia spotted frog in Snake Valley.

5.7.3 Monitoring Sites

Northern leopard frog sampling will be conducted at springs, ponds (Shoshone), and perennial streams selected for monitoring within the IBMA as described in Table 5-6. The sampling effort will also include areas of wetlands selected for monitoring within the IBMA that have standing water adjacent to the spring, pond (Shoshone), and perennial stream survey sites.

Table 5-6. Northern Leopard Frog monitoring sites

Monitoring Site	Phase 1	Phase 2
Stonehouse Spring Complex	√	If present
Willow Spring	√	If present
Keegan Ranch Spring Complex		√
West Spring Valley Complex		√
South Millick Spring		√
Unnamed Spring 5		√
4WD Spring	√	If present
Willard Spring	√	If present
Swallow Spring	√	If present
Minerva Spring Complex		√
Clay Spring-North	√	If present
Unnamed 1 – North of Big	√	If present
North Little Spring	√	If present
Shoshone Ponds		√
Big Springs Complex		
Big Spring Creek / Lake Creek	√	If present
Big Springs	√	If present
Stateline Springs	√	If present

5.7.4 Statistical Analysis

Since each egg mass is laid by a single female, counting all egg masses found at a given spring, pond, or stream gives an estimate of the number of females using the pond for reproduction. Assuming a 1:1 sex ratio, the total breeding population can be determined through egg mass surveys (K. Wilson, per. comm.). However, it is important to recognize the following possible concerns: not all females may breed during a given year, the sex ratio may not be 1:1, and egg mass surveys cannot determine the number of sexually immature individuals in the population (Smith 2003). Statistical analysis will include trend analysis of breeding population over time, comparisons of breeding populations between springs or regions (i.e., north Spring Valley vs. south Spring Valley vs. southern Snake Valley), an evaluation of spatial distribution, and evaluation of breeding habitat over time.

5.8 COVER AND COMPOSITION OF AQUATIC VEGETATION

The target population is the vegetation of the aquatic plant communities at each monitoring site with aquatic systems. Aquatic plant communities include both emergent and submerged plant communities in the monitoring site aquatic systems. Aquatic systems are those where standing water exists throughout the growing season in all years.

Each aquatic system is likely to support more than one aquatic plant community. For a plant assemblage to become a mapped community it must cover at least 5% of the area of the aquatic system (total of all areas supporting that assemblage at that site) and it must be sufficiently different from the other aquatic plant communities to justify separation. Sufficiently different means that the three most abundant species in the assemblage constitutes a unique three-species combination (order of species being considered) from those of the other communities.

5.8.1 Specific, Measurable Sampling Objectives

The objective for this indicator is to sample annual variation in species cover and composition of the aquatic vegetation at springs, perennial streams, and wetlands.

5.8.2 Sampling Design

The sampling units will be line-point transects. These will be the same transects as those used to measure Open Water and Aquatic Vegetation Cover (Section 5.3).

At each 1-cm mark along the transect, ocular counts will be made of each species that has vegetative material intersecting the transect at that mark. Data will be collected at 1-cm marks along the transect and recorded at 1-m intervals or the length of the aquatic plant community, whichever is shorter. First-hit (first species encountered at each mark) and multiple-hit (all species encountered at each mark) data will be collected by species. From these data, percent cover will be calculated by species for each community along each transect, on a first-hit and on a multiple-hit basis. Percent canopy cover per species will be calculated by dividing the number of hits (cm marks) recorded for that species within the particular community within a specific transect by the width of the community (in centimeters) along that transect.

The purpose of collecting these data is to detect changes in species cover and composition over time. Species composition (relative cover) is determined by dividing the cover value of a specific plant species in the community by the total plant cover (all species combined) in the same community.

At the end of the third year of Pre-Withdrawal sampling, the number of transects necessary to achieve a sampling accuracy of 20% of the sample mean at a 90% probability level will be calculated for each of the three variables (emergent vegetation, submerged vegetation, and open water), averaged over the three years. If the number of transects necessary to achieve this accuracy, or another accuracy determined by the BWG, is different than the number used in the first three years of monitoring, transects may be added or subtracted.

Each transect will be monitored once per year during the pre-withdrawal phase. Sampling will be conducted during the summer season, which is expected to correspond to the height of the growing season and the period of lowest water level (i.e., highest potential water-induced stress).

5.8.3 Monitoring Sites

This indicator will be sampled at all springs and wetlands proposed for biological monitoring.

5.8.4 Statistical Analysis

The data, canopy cover and species composition, will be summarized by plant community, transect, and monitoring site. The summary statistics will include mean, standard deviation, and 95% confidence interval of the mean for each species. These three summary statistics will be compared among years, using first-hit and multiple-hit data.

Additional statistical analyses will be conducted on those variables which have Normal distributions or distributions that are approximately Normal. For each of these variables, t-tests will be used to determine the statistical significance of differences between means in individual years. For variables with non-normal distributions, data transformations or non-parametric techniques will be applied. Multivariate statistical analysis (stepwise discriminant analysis) will be used to test the statistical significance of differences within communities over time. Each variable with a univariate Normal distribution (or approximate Normal) will be entered into the analysis, with initial grouping by year. Stepwise discriminant analysis will also be used to test the statistical significance of differences between reference sites and sites where groundwater withdrawal is expected to occur.

5.9 COVER AND COMPOSITION OF NON-AQUATIC VEGETATION

Target populations are non-aquatic plant communities at each monitoring site. A plant community is composed of the three most abundant species, in the order of abundance, and is given a three-species designation (e.g., greasewood-rabbitbrush-saltgrass community).

Each monitoring site is likely to support more than one plant community. For example, a meadow may contain several plant communities, distributed in mosaic fashion across the meadow in response to changes in micro-topography, depth to groundwater, or a combination of factors. For example, if such a meadow contained three communities (e.g., Baltic rush-saltgrass-spikerush; saltgrass-Baltic rush-wildrye; and saltgrass-Baltic rush-sacaton), each of the three communities would comprise a target population.

5.9.1 Specific, Measurable Sampling Objectives

There are three sampling objectives for this indicator: 1) sample annual variation in the canopy cover of the vegetation at particular monitoring sites, 2) sample annual variation in species composition (relative canopy cover) of the vegetation at particular monitoring sites, and 3) sample annual variation in spatial integrity of the vegetation at particular monitoring sites. Spatial integrity will be measured as change in cover of the various dominant species along the transects.

5.9.2 Sampling Design

The sampling units will be line-point transects (Bonham 1989:119-123). If possible and appropriate, these transects will be continuous with those used to measure Cover and Composition of Aquatic Vegetation (Section 5.8), as well as non-aquatic vegetation transects in adjacent groundwater-influenced ecosystems to track ecotone changes.

Each line-point transect will consist of a 100-m long line transect, permanently marked by placing metal stakes at both ends of the transect. If the habitat is less than 100-m wide, the line transect will be the width of the habitat. A 100-m tape, marked at 1-cm intervals, will be placed between the starting and ending stakes, as close to the ground or water surface as possible. Ocular counts will be made of each species that has live vegetative material intersecting the transect. Data will be collected at 1-cm marks on the tape and recorded in 1-m intervals. First-hit and multiple-hit data will be collected by species at each 1-cm point. From these data, percent cover will be calculated, by species, for each transect, on a first-hit basis and on a multiple-hit basis. Percent canopy cover per species will be calculated by dividing the number of hits (cm points) recorded for that species along the 100-m transect by 100 [percent cover = (number of hits/10,000) x 100]. The purpose of the line-point transects is to detect changes in species cover and species composition over time.

Sample size will depend on the spatial extent and heterogeneity of each habitat. Transects will be designed so that plant communities that occur along the transects are represented a minimum of five times per site, if possible. Vegetation maps being prepared by SNWA for springs, wetlands, and meadows will inform transect design. It is not possible to determine these locations at the present time because the number and location of the plant communities at each site are not currently determined. However, a hypothetical example of transect locations is presented in Fig. 5-1 to illustrate the concept. At the end of the third year of pre-withdrawal sampling, the average number of line-point transects necessary to achieve a sampling accuracy of 20% of the sample mean at a 90% probability level will be calculated for the most abundant species of the community (averaged over the three years). If the number of line-point transects necessary to achieve this accuracy is different than the number used in the first three years of pre-withdrawal monitoring, transects may be added or subtracted.

Each transect will be monitored once per year during the Pre-Withdrawal Phase. Sampling will be conducted during the summer season, which is expected to correspond to the height of the growing season and the period of greatest potential water stress.

5.9.3 Monitoring Sites

Cover and composition of non-aquatic vegetation will be sampled in all groundwater-influenced ecosystems with the exception of perennial streams and the ponds at Shoshone Ponds (to diminish disturbance to the site). Protocols for vegetation cover and composition in the swamp cedar woodlands differ; for those protocols see Vegetation Measurements in Swamp Cedar Communities (Section 5.10.2).

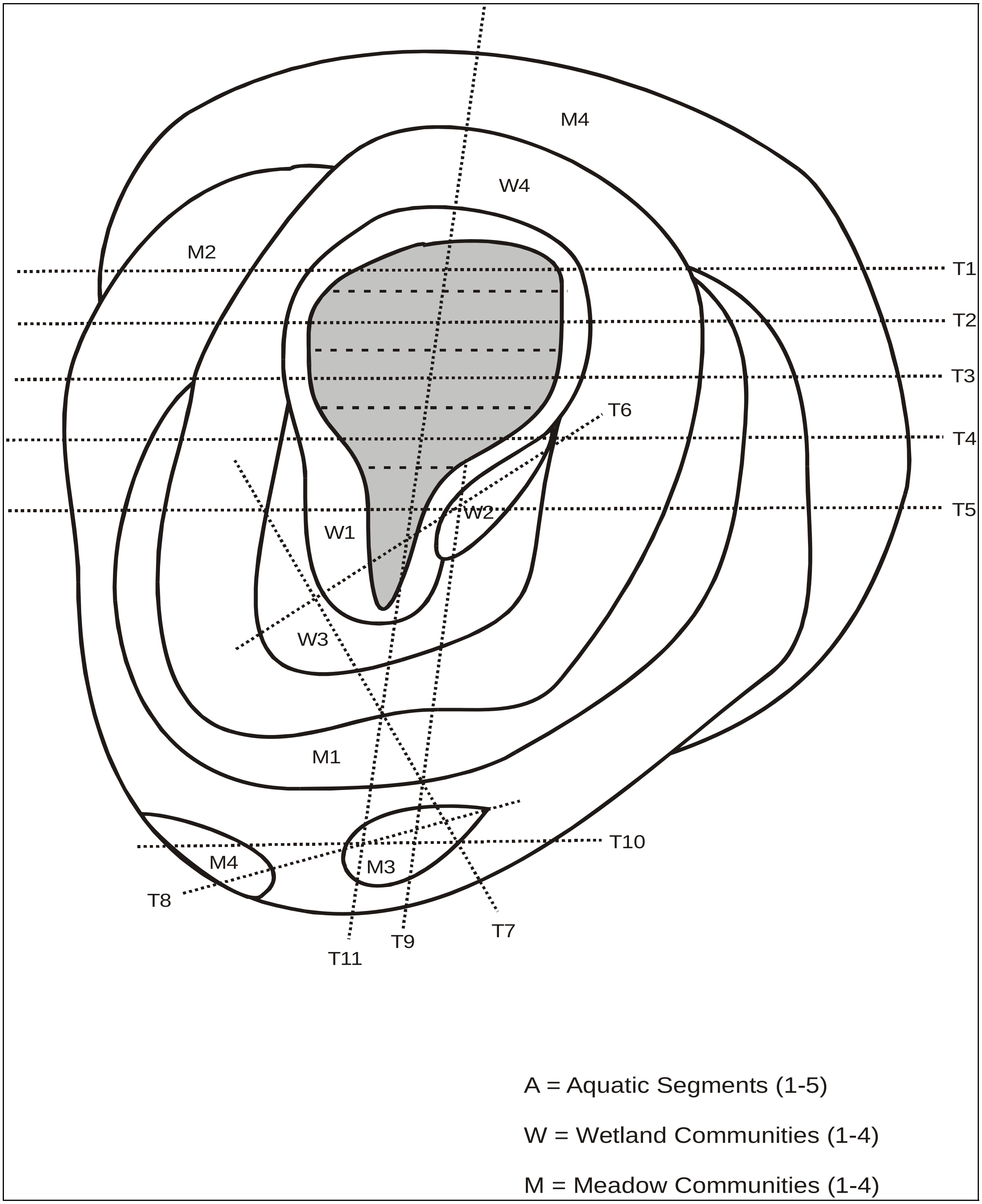

Fig. 5-1. Illustration of location of transects in aquatic and adjacent plant communities at a hypothetical site.

5.9.4 Statistical Analysis

All data will be summarized by transect, plant community, and monitoring site. The statistics will summarize the mean, standard deviation, and 95% confidence interval of the mean for each species, each lifeform (trees, shrubs, grasses, grass-likes, forbs), and overall (all species combined). These three summary statistics will be compared among years, using first-hit data and using multiple-hit data.

Additional statistical analyses will be conducted on those variables which have Normal distributions, or distributions that are approximately Normal. For each of these variables, t-tests will be used to determine the statistical significance of differences between individual years (McLendon and Redente 1992). For variables with non-normal distributions, data transformations or non-parametric techniques will be applied. Multivariate statistical analysis (stepwise discriminant analysis) will be used to test the statistical significance of differences within communities over time (Matthews 1979; McLendon and Dahl 1983; Stroup and Stubbendieck 1983; McLendon and Redente 1991). Each variable with a univariate Normal distribution (or approximate Normal) will be entered into the analysis, with initial grouping by year. Stepwise discriminant analysis will also be used to test the statistical significance of differences between reference sites and sites where groundwater withdrawal is expected to occur.

5.10 VEGETATION MEASUREMENTS IN SWAMP CEDAR COMMUNITIES

Target populations are the two swamp cedar communities in the IBMA.

5.10.1 Specific, Measurable Sampling Objectives

The three objectives of this indicator are to sample: 1) annual variation in canopy cover of the two plant communities, 2) annual changes in species composition in the two plant communities, and 3) reproductive success of swamp cedars at the two locations. Stem elongation, another indicator for swamp cedar woodlands, is presented in a separate section.

5.10.2 Sampling Design

The sampling unit will be a belt transect, 20-m long and 5-m wide. Each belt transect will be permanently marked by placing metal stakes at each corner of the enclosed rectangle. The number and heights of each juvenile juniper in the belt transect will be recorded. For the purposes of this sampling, juvenile junipers are defined as those less than 1 m in height. Rocky Mountain juniper begins producing seed when the plants are about 10 years old, at which time they may be 0.5-1.0 m tall (Fowells 1965:219-220). Number and trunk circumference (basal at ground level) will be recorded for each mature cedar in the belt transect, and heights of each mature cedar will be estimated. A 20-m line transect will be permanently located within each belt transect, extending the length of the belt transect along the middle of the belt transect. Data will be collected and analyzed in the same manner as under Indicator 5.9 (Cover and Composition of Non-Aquatic Vegetation).

Moisture status of the surface soil will be noted in each belt transect at the time of each sampling. If standing water is present, the depth of standing water (to the nearest millimeter) will be measured at 1-m intervals along each of three lines in each belt transect. These three lines will consist of the two 20-m long perimeter lines and the line transect bisecting the belt transect. Depth of surface water will be measured along all three lines.

Sixteen permanent belt transects will be established in each of the two cedar populations. The spatial extent of the two populations will be mapped, along with the understory plant communities. The 16 belt transects will be stratified-randomly located at each site, with stratification being on the basis of understory community. This stratification relative to understory community is based on expected differences in moisture availability in the cedar woodlands. The number of belt transects placed in each understory community will be in approximate proportion to the area within the cedar stand occupied by that understory community. The belt transects will be placed such that the long axis (20 m) runs approximately north-south.

Each belt transect and each line transect will be sampled once per year during the Pre-Withdrawal Phase. Sampling will be conducted during the summer season, which is expected to correspond to the peak of the growing season and to the period of greatest water stress.

5.10.3 Monitoring Sites

There will be two monitoring sites: the northern and the southern populations of swamp cedars in Spring Valley.

5.10.4 Statistical Analysis

Density (number), height, basal circumference (mature trees), canopy cover, and species composition data will be reported by transect (observations) and summarized by understory community and site (northern, southern). The summary statistics will include mean, standard deviation, and 95% confidence interval of the mean. These data will be compared among understory communities, sites, and years.

Additional statistical analyses will be conducted on those variables which have Normal distributions, or distributions that are approximately Normal. For each of these variables, t-tests will be used to determine the statistical significance of differences between individual years.

5.11 STEM ELONGATION IN SWAMP CEDAR COMMUNITIES

Thirty-two target populations are sampled by this indicator. These correspond to the 16 belt transect populations at each of the two swamp cedar sites sampled by Indicator 5.10 (Vegetation Measurements in Swamp Cedar Communities). These belt transects are expected to have dissimilar soil moisture characteristics. Moisture stress may therefore be evident sooner on the drier locations within the cedar community than on the wetter locations. Conversely, stress from high soil moisture (water-logging) may become evident sooner and more frequently on the wetter locations.

5.11.1 Specific, Measurable Sampling Objectives

The objective of this indicator is to sample annual growth in swamp cedars. This variable is expected to be an indicator of annual growth conditions for the species and therefore an earlier indicator of potential stress in mature trees.

5.11.2 Sampling Design

The sampling unit will be single branches on individual, mature trees. Ten branches from each sampled tree will be tagged, using colored metal or plastic bands. Branches will be selected that have healthy leaves and evidence of recent stem growth. The major growth point (longest stem extension on the branch) will be selected for monitoring. The tag will be placed at the first juncture of the longest leader to the main secondary branch. The distance from the juncture to the tip of the leader will be measured to the nearest millimeter. The distance from the same leader to the tag will be re-measured at each sampling date to determine the amount of stem growth that occurred since the last sampling date.

Ten branches will be sampled from each tree, and four mature trees will be sampled from each of the 32 belt transects (16 per site) described under Indicator 10. Natural losses of stems should be expected. The inclusion of ten branches per tree provides some assurances that at least one branch will remain throughout the Pre-Withdrawal Phase. As long as more than one branch per tree survives, it will be possible to have some measure of individual-tree variability. The inclusion of four trees per transect allows for assessing within-transect variability. Each branch will be measured once per year during the Pre-Withdrawal Phase. Sampling will be conducted in August-September, toward the end of the growing season. This should allow for measurement of most of the annual growth produced during the sample year.

5.11.3 Monitoring Sites

There will be two monitoring sites: the northern and the southern swamp cedar populations in Spring Valley.

5.11.4 Statistical Analysis

The length and annual growth will be recorded by branch and by tree. The mean value for each tree will be the value used for the observation. These data will be summarized by tree, transect, understory community, and site. The statistics will summarize the mean, standard deviation, and 95% confidence interval of the mean. These statistics will be compared among transects, understory communities, sites, and years. ANOVA will be used to test the statistical significance of differences due to transect, understory community, site, and year. Differences in statistical significance between individual years will also be tested using t-tests.

5.12 ADDITIONAL CONSIDERATIONS

5.12.1 Remote Sensing

Remote sensing, including both aerial photography and satellite imagery, holds potential as an efficient method of monitoring vegetation change over time. However, currently available technology does not provide sufficient precision to detect short-term changes in vegetation that may be induced by groundwater withdrawal at the fine scales necessary to meet the monitoring requirements of the Plan. Instead, permanent line transect data (Sections 5.7-5.10) will be used to detect these fine-scale vegetation changes.

The BWG will continue to evaluate various applications of remote sensing to monitor large-scale and longer-term vegetation changes in the IBMA. In particular, remote sensing will be utilized to develop time-series vegetation maps of the IBMA utilizing existing, and future improvements to, the remote sensing technologies employed by SNWA. Such vegetation maps prepared at intervals of approximately five years should provide an indication of large-scale changes in spatial extent of the vegetation communities of the IBMA over time. Change in spatial extent of the plant communities is not included as an indicator in the Plan, but instead is expected to be used as a QA/QC procedure. Remote sensing provides a potential means of quantifying these changes over the entire spatial extent of the IBMA, as compared to the more spatially-limited areas monitored by the transects. Correlation analysis might then be used to compare the vegetation changes detected by remote sensing with changes in groundwater levels based on data from monitoring wells and other groundwater measurements in the IBMA, as well as with other possible factors such as livestock grazing, fire, and changes in water diversions.

5.13 SUMMARY OF SAMPLING SCHEDULE AND ACTIVITIES

In summary, the protocols employed within the IBMA focus on facilitating the collection of objective information regarding the natural fluctuations of the physical, chemical, and biological aspects of the groundwater-influenced ecosystems. Over time, these data should serve to ascertain the effects of future effects to these areas and the biological communities that they support. The recommended monitoring activities are designed to supplement, not replace, existing monitoring program activities. Specific protocols are presented in Appendix C. Table 5-7 provides an overview of the monitoring activities proposed for groundwater-influenced ecosystems within IBMA.

Table 5-7. Summary of activities at monitoring sites.

Monitoring Site	Water Supply / Water Quality (5.1)	Physical Habitat (5.2)	Open Water and Aquatic Vegetation Cover (5.3)	Macro-inverte-brates (5.4)	Spring-snails (5.5)	Fish (5.6)	Northern Leopard Frog (5.7)	Aquatic Vegetation Cover and Composition (5.8)	Non-Aquatic Vegetation Cover and Composition (5.9)	Swamp Cedars (5.10, 5.11)
Stonehouse Spring Complex	$Y^{P,Q}$	$Y^{S,F}$	Y	Y	Y	Y	Y	Y	Y	
Willow Spring	$Y^{P,D,Q}$	Y^{S}	Y	Y	Y		Y	Y	Y	
Keegan Ranch Spring Complex	$Y^{P,D,Q}$	$Y^{F,N}$	Y	Y		Y	Y^{E}	Y	Y	
West Spring Valley Complex	$Y^{P,Q}$	$Y^{S,N}$	Y	Y	Y		Y^{E}	Y	Y	
South Millick Spring	$Y^{P,D,Q}$	Y^{N}	Y	Y			Y^{E}	Y	Y	
Unnamed Spring 5	$Y^{P,D,Q}$	$Y^{S,N}$	Y	Y	Y		Y^{E}	Y	Y	
4WD Spring	$Y^{P,Q}$	Y^{G}	Y				Y	Y	Y	
Willard Spring	$Y^{N,Q}$	Y^{G}	Y				Y	Y	Y	
Swallow Spring	$Y^{P,D,Q}$	Y^{G}	Y	Y			Y	Y	Y	
Minerva Spring Complex	$Y^{P,D,Q}$	$Y^{S,N}$	Y	Y	Y		Y^{E}	Y	Y	
Clay Spring-North	$Y^{N,Q}$	Y^{S}	Y	Y	Y		Y	Y	Y	
Unnamed 1 – North of Big	$Y^{N,Q}$	Y^{S}	Y	Y	Y		Y	Y	Y	
North Little Spring	$Y^{N,Q}$	Y^{G}	Y				Y	Y	Y	
Shoshone Ponds	$Y^{N,D,Q}$					Y	Y^{E}			
Big Springs Complex										
Big Spring Creek / Lake Creek	$Y^{N,D,Q}$	Y^{F}	Y	Y		Y	Y			
Big Springs	$Y^{N,D,Q}$	$Y^{S,F}$	Y	Y	Y	Y	Y	Y	Y	
Stateline Springs	$Y^{D,Q}$	$Y^{S,F}$	Y	Y	Y	Y	Y	Y	Y	
The Seep	Y^{P}	Y^{I}	Y					Y	Y	
Blind	Y^{P}	Y^{I}	Y					Y	Y	
Burbank		Y^{I}	Y					Y	Y	
Swamp Cedars (north and south)	Y^{N}	Y^{I}								Y
Phreatophytic Shrublands (Five regions)	Y^{N}								Y	

Water Supply / Water Quality: ^{P} Piezometer, ^{N} Nearby well, ^{D} Discharge, ^{Q} Water quality.
Physical Habitat: ^{I} Individual parameters, ^{G} General habitat characterization, ^{S} Springsnail comprehensive characterization, ^{F} Fish comprehensive characterization, ^{N} Northern leopard frog comprehensive characterization
Northern Leopard Frog: ^{E} Egg mass counts and breeding habitat. All other sites are for presence / absence surveys only, unless presence is detected.

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6.0 PREDICTIVE ECOLOGICAL MODEL

CONTENTS

6.1 Purpose
6.2 Objectives
6.3 Types of models
- **6.3.1 Statistical models**
- **6.3.2 State-and-transition models**
- **6.3.3 Mechanistic simulation models**

6.4 Timeline

6.1 PURPOSE

The Stipulation includes ecosystem modeling as a technique that would be included in the monitoring Plan (Exhibit B, Section C, p. 4). A landscape-scale ecological model is mentioned specifically as one potential method "that the BWG may use to evaluate the effects of SNWA groundwater development" (Exhibit B, Section 3.C, p. 6). Furthermore, it will be the responsibility of the BWG to determine if ecological modeling is a necessary and appropriate tool for monitoring, and if so, determine which model to use (Exhibit B, Section 3.C, p. 6).

Ecological models are numeric or computer-based abstractions of ecological systems. They are based on either observed responses of the ecological systems or their various components, or conceptual models of how the ecological systems are assumed to function. As such, they are simplifications of real-world processes and interactions. The complexity of ecological models varies from the relatively simple, such as some numeric models, to extremely complex, such as some dynamic simulation models. Ecological models are used for a wide variety of purposes, including to 1) better understand ecological relationships, functions, processes, and interactions of the systems being studied, 2) project ecological responses over time, and 3) predict ecological responses to changes in environmental conditions.

A predictive ecological model is a possible tool that could be used to evaluate potential unreasonable adverse ecological effects in the IBMA from groundwater withdrawal by SNWA in Spring Valley and if such effects are determined to occur, to quantify their magnitude and help develop alternative withdrawal, or possible mitigation, strategies. A predictive ecological model can project ecological responses of the groundwater-influenced ecosystems to levels of environmental stressors beyond what are likely to be encountered during the limited time of the Pre-Withdrawal Phase. Therefore, the model would provide decision makers with the ability to investigate potential impacts to these ecosystems from extreme short-term and sustained long-term impacts from natural and anthropogenic factors, including groundwater withdrawal.

6.2 OBJECTIVES

The BWG recognizes two primary purposes for including a predictive ecological model in the Plan: 1) to identify and describe ecological responses and 2) to quantify, predict, and project impacts. Three objectives are associated with each of the two purposes.

1. Identify and describe specific ecological responses:

    - to provide a tool to predict specific ecological responses of the groundwater-influenced ecosystems and indicators to various environmental factors, both natural and anthropogenic;

    - to provide a tool to assist in establishing potential threshold levels for the groundwater-influenced ecosystems and indicators relative to potential environmental stressors; and

    - to provide a tool to assist the overall scientific effort to better understand the interrelationships among the various ecological factors affecting the dynamics of groundwater-influenced ecosystems and indicators.

2. Quantify, predict, and project impacts:

    - to provide a tool to assist in identifying and quantifying the effects of various environmental factors, including groundwater withdrawal by SNWA, on ecological changes in groundwater-influenced ecosystems and indicators;

    - to provide a tool to project long-term effects of groundwater-withdrawal by SNWA on groundwater-influenced ecosystems and indicators; and

    - to provide a tool to assist in mitigation design, implementation, and monitoring, where applicable.

These purposes and objectives follow the framework of the monitoring plan as presented in Fig. 3-1. The first purpose involves the evaluation and use of baseline data to assist the BWG in their understanding of ecological responses, assigning threshold levels based on available information, and refining those levels over time with additional data collection and potentially, specific research opportunities. The second purpose involves quantifying impacts, determining attributability of impacts, projecting long-term impacts, and evaluating mitigation opportunities within the context of adaptive management.

6.3 TYPES OF MODELS

There are three broad categories of predictive ecological models, with numerous variations of each. These three categories are: 1) statistical models, 2) state-and-transition models, and 3) mechanistic simulation models. Each category has advantages and disadvantages associated with their use, some of which are discussed in this section.

6.3.1 Statistical Models

Statistical models are empirical models based on statistical relationships among a set of ecological variables. These models are developed from data sets resulting from experiments, field surveys, or other types of data collection (for example, O'Grady et al. 2006, Nussear and

Tracy 2007, McLendon et al. 2008). Simple examples include 1) the observed relationship between amount of annual precipitation received at a location and the change in canopy cover of the plant community at that location, 2) the observed relationship between water temperature at a spring head and number of springsnails in the associated spring pool, and 3) the relationship between change in depth to groundwater and flow rate of a nearby spring. Statistical models are not confined to only two variables. They can become quite complex, both as to number of variables included and the mathematical relationships defining the relationships among the variables.

A primary advantage of statistical models is that they are based on observed responses. Although the mathematical relationships used to define these responses are statistical in nature and may be somewhat arbitrary and therefore open to interpretation, they are based on real-world, observable data. Statistical models are also relatively easy to develop, provided appropriate data sets are available.

A primary disadvantage of statistical models is that they do require an appropriate data set. Collection of such data, especially for ecological systems, can be time-consuming and expensive. The statistical confidence associated with these models depends largely on the sample size. If time series are involved (i.e., the models are meant to project or predict responses over time), the data collection must be continued over a time period sufficient to sample the inherent temporal variability in the system. This can become a major limitation to the use of statistical models in ecology. Another major disadvantage to using statistical models is that the statistical relationships defining the model may only be valid for the set of variables included in the data collection. If so, then changes in an environmental variable that was not included in the data set can significantly alter the mathematical relationships in the model.

Even if effects of additional variables do not occur, the mathematical relationships defining the model are based on a finite range in values for each of the variables included in the model (i.e., the range in values include in the data set). Given the number of observations included in the data set, the probability associated with making correct decisions based on these data can be calculated with statistical certainty (statistical confidence levels), provided that the values of the variables remain within the range of the values included in the data set. However, the level of uncertainty associated with these predictions increases substantially as the values of the variables deviate beyond the upper or lower limits of the observed values. This increases the risk associated with the use of these models, regardless of how strong the statistical relationship is within the observed values.

6.3.2 State-and-Transition Models

State-and-transition (ST) models (for example, Callaway and Davis 1993, Allen-Diaz and Bartolome 1998, Chartier and Rostagno 2006) contain two types of information. The first type of information is a list of all "states" or conditions for each ecological response unit that is included in the model. An ecological response unit is an ecological community or ecosystem type (e.g. spring pools, ponds, stream communities, plant communities). A "state" is the ecological description of a specific ecological response unit, under a given set of environmental conditions or a given time period. For example, a pond might begin as a relatively open body of shallow water, with little emergent or submerged vegetation. This would be the first "state" of the pond. After a few years, emergent vegetation may colonize the edges of the pond and some submerged vegetation may begin to appear in the water slightly past the emergent vegetation. This would be the second "state" of the pond. Any number of states may be applied to an ecological response unit, the number depending on the ecological complexity of the response unit and the needs of the model application.

The second type of information included in these models is a transition probability for each state of each response unit. These are the probabilities that the response unit will change from one state to another, within a given time step or a given environmental condition. For example, under average conditions, the pond might transition from the first state to the second state with a probability of 100%. However, under conditions of above average precipitation, it might shift to a third state (e.g., half of the pond covered with emergent vegetation). If the probability of a wet year is 20%, then the transition probability for the pond would be 80% for changing to the second state and 20% for changing to the third state.

ST models have several advantages to their application. First, they are flexible. Any number of ecological response units, states, and transitions can be included. This number is limited only by the complexity of the ecological system being modeled, the needs of the application, and the imagination of the modeler. Both the states and the transition probabilities can be based on site-specific data, data from other sites, or "expert judgment". Secondly, ST models are relatively simple, and therefore are easy to build and use. If the states and transition probabilities are realistically defined, these models provide useful results that can be easily compared with real-world patterns of the dynamics of the ecological systems. If the results are not accurate, the parameters can be easily modified to fit the observed or assumed patterns. Thirdly, ST models are conceptually appealing in that they can be designed to closely match observed patterns.

ST models have two major disadvantages. First, the transition probabilities and the transition pathways are fixed in the model. There is no flexibility to allow for changes in environmental conditions. Second, the transition probabilities and pathways are subjectively determined. The assumptions inherent in the conceptual model are transferred directly into the ST model. If the assumptions are always correct, this is not a disadvantage. However, it is not likely that all the underlying assumptions are correct or accurate. This becomes a particularly important source of error in the results as the model simulates ecological dynamics over time because the effects of these incorrect assumptions become additive.

6.3.3 Mechanistic Simulation Models

Unlike ST models, mechanistic simulation (MS) models simulate how the ecological systems actually function (examples include Daly et al. 2000, Childress et al. 2002, Mata-Gonzalez et al. 2008a). For example, a ST model would assume what will happen to a meadow if it is grazed by livestock. In contrast, the MS model simulates how grazing actually functions ecologically, and the result of this ecophysiological impact on the meadow community is expressed in the model as changes in the dynamics of the plant community over time. Most MS models are at least moderately-complex models, and some are extremely complex. The most sophisticated of the MS ecosystem models simulate a wide variety of ecological processes including hydrology, plant growth, animal population dynamics, soil erosion, fire, and climatic fluctuations, along with their interactions, at spatial scales ranging from small (less than 1-m^2) to entire landscapes. Dynamics are simulated on the species-level, for both terrestrial and aquatic systems, and for time steps ranging from hours or days to decades or centuries.

There are several advantages of MS models over either ST models or statistical models. One advantage is that complex ecological interactions can be simulated without *a priori* assumptions being made about the outcomes of these interactions. A closely related advantage is that MS models can be used to test hypotheses related to relative importance of various environmental factors in determining ecological response patterns. MS models can also be used to test potential impacts from changes in environmental factors over time, potential effects of extreme values of various environmental factors, and existence of threshold values for various ecological variables and systems.

MS models have two potential disadvantages. First, because they are complex models, they often require more resources to operate than do ST models. These resources may include more training by personnel operating the models and the use of faster-running computers with more memory and storage. The computer limitations have been greatly reduced in the past 4-5 years with the advent of very powerful laptop computers. A second potential disadvantage is that their accuracy depends on the use of a large number of inter-related algorithms, each of which must have an acceptable degree of accuracy. Although the accuracy of the results of most MS models is not equally sensitive to the accuracy of each of the model algorithms, the output accuracy is affected to some degree on each algorithm. Some MS models require extensive calibration and relatively large amounts of site-specific data to be effective. However, this is not true of all complex MS models.

6.4 TIMELINE

The BWG will use the following approach and timeline for implementation.

1. The BWG will review which models are available that might be appropriate for the applications required by the Plan. This review process will be conducted within six months of the approval of this Plan.

2. The BWG will prepare a proposal to the EC specifying which model the BWG recommends for use in the Plan, along with specifics as to the capabilities, history, support requirements, potential for future development, and costs. The BWG will submit this proposal to the EC for their consideration twelve months after approval of the Plan.

3. If approved by the EC, the BWG will begin implementation of the model during 2010. Data collected in the Plan will be used to support the modeling effort.

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7.0 DATA MANAGEMENT, ANALYSIS, AND REPORTING

CONTENTS

7.1 Goals and objectives of data management
- **7.1.1 Quality maintenance**
- **7.1.2 Interpretability**
- **7.1.3 Security**
- **7.1.4 Longevity**
- **7.1.5 Availability**

7.2 Data stewardship roles and responsibilities of parties
7.3 Data management
- **7.3.1 Acquisition and processing**
- **7.3.2 Quality assurance/quality control**
- **7.3.3 Data documentation (metadata)**
- **7.3.4 Data dissemination**
- **7.3.5 Data maintenance, storage, and archiving**
- **7.3.6 Data ownership**

7.4 Data analysis
7.5 Reports
- **7.5.1 Expected products**
- **7.5.2 Intended audiences**

7.6 Resolving conflict regarding data analysis and interpretation

7.1 GOALS AND OBJECTIVES OF DATA MANAGEMENT

The goal of the data management program is to assemble and maintain the data collected under the Plan in a high quality and secure manner and to provide efficient access to these data by appropriate parties for the duration of the monitoring program. Attainment of this goal will be accomplished by meeting the five objectives outlined in Subsections 7.1.1-7.1.5.

7.1.1 Quality Maintenance

The data management program must maintain the original quality of the data. Data quality refers to the identity and integrity of each data entry, whether the entry is numeric, non-numeric, or a combination. Once entered into the data base, each entry must be maintained in its original form. Corrections, summations, deletions, and other types of operations on the data may be conducted on copies of the original data, but a set of the data in its original form must be maintained. Any corrections, summations, deletions, or any other operations on the data must be clearly noted in the data base.

7.1.2 Interpretability

The interpretability of the data must be maintained. Interpretability of the data means that the data must be clear and understandable by potential users. The relationship between each data entry and its respective descriptive and organizational categories in the data base must be maintained. Descriptive and organizational categories refer to information such as date, spatial location, type of data, and data collector.

7.1.3 Security

All data will be maintained in a secure environment. All reasonable precautions will be taken to prevent unauthorized access to the data base.

7.1.4 Longevity

The data base will be actively maintained for the duration of the monitoring program. At the termination of the period of active maintenance, an electronic version of the data base will be stored on the most permanent materials available at that time.

7.1.5 Availability

The data base will be maintained by SNWA. Access to the data base will be granted by SNWA to authorized users. Authorized users will have access to all relevant manipulations of the data (Subsection 7.1.1) and copies of the original data, but not to the source data file containing the original data. The source file will be accessible only by SNWA and its authorized agents. Authorized users will consist of SNWA, State and Federal agencies represented in the BWG, NSE, and agents acting on their behalf.

Copies of the data will be made available electronically to the general public by SNWA. SNWA will maintain a website through which these data can be accessed by the public. All data collected as part of the Plan, not protected by regulatory agencies, will be placed on the website once adequate quality assurance/quality control (QA/QC) procedures have been applied to the data (Subsection 7.3.2). This QA/QC process will be completed within a reasonable period of time following data collection.

7.2 DATA STEWARDSHIP ROLES AND RESPONSIBILITIES OF PARTIES

In accordance with the Stipulation, SNWA will be the responsible party for the maintenance of the data base, analysis of data as specified in Section 7.4, and preparation and distribution of the reports specified in Section 7.5. It is the responsibility of each party collecting a specific set of data to deliver these data to SNWA in a standardized format developed by, or acceptable to, the BWG.

7.3 DATA MANAGEMENT

Care must be taken to implement responsible data management practices throughout the lifetime of the project from planning to completion. This includes data from a variety of sources, including data that indirectly supports the project. Each type of data has its own particular use and management requirements. If the data are not properly documented and managed, it will limit their use and interpretation. This is especially important for baseline data. To maximize future use of the data for comparative purposes, the baseline data must be thorough, accurate, and well documented.

A detailed data management plan will be developed by the SNWA Data Management Resource Division and submitted to the BWG for review. This data management plan will be prepared and submitted to the BWG prior to the first-year of data collection in the Pre-Withdrawal monitoring period. In addition to standard data entry and management, any data collected under a collection permit will also be provided to the respective agency.

7.3.1 Acquisition and Processing

A careful inventory of existing data sources should be made to determine their potential utility and suitability for the project. In some cases, it may be expedient to purchase supporting data (e.g., geospatial data, climate data, soil survey data), if existing data are inadequate or the appropriate kind of data are not available. Purchased data must be properly archived to protect the investment and preserve its integrity. It may also have licensing restrictions preventing outside distribution. If restrictions to outside distribution exist, the associated data must be properly protected within the data base.

Anticipating the kinds of data analyses required may influence the way the data are gathered or collected. Early planning in this regard should be emphasized, which will provide a longer period of continuous data (with the same structure) maximizing its usefulness for analysis and interpretation. Standardized input formats will be developed by the BWG prior to and during the first-year of data collection (2009). These formats will apply to all routine monitoring data collected under the Plan.

7.3.2 Quality Assurance/Quality Control

Procedures will be established and followed to assure data quality. This includes how data are collected, transcribed, corrected, updated, stored, backed up, and archived. These procedures will be established and documented by the BWG during the first year of data collection (2009). All primary source and field data must be preserved in its initial state on immutable media as a permanent record. As corrections or adjustments are made, they must be annotated and logged. It may be necessary to review the appropriateness of any modification in the future, with the possibility of reversing the change, if necessary. Data to be analyzed frequently should be stored in a relational database management system for easy maintenance, retrieval and reporting. Standard relational database management practices should be used for maintaining its quality and availability.

QA/QC efforts for baseline data must be extremely thorough so that future comparative analyses have a solid basis. For this reason, all baseline data transcription work should be reviewed and corrected as a matter of procedure, not just a random sampling. The cost of doing this up-front is justified and can save considerable confusion, frustration, re-work, and expense in later phases.

Scientific nomenclature frequently changes. The data should be structured in such a way that the original species identification is preserved but can be transformed to current nomenclature for reporting or comparison with subsequent data. Evolving nomenclature should be distinguished from re-identification based on data review.

7.3.3 Data Documentation (Metadata)

Each data source should be thoroughly documented to enable future users of the data to understand the source of the data along with its content, accuracy, and suitable uses. Metadata is particularly important for geospatial data, where it is critical to know the exact projection, coordinate system, zone, and scale, as well as definition of each attribute. For example, data with too large of a scale cannot be used for some purposes because it does not have sufficient resolution. The standards established by Federal Geographic Data Committee (FGDC) should be followed wherever possible for spatial data. For all data sources, it is important to record the source of the data and when they were collected, along with any known quality parameters.

In addition to a relational data base management system (DBMS), the use of document management software (DMS) is recommended because it enables the collection and management of document-based metadata like spreadsheets, PDF files, MS Word documents, scanned images, photos, and other similar types of metadata. DMS makes collection of metadata part of everyday activity. Because metadata is useful for searching a DMS, it encourages collection of metadata for all types of documents. Using a DMS also improves sharing and collaboration.

7.3.4 Data Dissemination

All data collected under the Plan will be submitted to SNWA as soon after collection as is practical. These data will be submitted in raw data form (i.e., the form in which the data were collected in the field). If the data were collected in electronic format, electronic copies of these data will be submitted to SNWA. If the data were collected on data sheets, field maps, or similar paper formats, hard copies of these data will be submitted.

Provisional copies of each data set will be prepared from the raw data. Provisional copies will include any corrections to the raw data, along with any necessary re-formatting, including conversion of hard copies into electronic data files. Any such corrections or re-formatting will be clearly documented. It will be the responsibility of the data collector to provide SNWA with these provisional copies. It will be the responsibility of SNWA to assure that the provisional copies are submitted in a timely and accurate manner. SNWA will supply the BWG with electronic copies of the provisional data within 60 days of data collection.

It will be the responsibility of SNWA that the provisional data are subjected to appropriate QA/QC procedures (Subsection 7.3.2). Once appropriate QA/QC procedures have been completed on the provisional data by SNWA, the data will be considered to be correct and in their final form. The final copies of the data will be made available electronically to the public, by means of a designated SNWA website, at the time of the release of the annual report for that particular year.

7.3.5 Data Maintenance, Storage, and Archiving

The use of a SQL RDBMS (structured query language- relational data base management system) and appropriate document management software (DMS) is important to the success of the project. These systems can be housed at SNWA or outsourced, as appropriate. Initial estimates should be made for resource requirements along with growth projections. Geospatial, image, and document data can be very large and require planning for adequate storage and backup capacity.

Systems security and backup/restore procedures are critical. Procedures for capturing data snapshots and archiving/retrieval will be established by SNWA. The procedures will be tested periodically to ensure data can be properly retrieved from backup systems and archives.

Web and report servers will also be needed for data dissemination, particularly for public data access. Appropriate firewalls to protect secure database resources against intrusion through web access will be established, implemented, and maintained by SNWA.

7.3.6 Data Ownership

Ownership of all data collected by SNWA or their contractors will reside with SNWA. Although ownership of these data will remain with SNWA, BWG-associated agencies will retain full access to these data. Data collected as part of non-SNWA funded projects, but made available to the IBMA monitoring program, will remain under the ownership of the funding agency, but SNWA will have full access to these data.

7.4 DATA ANALYSIS

All data will be delivered by the collecting parties to SNWA in a raw state (i.e., in the form that the data were collected). A BWG meeting will be held in February each year for the purpose of reviewing the data and data analyses. Each set of data will have specific tabulation, summarization, and statistical protocols associated with it. These protocols will be developed by SNWA, in coordination with the BWG, in the first year of Pre-Withdrawal data collection (2009). Subsequently, all data will be organized and analyzed by SNWA based on these protocols. It is likely that over time, some of these protocols will need to be revised. Before being implemented, such revisions must be approved by the BWG.

7.5 REPORTS

7.5.1 Expected Products

Regular reports presenting the results of the data collection, data analyses, and interpretation of results will be prepared by SNWA in coordination with BWG. These reports will be produced on an annual basis and completed by March 31 of the year following the data collection. The annual reports will include brief descriptions of the sites, the indicators being monitored, the methodologies of data collection and data analyses, summaries of the data, results of the data analyses, interpretations of the results, and any recommendations and conclusions. Summaries and results will be presented for each indicator monitored, by site and overall. These summaries and results will be presented for the year covered by the report and these results compared to results from previous years. In the case of lack of consensus among BWG members, alternative interpretations may be prepared by the respective member and included as an addendum to the report.

A Pre-Withdrawal report will be produced at the end of the Pre-Withdrawal Phase. This will replace the annual report for that year. This report will address the same types of information as contained in the annual reports, plus an overall analysis of the data collected during the Pre-Withdrawal Phase and an interpretation of these results.

Annual reports will continue to be prepared by SNWA during the Withdrawal Phase. In addition, comprehensive reports will be prepared at five-year intervals during the Withdrawal Phase. These five-year reports will summarize all available monitoring data up to that point in time, along with analyses of the complete data sets and interpretations of these results.

Simplified and much shorter versions of each annual report and five-year report will also be produced by SNWA. These condensed versions will be approximately 3-10 pages long and will highlight the material presented in the technical versions.

7.5.2 Intended Audiences

The intended audiences for the annual and the five-year reports will be the technical, regulatory, and scientific communities. Therefore, these reports will contain large amounts of technical material. The intended audience for the condensed versions will be the general public. As such, every attempt will be made to simplify and reduce the amount of technical language they contain.

7.6 RESOLVING CONFLICT REGARDING DATA ANALYSIS AND INTERPRETATION

Standardized procedures for data analysis will be developed by SNWA in coordination with the BWG (Section 7.4). In the event that the BWG cannot reach a consensus on a particular analysis or interpretation, the BWG shall submit the study or analysis to one or more mutually acceptable, disinterested parties for scientific or technical opinion. The cost of this review shall be borne by the requesting Party or Parties. The BWG shall consider the recommendation(s) of the neutral reviewer and determine whether to adopt the recommendation(s) in full or in part. If the BWG is still unable to reach consensus on the technical aspect(s) in question, the concern will be elevated to the Executive Committee (Stipulation Exhibit B, Section C, p.3).

8.0 PLAN IMPLEMENTATION AND SCHEDULE

CONTENTS

8.1 Roles and responsibilities of parties
8.2 Summary of sampling schedule and frequency
8.3 Target completion dates for outstanding products
- **8.3.1 Protocol review**
- **8.3.2 Withdrawal Phase**
- **8.3.3 Ecological model**
- **8.3.4 Defining unreasonable adverse effects**
- **8.3.5 Data management plan**
- **8.3.6 Statistical protocols**

8.4 Mitigation

8.1 ROLES AND RESPONSIBILITIES OF PARTIES

SNWA will have primary responsibility for implementing the Plan, in coordination with the BWG. Implementation will include:

- coordinating field activities,
- collecting the monitoring data,
- establishing and maintaining the data base and data management systems,
- summarizing and analyzing all monitoring data,
- applying the predictive ecological model, and
- preparing and distributing all reports.

The BWG will be responsible to the EC for oversight of the implementation of the Plan. Oversight will include:

- meeting at least annually to evaluate and discuss progress of the plan,
- reviewing data analyses and associated interpretations provided by SNWA,
- developing any necessary modifications to the monitoring plan, and
- providing the EC with annual evaluations of the adequacy and progress of the monitoring program.

8.2 SUMMARY OF SAMPLING SCHEDULE AND FREQUENCY

Details of the sampling schedules and frequency of sampling are provided in Chapter 5 and in Appendix C (Protocols). A summary of these schedules and frequencies are presented in Table 8-1.

Table 8-1. Data Collection for the Pre-Withdrawal Phase. [1]

Activity	Frequency	Sampling Period[2]
Water Supply		
Depth to groundwater	Continuous or quarterly	
Discharge[3]	Biannual	Spring & Fall
Water quality (DO, T, pH, Ec, turbidity, N, P)		
DO, T, pH, Ec, turbidity, N, P		
Springs	Biannual	Spring & Fall
Ponds (Shoshone)	Annual	Summer
Perennial stream reaches (Big Springs Complex)	Annual	Summer
Physical habitat		
Qualitative (photography, site condition)	Biannual	Spring & Fall
Maps		
Springs	Biannual	Spring & Fall
Perennial stream reaches (Big Springs Complex)	Annual	Summer/Fall
Substrate composition[4]	Biannual	Spring & Fall
Areal extent	Biannual	Spring & Fall
Water depth, width, and length	Biannual	Spring & Fall
Open water and aquatic vegetation cover	Annual	Summer
Aquatic animals		
Macroinvertebrate composition and abundance		
Springs	Biannual	Spring & Fall
Perennial stream reaches (Big Springs Complex)	Annual	Summer/Fall
Springsnail abundance and distribution	Biannual	Spring & Fall
Fish age class structure and distribution		
Stonehouse and Keegan Ranch Complex	Biannual	Spring & Fall
Shoshone Ponds and Big Springs Complex	Annual	Summer/Fall
Northern leopard frog presence/absence	Annual	Spring
Northern leopard frog egg masses	Every other week (up to 3 visits)	Spring
Northern leopard frog breeding habitat	Annual	Spring/Summer[6]
Vegetation		
Cover and composition	Annual	Summer
Pattern of internal heterogeneity	Annual	Summer
Size and density of mature cedar trees	Annual	Summer
Size and density of sapling/ juvenile cedar trees	Annual	Summer
Stem elongation in swamp cedars	Annual	Summer

[1]Schedule is for the first two years of the seven-year sampling effort; data analysis may result in changes to sampling frequency and schedule later in the Pre-Withdrawal Phase.

[2]Spring = April-May, Summer = June-August, and Fall = September-October. Note: sampling dates each year may vary depending on climatic conditions.

[3]In addition to discharge measurements taken by the BWG (shown in this table), the TRP will be taking continuous discharge measurements in Big Springs channels leading to Big Spring Creek, and stream discharge measurements during their gain/loss study on Big Spring / Lake Creek.

[4]Substrate type will be recorded during springsnail surveys and during physical habitat mapping at select locales (e.g., springsnail and mottled sculpin sites).

[5]Initially, surveys will entail weekly trips (as necessary) for a period not to exceed four weeks; once egg masses are located at a given spring, the site will be visited up to three times at two-week intervals to count additional egg masses.

[6]Water measurements will be taken in the spring; vegetation measurements will be taken in the summer.

Pre-Withdrawal sampling is anticipated to begin in 2009 and will take place during a minimum of seven years. Measurement variables associated with aquatic ecosystems will generally be sampled twice per year, once in the spring and once in the fall. Precise sampling dates each year will depend on climatic conditions but in general, spring samples will be collected during April-May and fall samples collected during September-October. Vegetation and open water measurement variables will be sampled once per year. Sampling will be conducted during the summer (June-August). Each sampling location will be sampled in approximately the same month as it was sampled in the previous year in order to minimize seasonal variability in the data.

8.3 TARGET COMPLETION DATES FOR OUTSTANDING PRODUCTS

Completion dates for outstanding products are presented in Table 8-2.

Table 8-2. Schedule for Biological Monitoring Plan Development and Implementation.

Activity	Completion Date[1]
Develop monitoring plan for Pre-Withdrawal Phase	January 30, 2009
Develop Data Management Plan	April 2009 (or prior to baseline data collection)
Develop Statistical Protocols	April 2009 (or prior to baseline data collection)
Develop predictive ecological modeling proposal	February 2010
Collect baseline data[2]	Fall 2015
Review Plan and sampling protocols	As needed; modifications will be incorporated into the Plan upon approval of BWG and EC
Define “unreasonable adverse effect” & establish criteria for BWG consultation	By end of Pre-Withdrawal Phase
Revise monitoring plan for Withdrawal Phase	
Initiate work on revised Plan	December 2013 (or 24 months prior to Withdrawal Phase)
Submit revised Plan to EC	June 2015 (or 6 months prior to Withdrawal Phase)
Report on data analysis & interpretations	
BWG data analysis meetings	February of each year
SNWA report to NSE	March 31 of each year
Conduct peer review[3]	After refinement of Plan, based on two years of baseline data collection

[1]These dates are approximations and may be modified as needed.
[2]Dates are based on seven years of baseline data collection starting Spring 2009 and occurring in consecutive years. Actual years may vary. NSE Order 5726 requires five years of data prior to pumping.
[3]Additional peer reviews may occur, but is subject to EC approval.

8.3.1 Protocol Review

Sampling protocols have been established for all measurement variables (Appendix C). However, these protocols will be reviewed throughout the Pre-Withdrawal Phase of the Plan. It is likely that modifications of some of the protocols will result from experience gained during the Pre-Withdrawal Phase. Any such modifications will be incorporated into the Plan upon approval by the BWG. If such modifications are recommended, care must be taken that changes in the protocols will have a minimum impact on the usefulness of data collected prior to the modifications. If modifications to any of the protocols are expected to result in incompatibility of subsequent data with previous data, data may be collected for two years using both sets of protocols (pre-modification and modification). This would allow for the development of correlation equations that can be used to compare both data sets.

8.3.2 Withdrawal Phase

A revised Plan for the Withdrawal Phase and will be in place before the end of the Pre-Withdrawal Phase. The revised Plan will benefit from the monitoring data collected during the Pre-Withdrawal Phase and the associated analyses, ecological modeling, and possible revision of the conceptual models.

Scheduling the initiation of work on modifying the Plan for the Withdrawal Phase must be balanced between 1) the benefits received from collecting, analyzing, and interpreting pre-withdrawal data over as many years as feasible and 2) the need to provide sufficient time to develop the Withdrawal Phase monitoring activities without causing an un-necessary delay in the withdrawal program. This balance can be achieved by beginning work on the Plan modifications for the Withdrawal Phase at least 24 months prior to the proposed initiation of groundwater withdrawal. The draft plan will be submitted to the EC for approval at least six months prior to the start of the Withdrawal Phase.

8.3.3 Ecological Model

The BWG recommends that a predictive ecological simulation model be selected for use in the Plan (Chapter 6), and that a review of existing models begin upon approval of the Plan. This review process is scheduled to take six months to complete. Following the review process, the BWG will submit a proposal to the EC that recommends a specific model to be used, with details as to the implementation process and costs associated with its implementation. This proposal is expected to be submitted within twelve months of the approval of the Plan. If approved by the EC, the BWG recommends that implementation of the selected model begin as soon as possible thereafter.

8.3.4 Defining Unreasonable Adverse Effects

Each indicator and groundwater-influenced ecosystem has a natural range in variability. At the present time, data are insufficient to determine indicator threshold levels. The BWG will establish an acceptable range in variation, thresholds, and criteria for BWG consultation for each of these indicators and groundwater-influenced ecosystems by the end of the Pre-Withdrawal Phase. A major purpose of the Plan is to provide additional information and tools that can be used to better understand the dynamics of these indicators and ecosystems under conditions approaching their tolerance limits (i.e., threshold levels). While 5-7 years of data may not be sufficient to firmly establish threshold levels for all of the indicators and ecosystems, these data will provide better estimates than are currently possible.

The acceptable range of variation developed by the BWG for each indicator or suite of indicators will be used during the Withdrawal Phase to determine if an adverse effect has occurred or is likely to occur. An adverse effect occurs if an indicator or suite of indicators falls outside the acceptable range of variation. Consultation, as defined by the Stipulation, will be initiated when an adverse effect occurs, or if the trend in the data indicates an adverse effect is likely to occur. Consultation will determine if the adverse effect is attributable to groundwater withdrawal, and if so, if the adverse effect is unreasonable.

8.3.5 Data Management Plan

The basic components of the data management plan (DMP) are presented in Chapter 7. Detailed development of the various aspects of the DMP will need to occur during the first year of data collection. To do so before then will be premature and inefficient. Details for each of the components outlined in Chapter 7 will incorporated into a comprehensive DMP document which will be appended to the Pre-Withdrawal management plan. This comprehensive DMP will be developed by SNWA and submitted to the BWG for review by March 2009. The DMP will be completed prior to the beginning of the 2009 data collection.

8.3.6 Statistical Protocols

Statistical protocols will be developed by SNWA for the analysis of each indicator variable sampled in the Plan (Chapter 5 Monitoring Approach). A draft of these protocols will be submitted to the BWG for review by March 2009. Based on input from the BWG, necessary changes to these protocols will be made prior to the beginning of the 2009 data collection. The protocols will be applied to the analysis of the 2009 data and their adequacy will be re-evaluated by SNWA by April 2010. Results of this evaluation will be reviewed by the BWG. Additional modifications to the protocols may be made following this evaluation, and at other times during the Pre-Withdrawal Phase, upon review by the BWG.

8.4 MITIGATION

The Plan relates to non-withdrawal conditions. Potential mitigation actions will be in response to possible changes induced by groundwater withdrawal by SNWA. Therefore, mitigation approaches will be addressed during the Withdrawal Phase.

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9.0 LITERATURE CITED

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10.0 GLOSSARY

Abiotic The non-living portions of an ecosystem; includes climatic, edaphic, geologic, hydrologic, pyric, and topographic factors.

Acceptable Range in Variation The range in values, rates of change, and frequency of change associated with ecosystem integrity and long-term viability.

Adaptive Management Modification or changes through time to accomplish an end, objective, or goal as more useful information becomes available.

Alluvial Fan Geological material and soil from a hill or mountain slope that has been deposited at the base of the slope forming a delta.

Animal Community The animal components characteristic of an ecological community.

Anthropogenic Relating to human activities.

Aquitard Units Stratigraphic units that constitute an aquifer.

Baseline Conditions that exist immediately prior to the beginning of implementation of a specified set of changes to the ecosystem.

Belt Transect A rectangular area, generally much longer than wide, used to sample vegetation, especially woody vegetation.

Benthic Relating to the bottom of body of water.

Biodiversity A measure of species, community, or ecosystem composition and richness.

Biological Integrity The maintenance of community composition, structure, and function characteristic of a particular locale or deemed satisfactory by society.

Biotic Community An assemblage of plants and animals living together in a specific location.

Bulk Density The physical property of a soil associated with the weight of one cubic centimeter of the soil, expressed in grams.

Canopy cover The ground or water surface area covered by a vertical projection of the leaves and stems of the overlying vegetation.

Capillarity Upward movement of a liquid in a thin-diameter cylinder, tube, or similar structure (e.g., pore spaces in a soil).

Capillary Fringe The moist zone in a soil directly above a saturated layer, resulting from upward movement of water by capillarity.

Capillary Rise Upward movement of water in soil from a zone of higher water content to a zone of lower water content by capillarity.

Chironimid Any of the family Chironomidae of midges that lack piercing mouthparts.

Coarse-Textured Soil One relatively high in sand or gravel.

Community Structure Relating to the size, mass, dimensions, and numbers of organisms within a specified area.

Confidence Interval The interval around a population mean associated with a specified probability.

Diapause A period of dormancy, usually seasonal, in the life cycle of an insect in which growth and development cease and metabolism is greatly decreased (Smith 1992).

Disturbance Any impact, natural or anthropogenic, to an ecological community that results in the composition, structure, or function of the community to change beyond its usual range in variability.

Early-Successional Relating to the first few stages of an ecological succession where the plant communities are typically dominated by fast-growing and short-lived species.

Ecological Community An assemblage of populations living in a prescribed area or physical habitat (Odum 1971); used in a broad sense to refer to ecological units of various sizes and degrees of integration (Stiling 1992); used in a narrow sense to refer to an ecological unit characterized by the same dominant plant or animal species (Oosting 1956).

Ecological Function Transport and use of water, nutrients, and energy within a community or ecosystem.

Ecosystem An ecological community and its associated abiotic factors treated as a functional unit (Odum 1971, Smith 1992, Stiling 1992).

Ecosystem Health The condition of the structure, function, and composition of an ecosystem.

Ecotone A zone of intergradations or interfingering, narrow or broad, between contiguous stypes of vegetation (Daubenmire 1968).

Edaphic Pertaining to soils.

Electrofishing A method where an electrical current is passed through water between electrodes to stun fish, causing them to rise to the surface.

Emergent Vegetation Rooted aquatic plants with substantial portions of their photosynthetic tissue above the water surface.

Endangered Species A species listed as such by the U.S. Fish and Wildlife Service as requiring some mitigation measures to insure that it does not go extinct.

Endemic Restricted to a given region (Smith 1992).

Ephemeral Temporary, often in response to seasonal or episodic events.

Estivate Animals becoming dormant in response to drought or a dry season.

Evapotranspiration The combined water loss from evaporation from the soil or water surface and transpiration through plants.

Field Capacity The amount of water a retained in a soil layer after gravitational water has drained away.

Fine-Textured Soil One relatively high in silt or clay particles.

Grassland An area where the dominant plant lifeforms are grasses or grass-like plants.

Great Basin The ecological region in the western United States broadly located between the Sierra Nevada Mountains and the Rocky Mountains and north of the Mojave, Sonoran, and Chihuahuan Deserts.

Groundwater Water beneath the soil surface located in a zone of saturation.

Groundwater-influenced ecosystem An ecosystem that is substantially affected by groundwater at least most of the year; includes aquatic ecosystems and wetlands, and those meadows, shrublands, and woodlands where the vegetation utilizes substantial amounts of groundwater on an annual basis and where the composition, structure, or productivity is dependent on this groundwater utilization. The term "water-dependent ecosystems" is used in the Stipulation to denote these ecosystems. The term "groundwater-influenced ecosystems" is used in the Monitoring Plan instead of "water-dependent ecosystems" because groundwater-influenced is a more biologically descriptive term since all ecosystems are dependent on water.

Habitat Location and associated environmental conditions characteristic of where an organism or species lives.

Hardpan A soil layer with high bulk density, generally resulting from compaction or the accumulation of translocated silt or clay particles.

Helocrene A spring that discharges into a marshy and comparatively shallow wetland.

Herbivory Consumption of plant tissue by animals.

Key Ecological Attributes Characteristics that describe groundwater-influenced ecosystems and potentially are critical to their long-term viability or integrity, including biological composition, interactions, and processes (Parrish et al. 2003).

Late-Successional Relating to the later stages of an ecological succession where the plant communities are typically dominated by relatively slow-growing and long-lived species and relatively well-developed vegetation structure.

Limnocrene A spring that discharges into a ponded or pooled habitat before flowing into a defined channel.

Line Transect A one-dimensional extension of a tape measure or similar device used to sample vegetation.

Lithology The study of the stratification of rocks.

Macrophyte A relatively large aquatic plant.

Meadow A plant community dominated by grasses or grass-like plants and that generally has relatively wet soil for at least part of the growing season; when standing water is present, it is for less than the entire growing season.

Micro-community Communities of very limited spatial extent within the matrix of a large community.

Micro-topography The small-scale differences in surface elevation across a landscape.

Mitigate To cause to become less harsh or to reduce the effect of some intrusion.

Monoculture The occurrence of a single species in a specific area.

Mountain Block Spring Discharge of water at the surface from localized or perched groundwater systems that are not hydrologically connected to the regional groundwater system (Prudic et al. 1995).

Nested Target Biota of special interest that are dependent on one or more groundwater-influenced ecosystems.

Peer Review Examination of information or findings by those of equal stature.

Perched Water Table Zone of saturated soil above unsaturated layers that is held in place by underlying dense materials.

Periphyton Organisms that live attached to underwater surfaces.

pH A measure of hydrogen ion concentration used to evaluate whether a water or soil sample is acidic (low value) or basic (high value).

Photoperiod Relating to the relative amounts of light and dark during a 24-hour period.

Phreatophytic Relating to the use of subsurface groundwater by plants.

Phytoplankton Small, free-floating plants in the water column of an aquatic ecosystem.

Piezometer An instrument used to determine the depth to groundwater.

Plant Community The plant components of an ecological community.

Pond A confined body of water smaller than a lake.

Range Front Spring A spring located at elevations higher than the valley floor and in proximity to the slope or bench that precedes the mountain block.

Range in Variation The difference between maximum and minimum values of a measurement metric.

Recruitment The increase in a species or ecological community resulting from addition of new individuals, either from reproduction or migration.

Replication Repetition of a set of observations or an experiment used to reduce statistical error.

Rheocrene A spring that discharges into a defined channel.

Riparian The ecological zone along the banks of a stream or river.

Root Architecture The size, number, mass, and distribution of plant roots in the soil and sub-soil matrix.

Saline Relating to a high concentration of soluble salts.

Sample Size The number of observations in a given sample.

Saturated Soil Soil where all pore spaces are filled with water.

Seep An area where groundwater slowly discharges to the surface.

Sensitive Environmental Resources Those that are easily affected by human interactions or intrusions.

Shrubland An area on which the vegetation is dominated by woody plants generally less than 4 meters tall, and often multi-stemmed.

Siltation The accumulation of fine-sized soil particles on the bottom of a body of water.

Soil Aeration The amount of air present in a soil.

Soil Permeability The movement of liquids and gases from one location in the soil to another location.

Soil Texture The physical property of a soil associated with the relative amounts of the three soil particle classes (sand, silt, clay) the soil contains.

Sodic Relating to a high concentration of sodium.

Spatial Extent The area covered by an ecological unit.

Species Composition The proportion of a vegetation metric (e.g., cover or biomass) contributed by a particular plant species.

Species Cover The ground or water surface area covered by a vertical projection of plant tissue.

Spring Brook The channel flow of water downslope from the spring orifice.

Spring Orifice The opening of a spring from which the water flows.

Springsnails A class of gastropods that inhabit fresh water springs.

Staff Gauge A measuring device that is placed in a body of water that has a graduated scale used for the determination of the water level in contact with the device.

Standard Deviation The square root of the variance.

Stratified Random A sampling technique in which the area or population to be sampled is first divided into units based on a defined criteria and then the samples are randomly selected from each of the units.

Stressor Any factor that shifts conditions away from optimum for a species.

Submergent Vegetation Rooted aquatic plants with their tissue below the water surface.

Subsurface Flow The down-slope movement of water below the soil surface.

Succession The ecological process of the natural replacement of one plant community by another at a given location over time, progressing in the direction of a relatively stable plant community that is in balance with the environmental factors at the site.

Surface Water Water occurring above the ground surface.

Threshold The level of an ecological variable corresponding to the shift from one condition level to another, for that variable for a given ecological entity.

Tolerance The ability of an organism to continue to exist when subjected to an unfavorable environmental factor or level.

Toposequence A sequence of soils or plant communities arranged along a topographic gradient.

Transect An extension, either single- (line) or two-dimensional, of some defined distance or length and width, through an area to be sampled and used to collect data.

Turbidity Decrease in light penetration in water caused by small solid particles suspended in the water column.

Understory Vegetation Plants that exist beneath the canopy of taller plants.

Unsaturated Soil Soil with a water content at or below field capacity.

Valley Floor Spring A spring located on the valley floor.

Variance A statistical measure of variability in a data set.

Vegetation Composition The relative amounts of the plant species of the vegetation.

Vegetation Structure Relating to the spatial arrangement of vegetation, including height, stratification, cover, and spatial pattern.

Vertebrate A animal having a spinal column.

Water Table The upper surface of groundwater.

Weir A barrier or other control device placed in a channel to allow for measurement of water discharge.

Wetland An area with soils that are saturated to the surface most of the time.

Woodland An area on which the vegetation is dominated by woody plants generally more than 4 meters tall and usually single-stemmed, and where canopy cover of the woody plants is not continuous.

Xeric Pertaining to dry conditions.

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APPENDIX A

STIPULATION FOR WITHDRAWAL OF PROTESTS, WITH EXHIBITS A AND B

STIPULATION FOR WITHDRAWAL OF PROTESTS

This Stipulation is made and entered into between the Southern Nevada Water Authority (SNWA) and the United States Department of the Interior on behalf of the Bureau of Indian Affairs, the Bureau of Land Management, the National Park Service, and the Fish and Wildlife Service (collectively the "DOI Bureaus"). Collectively, SNWA and each of the DOI Bureaus are referred to as the "Parties."

RECITALS

A. In October 1989, the Las Vegas Valley Water District (SNWA's predecessor-in-interest) filed Applications 54003 through 54021, inclusive, (hereinafter referred to as the "SNWA Applications") for a combined 126 cfs of groundwater withdrawals in the Spring Valley Hydrographic Basin ("Spring Valley HB"). SNWA intends to pump up to 91,224 acre-feet of groundwater annually from the Spring Valley HB for municipal purposes with concurrent monitoring, management, and mitigation as specified in Exhibits A and B. In the future, SNWA may seek to change the points of diversion within the Spring Valley HB for any quantities of groundwater permitted pursuant to the SNWA Applications.

B. The DOI Bureaus filed timely protests to the granting of the SNWA Applications pursuant to the DOI Bureaus' responsibilities to protect their state and federal water rights ("Federal Water Rights") and other water-dependent resources ("Federal Resources") of the DOI Bureaus in the Area of Interest (depicted in Figure 1). The DOI Bureaus are required by law to manage, protect, and preserve all Federal Water Rights and Federal Resources that fall under their jurisdiction. A number of these Federal Water Rights and Federal Resources occur within the Area of Interest. As of the date of this Stipulation, those Federal Water Rights that are based upon the application of federal law have not been quantified pursuant to an adjudication that complies with the requirements of the McCarren Amendment, 43 U.S.C. § 666. SNWA expressly reserves the right to contest any and all claims of the DOI Bureaus to such Federal Water Rights as are based upon the application of federal law in any proceeding that conforms to the requirements of the McCarren Amendment, 43 U.S.C. § 666.

C. The DOI Bureaus are concerned that the proposed groundwater withdrawals from the Spring Valley HB may injure Federal Water Rights and and/or affect Federal Resources, including but not limited to those associated with the refugia located at the Shoshone Ponds, or may affect Federal Resources within the boundaries of Great Basin National Park and are desirous of working in a cooperative manner with the SNWA to protect these Federal Water Rights and Federal Resources.

D. The Parties acknowledge that Nevada Water Law provides pursuant to NRS 534.110(4) that "[i]t is a condition of each appropriation of groundwater acquired under this chapter [534] that the right of the appropriator relates to a specific quantity of water and that the right must allow for a reasonable lowering of the static water level at the appropriator's point of diversion." Further, pursuant to NRS 534.110(5), Nevada Water Law "does not prevent the granting of permits to applicants later in time on the ground that the diversions under the proposed later appropriations may cause the water level to be lowered at the point of diversion of a prior appropriator, so long as the rights of holders of existing appropriations can be satisfied under such express conditions." It is the intent of the Parties that this Stipulation provides the initial "express conditions" to allow development of the SNWA Applications to proceed; however, such future conditions may be adjusted based on implementation of the monitoring, management, and mitigation plans specified in Exhibits A and B, which are attached to this Stipulation and made a part hereof.

E. The State Engineer has set an administrative hearing on the protests of the DOI Bureaus and other protestants commencing September 11, 2006.

F. The Parties acknowledge that other entities and individuals have lodged protests to the SNWA Applications, but such additional protestants are not Parties to or in any way bound or prejudiced by this Stipulation. Further, these protestants may enter into stipulations with SNWA concerning the SNWA Applications. Such stipulations shall not require the participation of the DOI Bureaus nor modify in any way the intent or content of this Stipulation, nor shall the DOI Bureaus be bound or prejudiced by such stipulations.

G. The common goals of the Parties are 1) manage the development of groundwater by SNWA in the Spring Valley HB without causing injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources in the Area of Interest, 2) accurately characterize the groundwater gradient from Spring Valley HB to Snake Valley HB via Hamlin Valley, and 3) to avoid any effect on Federal Resources located within the boundaries of Great Basin National Park from groundwater withdrawal by SNWA in the Spring Valley HB. The Parties agree that the preferred conceptual approach for protecting Federal Water Rights from injury and Federal Resources from unreasonable adverse effects within the Area of Interest and for avoiding any effect on Federal Resources located within the boundaries of Great Basin National Park that may be caused by groundwater withdrawals by SNWA in the Spring Valley HB is through the development of such groundwater in conjunction with the implementation of the monitoring, management, and mitigation plans described in Exhibits A and B. The effects of groundwater withdrawals pursuant to the development of any or all of the SNWA Applications and any future changes in points of diversion and/or rates of withdrawal need to be properly monitored and managed to avoid any injury to Federal Water Rights and unreasonable adverse effects to Federal Resources within the Area of Interest and any effect on Federal Resources located within the boundaries of Great Basin National Park. There is a need to better understand the response of the aquifers and associated discharge points, such as artesian wells, springs, streams, wetlands, and playas, to pumping stresses from development of permitted quantities of groundwater in accordance with the monitoring, management, and mitigation plans set forth in Exhibits A and B to this Stipulation. The Parties have determined that it is in their best interests to cooperate in the collection and analysis of additional hydrologic, hydrogeologic, and water chemistry information. The Parties shall cooperate in the development of a regional groundwater-flow numerical model, for assessing the effects of groundwater withdrawals by SNWA in the Spring Valley HB.

H. The common goals of the Parties are 1) to manage the development of groundwater by SNWA in the Spring Valley HB in order to avoid unreasonable adverse effects to wetlands, wet meadow complexes, springs, streams, and riparian and phreatophytic communities (hereafter referred to as Water-dependent Ecosystems) and maintain the biological integrity and ecological health of the Area of Interest over the long term, and 2) to avoid any effects to Water-dependent Ecosystems within the boundaries of Great Basin National Park. The Parties agree that the preferred conceptual approach is development of groundwater by SNWA in conjunction with the implementation of the monitoring, management, and mitigation plans described in Exhibits A and B to this Stipulation. The Parties further agree that there is a need to better understand: 1) the response of aquifers and associated discharge areas, such as artesian wells, springs, streams, wetlands, playas, and riparian and phreatophytic communities to pumping stresses, and 2) the response of aquatic and terrestrial organisms to changes in water-dependent habitats caused by groundwater withdrawals by SNWA in the Spring Valley HB. The Parties have determined that it is in their best interests to cooperate in data collection and analysis related to groundwater levels and the long-term maintenance of Water-dependent Ecosystems within the Area of Interest.

I. The common goal of the Parties is to manage the development of groundwater by SNWA in the Spring Valley HB to avoid an unreasonable degradation of the scenic values of, and visibility from Great Basin National Park due to a potential increase in airborne particulates and loss of surface vegetation which may result from groundwater withdrawals by SNWA in the Spring Valley HB. The Parties agree that the preferred conceptual approach for protecting existing visibility from unreasonable degradation is through the implementation of appropriate monitoring, management, and mitigation activities in conjunction with SNWA's groundwater development. The purpose of this goal is to support the "significant … scenic values" of Great Basin National Park, as recognized by Congress in establishing the park. 16 U.S.C. § 410mm(a). The NPS has interpreted this mandate in its Great Basin National Park General Management Plan to be "the ability to view broad areas of basin and range topography and distant mountains is central to interpreting the entire Great Basin region." Additionally, a goal of the Parties for SNWA's Clark/Lincoln/White Pine Counties Ground-water Development Project also includes managing the construction and operation activities related to any wells and water delivery pipelines and support structures associated with the use of water under the SNWA Applications to avoid unreasonable degradation of the scenic values of and the visibility from Great Basin National Park. Further, it is in the Parties' best interests to cooperate in the collection and analysis of additional information regarding the relationship between the development of groundwater resources, loss of surface vegetation, drying of surface soils, increased susceptibility of land surfaces to wind erosion, and the long-term avoidance of unreasonable degradation of the scenic values of, and visibility from, Great Basin National Park.

J. The Parties desire to resolve the issues raised by the protests according to the terms and conditions contained herein.

NOW, THEREFORE, in consideration of the mutual promises and covenants contained herein, the Parties do agree as follows:

1. The DOI Bureaus hereby expressly agree to withdraw their protests to the SNWA Applications and agree that the Nevada State Engineer may rule on the SNWA Applications based upon the terms and conditions set forth herein. It is expressly understood that this Stipulation is binding only upon the Parties hereto and their successors, transferees and assignees, and shall not bind or seek to bind or prejudice any other Parties or protestants, including any Indian Tribe.

2. The Parties agree to implement the Monitoring, Management and Mitigation Plans, attached hereto "Exhibits A and B," which are expressly incorporated into this Stipulation as if set forth in full herein, if and only if the Nevada State Engineer grants any of the SNWA Applications in total or in part; however, at any future date if all of the permits issued by the Nevada State Engineer pursuant to the SNWA Applications are cancelled, then this Stipulation shall be of no further force and effect among the Parties. To facilitate the implementation of the Monitoring, Management, and Mitigation Plans, the Parties shall establish a Technical Review Panel (TRP), a Biological Working Group (BWG), and an Executive Committee. The establishment, membership, conduct,

obligations and responsibilities of the TRP, BWG, and Executive Committee shall be as set forth in Exhibits A and B of this Stipulation.

3. SNWA recognizes that the DOI Bureaus are concerned that groundwater withdrawals from the existing point of diversion for Application No. 54019 may unreasonably adversely affect Shoshone Ponds. Prior to withdrawing any quantity of water for beneficial use at this point of diversion, SNWA shall in good faith work with the TRP to evaluate reasonable alternative point(s) of diversion for any water rights permitted pursuant to Application No. 54019. If the TRP and Executive Committee unanimously recommend that any such point(s) of diversion be pursued, then SNWA will file applications with the Nevada State Engineer to change the point of diversion as recommended by the TRP and Executive Committee.

4. SNWA may seek to change the points of diversion and rates of withdrawal within the Spring Valley HB for any quantities of groundwater permitted pursuant to the SNWA Applications. Prior to filing such change applications, SNWA shall consult with the TRP and the BWG about the potential effects of any proposed changes on Federal Water Rights and Federal Resources. If the consensus of the TRP and the BWG is that the proposed change(s) will not 1) increase the risk of injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources, 2) have any effect on Federal Resources and/or Water-dependent Ecosystems located within the boundaries of Great Basin National Park, 3) have unreasonable adverse effects on the biological integrity and ecological health of Water-dependent Ecosystems in the Area of Interest, or 4) cause unreasonable degradation of scenic values of, and the existing visibility from, Great Basin National Park, then the TRP and the BWG will recommend to the Executive Committee that protests not be filed to the proposed change(s). If there is no such

consensus between the TRP and the BWG, or within the Executive Committee, then the DOI Bureaus shall be free to file such protests as they deem necessary.

5. To meet the common goal specified in Recital I above, the Parties agree to 1) assess the potential impacts of both groundwater withdrawals and construction and operation activities on the scenic values of, and visibility from, Great Basin National Park in the Environmental Impact Statement for the Clark/Lincoln/White Pine Counties Groundwater Development Project ("Groundwater Development Project"); and 2) implement appropriate monitoring, management, and mitigation actions needed to avoid unreasonable degradation of scenic resources, including maintaining visibility. The Parties agree to cooperate in good faith in the right-of-way permitting process associated with the Groundwater Development Project to produce monitoring, management, and mitigation requirements consistent with the above stated goal.

6. This Stipulation does not waive any authorities of the DOI Bureaus or the United States, including any other agency or bureau not specified in this Stipulation. Further, this Stipulation does not override or relieve the Parties from complying with applicable federal laws, including, but not limited to, the National Environmental Policy Act, the Endangered Species Act, the Federal Land Policy and Management Act, and any and all rules and regulations thereunder.

7. It is the expressed intention of the Parties that by entering into this Stipulation, the DOI Bureaus, the United States, and SNWA are not waiving legal rights of any kind, except as expressly provided herein. Nor is this Stipulation intended to modify any legal standard by which Federal Water Rights, Federal Resources, and Water-dependent Ecosystems are protected.

8. The Parties expressly acknowledge that the Nevada State Engineer has, pursuant to both statutory and case law, broad authority to administer groundwater resources in the State of Nevada and, furthermore, that nothing contained in this Stipulation shall be construed as waiving or in any manner diminishing such authority.

9. The Parties agree that a copy of this Stipulation shall be submitted to the Nevada State Engineer at the commencement of the administrative proceedings scheduled to begin on September 11, 2006. At that time, the Parties shall request on the record at the beginning of the scheduled proceeding that the State Engineer include this Stipulation and Exhibits A and B as part of the permit terms and conditions in the event that he grants any of the SNWA Applications in total or in part. Following the submission of this Stipulation and Exhibits A and B to the State Engineer, then the DOI Bureaus, at their option, may attend the hearing, but shall not present a case, witnesses, exhibits, or statements, nor assist any other party or protestant in presenting a case, witnesses, exhibits or statements, except as expressly provided herein. SNWA agrees that the DOI Bureaus may, without objection, introduce the exhibits identified in Attachment 1 to this Stipulation into evidence. The DOI Bureaus and SNWA shall jointly explain or defend this Stipulation and Exhibits A and B to the State Engineer. Furthermore, the National Park Service, during the public comment period for the hearing described above in Recital E, may have David Prudic of the U.S. Geological Survey comment for the record regarding the purpose, methodologies, and conclusions of a U.S.G.S. report entitled "Characterization of Surface-Water Resources in the Great Basin National Park Area and Their Susceptibility to Ground-Water Withdrawals in Adjacent Valleys, White Pine County, Nevada" (Scientific Investigations Report 2006-5099) and any testimony that was presented regarding said report during the hearing.

10. SNWA shall submit a copy of this Stipulation and Exhibits A and B to the Bureau of Land Management and request that it be included in any Environmental Impact Statement prepared for the "Clark/Lincoln/White Pine Counties Groundwater Development Project", or any other project related to the development of the SNWA Applications.

11. Notices. If notice is required to be sent by the Parties, the addresses are as follows:

If to DOI Bureaus:

Regional Director
Western Regional Office
Bureau of Indian Affairs
400 North 5th Street
Phoenix, AZ 85004

State Director
Nevada State Office
Bureau of Land Management
1340 Financial Blvd.
Reno, NV 89502

Field Supervisor
Nevada Field Office
Fish and Wildlife Service
1340 Financial Blvd., #234
Reno, NV 89502

Branch Chief
Water Rights Branch
National Park Service
1201 Oak Ridge Drive, Suite 250
Fort Collins, CO 80525

If to SNWA:

General Manager
Southern Nevada Water Authority
1900 E. Flamingo Road
Las Vegas, NV 89153

12. Any Party hereto may transfer or assign its interest, if any, in the water rights here involved. Any and all transferees and assignees shall be bound by the terms and conditions of this Stipulation. As a condition to any such transfer or assignment, the

transferee and/or assignee shall execute a stipulation expressly stating it is bound to all of the terms and conditions of this Stipulation.

13. This Stipulation shall be governed in accordance with the laws of the State of Nevada to the extent not inconsistent with federal law.

14. Copies of all correspondence between and data gathered by the Parties pertinent to the SNWA Applications and the Area of Interest shall be submitted to the Nevada State Engineer. It is the intentions of the Parties hereto that the Nevada State Engineer shall be kept informed of all activities in the same fashion as are the Parties hereto; however, the Executive Committee, in consultation with the Nevada State Engineer, may specify the types of data and documents that shall be submitted to the Nevada State Engineer.

15. By entering into this Stipulation, the DOI Bureaus do not become a party to any proceeding other than the protest proceeding referenced above or waive its immunity from suit or consent to or acknowledge the jurisdiction of any court or tribunal. Nothing in the Stipulation shall affect any federal reserved water rights of the DOI Bureaus or the United States on behalf of any Indian Tribe and the DOI Bureaus by entering into this Stipulation do not waive or prejudice any such rights. The DOI Bureaus reserve all legal rights, of any kind, they possess pursuant to or derived from Executive Orders, acts of Congress, judicial decisions, or regulations promulgated pursuant thereto. The Parties do not waive their rights to seek relief in any appropriate forum not expressly prohibited by this Stipulation.

16. Any commitment of funding by the DOI Bureaus or the SNWA in this Stipulation, including specifically any monitoring, management, and mitigation actions provided for in Exhibits A and B is subject to appropriations by Congress or the governing body of the SNWA as appropriate.

17. This Stipulation may be amended by mutual written agreement of the Parties.

18. This Stipulation sets forth the entire agreement of the Parties and supercedes all prior discussions, negotiations, understandings or agreements. No alteration of variation of this Stipulation shall be valid or binding unless contained in an amendment in accordance with paragraph 17.

19. This Stipulation is entered into for the purpose of resolving a disputed claim and establishing the monitoring, management, and mitigation plans contained in Exhibits A and B. Except as expressly provided herein, the Parties agree that the Stipulation shall not be offered as evidence or treated as an admission regarding any matter herein and may not be used in proceedings on any other application or protest whatsoever, except that the Stipulation may be used in any future proceeding to interpret and/or enforce its terms. Further, the Parties agree that neither the Stipulation nor any of its terms shall be used to establish precedent with respect to any other application or protest in any water rights adjudication or water rights permitting proceeding, including but not limited to any hearing regarding the SNWA Applications in the Snake Valley HB, before the Nevada State Engineer or in any other administrative or judicial proceeding.

20. The terms and conditions of this Stipulation shall be binding upon and inure to the benefit of the Parties hereto and their respective agents, officers, employees, personal representatives, successors, transferees and assigns.

21. Each Party agrees to bear its own costs and attorney fees.

22. This Stipulation shall become effective as between the Parties upon all Parties signing this Stipulation. The Parties may execute this Stipulation in two or more counterparts, which shall, in the aggregate, be signed by all Parties; each counterpart shall be deemed an original as against any Party who has signed it.

23. Other entities may become Parties to this Stipulation by mutual assent of the Parties.

IN WITNESS WHEREOF, the Parties hereto have executed this Agreement on the dates written below.

Date: 9/8/06

UNITED STATES DEPARTMENT OF THE INTERIOR

Bureau of Indian Affairs

By Catherine Wilson

Title: Acting Regional Director

09/08/2006 16:58 FAX ☑002/002

Date: SEP 0 8 2006

UNITED STATES DEPARTMENT OF THE INTERIOR

Bureau of Land Management

By Ron Wenker

Title: State Director

Date: 9-8-2006

UNITED STATES DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

By [signature]

Title: Deputy Manager, CNO

Date: 9/8/06

UNITED STATES DEPARTMENT OF THE INTERIOR

National Park Service

By [signature]

Title: Regional Director

Date: 9-8-2006

SOUTHERN NEVADA WATER AUTHORITY

By P Mulroy

Title: General Manager

ATTEST:

John J. Entsminger

Deputy General Counsel

Attachment 1- Exhibits Offered into Evidence by the DOI Bureaus in the Matter of Protested Applications 54003-54021, Before the State Engineer of the State of Nevada, September 11-29, 2006

NPS-2501	Written report for Tod Williams, Chief of Resources Management, Great Basin National Park (*This Exhibit is submitted without Attachments 1, 2, and 3)*
FWS-2035	Hershler, R. 1998. A systematic review of the Hydrobiid snails (Gastropoda: Rissooidea) of the Great Basin, western United States. Part I. Genus *Pyrgulopsis*. The Veliger 41, pages 1-3, 11-14, 56-57, 99-132.
FWS-2036	Hershler, R. and D.W. Sada. 2002. Biogeography of Great Basin aquatic snails of the Genus *Pyrgulopsis*. Pages 255-276 *in* R. Hershler, D.B. Madsen, and D.R. Curvey, eds. Great Basin Aquatic Systems History. Smithsonian Contributions to the Earth Sciences, Number 33.
FWS-2049	*Attachment 2:* Bailey, C., K. W. Wilson and M. E. Andersen. 2005. Conservation Agreement and Strategy for Least Chub (*Iotichthys phlegethontis*) in the State of Utah. Utah Division of Wildlife Resources Pub No. 05-24.
FWS-2049	*Attachment 3:* Bailey, C., K. W. Wilson and M. E. Andersen. 2006. Conservation Agreement and Strategy for Columbia Spotted Frog (*Rana luteiventris*) in the State of Utah. Utah Division of Wildlife Resources Pub No. 06-01.
FWS-2060	Sage Grouse Conservation Team. 2004. Greater Sage-Grouse Conservation Plan for Nevada and Eastern California. First Edition. Prepared for Nevada Governor Kenny C. Guinn. Nevada. Title page, table of contents, Executive Summary, acknowledgements, Pages 1-108, Appendix Q- White Pine County Sage-Grouse Conservation Plan, Appendix R- Lincoln County Sage-Grouse Conservation Plan.
FWS-2063	Mr. Shawn Goodchild's factual witness report entitled "Witness Report: Pahrump poolfish and Shoshone Ponds."
FWS-2086	Mr. Shawn Goodchild's factual witness report entitled "Witness Report: Relict dace and Shoshone Ponds."
FWS-2106	Skudlarek, E., ed. 2006. Nevada wetlands priority conservation plan, technical review draft. Nevada Natural Heritage Program, Department of Conservation and Natural Resources, Title Page and pages 1-11, 1-20, 1-22, 1-25, 3-3, 3-7, 3-8, 3-9, 4-26, 4-31, 4-32, 4-34, 4-35.
FWS-2111	Bat Field Survey Reports at Shoshone Ponds, 1997 and 2003, Nevada Division of Wildlife.

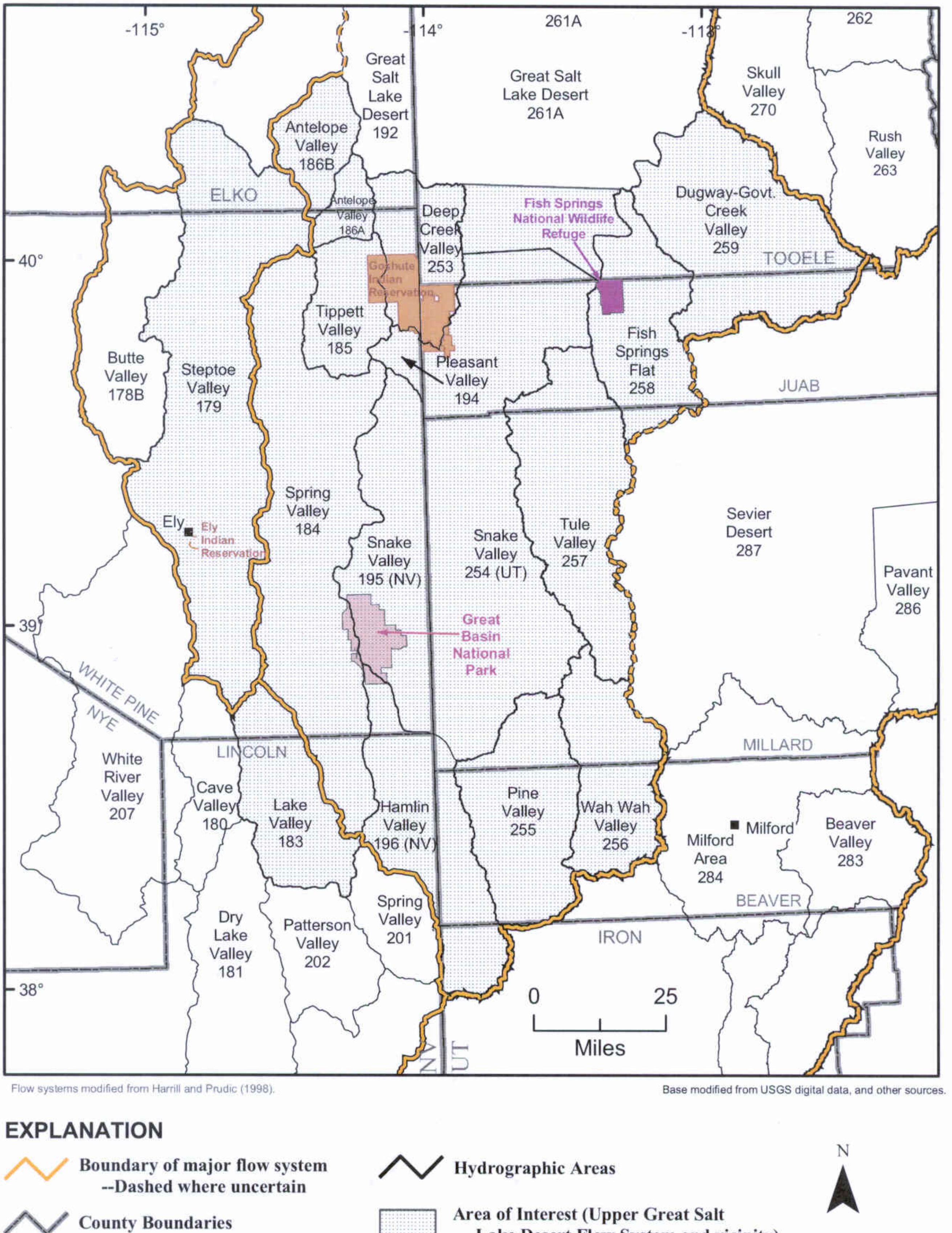

Figure 1.—Map showing the location of the Area of Interest.

EXHIBIT A

HYDROLOGIC MONITORING, MANAGEMENT AND MITIGATION PLAN FOR DEVELOPMENT OF GROUNDWATER IN THE SPRING VALLEY HYDROGRAPHIC BASIN PURSUANT TO APPLICATION NOS. 54003 THROUGH 54021 BY THE SOUTHERN NEVADA WATER AUTHORITY

1. Introduction

This hydrologic monitoring, management and mitigation plan (Plan) is a component of a Stipulation between the Southern Nevada Water Authority (hereinafter referred to as "SNWA") and the U.S. Department of the Interior bureaus, including the Bureau of Indian Affairs, the Bureau of Land Management, the Fish and Wildlife Service, and the National Park Service (hereinafter referred to as the "DOI Bureaus"). Collectively, SNWA and each of the DOI Bureaus are hereinafter referred to as the "Parties."

This Plan describes the Parties' obligations regarding the development, monitoring, management, and mitigation related to SNWA's applications 54003 through 54021 ("SNWA Applications") to withdraw groundwater from points of diversion in the Spring Valley Hydrographic Basin ("Spring Valley HB"). The Plan consists of three principal components:

Monitoring Requirements - including, but not limited to monitoring wells, spring flow measurements, water chemistry analyses, quality control procedures, and reporting requirements; and

Management Requirements – including, but not limited to the creation of a Technical Review Panel ("TRP") to review information collected under this Plan and advise the Executive Committee (a group consisting of one management-level person from each Party, as described below in Management Requirements), the use of an agreed-upon regional groundwater flow system numerical model(s) to predict effects of groundwater withdrawals by SNWA in the Spring Valley HB, and the establishment of a consensus-based decision-making process; and

Mitigation Requirements – including, but not limited to the modification, relocation or reduction in points of diversion and/or rates and quantities of groundwater withdrawals or the augmentation of Federal Water Rights and/or Federal Resources as well as measures designed and calculated to rehabilitate, repair or replace any and all Federal Water Rights and Resources if necessary to achieve the goals set forth in Recital G of the Stipulation.

A. Common Goals

The common goals of the Parties are 1) manage the development of groundwater by SNWA in the Spring Valley HB without causing injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources in the Area of Interest as defined in Recital B of the

Stipulation that this Exhibit A is attached to and incorporated therein, 2) accurately characterize the groundwater gradient from Spring Valley HB to Snake Valley HB via Hamlin Valley, and 3) to avoid any effect on Federal Resources within the boundaries of Great Basin National Park from groundwater withdrawals by SNWA in the Spring Valley HB. The Parties, through the TRP and BWG (as described in Exhibit B that is attached to and incorporated in the Stipulation), shall collaborate on data collection and technical analysis and shall rely on the best scientific information available in making determinations and recommendations required by the Plan.

2. <u>Monitoring Requirements</u>

A. General

The Parties agree to cooperatively implement a monitoring plan sufficient to collect and analyze data to assess the effects, if any, of SNWA's proposed groundwater withdrawals in the Spring Valley HB on Federal Water Rights and Federal Resources. The monitoring network shall be comprised of SNWA exploratory wells, SNWA production wells, existing monitoring wells selected by the TRP, new monitoring wells, the springs selected by the TRP and the BWG listed in Table 1, and certain selected stream discharge sites. Some of the wells within the monitoring network shall be designed and constructed to detect any potential change in the groundwater gradient from Spring Valley HB to Snake Valley HB via Hamlin Valley HB. Other wells in the monitoring network shall be located throughout Spring Valley to provide early warning of the spread of drawdown toward Federal Water Rights and Federal Resources as well as data for future groundwater model calibration. Shallow piezometers and wells shall be used to evaluate the effects of groundwater withdrawals near discharge areas that are within areas the Parties are seeking to protect and preserve.

The cost of the monitoring plan shall be borne primarily by SNWA. The DOI Bureaus shall provide staffing to the TRP and shall seek funding to contribute to monitoring efforts. Except as otherwise provided in this Plan, each DOI Bureau is responsible for monitoring its own Federal Water Rights and Federal Resources, and for sharing this information with the other Parties within 90 days of its collection.

Any requirement of SNWA to continuously monitor wells, piezometers, and surface water sites pursuant to the Plan shall require SNWA to install all equipment necessary to continuously record discharge and/or water levels at all monitoring sites and shall, unless prevented by circumstances beyond its control, ensure that all such discharge and/or water level data is recorded on a continuous basis.

B. Exploratory and Production Well Monitoring

SNWA shall record discharge and water levels in all SNWA production wells on a continuous basis.

SNWA shall record water levels in all SNWA exploratory wells at least quarterly. Following the beginning of the groundwater withdrawals pursuant to any permits issued for the SNWA

Applications, the TRP shall select a representative number of exploratory wells for which SNWA shall thereafter continuously record water levels.

C. Existing Monitoring Wells

SNWA shall monitor groundwater levels quarterly in 10 representative monitoring wells and continuously monitor groundwater levels in 15 representative monitoring wells in the Spring Valley HB and the Hamlin Valley HB. These wells shall be selected by the TRP from the wells listed in Table D.1-1 in SNWA exhibit 509 ("Water Resources Assessment for Spring Valley, June 2006"), which was submitted to the Nevada State Engineer on June 30, 2006. The wells shall include as many existing carbonate wells as is possible and the wells shall be selected to: (1) serve as monitoring points between SNWA's pumping and Federal Water Rights and Federal Resources; and (2) obtain hydrologic information throughout the Spring Valley HB in order to produce annual groundwater level contour and water-level change maps, calibrate the groundwater flow model(s), and evaluate the effects of SNWA's groundwater withdrawals.

Modification of this monitoring requirement, including any addition, subtraction or replacement of the wells initially selected by the TRP or the frequency of monitoring for these wells may be made through consensus recommendations from the TRP as set forth in Section 3 of this Plan.

D. New Monitoring Wells

The DOI Bureaus agree to expedite NEPA and other clearances, within the limits of applicable laws, to help meet the monitoring requirement of this Plan. The construction of the new monitoring wells is contingent upon accessibility and issuance of appropriate rights-of-way by various Federal and State agencies.

SNWA shall begin continuous measurement of water levels at all new monitoring wells upon their completion, contingent upon accessibility and issuance of appropriate rights-of-way by various Federal and State agencies. SNWA shall purchase and install all necessary water-level measuring equipment.

I. New Monitoring Wells located within the Interbasin Groundwater Monitoring Zone ("Zone")

The Parties agree to collect data to accurately characterize the groundwater gradient from Spring Valley HB to Snake Valley HB via Hamlin Valley. In doing so, the Parties agree to establish an Interbasin Groundwater Monitoring Zone ("Zone") having the initial boundaries as depicted on Figure A1 which is attached hereto.

SNWA, in consultation with the TRP, shall construct and equip four monitoring wells in the carbonate-rock aquifer and two monitoring wells in the basin-fill aquifer within the Zone. SNWA may substitute existing wells for the monitoring wells required to be constructed pursuant to this paragraph if agreed upon by the TRP. The Parties, through the TRP, shall work together on the design and location of the wells to be constructed to monitor potential changes in the groundwater gradient in the Zone. Such wells shall be located, designed, and constructed to achieve the monitoring goals and requirements of this Plan.

SNWA shall not file any applications with the Nevada State Engineer to change the points of diversion of any permits granted pursuant to the SNWA Applications to a point of diversion within the Zone for a period of five years following the completion of the six (6) monitoring wells within the Zone or ten (10) years from the date of the execution of this Stipulation, whichever is shorter.

II. New Monitoring Wells located outside the Zone that are adjacent to SNWA Production Wells

SNWA, in consultation with the TRP, shall construct and equip two monitoring wells in conjunction with the two SNWA production wells in the Spring Valley HB proposed to be constructed closest to the boundary of the Zone, unless alternative monitoring sites are recommended by the TRP and approved by the Executive Committee. The TRP shall determine the location and aquifer in which these wells will be completed. Both these near-field monitoring wells shall have their water levels monitored continuously. To ensure baseline aquifer conditions are established, SNWA shall use its best efforts to construct, begin monitoring, and make available for sampling the two monitoring well described in this paragraph at least two years prior to any groundwater withdrawals, other than for aquifer tests and construction water, from the two SNWA production wells described in this paragraph.

III. New Monitoring Wells located outside the Zone that are in the vicinity of Shoshone Ponds

SNWA, in consultation with the TRP, shall construct and equip two monitoring wells in the vicinity of Shoshone Ponds. One of these shall be located in the basin-fill aquifer near the SNWA carbonate-rock aquifer production well that is closest to Shoshone Ponds. The other monitoring well shall be located in the carbonate-rock aquifer near the SNWA carbonate-rock aquifer production well closest to the Shoshone Ponds. The Parties, through the TRP, shall work together on the design and location of the wells to be constructed to monitor potential changes in the basin-fill and carbonate-rock aquifers near Shoshone Ponds. Such wells shall be located, designed, and constructed to achieve the monitoring goals and requirements of this Plan. SNWA shall continuously monitor the water levels in each of the wells. SNWA may substitute existing wells for the monitoring wells required to be constructed pursuant to this paragraph if agreed upon by the TRP. SNWA shall not withdraw any quantity of groundwater for beneficial use in accordance with any permit issued pursuant to SNWA Application No. 54019 for a period of three years from the completion of the last of the two monitoring wells referred to in this paragraph or four years from the issuance of the permit for the SNWA carbonate-rock aquifer production well constructed closest to the Shoshone Ponds.

IV. New Monitoring Wells located outside the Zone that are adjacent to Federal Water Rights and Federal Resources

SNWA shall install, equip, and maintain at least one shallow well or piezometer near twelve (12) of the springs listed in Table 1 in order to measure water-level changes nearby. While the TRP, in coordination with the BWG, shall determine which sites are to be monitored, and may increase or decrease the total number of sites, the following seven (7) sites should be monitored because of their location and/or the habitat or species associated with the site unless the TRP determines other sites are better suited. The basis for the selection of any site and the total number of sites selected shall be to meet the goals and objectives of this Plan.

Number	Latitude	Longitude	Name	Township/Range/Sec
58134	38.936493	-114418228	Shoshone Ponds	12N 67E 02 SW NE
54109	38.842444	-114.366388	Swallow Spring	11N 68E 5 SE NW
R05276	38.611113	-114.429845	Deer Spring	09N 67E 26 NE SW
	39.159833	-114.352416	Turnley Spring	15N 68E 16 SW SW
	39.1075	-114.453305	Layton Spring	14N 67E 04 NW SE
R05289	39.22918	-114.543761	Unnamed	16N 66E 22 SW SW
R05294	39.204746	-114.462256	Unnamed	16N 67E 32 NE SW

Table 1 – List of Springs to be Monitored

Number	Latitude	Longitude	Name	Township/Range/Sec
R05269	38.878515	-114.495421	4WD Spring	15N 67E 30 SE NW
R05272	38.878053	-114.496272	Unnamed	15N 67E 30 SE NW
R05273	38.957224	-114.488871	Spring Creek Springs	13N 67E 30 SE SE
R05274	38.979402	-114.404312	Unnamed	13N 67E 24 SE NW
R05276	38.611113	-114.429845	Deer Spring	09N 67E 26 NE SW
R05278	39.139732	-114.496816	Unnamed	15N 67E 30 NW NW
R05279	39.195582	-114.457849	Unnamed	15N 67E 04 SE NW
R05280	39.187502	-114.464393	Unnamed	15N 67E 04 SW SW
R05281	39.181658	-114.37323	Rock Spring	15N 68E 08 SW NW
R05282	39.178682	-114.358414	Unnamed	15N 68E 08 NW SE
R05283	39.183993	-114.35807	Unnamed	15N 68E 08 NE NE
R05284	39.1852	-114.3563	Unnamed	15N 68E 08 SE NE
R05285	39.177372	-114.37053	Unnamed	15N 68E 08 NW SW
R05286	39.171858	-114.368555	Unnamed	15N 68E 17 NW NW
R05287	39.243687	-114.535882	Unnamed	16N 66E 22 NE NW
R05288	39.244052	-114.542418	Unnamed	16N 66E 22 NW NW
R05289	39.22918	-114.543761	Unnamed	16N 66E 22 SW SW
R05290	39.246442	-114.522184	Indian Spring	16N 66E 14 SW SW
R05291	39.255056	-114.430904	Unnamed	16N 67E 15 NW NW
R05292	39.203392	-114.461555	Unnamed	16N 67E 32 SE SW
R05293	39.214819	-114.45982	Unnamed	16N 67E 32 NE NW
R05294	39.204746	-114.462256	Unnamed	16N 67E 32 NE SW
R05295	39.228372	-114.38669	Unnamed	16N 67E 25 NE NW
58134	38.936493	-114418228	Shoshone Ponds	12N 67E 02 SW NE
	39.159833	-114.352416	Turnley Spring	15N 68E 16 SW SW
	39.1075	-114.453305	Layton Spring	14N 67E 04 NW SE
	39.135611	-114.473305	South Bastian Spring	15N 67E 29 NW SE
	38.801888	-114.411388	Blind Spring	11N 67E 23 NE SE
	38.842444	-114.366388	Swallow Spring	11N 68E 5 SE NW

SNWA shall continuously monitor the water level in each well or piezometer using a pressure transducer/data logger. SNWA shall use its best efforts to construct, begin monitoring, and make available for sampling the 12 shallow wells and piezometers selected by the TRP and the BWG as described in this paragraph at least two years prior to the withdrawal of any groundwater permitted by the State Engineer pursuant to the SNWA Applications for beneficial use, other than for aquifer tests and construction.

E. Constant Rate Aquifer Tests

An understanding of aquifer properties is necessary in order to make predictions regarding changes in groundwater levels and flows and facilitate the modeling of the groundwater flow systems. Furthermore, constant-rate aquifer tests are needed to help determine such aquifer properties. As such, two constant-rate aquifer tests shall be performed. The TRP shall examine the distribution of aquifer property data and determine the need for specific parameters, such as duration, depth, and monitoring points, for such tests. One constant-rate aquifer test shall be performed by pumping the SNWA basin-fill aquifer production well located closest to the boundary between the Spring Valley HB and the Hamlin Valley HB. Similarly, one constant-rate aquifer test shall be performed by pumping the SNWA carbonate production well located closest to the boundary between the Spring Valley HB and the Hamlin Valley HB. In the event that SNWA constructs a production well at the point of diversion specified in Application No. 54019, SNWA shall perform one constant-rate aquifer test pursuant to the parameters determined by the TRP.

F. Water Chemistry Sampling Program

SNWA shall collect and analyze water chemistry for the parameters set forth in Table 2 for the wells, piezometers, and surface water sites in the monitoring network. An initial sampling of 40 wells, piezometers, and surface water sites selected by the TRP from the monitoring network, excluding however all SNWA production wells, shall be conducted three times at six-month intervals pursuant to a schedule determined by the TRP, but completed by no later than five years from the date of the execution of the Stipulation, unless prevented by circumstances beyond SNWA's control. Thereafter, sampling of the 40 wells, piezometers, and surface water sites selected by the TRP shall be conducted once every five years following the start of groundwater withdrawals by SNWA. The TRP, in consultation with the BWG, may change any aspect of this water chemistry sampling program, including but not limited to the addition and/or deletion of sampling sites, the addition and/or deletion of water chemistry parameters, and an increase or decrease in sampling frequency, if deemed appropriate by the TRP. SNWA may subcontract this obligation to a third party, such as but not limited to the U.S. Geological Survey (USGS), the Desert Research Institute (DRI), etc., if approved by the TRP.

Table 2 - 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	Oxygen-18 Deuterium Tritium Chlorine-36 Carbon-14 Carbon-13	Arsenic Barium Cadmium Chromium Lead Mercury Selenium Silver

	Carbonate alkalinity Alkalinity Silica Manganese Magnesium Aluminum Iron		

All analyses shall be conducted and reported in accordance with standard EPA listed methods.

SNWA shall make the monitoring wells available to the DOI Bureaus for additional data collection.

G. Spring and Stream Discharge Measurements

SNWA shall either directly or through funding of the USGS, DRI or another mutually agreed to third party operate and maintain a discharge monitoring site on Big Springs Creek and report such measurements over the Internet via the USGS NWIS or other appropriate publicly available website throughout the duration of this Plan.

SNWA shall either collect or fund the collection of at least two sets of synoptic-discharge measurements (a/k/a "gain/loss runs") for the Big Springs Creek surface water system from the spring orifice to Preuss Lake. These data shall be collected during the irrigation and non-irrigation seasons at least one year prior to the start of groundwater withdrawals by SNWA and again during the irrigation and non-irrigation seasons every five years following the start of groundwater withdrawals by SNWA. Through consensus, the TRP shall recommend the number of measurement sites during the discharge study. Measurements at each site shall include discharge, water temperature, and electrical conductivity.

SNWA shall work with the TRP to collect data in order to investigate the relationship between discharge at Big Springs and hydraulic head in the basin-fill and regional carbonate-rock aquifers, including but not limited to the installation, equipping, and maintenance of one or more monitoring wells located in the immediate vicinity of Big Springs.

SNWA shall either directly or through funding of the USGS, DRI, or another mutually agreed to third party continue to operate and maintain a discharge monitoring site on Cleve Creek and report such measurements over the Internet via the USGS NWIS or other appropriate website throughout the duration of this Plan.

H. Precipitation Stations

The coverage of existing precipitation stations shall be reviewed by the TRP, and, if necessary, the TRP may recommend that additional precipitation stations be established. SNWA shall fund the construction, operation, and maintenance of any such additional stations.

I. Elevation Control

SNWA shall conduct a detailed elevation survey of all production wells and monitoring sites that are used in this Plan.

J. Quality of Data

SNWA and the DOI Bureaus shall ensure that all measurement and data collection is done according to USGS established protocols, unless otherwise agreed-upon by the TRP.

K. Reporting

All data collected pursuant to this Plan shall be fully and cooperatively shared among the Parties.

Using data derived from groundwater level measurements of all production and monitoring wells used in this Plan, SNWA shall produce groundwater contour maps and water-level change maps for both the basin-fill and carbonate-rock aquifers at the end of baseline data collection, and annually thereafter at the end of each year of groundwater withdrawals by SNWA, or at a frequency agreed-upon by the TRP.

Water level and water production data shall be made available to the other Parties within 90 calendar days of collection using a shared data-repository website administered by SNWA. Water quality laboratory reports shall be made available to the other Parties within 90 calendar days of receipt using a shared data-repository website administered by SNWA.

SNWA shall report the results of all monitoring and sampling pursuant to this Plan in an annual monitoring report that shall be submitted to the TRP and the Nevada State Engineer's Office by no later than March 31 of each year that this Plan is in effect. SNWA shall submit as part of its annual report a proposed schedule of groundwater withdrawals (testing and production) for the immediately succeeding two calendar years. The DOI Bureaus may, at their option, provide comments to the Nevada State Engineer's Office on the annual report.

3. <u>Management Requirements</u>

A. General

Through the TRP, described below, the Parties shall collaborate on data collection and technical analysis to ensure decisions are consistent with the common goals as stated in Section 1.A. of this Exhibit A. Decisions must be based on the best scientific information available and the Parties shall collaborate on technical data collection and analysis. The Parties shall use existing data, data collected under this Plan, and an agreed-upon regional groundwater flow system numerical model(s) as tools to evaluate the effects of groundwater development on Federal Water Rights and Federal Resources in the Area of Interest. The Parties agree that a model(s) shall be used to inform the Executive Committee about the potential for effects of groundwater withdrawals to spread through the basin-fill and the regional carbonate-rock aquifers, as well as the effectiveness of the potential mitigation actions.

B. Executive Committee

The Parties shall create and convene an Executive Committee, to include one manager from each of the Parties, within 30 days of a State Engineer Office decision granting any of the SNWA Applications in total or in part. The purpose of the Executive Committee is to: 1) review agreed-upon TRP recommendations for actions to reduce or eliminate an injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources in the Area of Interest and/or any effect on Federal Resources within the boundaries of Great Basin National Park from groundwater withdrawals by SNWA in the Spring Valley HB and 2) negotiate a resolution in the event that the TRP cannot reach consensus on monitoring requirements/research needs, technical aspects of study design, interpretation of results, and/or appropriate actions to minimize or mitigate unreasonable adverse effects or to avoid any effects on Federal Resources located within the boundaries of Great Basin National Park from groundwater withdrawals by SNWA in the Spring Valley HB.

The Executive Committee shall meet within 21 calendar days of being notified by the TRP of a need for action. The Executive Committee shall strive for consensus in all decisions and work to begin implementation of TRP recommendations or other mutually acceptable course(s) of action as negotiated by the Executive Committee within 60 calendar days of TRP notification. If any Party disagrees on recommended courses of action, then the Executive Committee shall refer the issue to a neutral third party, as described below in Section E.II.

C. Technical Review Panel (TRP)

The Parties shall create and convene a Technical Review Panel within 30 days of a State Engineer Office decision granting any of the SNWA Applications in total or in part, or at such earlier date as mutually agreed-upon by the Parties. The purpose of the TRP is to carry out the functions required of it under this Plan, including reviewing, analyzing, and interpreting information collected under this Plan, evaluating the results of the model(s), and making recommendations to the Executive Committee. Membership shall include one representative from SNWA and one representative from each of the DOI Bureaus. Each Party at its sole discretion may invite such additional staff or consultants to attend, as each deems necessary. To assist the TRP, the Parties mutually agree to invite a representative of the State Engineer's Office to participate in the TRP. Furthermore, the Parties may mutually agree to invite other non-Party entities to assist and participate in the TRP as deemed necessary or appropriate.

The TRP shall meet annually through the first ten years of SNWA production pumping in the Spring Valley HB and then as often as mutually agreed upon by the Parties.

The TRP shall:

1. strive for consensus in all determinations and recommendations;
2. disseminate data and provide a scientific and technical forum to evaluate data and analyses, including hydrologic parameters of a model(s) and model(s) results;
3. review data collection and quality assurance procedures;
4. identify needs for additional data collection and scientific investigations;
5. review and consider any and all data and analysis resulting from the ongoing USGS "Basin and Range Carbonate Aquifer System Study";
6. consider from time to time whether the modification of the initial boundaries of the Interbasin Groundwater Monitoring Zone is warranted as new data become available;
7. review SNWA proposed or ongoing pumping schedules (testing and production);
8. provide a forum for discussion to help develop agreement for prescribed courses of action on technical issues and make recommendations to the Executive Committee; and,
9. form recommendations about monitoring, modeling, groundwater management, and mitigation, including but not limited to the addition, deletion, or replacement of monitoring wells, the frequency of data collection, and the types of monitoring, sampling, and testing to be conducted; and,
10. other responsibilities as delegated by the Executive Committee.

D. Regional Groundwater Flow Numerical Modeling

The Parties agree that regional groundwater flow system numerical modeling is a useful tool in the prudent management of basin-fill and regional carbonate-rock aquifer systems. Therefore, the Parties agree that this Plan must include a well calibrated regional groundwater flow system numerical model(s). The Parties acknowledge that model results must be qualified based on a comparison of the accuracy of the model(s) and the capability of the model(s) to predict actual conditions. As the effects of SNWA's groundwater withdrawals in the Spring Valley HB on groundwater levels and spring flows are measured, refinement of the model(s) shall be necessary to achieve better agreement with the actual field measurements. Furthermore, the collection of additional hydrologic, geologic, geophysical, and/or geochemical data may indicate that modification of the conceptual and numerical model(s) of the regional groundwater flow system is warranted.

The Parties shall share all geologic, geophysical, hydrologic, and geochemical information collected in the Spring Valley HB and adjacent hydrographic basins. This data shall be evaluated by the TRP for inclusion into the regional groundwater flow system numerical model(s).

SNWA shall maintain, update, and operate an agreed-upon regional groundwater flow system numerical model(s), in cooperation with the TRP. SNWA may subcontract this obligation to a third party, such as but not limited to the USGS or DRI, if approved by the TRP. The cost of all modeling described herein shall be borne by SNWA.

SNWA shall provide model output in cooperation with the TRP for evaluation by the TRP in the form of input files, output files, drawdown maps, tabular data summaries, and plots of simulated water levels through time for the aquifer system, unless otherwise recommended by the TRP.

E. Criteria Initiating TRP Consultation and Management or Mitigation Actions

The Parties recognize that the establishment of accurate early-warning indicators to meet the goals stated in Section 1.A. of this Exhibit A is difficult until adequate monitoring data are developed during a period of groundwater withdrawals by SNWA and the model is calibrated to actual pumping effects. The TRP shall be responsible for determining the sufficiency of monitoring data and recommending changes to established specific early warning indicators, based on actual hydrologic effects of groundwater withdrawals, to the Executive Committee. The TRP shall review water-level responses and model results to determine if potential injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources and if any effect on Federal Resources within the boundaries of Great Basin National Park are occurring or are predicted to occur due to ongoing or proposed groundwater withdrawals by SNWA in the Spring Valley HB. Criteria for the initiation of consultation, management, and/or mitigation actions are as follows:

I. <u>TRP Consultation Initiation Criteria</u>

Any Party may initiate a TRP consultation when that Party is concerned that there may be 1) an injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources, and 2) any effect on Federal Resources within the boundaries of Great Basin National Park as the result of:

a) a change in surface water and/or groundwater level and/or discharge measured by one or more of the monitoring wells included in this Plan, or
b) a change in groundwater level predicted by the agreed-upon regional groundwater flow system model(s),

that is due to groundwater withdrawals by SNWA in the Spring Valley HB.

Any Party may also initiate a TRP consultation when that Party is concerned about a possible change in a regional groundwater gradient as the result of:

c) change in surface water and/or groundwater level and/or discharge measured by one or more of the monitoring wells included in this Plan, or
d) a change in groundwater level predicted by the agreed-upon regional groundwater flow system model(s),

that is due to groundwater withdrawals by SNWA in the Spring Valley HB.

If TRP consultation is initiated pursuant to Section E. I.a) or c) above, the following TRP consultation process shall apply:

1) Parties shall notify each other and the TRP shall confer by teleconference or in person within 30 calendar days;

2) The TRP shall evaluate the water level and/or discharge measurement data. The TRP objective for the consultation is to determine if the change in water level and/or discharge may be due to groundwater withdrawals by SNWA in the Spring Valley HB.

i. The TRP shall compare the observed field data with model predictions to evaluate how well the model predictions match observed drawdown and shall discuss potential changes to the model(s) as agreed to by consensus of the TRP.

ii. Based on observed data, the model(s) shall be recalibrated and sensitivity analysis applied if necessary, and the model(s) shall be rerun to evaluate the effects of groundwater withdrawals by SNWA in the Spring Valley HB on Federal Water Rights and Federal Resources and on regional groundwater gradients.

iii. If the TRP agrees the measured change in water level and/or discharge is not attributable to groundwater withdrawals by SNWA in the Spring Valley HB, no further management actions shall be taken at that time. The TRP may conduct further investigation into the cause(s) of such changes.

iv. If any member of the TRP is concerned that the measured change in water level and/or discharge is attributable to groundwater withdrawals by SNWA in Spring Valley HB and is causing or has the potential to cause injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources and/or an effect on Federal Resources within the boundaries of Great Basin National Park, then the TRP shall work to develop consensus-based courses of action to address the concern and/or that manage or mitigate any injury or unreasonable adverse effect(s) or affect on Federal Resources within the boundaries of Great Basin National Park. The TRP may use the model(s) to evaluate the effects of various courses of action outlined in the Section 4 to manage or mitigate such injury, unreasonable adverse effect(s) and/or effects on Federal Resources within the boundaries of Great Basin National Park. The TRP shall convey all recommended courses of action to the Executive Committee, and the Parties shall proceed to Section E.II.1.

v. If the water level and/or discharge measurement data indicates that there is injury or the potential for injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources and/or effect Federal Resources within the boundaries of Great Basin National Park, and the TRP is unable to develop a consensus-based course of action, the TRP shall notify the Executive Committee, and the Parties shall proceed to Section E.II.2.

If TRP consultation is initiated pursuant to Section E.I.b) or d) above, the following TRP consultation process shall apply:

1) Parties shall notify each other and the TRP shall confer by teleconference or in person within 30 calendar days;

2) The TRP shall evaluate the modeling parameters, variances to water level changes relative to modeling predictions, the translation of modeling variances to areas of interest and variables influencing the model results. The TRP objective for the consultation is to determine if the response may be due to groundwater withdrawals by SNWA in the Spring Valley HB.

i. The TRP shall compare the observed field data with model predictions to evaluate how well the model predictions match observed drawdown and shall discuss potential changes to the model(s) as agreed to by consensus of the TRP. All Parties recognize that future modeling of predicted effects for the verification of the model(s) shall be a necessary component to determine the validity of the modeling results and any course of action.

ii. Based on observed data, the model(s) shall be recalibrated as necessary, and shall be rerun to evaluate the effects of groundwater withdrawals by SNWA in the Spring Valley HB on Federal Water Rights and Federal Resources and on regional groundwater gradients.

iii. If the TRP agrees the recalibrated model(s) does not predict a potential injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources and/or an effect on Federal Resources within the boundaries of Great Basin National Park, no further management actions shall be taken at that time.

iv. If any member of the TRP is concerned that the recalibrated model(s) predicts a potential injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources and/or an effect on Federal Resources within the boundaries of Great Basin National Park, then the TRP shall develop consensus-based actions to address the concern and/or that manage or mitigate those effect(s). The TRP shall also use the model(s) to evaluate the effects of different courses of action to manage or mitigate those effect(s) outlined in the Section 4. The TRP shall convey all recommended courses of action to the Executive Committee, and the Parties shall proceed to Section E.II.1.

v. If the recalibrated model(s) predicts a potential injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources and/or an effect on Federal Resources within the boundaries of Great Basin National Park, and the TRP is unable to develop a consensus-based course of action, the TRP shall notify the Executive Committee, and the Parties shall proceed to Section E.II.2.

II. <u>Actions to Manage or Mitigate Injury, Unreasonable Adverse Effects, and/or Effects to Federal Resources within the boundaries of Great Basin National Park</u>

1) If the TRP determines, by consensus, that a predicted or measured change in groundwater levels would result in injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources and/or an effect on Federal Resources within the boundaries of Great Basin National Park, the Executive Committee shall consider the TRP's recommended courses of action. Upon receiving any consensus-based TRP recommendation, the Parties, through the Executive Committee (with input from the TRP as necessary), may seek a negotiated resolution of a course of action to reduce or eliminate the injury, unreasonable adverse effect, and/or effects to Federal Resources within the boundaries of Great Basin National Park, through the management of

groundwater withdrawals and/or the mitigation of the injury, unreasonable adverse effect, or effects. If the Executive Committee cannot reach consensus, any Party may refer the issue to the Nevada State Engineer or other agreed-upon third party after notifying all other Parties of its intent to refer the matter to the Nevada State Engineer or other agreed-upon third party.

2) If the TRP notifies the Executive Committee that it is unable to make a determination by consensus that a predicted or measured change in groundwater levels would result in injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources and/or effects to Federal Resources within the boundaries of Great Basin National Park, or that the TRP is unable to obtain consensus on a recommended course of action, the Executive Committee shall attempt to negotiate a mutually acceptable course(s) of action. If that is not successful, any Party may refer the issue to the Nevada State Engineer or other agreed-upon third party after notifying all other Parties of such actions.

4. Mitigation Requirements

SNWA shall mitigate any injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources and/or effects to Federal Resources within the boundaries of Great Basin National Park agreed upon by the Parties as determined through the process described in Section 3.E.II. above or after the Nevada State Engineer determines whether there are any such effects due to groundwater withdrawals by SNWA in the Spring Valley HB. The Parties shall take all necessary steps to ensure that mitigation actions are feasible and are timely implemented. Mitigation measures may include, but are not limited to one or more of the following:

1. Geographic redistribution of groundwater withdrawals;
2. Reduction or cessation in groundwater withdrawals;
3. Provision of consumptive water supply requirements using surface and groundwater sources;
4. Augmentation of water supply for Federal Water Rights and Federal Resources using surface and groundwater sources; and
5. Other measures as agreed to by the Parties and/or required by the State Engineer that are consistent with the Stipulation

5. Modification of the Plan

The Parties may modify this Plan by mutual written agreement.

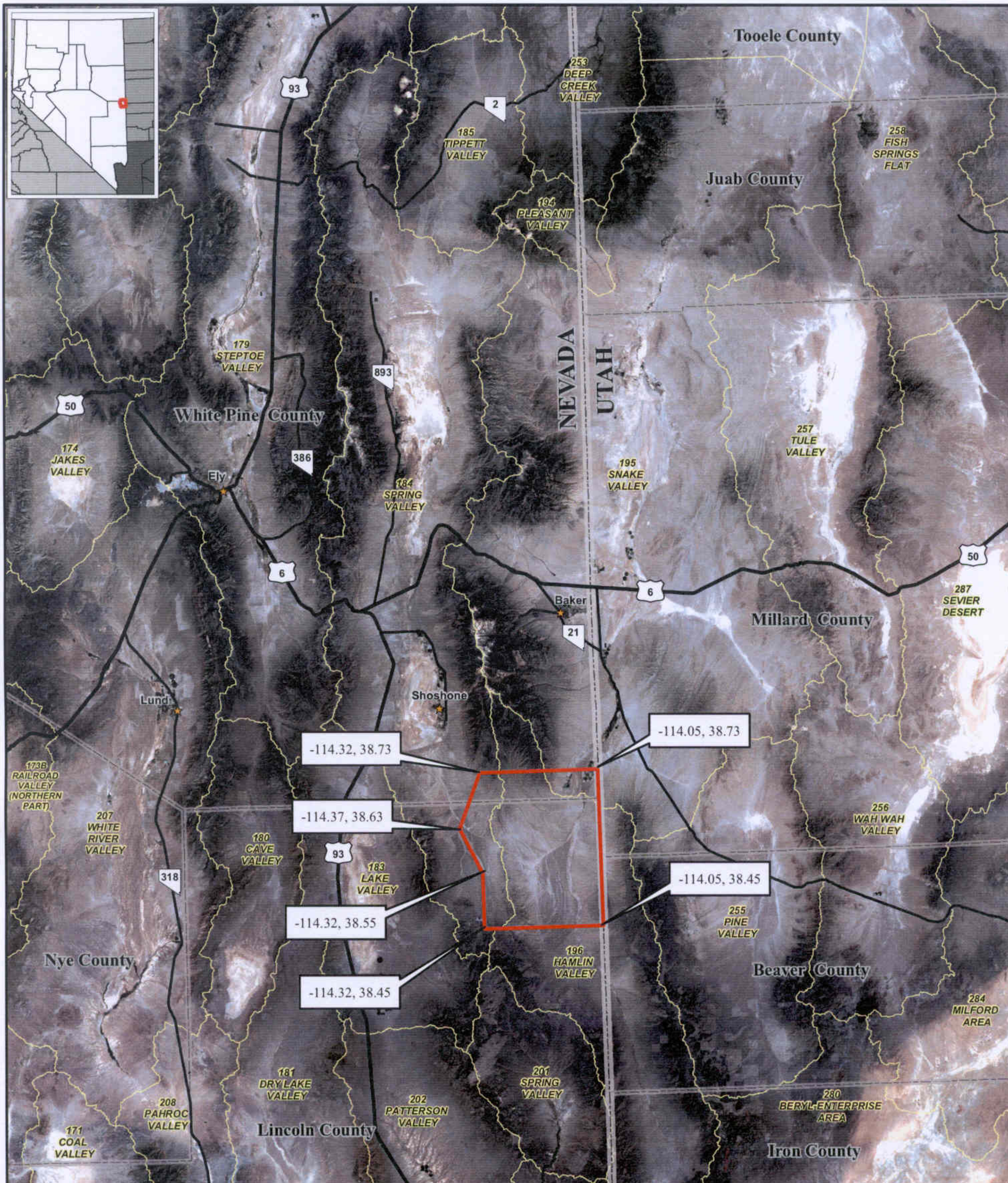

Figure A1. Interbasin Groundwater Monitoring Zone

Legend

- Town
- Interstate
- US Highway
- State Route
- County Boundary
- State Boundary
- Hydrographic Basin
- Interbasin Groundwater Monitoring Zone

N
W E
S

0 2.5 5 10 15 20 25
Miles
Scale 1:1,000,000

Grid based on Universal Transverse Mercator projection, North American Datum 1983, Zone 11 meters.

Map ID # 12866 9/7/06 RH

EXHIBIT B

BIOLOGIC MONITORING, MANAGEMENT AND MITIGATION PLAN FOR DEVELOPMENT OF GROUNDWATER IN SPRING VALLEY HYDROGRAPHIC BASIN PURSUANT TO APPLICATION NOS. 54003 THROUGH 54021 BY THE SOUTHERN NEVADA WATER AUTHORITY

1. Introduction

This biologic monitoring, management, and mitigation plan (Plan) is a component of a stipulation between the Southern Nevada Water Authority (hereinafter referred to as "SNWA") and the U.S. Department of the Interior bureaus, including the Bureau of Indian Affairs, the Bureau of Land Management, the Fish and Wildlife Service, and the National Park Service (hereinafter referred to as the "DOI Bureaus"). Collectively, SNWA and each of the DOI Bureaus are hereinafter referred to as the "Parties".

This Plan describes the Parties' obligations regarding biologic monitoring, management, and mitigation related to SNWA's applications 54003 through 54021, inclusive, ("SNWA Applications") to withdraw groundwater from points of diversion in the Spring Valley Hydrographic Basin ("Spring Valley HB"). The Plan consists of three principal components:

Management Requirements – including, but not limited to the creation of a Biological Work Group ("BWG") and an Executive Committee to review information collected under this Plan; coordinate with the hydrology Technical Review Panel (TRP), as described in Exhibit A attached to the Stipulation and made a part thereof; determine the appropriate course of action to avoid and/or mitigate any effects to Water-dependent Ecosystems, as defined in Recital H of the Stipulation, within the boundaries of Great Basin National Park and unreasonable adverse effects to Water-dependent Ecosystems, also as defined in Recital H of the Stipulation, within the Area of Interest, as defined in Recital B to the Stipulation, resulting from SNWA's withdrawal of groundwater from the Spring Valley HB; and the establishment of a consensus-based decision-making process.

Monitoring Requirements - including, but not limited to assembling known (baseline) information on biological resources; identifying baseline data gaps and implementing supplemental baseline data collection; identifying research needs and implementing studies to determine potential indicator species and appropriate parameters to monitor for early warning of unreasonable adverse effects and of any effect within the boundaries of Great Basin National Park; developing and implementing a plan that monitors the response of Water-dependent Ecosystems in the Area of Interest to hydrological changes resulting from SNWA's withdrawal of groundwater from the Spring Valley HB; identifying research needs related to understanding this response; and monitoring the success of mitigation actions; and

Mitigation Requirements – including, but not limited to the modification, relocation or reduction in points of diversion and/or rates and quantities of groundwater withdrawals to achieve the goals set forth in Recital H of the Stipulation.[1] Mitigation may also include the restoration of degraded Water-dependent Ecosystems adversely affected by groundwater withdrawals, grazing, or other factors, and/or establishment of new habitat in a mutually agreed upon location that is comparable in ecological function to that which was affected or lost.

A. Common Goal

The common goals of the Parties are to 1) manage the development of groundwater by SNWA in the Spring Valley HB in order to avoid unreasonable adverse effects caused by such groundwater development to Water-dependent Ecosystems and maintain and/or enhance the baseline biological integrity and ecological health of the Area of Interest over the long term and 2) avoid any effects to Water-dependent Ecosystems within the boundaries of Great Basin National Park from groundwater withdrawals by SNWA in the Spring Valley HB. The terms "unreasonable adverse effect(s) to Water-dependent Ecosystems within the Area of Interest" and "any effect(s) to Water-dependent Ecosystems within the boundaries of Great Basin National Park" are hereinafter collectively referred to as "Water-dependent Ecosystem Effects" or "a Water-dependent Ecosystem Effect" in this Exhibit B. The Parties agree that the preferred conceptual approach is the development of groundwater by SNWA in conjunction with the implementation of the monitoring, management, and mitigation plans described in Exhibits A and B to this Stipulation. The Parties further agree that there is a need to better understand: 1) the response of aquifers and associated discharge areas, such as artesian wells, springs, streams, wetlands, playas, riparian and phreatophytic communities to pumping stresses, and 2) the response of aquatic and terrestrial organisms to changes in Water-dependent Ecosystems due to pumping-induced groundwater declines through the preferred conceptual approach described above. The Parties have determined that it is in their best interests to cooperate in data collection and analysis related to groundwater levels and the long-term maintenance of Water-dependent Ecosystems within the Area of Interest.

Determination of what constitutes a Water-dependent Ecosystem Effect that requires an action as described in Section 4. B shall be made by the Executive Committee with recommendations from the BWG, as described below.

2. <u>Management Requirements</u>

A. General

Through the BWG, described below, the Parties shall collaborate on data collection and technical analysis to ensure decisions meet the common goals as defined in Section 1.A. above. Decisions must be based on the best scientific information available. The Parties shall use existing data, data collected under this Plan, and modeling and/or other management tools, to evaluate the effects of groundwater development by SNWA in the Spring Valley HB upon Water-dependent Ecosystems in the Area of Interest.

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[1] Included in Karr (1991), these terms were defined as the ability to support and maintain "a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region;" and "a biological system... can be considered healthy when its inherent potential is realized, its condition is stable, its capacity for self-repair when perturbed is preserved, and minimal external support for management is needed."

B. Executive Committee

The Parties shall create and convene an Executive Committee, to include one manager from SNWA and from each of the DOI Bureaus, within 30 days of a State Engineer Office decision granting any of the SNWA Applications in total or in part. The purpose of the Executive Committee is to: 1) review agreed-upon BWG recommendations for actions to avoid Water-dependent Ecosystem Effects from groundwater development by SNWA in the Spring Valley HB, seek a negotiated resolution of a course of action, and implement the action, and 2) negotiate a resolution in the event that the BWG cannot reach consensus as to any of the BWG's responsibilities as set forth in this Exhibit B.

The Executive Committee shall meet within 21 calendar days of being notified by the BWG of a need for action. The Executive Committee shall strive for consensus in all decisions and work to begin implementation of BWG recommendations or other mutually acceptable course(s) of action as negotiated by the Executive Committee within 60 calendar days of BWG notification. If any Party disagrees on recommended courses of action, then the Executive Committee shall refer the issue to a neutral third party, as described below in Section 4. B.

C. Biological Work Group

The Parties shall create and convene a BWG within 30 days of a State Engineer Office decision granting any of the SNWA Applications in total or in part, or at such earlier date as mutually agreed upon by the Parties. The purpose of the BWG is to carry out the management, monitoring, and mitigation requirements of the Plan. Membership in the BWG shall include one representative of SNWA and one representative of each of the DOI Bureaus; these members shall have responsibility for providing recommendations to the Executive Committee. Each Party at its sole discretion may invite such additional staff or consultants to attend as each deems necessary. To assist the BWG, the Parties shall invite a representative of the Nevada Department of Wildlife and the Utah Division of Wildlife Resources, and, upon mutual agreement of the Parties, shall invite the participation of other non-Party entities, to assist the BWG by providing technical expertise. These entities, as well as any additional staff or consultants, shall not be members of the BWG and shall not be involved in formulating final recommendations to the Executive Committee.

The BWG shall strive for consensus in all determination and recommendations. If any Party disagrees on the need for a particular study or disagrees on technical aspects of ecological monitoring/studies (e.g., study design, analyses, etc.), then the BWG shall submit the studies in question to one or more mutually acceptable, disinterested parties for scientific or technical opinion. The cost of this review shall be borne by the requesting Party or Parties. The BWG shall consider the recommendation(s) of the neutral reviewer and determine whether to adopt the recommendation(s) in full or in part. If the BWG is still unable to reach consensus on the technical aspect(s) in question, then the concern will be elevated to the Executive Committee.

If the BWG determines that a Water-dependent Ecosystem Effect is occurring or will occur as a result of SNWA's groundwater development in the Spring Valley HB, the BWG shall develop a recommended course of action and refer this to the Executive Committee, as described below in Section 4. B.

The BWG's responsibilities shall include the following:

1. Within 12 months of the Nevada State Engineer's decision granting any of the SNWA Applications, in total or in part, the BWG shall develop and recommend to the Executive Committee a monitoring plan, to include baseline condition assessment (i.e., assembling and reviewing existing baseline data and collecting additional baseline data as appropriate); collection of data at appropriate regional reference sites; species and parameters to monitor; and protocols and techniques to use (i.e., spatial analyses, ecosystem modeling, etc.). The monitoring plan will be for specified Water-dependent Ecosystems within the following area, hereafter referred to as the Initial Biologic Monitoring Area (IBMA): Spring Valley HB, northern Hamlin Valley HB north of the southern boundary of the Zone as defined in Exhibit A, and the Big Springs Creek sub-watershed in southern Snake Valley HB, as depicted on figure 2, attached to this Exhibit B.
2. oversee implementation of the monitoring plan;
3. review and recommend revisions to the Executive Committee on the monitoring plan as needed, including additional baseline data collection and/or monitoring to sites outside the IBMA but within the Area of Interest;
4. discuss values for particular parameters (e.g., *composition, diversity, density, vigor, invasive species, soil stability*, etc.) that may be of concern to the Parties and make recommendations to the Executive Committee on what constitutes a Water-dependent Ecosystem Effect in any particular circumstance;
5. identify indicators that can best predict Water-dependent Ecosystem Effects and periodically review and revise as needed;
6. review data collection (Quality Assurance/Quality Control);
7. identify and recommend to the Executive Committee data collection and scientific research needs for investigating the response of Water-dependent Ecosystems to hydrologic changes resulting from SNWA's withdrawal of groundwater from the Spring Valley HB;
8. disseminate data and provide a scientific and technical forum to evaluate data and analyses and review models and model results, as may be deemed necessary;
9. meet with the TRP at least annually or as needed to exchange information and discuss monitoring of potential impacts and courses of action;
10. review annual activity report;
11. develop criteria and make recommendations to the Executive Committee on when a course of action shall be taken to avoid Water-dependent Ecosystem Effects and on the success of such actions;
12. oversee implementation of management and mitigation actions as approved by the Executive Committee;
13. solicit the scientific or technical opinion of one or more mutually acceptable, disinterested parties if consensus cannot be reached;
14. meet at least annually through the first ten years of SNWA groundwater withdrawals in the Spring Valley HB, and then as mutually agreed upon by the Parties, to evaluate monitoring/research progress, needs, results, and mitigation, if required; and
15. other responsibilities as delegated by the Executive Committee.

3. <u>Monitoring Requirements</u>

A. General

SNWA, in coordination and collaboration with the BWG, shall implement the monitoring plan for the IBMA prior to SNWA's proposed groundwater production in the Spring Valley HB. Within twelve months from the date that the Nevada State Engineer issues any water rights pursuant to the SNWA Applications, the BWG shall recommend the monitoring plan for the IBMA to the Executive Committee. Notwithstanding any other provisions of this Exhibit B, if the BWG is unable to recommend a consensus-monitoring plan within this timeframe, then the BWG shall submit to the Executive Committee any alternative monitoring plans for the IBMA. If the Executive Committee cannot agree by consensus to one alternative or a combination of alternatives recommended by the BWG within 90 days, then the Parties agree that each of the alternatives submitted to the Executive Committee by the BWG shall be submitted to a mutually-agreeable third party for final selection among the submitted alternatives or a combination thereof. The alternatives selected by the third party shall be binding on the Parties. In the event that the third party does not make a final selection within twelve months of submittal, then SNWA shall select and implement a monitoring plan from among the alternatives proposed by the BWG.

The cost of the monitoring plan shall be primarily borne by SNWA. The DOI Bureaus shall provide staffing to the BWG and shall seek funding to contribute to monitoring efforts.

B. Determining Monitoring Parameters and Techniques

The monitoring plan shall be designed to determine the response of Water-dependent Ecosystems to hydrologic changes resulting from SNWA's withdrawal and export of groundwater from the Spring Valley HB. Development of the monitoring plan and subsequent modifications shall be coordinated with hydrologic monitoring by the Technical Review Panel (TRP) established in Exhibit A. The BWG shall choose species and parameters for monitoring that will be the best indicators of biologic and hydrologic change resulting from pumping. This process may require the design and implementation of research projects to determine the most appropriate early-warning indicators of Water-dependent Ecosystem Effects.

Monitoring may include both landscape-scale ecological monitoring and site-specific monitoring, as recommended by the BWG. The overall monitoring plan and any site-specific monitoring plans shall be designed to detect and track changes in Water-dependent Ecosystems resulting from SNWA's groundwater pumping in Spring Valley HB, monitor the effectiveness of mitigation measures, and differentiate the effects of other sources of ecosystem stress.

The BWG shall consider whether to include monitoring and research on the following parameters in its recommendations to the Executive Committee:

1. vegetation community extent and composition, diversity, density, structure, and/or vigor, including tracking non-native, invasive species;
2. faunal community composition, diversity, density, health (body condition, disease, parasitism, reproductive success, etc.), potentially including monitoring of the following taxonomic groups: invertebrates; migratory, wintering, and breeding birds; bats; rodents; medium and large mammals; amphibians; and/or fish;

3. forage and prey base extent and condition;
4. nesting, wintering, and migratory area extent and condition;
5. competition and predation;
6. aquatic habitat structure (water depth and velocity; substrate; spawning, nursery, and hiding places; stream cover and shading; stream diversity, i.e., pools, runs, and riffles; woody debris input; etc.)
7. soil stability, erosion, sedimentation; and
8. physical and chemical water quality parameters.

The BWG shall recommend techniques for monitoring, and shall include a spatial analysis using remote-sensing (multi-spectral or hyper-spectral image analysis) and/or high resolution aerial surveys such as Very Large Scale Aerial (VLSA) imaging, with ground-truthing and/or the collection of complementary ground data as appropriate. Collection and interpretation of these images shall be used in order to track changes in Water-dependent Ecosystems caused by groundwater withdrawals by SNWA in the Spring Valley HB. Determination of techniques to use will take into account compatibility with on-going and/or planned monitoring of the Parties or any other entity in the Area of Interest.

C. Ecological Models

As mentioned above, developing a landscape-scale ecological model is one of several potential methods that the BWG may use to evaluate the effects of SNWA groundwater development upon Water-dependent Ecosystems in the IBMA and/or Area of Interest if data collected during monitoring in comparison to baseline conditions is not sufficient to understand the effects of groundwater development by SNWA in the Spring Valley HB. The Parties agree that modeling is a useful tool in understanding the potential for such groundwater withdrawals to adversely affect Water-dependent Ecosystems in the IBMA and/or Area of Interest, informing management decisions, and evaluating the effectiveness of potential mitigation action.

If the BWG determines that ecological modeling is a necessary and appropriate tool for monitoring, SNWA shall maintain, update, and operate a BWG agreed-upon ecosystem model, in cooperation with the BWG. The cost of this work shall be borne primarily by SNWA. SNWA may subcontract this obligation to a third party, if approved by the BWG. The actual domain of the model, data input, and timeframe for model development shall be recommended by the BWG. The Parties acknowledge that such models are not static and that their accuracy would be improved by refinement and modification as additional biological data is collected and the effects of groundwater withdrawals by SNWA in the Spring Valley HB on Water-dependent Ecosystems in the IBMA and/or Area of Interest are measured.

D. Quality of Data

All data collection shall be according to established, standardized protocols, unless otherwise recommended by the BWG. All data will undergo Quality Assurance/Quality Control.

E. Reporting

All information collected or described in this plan shall be fully and cooperatively shared among the Parties. SNWA shall report the results of all activities pursuant to this Plan in an annual report that shall be submitted to the BWG by no later than March 31 of each year that this Plan is in effect.

Biological monitoring data shall be made available to the other Parties within 60 calendar days of collection using a shared data-repository website administered by SNWA. Annual reports and monitoring data that have undergone Quality Assurance/Quality Control shall be made available to the general public through the website or another mutually agreed upon manner.

4. Criteria Initiating BWG Consultation and Management or Mitigation Actions

The Parties recognize that establishing early-warning indicators to predict and avoid Water-dependent Ecosystem Effects may not be possible until sufficient monitoring data has been obtained to document the effects of such groundwater withdrawals in the Spring Valley HB, and/or an agreed-upon model is calibrated to the actual changes in Water-dependent Ecosystems caused by such ground water withdrawals. The BWG shall be responsible for evaluating the sufficiency of monitoring data and determining specific early-warning indicators, based on the responses of Water-dependent Ecosystems to changes in groundwater levels due to groundwater development by SNWA in the Spring Valley HB. Until the BWG agrees on specific indicators, the BWG shall review water-level data and landscape-scale floral and faunal responses as revealed through spectral imaging and other BWG-recommended tools (e.g., ecosystem modeling) to determine if Water-dependent Ecosystem Effects are occurring due to groundwater withdrawals by SNWA in the Spring Valley HB.

Criteria for initiation of consultation, management, and/or mitigation actions are as follows:

A. BWG Consultation Initiation Criteria

Any Party may initiate a BWG consultation if that Party is concerned that there may be a Water-dependent Ecosystem Effect as the result of:

1) a change in a measured biological parameter in a Water-dependent Ecosystem in the Area of Interest, or
2) a predicted change in a biological parameter in a Water-dependent Ecosystem in the Area of Interest

that can be ascribed to the withdrawal of groundwater pursuant to one or more of the permitted SNWA Applications in the Spring Valley HB.

If BWG consultation is initiated pursuant to Section 4. A. 1) above, then the following BWG consultation process shall apply:

a) Parties shall notify each other and the BWG shall confer by teleconference or in person within 30 calendar days;

b) The BWG shall evaluate the biological data and confer with the TRP regarding measured hydrological data and predicted hydrological changes. The BWG objective for the consultation is to determine if the change in the measured biological parameter may be due to groundwater withdrawals by SNWA in the Spring Valley HB.

i. The BWG shall compare observed changes in biological parameters to changes in hydrologic conditions evaluated by the TRP and/or predicted by a TRP model and ascribed to groundwater withdrawal by SNWA in the Spring Valley HB.

ii. If a landscape-scale ecological model is available, the BWG shall compare how well observed field data fit model predictions and shall discuss potential changes to the ecological model as agreed to by consensus of the BWG. Should such consensus be obtained, the model shall be recalibrated based on observed data and the model shall be rerun to evaluate the effects of groundwater withdrawals of any of the SNWA Applications in the Spring Valley HB on Water-dependent Ecosystems in the Area of Interest.

iii. If the BWG agrees the change in a measured biological parameter is not attributable to the withdrawal of groundwater by SNWA in the Spring Valley HB, no further management actions shall be taken at that time. The BWG may conduct further investigation into the cause(s) of such changes.

iv. If any member of the BWG is concerned that the change in a measured biological parameter is attributable to the withdrawal of groundwater by SNWA in Spring Valley HB and is causing or has the potential to cause a Water-dependent Ecosystem Effect, then the BWG shall work to develop consensus-based courses of action to address the concern and/or manage or mitigate Water-dependent Ecosystem Effect(s), as appropriate. The BWG may use an ecological model to evaluate the effects of various courses of action outlined in Section 5 of this Exhibit B to manage or mitigate such adverse effect(s). The BWG shall convey all recommended courses of action to the Executive Committee, and the Parties shall proceed to Section 4. B. 1).

v. If the biological data indicate that there is, or is a potential for, a Water-dependent Ecosystem Effect attributable to the withdrawal of groundwater by SNWA in Spring Valley HB and the BWG is unable to develop a consensus-based course of action, the BWG shall notify the Executive Committee, and the Parties shall proceed to Section 4. B. 2).

If an ecological model has been developed, and BWG consultation is initiated pursuant to Section 4. A. 2) above, then the following BWG consultation process shall apply:

1) Parties shall notify each other and the BWG shall confer by teleconference or in person within 30 calendar days;

2) The BWG shall evaluate the Ecological modeling parameters, variances in biological parameters relative to modeling predictions, and variables influencing the ecosystem model results. The BWG objective for the consultation is to determine if the response may be due to groundwater withdrawals by SNWA in the Spring Valley HB.

i. The BWG shall compare how well observed field data fit model predictions and shall discuss potential changes to the ecological model as agreed to by consensus of the BWG. All Parties recognize that should a model be used to predict effects, future modeling for the verification of the ecosystem model is a necessary component to determine the validity of the modeling results.

ii. Based on observed data, the Ecological model shall be recalibrated as necessary, and shall be rerun to evaluate the effects of groundwater withdrawals pursuant to any of the SNWA Applications in the Spring Valley HB on Water-dependent Ecosystems in the Area of Interest.

iii. If the BWG agrees the recalibrated Ecological model does not predict a Water-dependent Ecosystem Effect as a result of SNWA groundwater withdrawals in the Spring Valley HB, no further management actions shall be taken at that time.

iv. If any member of the BWG is concerned that the recalibrated Ecological model predicts a Water-dependent Ecosystem Effect as a result of SNWA groundwater withdrawals in the Spring Valley HB, then the BWG shall work to develop consensus-based recommendations for courses of action to address the concern and/or manage or mitigate those effect(s), as appropriate. The BWG shall also use the ecosystem model to evaluate the effects of various courses of action to manage or mitigate those effect(s) outlined in Section 5. The BWG shall convey all recommended courses of action to the Executive Committee, and the Parties shall proceed to Section 4. B. 1.

v. If the recalibrated Ecological model predicts a Water-dependent Ecosystem Effect as a result of SNWA groundwater withdrawals in the Spring Valley HB and the BWG is unable to develop a consensus-based course of action, the BWG shall notify the Executive Committee, and the Parties shall proceed to Section 4. B. 2.

B. <u>Actions to Manage or Mitigate Water-dependent Ecosystem Effects.</u>

1) If the BWG determines, by consensus, that a predicted or measured change in a biological parameter would result in a Water-dependent Ecosystem Effect as a result of SNWA groundwater withdrawals in the Spring Valley HB, it shall forward its concerns and agreed-upon recommendations for action to the Executive Committee for consideration. Upon receiving any consensus-based BWG recommendation, the Executive Committee shall seek a negotiated resolution of a course of action to eliminate or reduce the Water-dependent Ecosystem Effect through the management of SNWA's groundwater

withdrawals in the Spring Valley HB and/or the mitigation of the Water-dependent Ecosystem Effect. If the Executive Committee cannot reach consensus, then the matter will be elevated to a neutral third-party to provide advice on a course of action. If, upon considering the neutral party's advice, the Executive Committee is still unable to come to resolution, then any Party may refer the issue to the Nevada State Engineer or an appropriate forum after notifying all other Parties of its intent to do so.

2) If the BWG notifies the Executive Committee that it is unable to make a determination by consensus that a predicted or measured change in a biological parameter would result in a Water-dependent Ecosystem Effect as a result of SNWA groundwater withdrawals in the Spring Valley HB or that it is unable to obtain consensus on a recommended course of action, the Executive Committee shall attempt to negotiate a mutually acceptable determination and/or course(s) of action. If that is not successful, then the matter will be elevated to a neutral third-party to provide advice on any such determination and/or a course of action. If, upon considering the neutral party's advice, the Executive Committee is still unable to come to resolution, then any Party may refer the issue to the Nevada State Engineer or an appropriate forum after notifying all other Parties of its intent to do so.

The Executive Committee shall act within the timeframes stated above in Section 2.B.

5. <u>Mitigation Requirements</u>

The goal of the Parties shall be to avoid Water-dependent Ecosystem Effects. The Parties shall make all reasonable efforts to achieve this goal. In the event that this goal is not achieved, SNWA shall mitigate any Water-dependent Ecosystem Effects so as to ensure that the baseline biological integrity and ecological health of Water-dependent Ecosystems are maintained and/or enhanced over the long term, either as agreed upon by the Parties as determined through the process described in Section 4.B. above or after the State Engineer determines that there are any such effects due to groundwater withdrawals by SNWA in the Spring Valley HB. The Parties shall take the necessary steps to ensure that such mitigation actions are feasible and are implemented in a timely manner. Avoidance and/or mitigation measures may include, but are not limited to one or more of the following:

1. Geographic redistribution of pumpage;
2. Reduction or cessation in pumpage;
3. Restoration/modification of existing habitat;
4. Acquiring and/or using alternative surface and/or groundwater for the purposes of augmenting existing water resources and protecting/restoring habitat;
5. Establishment of new habitat in a mutually agreed upon location that is comparable in ecological function to that which was affected or lost; and
6. Other measures as agreed to by the Parties and/or required by the State Engineer, to the extent not inconsistent with this agreement.

Clearly defined and measurable criteria will be developed by the BWG to evaluate the success of these actions.

6. Modification of the Plan

The Parties may modify this Plan by mutual written agreement.

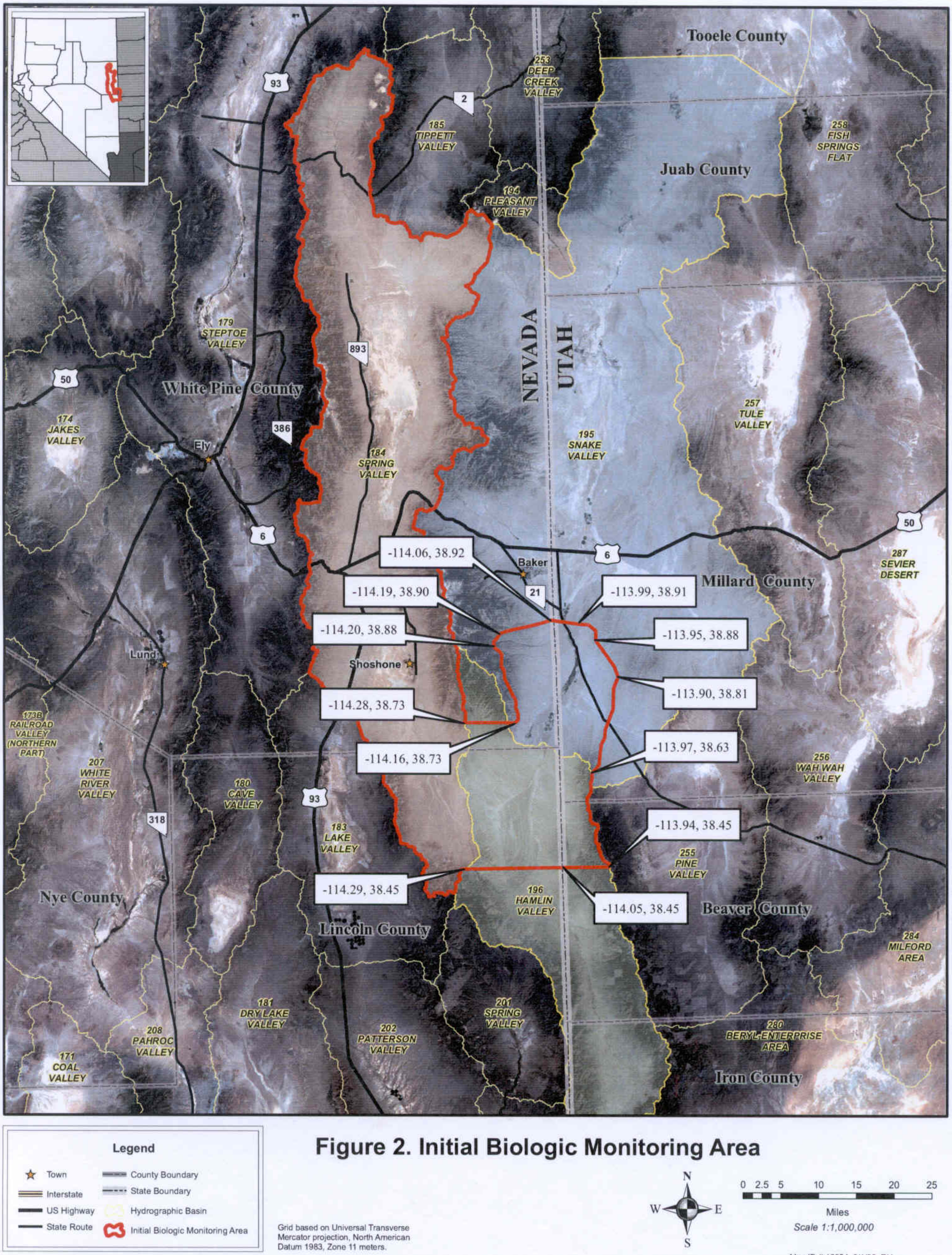

Figure 2. Initial Biologic Monitoring Area

Grid based on Universal Transverse Mercator projection, North American Datum 1983, Zone 11 meters.

Map ID # 12854 9/1/06 RH

APPENDIX B

NEVADA STATE ENGINEER RULING 5726

IN THE OFFICE OF THE STATE ENGINEER
OF THE STATE OF NEVADA

IN THE MATTER OF APPLICATIONS	)	
54003 THROUGH 54021, INCLUSIVE, FILED	)	
TO APPROPRIATE THE UNDERGROUND	)	**RULING**
WATER OF THE SPRING VALLEY	)	**#5726**
HYDROGRAPHIC BASIN (184),	)	
WHITE PINE COUNTY, NEVADA	)	

GENERAL

I.

Application 54003 was filed on October 17, 1989, by the Las Vegas Valley Water District[1] to appropriate 6 cubic feet per second (cfs) of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined within NRS § 243.210-243.225 (Lincoln), 243.275-243.315 (Nye), 243.365-243.385 (White Pine), and 243.035-243.040 (Clark). The proposed point of diversion is described as being located within NW¼ NE¼ of Section 20, T.8N., R.68E., M.D.B.&M.[2] In Item 12, the remarks section of the application, it indicates that the water sought under the application shall be placed to beneficial use within the Las Vegas Valley Water District service area as set forth in Chapter 752, Statutes of Nevada 1989, or as may be amended. Further, that the water may also be served and beneficially used by lawful users within Lincoln, Nye and White Pine Counties, and that water would be commingled with other water rights owned or served by the applicant or its designee. By letter dated March 22, 1990, the Applicant further indicated, in reference to Item 12, that the approximate number of persons to be served is 800,000 in addition to the current service of approximately 618,000 persons, that the applications seek all the unappropriated water within the particular ground-water basins in which the water rights are sought and that the projected population of the Clark County service area at the time of the 1990 letter was estimated to be 1,400,000 persons by the year 2020.

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[1] These applications are now held in the name of the Southern Nevada Water Authority.
[2] File No. 54003, official records in the Office of the State Engineer. Exhibit No. 3, public administrative hearing before the State Engineer, September 11 – 25, 2006. Hereinafter, the transcript and exhibits from this hearing will be referred to solely by the transcript page number or the exhibit number.

II.

Application 54004 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within NE¼ SE¼ of Section 25, T.9N., R.67E., M.D.B.&M.[3] This application, along with the others referenced below all contain the same remarks as those identified as to Application 54003.

III.

Application 54005 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within NE¼ NE¼ of Section 14, T.9N., R.67E., M.D.B.&M.[4]

IV.

Application 54006 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SE¼ SE¼ of Section 22, T.10N., R.67E., M.D.B.&M.[5]

V.

Application 54007 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SE¼ NW¼ of Section 34, T.11N., R.66E., M.D.B.&M.[6]

VI.

Application 54008 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SW¼ SW¼ of Section 1, T.11N., R.66E., M.D.B.&M.[7]

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[3] Exhibit No. 4.
[4] Exhibit No. 5.
[5] Exhibit No. 6.
[6] Exhibit No. 7.
[7] Exhibit No. 8.

VII.

Application 54009 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within NW¼ NE¼ of Section 36, T.13N., R.66E., M.D.B.&M.[8]

VIII.

Application 54010 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SE¼ SE¼ of Section 25, T.14N., R.66E., M.D.B.&M.[9]

IX.

Application 54011 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within NE¼ SE¼ of Section 14, T.14N., R.66E., M.D.B.&M.[10]

X.

Application 54012 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SE¼ NE¼ of Section 16, T.14N., R.67E., M.D.B.&M.[11]

XI.

Application 54013 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SW¼ SW¼ of Section 25, T.15N., R.66E., M.D.B.&M.[12]

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[8] Exhibit No. 9.
[9] Exhibit No. 10.
[10] Exhibit No. 11.
[11] Exhibit No. 12.
[12] Exhibit No. 13.

XII.

Application 54014 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SW¼ SW¼ of Section 15, T.15N., R.67E., M.D.B.&M.[13]

XIII.

Application 54015 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SW¼ NW¼ of Section 14, T.15N., R.67E., M.D.B.&M.[14]

XIV.

Application 54016 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within NE¼ SW¼ of Section 7, T.15N., R.67E., M.D.B.&M.[15]

XV.

Application 54017 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within NW¼ SE¼ of Section 25, T.16N., R.66E., M.D.B.&M.[16]

XVI.

Application 54018 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 6 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SE¼ NE¼ of Section 24, T.16N., R.66E., M.D.B.&M.[17]

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[13] Exhibit No. 14.
[14] Exhibit No. 15.
[15] Exhibit No. 16.
[16] Exhibit No. 17.
[17] Exhibit No. 18.

XVII.

Application 54019 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 10 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SW¼ NE¼ of Section 32, T.12N., R.68E., M.D.B.&M.[18]

XVIII.

Application 54020 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 10 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SE¼ SE¼ of Section 14, T.14N., R.67E., M.D.B.&M.[19]

XIX.

Application 54021 was filed on October 17, 1989, by the Las Vegas Valley Water District to appropriate 10 cfs of underground water from the Spring Valley Hydrographic Basin for municipal and domestic purposes within Clark, Lincoln, Nye and White Pine Counties as more specifically described and defined above. The proposed point of diversion is described as being located within SW¼ NE¼ of Section 33, T.16N., R.66E., M.D.B.&M.[20]

XX.

Many persons or entities protested applications 54003 – 54021, inclusive; however, not every person protested every application.[21] The applications were protested by the following persons as identified below and on many grounds as also identified below.

<u>PROTESTANTS</u>: Janell Ahivers, Joseph I. Anderson, Keith M. Anderson, Mary Ellen Anderson, Dolores A. Arnold, Bruce Ashby, Fred Baca & John Theissen, John Barney, Evan R. Barton, Bath Lumber Co., Donna Bath, James H. Bath, Walter J. Benson, Neva Bida, Bidart Brothers, Sarah G. Bishop, Joseph Boland, Boundy & Forman, Inc., Lance Burns, Donald R. Carrick, Cory Carson, Dewey E. Carson, Kay Carson, Marietta Carson, City of Caliente, Citizen Alert, Steve Collard, Mary Collins, Don Cooper, County of Nye, County of White Pine and City of Ely, Cindy Cracraft, Danny Cracraft, Diana B. Crane, Tara Cutler, Rutherford Day, Irvin Baker Edwards, David Eldridge, Delbert D. Eldridge, Dennis H. Eldridge, Elva J. Eldridge, George Eldridge & Sons, Inc., Gordon D. Eldridge, Helen Eldridge, Mary R. Eldridge, Nancy J. Eldridge, El Tejon Cattle Co., Ely Shoshone Tribe of Indians, Juan M. Escobedo, Donald T. Fackrell, Sherlyn K. Fackrell, Marcia

[18] Exhibit No. 19.
[19] Exhibit No. 20.
[20] Exhibit No. 21.
[21] Exhibit Nos. 22-41.

Forman, Richard Forman, Richie Forman, Selena M. Forman, James F. Fraser, Lory M. Free, Beverly R. Gaffin, Mary Goeringer, Danny E. Griffith, Sally Gust, Helen Hackett, Max Hannig, Monte Hansen, Joan F. Hanson, Robert L. & Fern A. Harbecke, Glen W. Harper, John A. and Vivian A. Havens, Rick Havenstrite, Randy Heinfer, Christine Hermansen, Jess Hiatt, Bonnie J. Higdon, Bunny R. Hill, Harry James Hill, Edith Jean Hill, Merle C. Hill, Garland N. Hollingshead, Karma H. Hollingshead, Charlene R. Holt, Wesley A. Holt, Barry C. Isom, Linda H. Isom, Abigail C. Johnson, Lee Jensen, Kristine P. Kaiser, Art Kinder, Kirkeby Ranch, Rudolph E. Krause, Las Vegas Fly Fishing Club, Alton C. Leavitt, James I. Lee, Sarah Locke, Dr. Dan A. Love, John R. McKay, Wanda McKrosky, Lenora McMurray, Daniel Maes, Dennis Mangum, Robert N. Marcum, Chuck Marques, Beatrice D. Mathis, Laurel Ann Mills, Moriah Ranches, Inc., Mary Mosley, Frances Murrajo, Nevada Cattlemen's Association, Eastern Unit, Nevada Farm Bureau Federation, Dean G. Neubauer, Janet K. Neubauer, Bob Nichols, Jim & Betty Nichols, Lyle Norcross, Donna A. Nye, Helen O'Connor, Nancy Overson, Edna Oxborrow, Linda Palczewski, Panaca Irrigation Co., Bruce Pencek, Carter L. Perkins, John Perondi, Pioche Town Board, Clarence S. Prestwich, Karen L. Prestwich, Duane Reed, Debbie Rollinson, Katherine A. Rountree, William R. Rountree, Margaret Rowe, Marsha Lynn Sanders, Mark Schroeder, Larry Shew, Diana Smith, Amelia Sonnenberg, Irene Spaulding, Sportsworld, Karen Sprouse, Connie K. Stasiak, Mildred L. Stevens, Virgina B. Terry, Roy Theiss, Toiyabe Chapter of the Sierra Club, Tonya K. Tomlinson, John G. Tryon, Candi Tweedy, Freddy Van Camp, Jack Van Camp, John M. Wadsworth, Daniel Weaver, Lois Weaver, Randy Weaver, Selena Weaver, Barlow White, White Pine County Cowbelles, Kelly Wiedmeyer, Thomas R. Wiedmeyer, Patricia Williams, Paula Williams, Unincorporated Town of Pahrump, U.S. Department of Interior, Bureau of Land Management, U.S. Department of Interior, Fish and Wildlife Service, U.S. Department of Interior, National Park Service.

Prior to the administrative hearing, the Applicant filed a Motion to Dismiss Individual Protest Claims Regarding Spring Valley Applications and Memorandum in Support.[22] In response to the motion, replies were filed and stipulations entered into with the Federal agencies.[23] The State Engineer's response to the motion is found in State Engineer's Intermediate Order No. 4 pursuant to which he dismissed some protest claims and denied the request as to others.[24] Some of the claims may be addressed below, as they are also statutory criteria that must be met. Other protest claims were resolved by the Stipulation entered into with Federal agencies that resulted in the withdrawal of their protests.[25] The remaining protest grounds are summarized as follows:

[22] Exhibit No. 44.
[23] Exhibit Nos. 47, 50, 51, 52, 53.
[24] Exhibit No. 57.
[25] Exhibit No. 63.

PROTEST GROUNDS:

1. The applications should be denied because they fail to adequately describe the proposed works, the cost of such works, estimated time required to construct the works and place the water to beneficial use and the approximate number of persons to be served.

2. The water is not available for appropriation and the quantity requested for appropriation will exceed the safe yield of the area. Mining of ground water is not acceptable and appropriation of this magnitude will lower the water table and degrade the quality of water from existing wells, cause negative hydraulic gradient influences and other negative impacts and adversely affect existing rights and the public interest.

3. The proposed diversions are from the carbonate-rock province of Nevada that is typified by complex, interbasin, regional-flow systems that include both basin-fill and carbonate-rock aquifers along with interbasin flows that are poorly defined, and the diversions will reduce the interbasin flows, and modify the direction of ground-water movement in adjoining and hydraulically connected basins thereby reducing spring and stream flows. Different flow systems underlie the state of Nevada and these flow systems link the ground water beneath many of the hydrologic basins over distances greater than 200 miles. While water taken from a basin may be within the perennial yield of that basin, areas as far away as 200 miles may experience drawdown thereby experiencing negative impacts.

4. Granting the applications in the quantity requested will impair, conflict and interfere with existing water rights, sources and uses.

5. The granting of the applications would conflict with or tend to impair existing water rights because, if granted, the amount of water appropriated would exceed the safe yield thereby unreasonably lowering the water table.

6. It is unclear whether the amount contemplated in the applications is necessary and reasonably required for the proposed purposes.

7. The Applicant has not shown a need for the water or that the project is feasible.

8. The Applicant lacks the financial capability for developing the project.

9. Further study is needed because the potential effects are impossible to anticipate and we do not want to render Spring Valley into another Owens Valley.

10. The available scientific literature is not adequate to reasonably assure that the proposed diversions will not impact senior rights and water resources.

11. The water will not be put to a good use and it will not serve or benefit the public interest. The Las Vegas Valley population is big enough. Further growth is not in the best interest of the Las Vegas community; neither will it benefit Nevada and the Nation. Rather than give the Las Vegas Valley more water, the State should encourage growth control, water economy, a sustainable life-style, and the building up of other communities.

12. The applications should be denied because the Applicant has failed to provide information necessary for the State Engineer to protect the public interest, such information including, the cumulative impacts of the proposed extractions, mitigation measures that will reduce the impacts of the proposed extractions and alternatives to the proposed extractions.

13. The applications should be denied because the per capita water consumption rate for the Las Vegas area is far above that of similarly situated southwestern cities.

14. Clark County must grow within the limits of their natural resources or the environmental and socioeconomic balance of the state of Nevada will be destroyed.

15. The use of water as proposed will interfere with the purpose for which federal lands are managed under the Federal Land Use Policy and Management Act of 1976.

16. The water is now being used and further pumping in large amounts would deplete the underground water and dry up springs thereby adversely affecting wildlife, livestock and game animals, birds, fish and Homo sapiens forever. It is about time for Clark County to solve their problems and not steal the good things rural Nevada offers.

17. The applications will encourage and enable the uncontrolled population growth in the Las Vegas Valley, which will exacerbate existing problems of air quality, traffic and crime.

18. The applications will cause water rates to go up thereby causing demand to go down thereby rendering the water unnecessary.

19. The applications should be denied because they lie within the land covered by the Treaty of Ruby Valley of 1863 and land claims under this treaty are currently in litigation and would conflict with the reserved rights of the Western Shoshone Tribe.

20. A project of such unprecedented magnitude is likely to cost far more than the Applicant has anticipated; a partially completed project – a white elephant – will burden local rate payers, bond holders, and eventually the State with higher costs, while neither meeting the water demands of the metropolitan Las Vegas area nor mitigating adverse ecological, economic and cultural effects of the project on rural Nevadans.

21. California's experiences suggest that large-scale water projects injure the state's reputation, promote factious politics and allegations of corruption, waste horrendous quantities of water through leakage and evapotranspiration, and foster dangerous illusions that water supplies are limitless and are either free for the wasting or are allocated solely for the advantage of the rich and powerful.

22. A lack of water will restrict growth in the Pioche area.

23. The D-X Ranch plans to re-open previously existing commercial businesses and the applications would affect the owner's lifestyle.

24. The applications will discourage lower cost, more efficient alternatives to obtaining water and pass the development costs on to the consumer.

25. The applications should be denied because removal of the water will adversely impact economic activity such as agriculture, power generation and transmission, mineral extraction, manufacturing, tourism, and concentration of population.
26. Mining of the water resources will negate recreational and fish habitat benefits provided through voluntary contributions.
27. Rural water sources have value in their natural state for recreation and scenic vistas.
28. The applications were some of the 146 applications to appropriate water filed by the Las Vegas Valley Water District, which combined seek approximately 800,000 acre-feet annually of underground and surface water, and diversion of such a quantity of water would deprive the area of origin of water needed to protect and enhance its environment and economic well being, and would unnecessarily destroy environmental, ecological, scenic and recreational values the State holds in trust for its citizens. Additionally, the diversion and exportation of this water will lower the static water level adversely affecting water quality, existing wells, cause negative hydraulic gradient influences, negative impacts, threaten springs, seeps and phreatophytes, which provide water and habitat critical to the survival of wildlife and grazing livestock, and will adversely affect existing rights and the public interest.
29. In as much as an interbasin transfer project of this magnitude has never been considered, it is impossible to anticipate all possible adverse effects without further information and study. This project cannot be properly evaluated without an independent, formal and public reviewable assessment.
30. The granting of the applications is not in the public interest, as it would allow the Applicant to "lock-up" vital water resources for possible use in the distant future beyond current planning horizons.
31. The applications should be denied because population projection numbers are unrealistic, current and developing trends in housing, landscaping, plumbing fixture standards and demographic patterns all suggest that the simplistic water demand forecasts upon which the proposed transfers are based substantially overstate future water demands.
32. The applications should be denied because conservation programs in the water district are ineffective and the granting of these applications will increase the waste of water in Las Vegas.
33. These appropriations, even if limited to annual recharge, will inevitably damage plant and animal life on the surface. Precious wild and cultivated areas will be destroyed, wildlife will be disturbed or killed off and the lives of human residents and visitors damaged. In this sense, the water is not available for appropriation.
34. Spring Valley is home to the Swamp Cedar and Spring Valley Pupfish, which are rare and unique species. The survival of both depends on water quality and water levels that currently exist and they cannot tolerate less.

35. The appropriation of the quantity requested will have negative impacts to the streams and pools within the Great Basin National Park; thus, having a negative effect on migratory birds and the plant and animal species. Great Basin National Park is the state's only national park and to divert and export water from it without a water resource plan would be sinful. The environmental impact and economic well-being of the basin of origin need to be addressed.

36. The use of water as proposed under the applications would threaten to prove detrimental to the public interest because they would likely jeopardize the continuance of threatened and endangered species. The use of the water as proposed under the applications will impair wetlands and water in the area that support migratory birds, native fish and other wildlife in conflict with Federal laws that seek to protect wetlands, migratory birds and wildlife for the benefit of all.

37. The granting of the applications will lower the water table, sanction water mining, degrade water quality, cause negative hydraulic gradient influences, threaten springs and seeps and phreatophytes which provide water and habitat critical to the survival of wildlife including, endangered species and grazing livestock.

38. The applications will negatively impact Nevada's environment. The applications should be denied since it is the public policy of the State of Nevada, per Governor Bob Miller's January 25, 1990, State of the State Address to protect Nevada's environment, even at the expense of growth.

39. Granting the applications in the quantity requested, that is for all the unappropriated water in the basin, will adversely affect agricultural operations in that it will affect the economic welfare of all farms and ranches, it will destroy the environmental balance thereby destroying grazing lands, wetlands and farm lands, and it will halt all potential agricultural growth.

40. In modern periods of drought there is insufficient water that currently creates hardships on cattlemen in that grazing areas do not have sufficient feed, surface waters are insufficient for irrigation and stock watering, water tables are lowered making it more difficult and expensive to pump water, which all affects the economic welfare. If drought creates this many hardships, continual removal of the perennial yield will destroy ranching.

41. The State Engineer must consider all of the future environmental and socioeconomic ramifications of the trans-basin transfer of ground water in order to protect the state of Nevada by not allowing these transfers.

42. The State Engineer has a responsibility to all of the people of Nevada and must consider all adverse effects, which the granting of these applications will have on all areas in the state of Nevada. The appropriation of this magnitude of water will deprive the area of origin of water needed for its environmental and economic well being, especially as it applies to the agricultural uses for this area.

43. Granting the applications would be inconsistent with the federally owned water rights as to lands affected by Applications 54003-54005 and the proposed points of diversion are located near a wilderness study area that is managed by the BLM for study and potential designation as a National Wilderness Area.

44. Granting the applications will be detrimental to the public interest because it will eliminate the capability of the federal agencies to fulfill federal land management activities imposed by legislative action.

XXI.

The United States Department of Interior, Bureau of Land Management (BLM), National Park Service and Fish and Wildlife Service were Protestants to the applications. The Ely Shoshone Tribe of Indians protested Application 54019. A Stipulation for the Withdrawal of Protests (Stipulation) was entered into between the Southern Nevada Water Authority and the United States Department of Interior on behalf of the Bureau of Indians Affairs, the Bureau of Land Management, the National Park Service, and the Fish and Wildlife Service.[26] The intent of the Parties to the Stipulation was to provide initial express conditions to allow development of the waters applied for to proceed; however, to recognize that future conditions may be adjusted based on the implementation of the monitoring, management and mitigation plans specified in the attachments to the Stipulation. The common goals stated by the Parties to the Stipulation are that the Parties are (1) to manage the development of ground water by the Applicant in the Spring Valley Hydrographic Basin without causing injury to Federal Water Rights and/or unreasonable adverse effects to Federal Resources in the Area of Interest, (2) to accurately characterize the ground-water gradient from Spring Valley Hydrographic Basin to Snake Valley Hydrographic Basin via Hamlin Valley, and (3) to avoid any effect on Federal Resources located within the boundaries of the Great Basin National Park from ground-water withdrawal by the Applicant in the Spring Valley Hydrographic Basin. Additional common goals were indicated to be (1) to manage the development of ground water in order to avoid unreasonable adverse effects to wetlands, wet meadow complexes, springs, streams, and riparian and phreatophytic communities and maintain biologic integrity and ecological health of the Area of Interest over the long term, (2) to avoid any effect to water-dependent ecosystems within the boundaries of the Great Basin National Park, and (3) to avoid an unreasonable degradation of the scenic values of and visibility from the Great Basin National Park due to a potential increase in airborne particulates and loss of surface vegetation which may result from ground-water withdrawals by the Applicant.

The Parties agreed that the preferred conceptual approach for protecting Federal Water Rights from injury and Federal Resources from unreasonable adverse effects within the Area of Interest and for avoiding any effect on Federal Resources located within the boundaries of the Great Basin National Park that may be caused by ground-water withdrawals by the Applicant in Spring Valley is through the development of such ground water in conjunction with the implementation of the monitoring, management and mitigation plans described in Exhibits A and B to the Stipulation.

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[26] Exhibit No. 63.

The Parties agreed that it was in their best interests to cooperate in the collection and analysis of hydrologic, hydrogeologic, and water chemistry information. The Parties are also to cooperate in the development of a regional ground-water-flow numerical model for assessing the effects of ground-water withdrawals by the Applicant in the Spring Valley Hydrographic Basin.

To facilitate the implementation of the Monitoring, Management, and Mitigation Plans, the Parties agreed to establish a Technical Review Panel, a Biological Working Group, and an Executive Committee. The Parties requested that the Stipulation and Exhibits A and B to the Stipulation be included as part of the permit terms and conditions of any applications granted.

Exhibit A to the Stipulation provides for agreed upon monitoring requirements including, but not limited to monitoring wells, spring flow measurements, water chemistry analysis, quality control procedures, and reporting requirements. The management requirements include, but are not limited to the modification, relocation or reduction in points of diversion and/or rates and quantities of ground-water withdrawals or the augmentation of Federal Water Rights and/or Federal Resources as well as measures designed and calculated to rehabilitate, repair or replace any and all Federal Water Rights and Resources, if necessary, to achieve the goals set forth in Recital G of the Stipulation. The Parties agreed that the monitoring network shall be comprised of the Applicant's exploratory wells, the springs selected by the Technical Review Panel and Biological Working Group listed in Table 1 of the Stipulation and certain selected stream discharge sites. The Applicant is to monitor ground-water levels quarterly in 10 representative monitoring wells and continuously monitor ground-water levels in 15 representative monitoring wells in the Spring Valley and Hamlin Valley Hydrographic Basins. These wells are to be selected by the Technical Review Panel from the wells listed in Table D.1-1 of the Stipulation, which are all existing wells. The Parties agreed to collect data to characterize the ground-water gradient from the Spring Valley Hydrographic Basin to the Snake Valley Hydrographic Basin via Hamlin Valley by establishing an Interbasin Groundwater Monitoring Zone in which the Applicant will construct and equip four monitoring wells in the carbonate-rock aquifer and two monitoring wells in the basin-fill aquifer. The Stipulation also calls for monitoring wells adjacent to several production wells in the vicinity of the Interbasin Groundwater Monitoring Zone, in the vicinity of Shoshone Ponds, and in the vicinity of 12 springs listed in Table 1. The Parties agreed constant-rate aquifer tests are needed and a water-chemistry sampling program must be initiated and that spring and stream discharge measurements are needed, particularly referencing Big Springs Creek and Cleve Creek.

The Stipulation also provides a plan for biologic monitoring, management and mitigation the purpose of which is to avoid and/or mitigate any effects to water-dependent ecosystems within the boundaries of the Great Basin National Park or Area of Interest. The plan includes the collection of baseline data, identifying research and study needs, among other things.

The State Engineer is not a party to the Stipulation.

XXII.

After all parties were duly noticed a public administrative hearing was held before the Office of the State Engineer on September 11 - 25, 2006.

FINDINGS OF FACT

I.

By Notice dated October 26, 2005, the State Engineer sent notice to all Protestants at their addresses of record in the Office of the State Engineer and to the Applicant as to the scheduling of a pre-hearing conference. To the right of each Protestant's name on the list below, the State Engineer indicates whether or not he received any response from said Protestant or the information received from the U.S. Postal Service as to its ability to deliver the notice.

Janell Ahivers	No information
Joseph I. Anderson	Responded as no intent to participate
Keith M. Anderson	Not deliverable as addressed
Mary Ellen Anderson	Responded as no intent to participate
Dolores A. Arnold	Attempted not known
Bruce Ashby	Attempted not known
Fred Baca & John Theissen	No receptacle
John Barney	Forwarding order expired
Evan R. Barton	No information
Bath Lumber Co.	No response, but signed for certified mail
Donna Bath	No response, but signed for certified mail
James H. Bath	No response, but signed for certified mail
Walter J. Benson	No receptacle
Neva Bida	Unclaimed, resent regular mail
Bidart Brothers	Responded as no intent to participate
Sarah G. Bishop	No information
Joseph Boland	Telephone call received, not at that address
Boundy & Forman, Inc.	Resent to new address
Lance Burns	Attempted not known
Donald R. Carrick	No response, but signed for certified mail
Cory Carson	No receptacle
Dewey E. Carson	No receptacle
Kay Carson	Attempted not known
Marietta Carson	No receptacle
City of Caliente	No response, but signed for certified mail
Citizen Alert	Addressee unknown
Steve Collard	Attempted not known
Mary Collins	No such number
Don Cooper	No response, but signed for certified mail
County of Nye	Responded with intent to participate
County of White Pine and City of Ely	Responded with intent to participate

Cindy Cracraft	Responded as no intent to participate
Danny Cracraft	Responded as no intent to participate
Diana B. Crane	No response, but signed for certified mail
Tara Cutler	No such number
Rutherford Day	Unclaimed, resent regular mail
Irvin Baker Edwards	Responded as no intent to participate
David Eldridge	Responded as no intent to participate
Delbert D. Eldridge	No such number
Dennis H. Eldridge	No such number
Elva J. Eldridge	No such number
George Eldridge & Sons, Inc.	No such number
Gordon D. Eldridge	No such number
Helen Eldridge	Responded as no intent to participate
Mary R. Eldridge	No such number
Nancy J. Eldridge	No such number
El Tejon Cattle Co.	No response, but signed for certified mail
Ely Shoshone Tribe of Indians	Responded with intent to participate
Juan M. Escobedo	No response, but signed for certified mail
Donald T. Fackrell	Forwarding order expired
Sherlyn K. Fackrell	No response, but signed for certified mail
Marcia Forman	No such number, forwarded to company address
Richard Forman	Deceased
Richie Forman	No such number, forwarded to company address
Selena M. Forman	No such number, forwarded to company address
James F. Fraser	Deceased
Lory M. Free	Not deliverable as addressed
Beverly R. Gaffin	No response, but signed for certified mail
Mary Goeringer	Not deliverable as addressed
Danny E. Griffith	No receptacle
Sally Gust	No such number
Helen Hackett	Addressee unknown
Max Hannig	No response, but signed for certified mail
Monte Hansen	No response, but signed for certified mail
Joan F. Hanson	No response, but signed for certified mail
Robert L. & Fern A. Harbecke	No such number
Glen W. Harper	Not deliverable as addressed
John A. and Vivian A. Havens	No response, but signed for certified mail
Rick Havenstrite	Not deliverable as addressed
Randy Heinfer	Responded as no intent to participate
Christine Hermansen	Not deliverable as addressed
Jess Hiatt	No such number
Bonnie J. Higdon	Addressee unknown
Bunny R. Hill	No response, but signed for certified mail

Harry James Hill	No response, but signed for certified mail
Jean Edith Hill	No response, but signed for certified mail
Merle C. Hill	No response, but signed for certified mail
Garland N. Hollingshead	No response, but signed for certified mail
Karma H. Hollingshead	No response, but signed for certified mail
Charlene R. Holt	No response, but signed for certified mail
Wesley A. Holt	No response, but signed for certified mail
Barry C. Isom	No response, but signed for certified mail
Linda H. Isom	No response, but signed for certified mail
Abigail C. Johnson	Responded with intent to participate
Lee Jensen	Attempted not known
Kristine P. Kaiser	No response, but signed for certified mail
Art Kinder	Attempted not known
Kirkeby Ranch	No such number
Rudolph E. Krause	No response, but signed for certified mail
Las Vegas Fly Fishing Club	No information
Alton C. Leavitt	No information
James I. Lee	No response, but signed for certified mail
Sarah Locke	No such number
Dr. Dan A. Love	Responded with intent to participate
John R. McKay	Attempted not known
Wanda McKrosky	Responded with no intent to participate
Lenora McMurray	No response, but signed for certified mail
Daneil Maes	Not deliverable as addressed
Dennis Mangum	Attempted not known
Robert N. Marcum	Attempted not known
Chuck Marques	No such number
Beatrice D. Mathis	Deceased
Laurel Ann Mills	Responded with no intent to participate
Moriah Ranches, Inc.	Responded with intent to participate
Mary Mosley	No response, but signed for certified mail
Frances Murrajo	No response, but signed for certified mail
Nevada Cattlemen's Association, Eastern Unit	No response, but signed for certified mail
Nevada Farm Bureau Federation	Undeliverable
Dean G. Neubauer	Not deliverable as addressed
Janet K. Neubauer	Not deliverable as addressed
Bob Nichols	No such number
Jim & Betty Nichols	No such number
Lyle Norcross	No such number
Donna A. Nye	Not deliverable as addressed
Helen O'Connor	Responded with no intent to participate
Nancy Overson	No such number
Edna Oxborrow	Not deliverable as addressed
Linda Palczewski	No such number
Panaca Irrigation Co.	Responded with intent to participate
Bruce Pencek	No information

Carter L. Perkins	No receptacle
John Perondi	No such number
Pioche Town Board	No response, but signed for certified mail
Clarence S. Prestwich	Not deliverable as addressed
Karen L. Prestwich	Not deliverable as addressed
Duane Reed	No response, but signed for certified mail
Debbie Rollinson	Not deliverable as addressed
Katherine A. Rountree	Responded with intent to participate
William R. Rountree	Responded with intent to participate
Margaret Rowe	Forwarding order expired
Marsha Lynn Sanders	Attempted not known
Mark Schroeder	Attempted not known
Larry Shew	No such number
Diana Smith	No such number
Amelia Sonnenberg	No response, but signed for certified mail
Irene Spaulding	Attempted not known
Sportsworld	No response, but signed for certified mail
Karen Sprouse	No such number
Connie K. Stasiak	Forwarding order expired
Mildred L. Stevens	Attempted not known
Virgina B. Terry	Attempted not known
Roy Theiss	Attempted not known
Toiyabe Chapter of the Sierra Club	Responded with intent to participate
Tonya K. Tomlinson	No response, but signed for certified mail
John G. Tryon	No response, but signed for certified mail, later made appearance
Candi Tweedy	Attempted not known
Freddy Van Camp	No response, but signed for certified mail
Jack Van Camp	No response, but signed for certified mail
John M. Wadsworth	No response, but signed for certified mail
Daniel Weaver	No such number
Lois Weaver	No such number
Randy Weaver	No such number
Selena Weaver	No such number
Barlow White	No such number
White Pine County Cowbelles	No such number
Kelly Wiedmeyer	No response, but signed for certified mail
Thomas R. Wiedmeyer	No response, but signed for certified mail
Patricia Williams	No such number
Paula Williams	No receptacle
Unincorporated Town of Pahrump	Undeliverable, resent to new address, no response

U.S. Dept .of Interior, Bureau of Land Management – Responded with intent to participate
U.S. Dept. of Interior, Fish and Wildlife Service– Responded with intent to participate
U.S. Dept. of Interior, National Park Service– Responded with intent to participate

Nevada Revised Statute (NRS) § 533.365 requires that if within the State Engineer's discretion he decides to hold a public administrative hearing on a protested application he shall give notice of the hearing by certified mail to the applicant and protestant(s). The State Engineer provided the required notice to Applicant and Protestants at the addresses of record in the relevant application files in the Office of the State Engineer. Additionally, two days after the State Engineer's Notice of Pre-hearing Conference was issued, The Ely Times, the local newspaper in the area, also published an article addressing the notice of pre-hearing conference. The State Engineer finds it was well publicized in the local area that the pre-hearing conference was going to be held and when and where. Additionally, the State Engineer finds he provided notice of the hearing to all Protestants at their addresses of record in the files of the Office of the State Engineer. The State Engineer also finds it is the responsibility of every applicant and protestant to keep the Office of the State Engineer informed as to a current address.

II.

STATUTORY STANDARD TO GRANT

The State Engineer finds that NRS § 533.370(1) provides that the State Engineer shall approve an application submitted in proper form which contemplates the application of water to beneficial use if the applicant provides proof satisfactory of his intention in good faith to construct any work necessary to apply the water to the intended beneficial use with reasonable diligence, and his financial ability and reasonable expectation actually to construct the work and apply the water to the intended beneficial use with reasonable diligence.

III.

STATUTORY STANDARD TO DENY

The State Engineer finds that NRS § 533.370(5) provides that the State Engineer shall reject an application and refuse to issue the permit where there is no unappropriated water in the proposed source of supply, or where the proposed use conflicts with existing rights or with protectible interests in existing domestic wells as set forth in NRS § 533.024, or where the proposed use threatens to prove detrimental to the public interest.

IV.

STATUTORY STANDARD FOR INTERBASIN TRANSFERS

The State Engineer finds that NRS § 533.370(6) provides that in determining whether an application for an interbasin transfer of ground water must be rejected, the State Engineer shall consider: (1) whether the applicant has justified the need to import the water from another basin; (2) if the State Engineer determines a plan for conservation of water is advisable for the basin into which the water is imported, whether the applicant has demonstrated that such a plan has been adopted and is being effectively carried out; (3) whether the proposed action is environmentally sound as it relates to the basin from which the water is exported; (4) whether the proposed action is an appropriate long-term use which will not unduly limit the future growth and development in the basin from which the water is exported; and (5) any other factor the State Engineer determines to be relevant.

V.
INADEQUACY OF APPLICATIONS

The Protestants allege that the applications should be denied because they fail to adequately describe the proposed works, the cost of such works, estimated time required to construct the works and place the water to beneficial use and the approximate number of persons to be served. The application form used by the Office of the State Engineer only requires a brief explanation of the description of the proposed works of diversion and delivery of water. On its applications, the Applicant described that the water was to be diverted via a cased well, pump, pipelines, pumping stations, reservoirs and distribution system.[27] The Applicant estimated the cost of each well and indicated it believed it would be a minimum of 20 years to construct the works of diversion and place the water to beneficial use.

Applicants who request an appropriation for municipal water use are required by NRS § 533.340(3) to provide information approximating the number of persons to be served and future requirement. While the Applicant did not have this information physically on its application, by letter dated March 22, 1990, the Applicant supplemented its applications and indicated the approximate number of persons to be served was 800,000 in addition to the 618,000 persons it was currently serving. The population of Southern Nevada already exceeds this projection as it now is nearing 2,000,000 citizens.[28]

The Southern Nevada Water Authority's 2006 Water Resource Plan and the Integrated Water Planning Advisory Committee Recommendations Report[29] provide information on the projections of the need for water in the area through 2050, and the need for future resources in relationship to the population growth was testified to at the hearing.[30] The information indicates that by the year 2030 it is anticipated that Southern Nevada will need about 900,000 acre-feet annually of water to serve its citizens.[31]

The State Engineer finds this protest claim was dismissed in State Engineer's Intermediate Order No. 4. The State Engineer finds for the purposes of the application form, the applications

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[27] Exhibit Nos. 3 – 21.
[28] Transcript, p. 77.
[29] Exhibit Nos. 511, 516.
[30] *See generally,* Testimony of Pat Mulroy, Kay Brothers, Ken Albright.
[31] Exhibit No. 516, pp. 37 - 41.

adequately describe the proposed works, the cost of such works, estimated time required to construct the works and place the water to beneficial use and the approximate number of persons to be served.

VI.
NEED FOR THE WATER

The Protestants allege that it is unclear whether the amount of water contemplated in the applications is necessary and reasonably required for the proposed municipal purposes and that the Applicant has not shown a need for the water. Some of the Protestants allege that the population projection numbers are unrealistic. Protestants also allege that the applications will cause water rates to go up thereby reducing demand and rendering the water unnecessary.

As noted above, the Applicant by letter dated March 22, 1990, supplemented its applications and indicated the approximate number of persons to be served was 800,000 in addition to the 618,000 persons it was currently serving. The evidence indicates that the actual population has consistently been in excess of the estimated numbers[32] and the current population is nearing 2,000,000 people. Additionally, the State Engineer dismissed this protest claim in State Engineer's Intermediate Order No. 4.

The Applicant provided witnesses who addressed the water resource planning for the service area of all the members of the Southern Nevada Water Authority (SNWA) over the last decade. The testimony indicated that for many years the planning efforts went into solutions that could be provided by the Colorado River and conservation. However, around 2002 a severe drought was seen on the Colorado River, Lake Mead dropped nearly 100 feet and it became very clear that other in-state resources needed to be developed not only to support future growth but as protection from drought on the Colorado River. A concern was expressed about reliance on the Colorado River for 90% of the municipalities' water-resource supplies and that this reliance was not prudent in the face of severe drought.[33] By 2002-2003, surplus water in the river was no longer an option and the water banking that had been arranged with Arizona was not going forward as planned.[34] The Applicant is pursuing these ground-water rights for anticipated future growth, because severe drought continues to be a possibility on the Colorado River, reservoir levels in Lake Mead and Lake Powell could drop further impacting intake structures in Lake Mead, and the Secretary of the Interior has taken actions on the Colorado River which have limited available options. It is believed that Southern Nevada must diversify its water supply and not rely so heavily on the Colorado River. The testimony indicated there is a need to protect the health and safety of approximately 2,000,000 citizens of Southern Nevada through the diversification of the area's

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[32] Exhibit No. 516, p. 11.
[33] *See generally,* testimony of Pat Mulroy and Kay Brothers, Transcript, pp. 51-115, 140-199.
[34] Transcript, pp. 64-65.

water supply and it is the responsibility of the Applicant to project demand and plan accordingly.[35]

The testimony indicated that by the middle of the next decade (approximately 2013), depending on the rate of growth and rate of conservation, the SNWA is going to need to bring in additional water resources to supply the region.[36] Southern Nevada has been for many years and continues to be one of the fastest growing areas in the United States. Actual growth has far out-paced population growth projections and the Chairman of the Clark County Commission testified that all credible projections show that Clark County will continue to experience growth in the future and the area is bumping up against the limits of the amount of water it can take from the Colorado River, not taking drought shortages into consideration.[37]

The Nevada Supreme Court, in a decision issued after this hearing was conducted, held that in an interbasin transfer of water the applicant must demonstrate how much water is needed in actual acre-feet.[38] It is noted that the Applicant was not aware of this exacting standard at the time of the hearing, but was aware that it had to show a need for the quantity of water for which it applied. However the Applicant provided testimony that indicated that Southern Nevada currently diverts approximately 480,000 acre-feet annually for a consumptive use of 300,000 acre-feet of Colorado River water, which is Nevada's total allotment of Colorado River water.[39] The Integrated Water Planning Advisory Committee report found that the drought conditions impacting the Colorado River Basin have reduced the projected availability of near-term additional water resources such as Interim Surplus on the Colorado River. The Committee report found that the drought has underscored the need for Southern Nevada to begin accessing undeveloped, non-Colorado River water supplies within the SNWA's water resource portfolio.[40] The 2006 Water Resource Plan indicates that by 2034 the projected demand for water in Southern Nevada will be approximately 900,000 acre-feet, which is an amount that is far in excess of the current resources of the SNWA.[41]

The State Engineer finds the Applicant has demonstrated a need for the water and has justified the need to import water from another basin. The State Engineer finds the evidence demonstrates that the amount of water contemplated in the applications is necessary and reasonably required for the proposed purposes and the protest claims are overruled. The State Engineer finds the population projections were not unrealistic and the protest claim is overruled. The State Engineer finds the allegation that the applications will cause water rates to go up thereby causing

[35] Transcript, pp. 76-77.
[36] Transcript, p. 99.
[37] Transcript, pp. 131, 135.
[38] *Bacher v. Office of the State Engineer*, 122 Nev. Adv. Op. No. 95 (November 22, 2006).
[39] Transcript, p. 161.
[40] Exhibit No. 516.
[41] Exhibit No. 511, p. 38.

demand to go down, rendering the water unnecessary to be completely hypothetical and not within the purview of his review and is hereby dismissed.

VII.

LAS VEGAS IS BIG ENOUGH

The State Engineer finds no evidence was provided in support of the protest claim that the population of Las Vegas is big enough and future growth is not in the interest of the Las Vegas community, the state or the nation. As to the protest claim that the applications will encourage and enable the uncontrolled population growth in the Las Vegas Valley, which will exacerbate existing problems of air quality, traffic and crime, the State Engineer finds he has not been delegated the responsibility to control growth and has not been delegated the responsibility for land use planning in Nevada. The decisions as to growth control are the responsibility of other branches of government; therefore, the protest claim is overruled.

VIII.

FAILED TO PROVIDE RELEVANT INFORMATION

Protestants allege that the applications should be denied because the Applicant has failed to provide Protestants relevant information and said failure denies the Protestants due process of law in that said information may provide the Protestants further grounds of protest that may forever be barred. The State Engineer finds no evidence was provided in support of this protest claim and there is no evidence that the public has been denied relevant information and due process; therefore, the protest claim is dismissed.

IX.

WILL EXACERBATE AIR POLLUTION

A Protestant alleges that the applications should be denied because the State Engineer is a member of the Nevada Environmental Commission and has a duty to prevent, abate and control air pollution in the state of Nevada and the air pollution in the Las Vegas Valley is so bad that the valley has been classified a non-attainment area for national and state ambient air-quality standards for carbon monoxide and PM-10. Since the applications are for the purpose of securing growth and more growth means more air pollution, the State Engineer should be taking steps to ameliorate the air-quality problem in the Las Vegas Valley, not exacerbate it. No evidence was provided in support of this protest claim.

The State Engineer finds this protest claim is not within the considerations found under Nevada water law, and it was held in *County of Churchill, et al. v. Ricci,* 341 F.3d 1172 (9th Cir. 2003) citing to *Pyramid Lake Paiute Tribe of Indians v. Washoe County*, 918 P.2d 697 (Nev. 1996) that the State Engineer's authority in the review of water right applications is limited to considerations identified in Nevada's water policy statutes. The State Engineer does not include consideration of factors identified in directives in Nevada statutes requiring other governmental agencies to act in the consideration of water right applications; therefore, the protest claim is dismissed.

X.

SUBDIVISION MAPS

The State Engineer finds no evidence was provided in support of the protest claim that the applications should not be approved if said approval is influenced by the State Engineer's desire or need to ensure there is sufficient water for new lots and condominium units created in the Las Vegas Valley by subdivision maps. The State Engineer finds it is his responsibility and obligation to follow the law, not his desire; therefore, the protest claim is dismissed.

XI.

MANAGEMENT OF FEDERAL LAND

A Protestant alleges that the use of water as proposed would interfere with the purpose for which federal lands are managed under the Federal Land Use Policy Act of 1976. The State Engineer finds no evidence was presented to support this protest claim; therefore, the protest claim is dismissed.

XII.

TREATY OF RUBY VALLEY

The State Engineer finds no evidence was presented to support the protest claim that the use of the water as proposed under the applications would interfere with the rights of the Ely Shoshone Tribe of Indians under the Treaty of Ruby Valley; therefore, the protest claim is dismissed. Additionally, the U.S. Department of Interior, Bureau of Indian Affairs stipulated to withdraw Federal agency protests.

XIII.

RESTRICT GROWTH IN PIOCHE

A Protestant alleges that a lack of water will restrict growth in the Pioche area. The State Engineer finds no evidence was provided in support of this protest claim and nothing in the records of the Office of the State Engineer would support this protest claim; therefore, the protest claim is dismissed.

XIV.

DX RANCH ISSUES

The D-X Ranch protested the applications on the grounds that the subject applications would adversely affect their ranching and commercial business, which depend on an existing water right. The owners of the D-X Ranch testified that they hold water right Permit 5546, Certificate 714, which is a water right on Woodman's Springs, also known as Turnley Spring. Certificate 714 is a water right for irrigation and domestic purposes that allows for the diversion of 0.2325 cubic feet per second from March 15^{th} to October 15^{th} with a priority date of June 18, 1919. The springs are located in the SW¼ of the SW¼ of Section 16, T. 15 N., R. 68 E., M.D.B.&M. Testimony indicated that spring flows varies from year to year and spring to fall, depending on the amount of precipitation, but that the trend of flow over the years they have lived there is down.

The springs are located approximately four miles east of the nearest application, Application 54015, and five miles east of Application 54014. The next nearest applications are approximately eight miles away. The nearest applications lie at an elevation 1,000 feet or more lower than Woodman's Springs. The Protestants testified to variable flows, depending on annual precipitation and time of year. Published geologic maps indicate that the springs occur at or near a geologic contact between overlying permeable carbonate rocks and underlying, relatively impermeable, metamorphic rocks. The State Engineer finds that the flow and geologic information supports a conclusion that the Woodman's Springs are not directly connected to the valley-fill alluvial or regional carbonate aquifers, are most likely derived from perched waters, are subject to seasonal and climatic variability, and will not be adversely affected by the subject applications.

XV.
NEED COMPREHENSIVE PLANNING

Some of the Protestants allege that the applications should not be granted in the absence of comprehensive planning. The State Engineer finds there is no provision in Nevada water law that requires comprehensive water-resource development planning prior to the granting of a water right application, and further, as demonstrated by Exhibit Nos. 511 and 516 and the testimony, the Applicant has engaged in comprehensive long-range planning.[42]

XVI.
LOCK-UP RESOURCES

Some Protestants allege that these applications, amongst others, would allow the Applicant to "lock-up" vital water resources for possible use in the distant future beyond current planning horizons, and further allege that the applications substantially overstate future water demand.

In 1989, when these applications were filed, the Las Vegas Valley Water District believed it was running out of additional water resources in the very near future. In 1991, the Las Vegas Valley Water District issued a moratorium, which prohibited any new hookups to the water system; thus, the future water demands were not beyond current planning horizons. Since the filing of the applications, the members of SNWA have been involved in many varied programs to plan for the future water resources of the Las Vegas Valley. In 1991, the SNWA was formed, and the SNWA purveyors agreed that any new contract with the Secretary of the Interior for remaining unallocated water from the Colorado River would be with the SNWA. The SNWA would then deliver water to

[42] *See generally,* testimony of Patricia Mulroy, Kay Brothers and Ken Albright.

purveyor members based on an agreed method of allocating the water received. The remaining Colorado River water was contracted for in 1992.

The October 1999 Southern Nevada Resource Plan (which outlined plans for water resources for all purveyors in the Las Vegas Valley through 2050) identified the Cooperative Water Project as a potential future option. However, at that time there were no current plans to move forward with the importation of ground water from the rural counties since other options, such as the Arizona Groundwater Bank and Colorado River water provided by the recently approved Interim Surplus guidelines, were more probable and cost effective. However, as noted in the testimony of the General Manager of the Southern Nevada Water Authority, much has changed on the river since 2002.

As demonstrated in Chapter 4 of the Southern Nevada Water Authority 2006 Water Resource Plan, SNWA is exploring many options for future water supply and as was testified to by the SNWA General Manager Patricia Mulroy, Deputy General Manager for Engineering Operation Kay Brothers, and Director of Ground-water Resources Development, Ken Albright, the Applicant is pursuing development of this project now.

The State Engineer finds that Nevada is a prior appropriation state, that is, first in time, first in right, and the Applicant is moving forward with a use for the water requested for appropriation under these applications. Therefore, there is a reasonable expectation to go to beneficial use within a reasonable amount of time and the Applicant is not locking-up vital water resources for possible use in the distant future beyond current planning horizons and, as found in other portions of this ruling, the applications do not substantially overstate future water demand needs.

XVII.
GROUND-WATER MODELS

As provided for in the Stipulation referenced above, the Parties to the Stipulation agreed that it was in their best interests to cooperate in the collection and analysis of hydrologic, hydrogeologic, and water chemistry information and to also cooperate in the development of a regional ground-water-flow numerical model for assessing the effects of ground-water withdrawals by the Applicant in the Spring Valley Hydrographic Basin. The State Engineer is concerned that the parties may use a model that is not readily usable and reviewable by other interested persons. Therefore, the State Engineer finds that any model created to be used in the monitoring and mitigation by the Office of the State Engineer must use available MODFLOW code. The State Engineer also finds that any model required by the State Engineer must first be reviewed and approved by the State Engineer.

XVIII.
PROOF OF GOOD FAITH AND REASONABLE DILIGENCE

Some of the Protestants alleged that the Applicant has not obtained rights-of-way from the BLM for the project. Testimony was provided that the Lincoln County Lands Act identified a utility corridor for this and other utilities and that the Applicant has met with cooperating agencies several times and is putting forth the application to the United States Department of Interior, Bureau of Land Management to obtain the rights-of-way to put the project in the ground.[43] The State Engineer dismissed this protest claim in State Engineer's Intermediate Order No. 4. Additionally, the State Engineer finds the evidence indicates the Applicant is pursuing the right-of-way.

XIX.
FINANCIAL ABILITY AND REASONABLE EXPECTATION TO PERFECT

Nevada Revised Statute § 533.370(1) provides that the State Engineer shall approve an application submitted in proper form which contemplates the application of water to beneficial use if the applicant provides proof satisfactory of his intention in good faith to construct any work necessary to apply the water to the intended beneficial use with reasonable diligence, and his financial ability and reasonable expectation to actually construct the work and apply the water to the intended beneficial use with reasonable diligence. Protestants alleged that the Applicant lacks the financial capability for developing the project and that a project of such unprecedented magnitude is likely to cost far more than the Applicant has anticipated. Additionally, that a partially completed project (a white elephant) will burden local rate payers, bond holders, and eventually the State with higher costs, while neither meeting the water demands of the metropolitan Las Vegas area nor mitigating adverse ecological, economic and cultural effects of the project on rural Nevadans.

The Applicant presented testimony about its financial ability to construct the project through its witness Mr. Bonow, who is the managing director and part owner of Public Financial Management. Mr. Bonow testified that his company is the largest independent financial investment advisor serving governments and non-profit entities in the United States.[44] He testified that the cost of the Integrated Water Plan for the six-basin approach, which includes the water applied for in this basin, would be approximately $1.9 billion dollars in 2006 dollars. Mr. Bonow testified that based on their conclusions bonds could be sold on capital markets in light of SNWA's past practices, high credit rating and financial wherewithal and that these bonds would achieve very high credit ratings, which means they would be readily accepted by the marketplace and investors. In his opinion, the bottom line was that the project could be financed.[45]

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[43] Transcript, p. 282.
[44] Transcript, p. 209.
[45] Transcript, pp. 250-251. *See also*, Exhibit No. 512 (financial report).

The Applicant provided evidence of other large projects it has constructed, such as the water intakes at Lake Mead, increasing its capacity from 400 million gallons per day to 900 million gallons per day in the last ten years, water treatment facilities and large transmission systems.[46]

The State Engineer finds the Applicant has provided proof satisfactory of the intention in good faith to construct any work necessary to apply the water to the intended beneficial use with reasonable diligence, and a financial ability and reasonable expectation actually to construct the work and apply the water to the intended beneficial use with reasonable diligence.

XX.

PLACE OF USE

The applications under consideration in this ruling were filed for municipal and domestic uses in Clark, Lincoln, Nye and White Pine Counties. No evidence was provided as to any beneficial use of water other than in Clark County and for potential mitigation in White Pine County. Nevada Revised Statute § 533.035 provides that beneficial use is the basis, the measure and the limit of the right to use water, and NRS § 533.370 provides that any applicant must demonstrate an intention in good faith to construct works with reasonable diligence to apply the water to a beneficial use. The State Engineer finds there was no demonstration of beneficial use of the water anywhere other than Clark County and Spring Valley in White Pine County; therefore, the place of use is restricted to those two places.

XXI.

FEDERAL LAND USE

Protestants allege that granting the applications would be inconsistent with the Federally owned water rights as to lands affected by Applications 54003-54005 and the proposed points of diversion are located near a wilderness study area that is managed by the BLM for study and potential designation as a National Wilderness Area. No evidence was provided in support of this protest claim and the Federal agencies withdrew their protests pursuant to the Stipulation; therefore, the State Engineer finds the protest claim is dismissed.

XXII.

PERENNIAL YIELD

In determining the amount of ground water available for appropriation in a given hydrographic basin, the State Engineer relies on all available hydrologic studies to provide relevant data to determine the perennial yield for a basin. The perennial yield of a ground-water reservoir may be defined as the maximum amount of ground water that can be salvaged each year over the long term without depleting the ground-water reservoir. Perennial yield is ultimately limited to the maximum amount of natural discharge that can be salvaged for beneficial use. The

[46] Exhibit Nos. 513, 516.

perennial yield cannot be more than the natural recharge to a ground-water basin and in some cases is less. If the perennial yield is exceeded, ground-water levels will decline and steady-state conditions will not be achieved, a situation commonly referred to as ground-water mining. Additionally, withdrawals of ground water in excess of the perennial yield may contribute to adverse conditions such as water quality degradation, storage depletion, diminishing yield of wells, increased economic pumping lifts, and land subsidence.[47]

In most Nevada basins, ground water is discharged primarily through evapotranspiration (ET). In those basins, the perennial yield is approximately equal to the estimated ground-water ET; the assumption being that water lost to natural ET can be captured by wells and placed to beneficial use. Many of the basins in the Carbonate Aquifer terrain discharge their ground water mostly via subsurface flow to adjacent basins, that is, there is little or no ET. The amount of subsurface discharge that can be captured is highly variable and uncertain. Perennial yields for these basins have historically been set at one-half of the subsurface discharge. However, when conditions are such that there is subsurface flow through several basins, there is a potential for double accounting and over appropriating the resource if the perennial yield of each basin is equal to one half of the subsurface outflow and basin subsurface inflows are not adjusted accordingly. Therefore, allowances and adjustments are required to the perennial yields of basins in these "flow systems" so that over appropriation does not occur. The Spring Valley Hydrographic Basin has a significant amount of discharge via ET and an uncertain amount of subsurface flow to adjacent basin(s). Historically, in basins similar to the Spring Valley Hydrographic Basin, the perennial yield has generally been established as equal to ET.

Rush and Kazmi completed the first comprehensive hydrologic study of the Spring Valley Hydrographic Basin in 1965.[48] Their study used the well-known Maxey-Eakin method of estimating ground-water recharge with the 1936 Hardman precipitation map. The authors note that recharge occurs within the mountain block, below streams on the alluvial fans, and through direct infiltration on the upper alluvial fans.[49] They estimated ground-water recharge to be 75,000 acre-feet annually.[50] Ground-water ET was estimated by mapping phreatophyte communities and applying a probable average rate of ground-water use to derive the basin's total discharge via ET. Their estimate of ground-water ET was 70,000 acre-feet annually, with an additional 4,000 acre-feet annually exiting the basin via subsurface flow to Hamlin Valley. In their study, Rush and Kazmi assumed that all of the 70,000 acre-feet annually of ET could be salvaged, but that none of the outflow to Hamlin Valley could be recovered; therefore, 70,000

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[47] State Engineer's Office, Water for Nevada, State of Nevada Water Planning Report No. 3, p. 13, Oct. 1971.
[48] Exhibit No. 608.
[49] Exhibit No. 608, p. 20 & Fig. 6.
[50] Exhibit No. 608, p. 20.

acre-feet annually could be considered as the minimum perennial yield. In addition, they estimated that up to one-third of the 90,000 acre-feet annually of the mountain front runoff "could be salvaged by extensive and well-distributed pumping;"[51] therefore, the maximum potential perennial yield of the basin was determined to be 100,000 acre-feet annually.

The Applicants presented testimony that questioned the accuracy of Rush and Kazmi's study. Mr. Burns testified that the 1936 Hardman precipitation map used in their study is inaccurate and underestimates actual average precipitation; therefore, recharge estimates made using the 1936 Hardman precipitation map would subsequently underestimate actual average recharge.[52] However, under questioning from the State Engineer it was recognized that the Maxey-Eakin recharge coefficients were calibrated to discharge from several basins, and if a different precipitation map had been used then the recharge coefficients would have been commensurately adjusted, the end result being the same estimate of average annual recharge.[53]

A second issue brought up by the Applicant was that the Maxey-Eakin method may have been calibrated to basin ground-water ET estimates that were less than actual average ET discharge. In addition, the Applicant points out that precipitation and runoff in the years up to and including the Rush and Kazmi study were below normal, which would result in estimates of ET that are less than the long-term average.[54]

Nichols (2000) estimated ground-water ET in Spring Valley and 15 other valleys using a relationship between plant cover and ET at 12 sites in and around the Great Basin and Landsat-derived vegetation indices.[55] Using his ET estimates and the 1961 to 1990 PRISM precipitation map,[56, 57] he then computed recharge coefficients for precipitation zones using multiple linear regressions, much as Maxey and Eakin did in their original work.[58] Nichols calculated ET for 1985, a relatively wet year, to be 102,000 acre-feet. He also estimated ET for 1989, a relatively dry year, to be 77,500 acre-feet. Nichols then averaged the two results to obtain an average basin-wide ET rate for Spring Valley of 90,000 acre-feet annually. Nichols' estimate of ground-water recharge in Spring Valley is 104,000 acre-feet annually, as determined by his computed

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[51] Exhibit No. 608, p. 26.
[52] Transcript, pp. 992 – 1129.
[53] Transcript, pp. 1105 – 1118.
[54] Transcript, pp. 1043-1044.
[55] Exhibit No. 610.
[56] Daly, C., et al., 1994, A statistical-topographic model for mapping climatological precipitation over mountainous terrain: Journal of Applied Meteorology, v. 33, pp. 140-158.
[57] Taylor, G.H., 1997 Oregon State University written with Nichols.
[58] Eakin et al., Contributions to the Hydrology of Eastern Nevada, Nevada Water Resources Bulletin No. 12, Nevada Division of Water Resources in cooperation with the United States Geological Survey, pp. 99-125, 1951.

recharge coefficients.[59] The 14,000 acre-feet annual imbalance between recharge and discharge was assumed to exit Spring Valley as subsurface flow to the east. It should be noted that Nichols did not estimate the perennial yield for Spring Valley.

The Protestants presented testimony and evidence to support their claim that the Nichols' ET estimates may be too high. The basis of the Protestants testimony and evidence can be summarized as follows: Nine of the 12 ET sites used by Nichols are located in Ash Meadows, Nevada and Owens Valley, California.[60] Ash Meadows and Owens Valley are much further south with higher evaporative demand than Spring Valley. As a result, these locations will have a greater ET rate for a given plant community and density than SpringValley, and using these sites as a basis for ET rates in Spring Valley is in error because it will result in an over-estimation of total annual ET. In addition, the Protestants claimed that the Nichols' study was completed in one of the wettest decades on record, which could result in more plant growth and measured ET that is greater than the long-term average.[61]

The water budget of Spring Valley was also addressed by the Applicant in Exhibit No. 509 and in the testimony of Andrew Burns.[62] Both the testimony and accompanying exhibits discuss the previous studies mentioned above, but also provide new estimates for precipitation, surface-water flows, ground-water recharge, and evapotranspiration. The Applicant estimated ground-water recharge using the Maxey-Eakin recharge coefficients, but with a precipitation distribution estimated from a local altitude-precipitation regression.[63] The Applicant's estimate of Spring Valley's average ground-water recharge from precipitation is 87,000 acre-feet annually.

The State Engineer finds that estimates of recharge using the Maxey-Eakin recharge coefficients with precipitation distributions other than the Hardman map[64] constitute a misapplication of the method. The Maxey-Eakin method uses the Hardman precipitation map, which relates elevation zones to annual precipitation. The amount of precipitation in each precipitation zone that recharged the ground water was balanced by trial-and-error with ground-water discharge estimates in 13 ground-water basins in eastern Nevada.[65] The percent of recharge in each zone was systematically adjusted until total basin recharge acceptably matched total basin discharge. Because the Maxey-Eakin recharge coefficients are tied to the Hardman map, the use of any other precipitation map would require that the recharge coefficients be re-established to match total basin discharge estimates in multiple basins. That is, if any other

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[59] Exhibit No. 610, pp. C14 – C29.
[60] Exhibit No. 610, pp. A4 and A5.
[61] Exhibit No. 3005, pp. 7 - 9.
[62] Exhibit No 789; Transcript, pp. 999 - 1122.
[63] Exhibit No. 509, Chapter 3.
[64] Exhibit No. 28.
[65] Exhibit No. 606, pp. 40 & 41.

precipitation map is used, the recharge coefficients need to be re-calibrated by trial-and-error against known ground-water discharge. The Applicant used a new precipitation distribution, but did not re-estimate recharge coefficients or calibrate those coefficients to ground-water discharge.

In addition to their estimate of recharge from precipitation, the Applicant proposes that recharge to ground water due to stream infiltration is a source of recharge not considered in the Maxey-Eakin method. It considers the Maxey-Eakin method to apply only to recharge within the mountain block,[66] and estimated an additional 11,750 acre-feet annually of recharge due to stream-flow infiltration. Because the Maxey-Eakin technique is balanced to the full basin discharge, the actual location of recharge is not material. Maxey-Eakin recognized that recharge occurs in locations other than the mountain block. In Water Resources Bulletin No. 33, Eakin writes "The distribution of water runoff from the mountains also permits some inferences of the distribution and manner of recharge to the groundwater system. For mountain areas of otherwise similar characteristics, proportionally large runoff suggests little recharge by deep infiltration in bedrock in the mountains, and small runoff suggests proportionally large recharge by deep infiltration in the bedrock. Also, substantial runoff from the mountains suggests that recharge by infiltration of stream flow on the valley fill may be significant."[67] Similarly, in the Spring Valley Reconnaissance report of Rush and Kazmi, the authors recognize recharge occurs below the streams. "Part of the snow and rain in the mountains infiltrates the rock material and part collects into small, short streams, which generally are absorbed on the alluvial fans. Much of this water is evaporated before and after infiltration, some adds to soil moisture, and some percolates to the water table and recharges the groundwater reservoir."[68] Additionally in Table 6, Rush and Kazmi clearly attribute 65,000 acre-feet annually to recharge from streams and underflow.[69] It is widely recognized that the above authors were experts – even pioneers – in Nevada hydrology. It is unreasonable to suggest that they did not fully understand and account for such a basic hydrologic process in their studies and reconnaissance reports. The State Engineer finds that the Maxey-Eakin method estimates the entire basin recharge, and to apply additional recharge in specific areas or hydrologic settings is a misapplication of the method.

The Applicant's discharge analysis included a report and testimony by Dr. Dale Devitt,[70] which addressed ET studies and basin-wide ET estimates for Spring Valley and White River Valley. Dr. Devitt placed meteorological stations in each of the valleys and measured ET from

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[66] Exhibit No. 509, pp. 7-3 & 7-4.
[67] Eakin, T.E., A Regional Interbasin Groundwater System in the White River Area, Southeastern Nevada, Nevada Dept. of Conservation and Natural Resources Water Resource Bulletin No. 33, p. 260, 1966.
[68] Exhibit No. 608, p. 20.
[69] *Id.,* Table 6, unnumbered page between p. 25 and p. 26.
[70] Exhibits Nos. 505 and 787.

August of 2004 to August 2005. For Spring Valley, the total ET estimate for the measurement period was approximately 307,000 acre-feet. This estimate includes ET from all sources within a delineated area of phreatophytes, including ground-water ET, surface-water ET, and precipitation. The ground-water component of ET was not differentiated, but can generally be calculated as total ET less surface-water contributions and total precipitation. It was also noted that the 2005 water year was a very wet year with Cleve Creek flowing at 208% of its long-term average. As was the case with Cleve Creek, other streams measured by SNWA in 2005 had flows much higher than their estimated long-term average, ranging from 170% to 440% of average.[71] The total acreage included in the ET study by Dr. Devitt was 150,030 acres; 127,430 acres in the phreatophytic zone, and 22,600 acres in the wetland meadows.[72] By subtracting the measured precipitation for the study period at their monitoring Site 2 of 12.8 inches (1.07 feet) from the total acreage, he estimated half of the total ET, or approximately 150,000 acre-feet, is derived from surface-water and ground-water sources.[73] However, if one were to consider 17.1 inches (1.42 feet) of precipitation at the Shoshone 5 N station for the same time period, and assume that Shoshone 5 N precipitation was representative for the area, then only 94,000 acre-feet of ET would be from surface-water and ground-water sources and the ET results of Dr. Devitt may be in line with the results of Rush and Kazmi, and Nichols.[74]

Additional evidence brought out at the hearing included potential errors in the regression function Dr. Devitt used to estimate actual ET from the Normalized Difference Vegetative Index, the satellite-based method he used to estimate ET. Dr. Devitt acknowledged that his regression function might overestimate ET because the regression[75] represents only cloud-free days and does not consider daily variations in meteorological conditions.[76] The Applicant presented a revised ground-water budget and perennial yield for Spring Valley of 101,000 acre-feet annually, which did not use Dr. Devitt's ET estimate. The Applicant's revised ground-water budget and perennial yield, were obtained by using an estimated annual recharge of 87,000 acre-feet using the Maxey-Eakin coefficients with their own precipitation map, adding 25% of stream flow as infiltration for an additional 12,000 acre-feet, and 2,000 acre-feet of underflow from Tippett Valley. Their outflow included Nichols' average ET of 90,000 acre-feet, 4,000 acre-feet of underflow to Hamlin Valley, and 6,000 acre-feet consumed by crops and other uses.[77]

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[71] Exhibit No. 509, Appendix C.
[72] Exhibit No. 789, p. 41.
[73] *Id.* at 45.
[74] Exhibits Nos. 608 and 509, respectively.
[75] Exhibit No. 787, p. 13.
[76] Transcripts, pp. 748 – 752.
[77] Exhibit No. 789, pp. 63 – 68.

The State Engineer finds that a reasonable and conservative estimate of the perennial yield of the Spring Valley Hydrographic Basin is 80,000 acre-feet. This estimate relies on the capture of ground-water ET as the limit of the perennial yield. The ET estimate of Rush and Kazmi is 70,000 acre-feet while the average estimate of Nichols is 90,000 acre-feet. Expert testimony and evidence was presented stating that Rush and Kazmi's ET estimate was too low and that Nichols' estimate was too high. Using an average of the two estimates to determine the likely long-term annual ground-water ET for the basin is therefore justified by the evidence. The location and volume of subsurface outflows are highly uncertain, and it is questionable if such flows can be captured without an unacceptable amount of storage depletion and water-level decline. The assertion of Rush and Kazmi that 30,000 acre-feet annually of mountain front runoff could be salvaged with an extensive pumping network is regarded as overly optimistic, without adequate factual support, and does not consider the State Engineer's requirement to protect existing surface-water rights.

XXIII.
EXISTING RIGHTS

Prior to making a determination of the total committed ground-water rights, a determination needs to be made regarding the effective duty of supplemental ground-water rights and the consumptive use portion of the non-supplemental ground-water rights and supplemental irrigation ground-water rights. Supplemental irrigation water rights, as discussed in this ruling, are ground-water rights which have a place of use appurtenant to the same place of use as an existing surface-water right and are available for use when the surface-water flow is inadequate to meet irrigation demands.

Testimony and evidence was presented in which the effective duty of supplemental ground-water rights ranged from zero to the full duty of 4.0 acre-feet per acre as indicated on the permit or certificate. While the Office of the State Engineer has not previously established an effective duty for supplemental irrigation ground-water rights for the purposes of determining total existing ground-water rights in Spring Valley it is reasonable to assume that the effective duty of a supplemental irrigation ground-water right is neither zero nor the full duty of 4.0 acre-feet per acre as indicated on the permit or certificate. Instead, it is much more reasonable to establish the effective duty of a supplemental irrigation ground-water right as the maximum annual amount of the ground-water right actually used to supplement the surface-water right to meet irrigation demands. The State Engineer's effective duty estimate of supplemental irrigation ground-water rights in Spring Valley is based on the following:

In Spring Valley, there is no information available regarding the amount of supplemental ground water used on a well by well basis in which to make a determination of the effective duty of supplemental irrigation ground-water rights; therefore, the State Engineer must look at other available data, which is limited, and then correlate the available data to the Spring Valley area. Of the basins in which the State Engineer's office conducts ground-water pumpage inventories, which also includes surface-water rights and supplemental ground-water rights, the tributary creeks to the Carson River in the Carson Valley Hydrographic Basin (Basin No. 105) best represents the conditions found in the Spring Valley area.

For the period of 1996 to 2005, a comparison was made of the places of use, which have surface-water rights from tributary creeks to the Carson River and supplemental ground-water rights for the entire place of use of the surface-water right. The total duty of supplemental ground-water rights used on a percentage basis during the review period ranged from a low of 9.3 percent to a high of 26.8 percent with an average of 18.1 percent.

When the State Engineer calculates the existing rights in a basin the actual permitted or certificated duty is used for all rights, not an average of each right's annual use. Therefore, while as previously stated it is reasonable to assume that the effective duty of a supplemental irrigation ground-water right is not the full duty, it is also reasonable to assume that the effective duty of a supplemental ground-water right is the maximum amount of the right required to supplement the surface-water source during a single irrigation season.

While the tributary creeks to the Carson River were the best representation of the available data to the Spring Valley area, they are not a direct representation. A review of the long-term hydrographs for Daggett Creek[78] (1966-2005) and Cleve Creek[79] (1914-2005) shows a difference in the timing of runoff, which affects the amount of supplemental ground water used to meet irrigation demands when the surface-water flow is inadequate. In making the correlation from the available data on Daggett Creek to Cleve Creek the following assumptions were made: (1) Seven month growing season – April to October; (2) No supplemental ground water is used prior to July, i.e., 3 months surface water only, 4 months supplemented by ground water; (3) The surface-water source is fully appropriated, but not over appropriated; and (4) Runoff hydrographs are of roughly similar shape and distribution for all creeks in Spring Valley.

For the four growing months (July to October) following the peak flow in Daggett Creek and Cleve Creek, the average flows in Daggett Creek were 65 percent of the peak flow and the average flows in Cleve Creek were 35 percent of the peak flow. This results in less surface water on a percentage basis being available post-peak flow in Cleve Creek than Daggett Creek, which in turn results in more ground water being needed to supplement Cleve Creek surface-water rights than Daggett Creek surface-water rights.

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[78] Carson Valley Hydrographic Basin.
[79] Spring Valley Hydrographic Basin.

During the comparison period for the tributary creeks to the Carson River, the maximum amount of supplemental ground-water rights used was 26.8 percent of the maximum duty of 4.0 acre-feet per acre annually. Solving for the proportional unknown percentage value results in a maximum supplemental use in Spring Valley of 49.8 percent. The State Engineer finds that based on the difference in base flow in Daggett Creek as compared to Cleve Creek the amount of supplemental ground-water rights used in the Spring Valley area is 49.8 percent of the 4.0 acre-feet per acre annual duty being approximately 2.0 acre-feet annually.

The State Engineer defines consumptive use of a crop as that portion of the annual volume of water diverted under a water right that is transpired by growing vegetation, evaporated from soils, converted to non-recoverable water vapor, incorporated into products, or otherwise does not return to the waters of the state. Consumptive use does not include any water that falls as precipitation directly on the place of use. The consumptive use of a crop is equal to the crop evapotranspiration less the precipitation amount that is effective for evapotranspiration by the crop, that is, the amount of water that is consumed in the growing of the crop.

Testimony presented at the hearing by the Applicant's witness indicated a consumptive use for crops of 2.5 to 3.2 acre-feet per acre.[80] The State Engineer's consumptive use estimate for Spring Valley is based on the Penman-Monteith short reference evapotranspiration and crop coefficient approach for estimating growing season crop evapotranspiration. The methods are described by the American Society of Civil Engineers[81] and the Food and Agriculture Organization of the United Nations,[82] and are for a crop of alfalfa with a growing season from the last killing frost to the first killing frost of 20° F (-6°C).[83] The mean annual last and first frost dates for Spring Valley are calculated to be April 16th and October 24th, respectively, using the National Weather Service Shoshone 5N Station (267450) minimum temperature 50-percentile probability at 20° F (-6° C). Using these methods, the State Engineer calculated the crop evapotranspiration during the growing season in Spring Valley to be 38.2 inches per year.

Effective precipitation as defined by the Natural Resource Conservation Service National Engineering Handbook[84] is the part of precipitation that can be used to meet the evapotranspiration of growing crops. Using the mean monthly precipitation for the period of record at the Shoshone 5N Station (267450) as reported by the Western Regional Climate Center, the calculated mean monthly effective precipitation during the growing season and a soil water balance during the non-growing season is 4.3 inches per year.

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[80] Transcript, pp. 513 – 515; Exhibit No. 503, pp. 2.4 & 2.5.
[81] State Engineer's Office, The ASCE Standardized Reference Evapotranspiration Equation, 2005.
[82] State Engineer's Office, Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements, 1998.
[83] State Engineer's Office, Evapotranspiration and Consumptive Irrigation Water Requirements for Idaho, 2006.
[84] State Engineer's Office, Irrigation Water Requirements, 2003.

The State Engineer finds that by using a crop evapotranspiration rate of 38.2 inches per year with an effective precipitation rate of 4.3 inches per year, the annual consumptive use of irrigated areas in Spring Valley is 33.9 inches (2.8 feet) per year, being 70 percent of the established duty of 4.0 acre-feet per acre annually.

Using the above findings for supplemental ground-water rights and consumptive use, the total committed ground-water rights in the Spring Valley Hydrographic Basin are as follows:

Method of Use	Annual Duty (acre-feet)	Consumptive Use (acre feet)
Irrigation – non-supplemental	9,831	6,882
Irrigation – supplemental	6,751	
Irrigation – supplemental (effective duty of 3,362 AF)		2,353
Mining/Milling	1,361	1,361
Quasi-Municipal	79	79
Stock water	393	393
Wildlife	20	20
Domestic	40	40
Total	**18,475**	**11,128**

XXIV.
IMPACTS TO EXISTING RIGHTS

Nevada Revised Statute § 533.370(5) provides that the State Engineer shall reject an application where the proposed use conflicts with existing rights. Water rights that could potentially be adversely affected by the proposed applications include both ground-water rights and surface-water rights originating as springs on the valley floor or valley margins. Surface-water rights with points of diversion within the mountain block are not likely to be measurably affected by the proposed project. Water-level drawdown will occur in a cone of depression around the pumping wells, which will eventually coalesce, resulting in wide-spread water-level declines. The Applicant did offer expert witnesses in hydrogeology; however, none of those witnesses presented any testimony or evidence pertaining to the magnitude or timing of water-level declines, decrease in spring flows, or impacts to existing rights. A ground-water flow model presented by the Applicant was completed for steady-state conditions only and was deemed unsuitable for predictive simulations.[85] Protestants' expert witness Dr. Myers completed

[85] Transcript, pp. 1345 – 1456.

a predictive ground-water flow model to evaluate future effects from pumping.[86] The model results indicate water-level declines throughout the southern portion of the valley of up to 100 feet or more after 100 years of pumping based on an annual recharge of 75,000 acre-feet and the pumping of the full amount applied for by the Applicant of 90,000 acre-feet annually.[87] The Applicant raised questions concerning the data used in Dr. Myers' model construction, conceptual accuracy and scale of the model, and testified that model results are uncertain and should be discounted.[88] The State Engineer finds that the Dr. Myers' model results may overestimate water-level decline, particularly over long periods of time, because in Dr. Myers' model recharge is less than the amount pumped. In essence, Dr. Myers' model simulations have a water budget deficit and steady state conditions cannot be reached until the deficit is made up by inflow from outside the modeled area. A decline in water levels always occurs when a new pumping stress is applied and water levels will continue to decline as transitional storage is removed until steady state conditions can be reached. The magnitude of transitional storage depletion and ground-water decline are dependent on the location and magnitude of pumping, the location and magnitude of natural inflow and outflow, and the hydraulic properties of the aquifers; thus, a water-level decline alone is not grounds for rejection of a water right application. Nevertheless, the State Engineer finds the effects of pumping of the subject applications could potentially result in significant water-level decline.

Applications 54016, 54017, 54018, and 54021 are located on the Cleve Creek alluvial fan. Distributed around the eastern toe of the fan there are 12 claims of vested spring rights, which total 9,600 acre-feet annually for the irrigation of 2,400 acres. Much of the land is sub-irrigated and the actual discharge of the springs is difficult, if not impossible, to measure due to the physical characteristics of the springs. None-the-less, the claims of vested rights are for all of the flow being discharged from the springs along the toe of the Cleve Creek alluvial fan. The Applicant proposes to pump 28 cfs (20,270 acre-feet annually) from points of diversion upgradient of the existing vested claims. Under questioning from the State Engineer, the Applicant's witness D'Agnese testified that there is insufficient data to determine either how much pumping might impact the claims of vested rights or how extensive those impacts might be.[89] Absent any presented evidence, the State Engineer must make a determination on potential conflicts based on past experience and professional judgment. The State Engineer finds that pumping under Applications 54016, 54017, 54018, and 54021 will impact existing spring rights at the Cleve Creek alluvial fan.

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[86] Exhibit No. 3001.
[87] *Id.* at 4.
[88] *See generally,* Testimony of D'Agnese, Transcript, pp. 1316-1456.
[89] Transcript, pp. 1428 – 1434.

The State Engineer finds that the remaining applications under consideration are in locations where the monitoring and mitigation plan that will be required as a condition of the approval will provide early warning for potential impacts to existing rights and also will provide for mitigation if unforeseen unreasonable impacts occur.

XXV.
PROTECTIBLE INTEREST IN EXISTING DOMESTIC WELLS

Nevada Revised Statute § 533.370(5) provides that the State Engineer shall reject an application and refuse to issue the permit where the proposed use of the water will conflict with protectible interests in existing domestic wells as set forth in Nevada Revise Statute § 533.024. Nevada Revise Statute § 533.024 provides that it is the policy of this State to recognize the importance of domestic wells as appurtenances to private homes, to create a protectible 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 be reasonably mitigated. The State Engineer finds that no evidence was presented which demonstrated with any certainty there would be unreasonable adverse effects to any specifically identified domestic well and it is not possible in this case to know in advance with any certainty that such impacts will occur and could not reasonably be mitigated. The State Engineer finds that if once the project is developed and unreasonable adverse effects are seen in any domestic well the Applicant will be required to mitigate the impacts in a timely manner.

XXVI.
PUBLIC INTEREST NRS § 533.370(5)

Nevada Revised Statute § 533.370 provides that the State Engineer must reject an application if the proposed use of the water threatens to prove detrimental to the public interest. More and more protestants are using this statutory provision to argue why an application should be denied and applicants are using it to argue their project is in the public interest; therefore, the application should be granted.

Only one Nevada Supreme Court case addresses this statutory criterion. In what is commonly known as the Honey Lake case,[90] the State Engineer found that the Nevada Legislature has provided substantial guidance as to what it determines to be in the public interest and identified thirteen policy considerations contained in Nevada water statutes (NRS chapters 533, 534 and 540) and also indicated that Nevada water law identified other principles that should also serve as guidelines in the determination of what constitutes "the public interest" within the meaning of NRS § 533.370. He found that it was in the public interest to facilitate the augmentation of the water supplies of the Reno-Sparks and North Valleys areas because of their declining water tables, so

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[90] *Pyramid Lake Paiute Tribe v. Washoe County*, 112 Nev. 743 (1996).

long as the other public interest values were not compromised or could be mitigated.

On appeal, the Appellants contended that the State Engineer's failure to include economic considerations, such as whether the proposal was economically feasible or an analysis of alternatives, in the public interest guidelines was a dereliction of duty. The Appellants referenced the statutes of other states to indicate the types of issues they believed should be encompassed in the analysis of whether the use of the water as proposed would threaten to prove detrimental to the public interest. However, the Nevada Supreme Court held that it could find no indication that Nevada's legislature intended the State Engineer determine public policy in Nevada by incorporating another state's statutes and vesting the State with the authority to re-evaluate the political and economic decisions made by local government. The Court held that the Nevada Legislature, presumably aware of the broad definition of the public interest enacted by other states (particularly Alaska and Nebraska), demonstrated through its silence that Nevada's water law statutes should remain as they have been for over forty-five years.

Only two other courts have specifically considered the meaning of Nevada's public interest criterion. The first case addressed State Engineer's Ruling No. 4848, pursuant to which the State Engineer was considering water right applications for the use of water at a nuclear waste storage facility. In the ruling, he found that the Nevada Legislature had determined the public interest through its determination of policy in the enactment of NRS § 459.910, which provides that it is unlawful for any person or governmental entity to store high-level radioactive waste in Nevada. The State Engineer held pursuant to that statutory provision that the Nevada Legislature had already determined that the use of water applied for threatened to prove detrimental to the public interest and denied the applications. The Federal District Court for the District of Nevada overturned the State Engineer's decision focusing its reasoning on the grounds that NRS § 459.910 is not a Nevada water law statute, either substantive or procedural.[91]

The second opinion addressing the criterion was from the Ninth Circuit Court of Appeals in *United States v. Alpine Land & Reservoir Co. (County of Churchill v. Ricci)*, 341 F.3d 1172 (9th Cir. 2003). In that case, the United States Fish and Wildlife Service (Service) had filed eight applications to transfer 2,855 acre-feet of water from irrigation use to the Stillwater National Wildlife Refuge to maintain wetland habitat. The transfers were in furtherance of a water right acquisition program that instructed the Service to acquire 75,000 acre-feet of water to fulfill the congressional directive set forth in Section 206(a) of Public Law 101-618, 104 Stat 3289. Churchill County and the City of Fallon had protested the applications on the grounds that the State Engineer should study the cumulative effect on the public interest of the entire acquisition program and not just the eight applications that were currently before him for decision. The Ninth Circuit Court of

[91] *See, United States v. Nevada*, CV-S-00-268-RLH (LRL) (D. Nev. 2003).

Appeals held that the State Engineer has broad discretion under Nevada law to determine whether the use of water as proposed under an application will threaten to prove detrimental to the public interest. The Court noted that the Nevada Legislature has not provided an explicit definition of what constitutes a threat to the public interest under NRS § 533.370(3) [now 533.370(5)], but held that the State Engineer's authority is limited to considerations identified in Nevada's water policy statutes.

To determine whether the use of water under these applications threatens to prove detrimental to the public interest, the State Engineer reviews how other State Engineers interpreted this provision of the law and finds that during the 1940s and 1950s the focus of the rulings was development of water resources and prevention of conflicts with existing rights. During these decades the public interest criterion was almost always tied to other statutory criteria such as water availability and impairment to existing rights.

Throughout the 1960s whether the use of water would threaten to prove detrimental to the public interest was still almost always tied to another provision of Nevada water law. Applications were denied because the applicant could not demonstrate the ability to apply the water to beneficial use; therefore, granting the application would threaten to prove detrimental to the public welfare. Applications in Pahrump were denied on the grounds that the Pahrump Fan was fully appropriated; therefore, granting the application would impair the value of existing rights and be detrimental to the public welfare. Also, applications were denied where a water purveyor under the provisions of NRS § 534.120 could supply water to the applicant, and to grant a water right under those circumstances would threaten to prove detrimental to the public welfare.

The analyses did not change much during the 1970s except rulings now denied applications where the use of the water conflicted with a basin designation order; therefore, granting the application would be detrimental to the public interest. Additionally, applications were denied where use of the water would create a cone of depression that would potentially draw in nearby poor quality water; therefore, the State Engineer determined that use would conflict with existing rights and be detrimental to the public welfare.

Environmental issues were also coming to the forefront in the 1970s. For example, in 1974 the Federal District Court for Nevada decided the case of *United States v. Cappaert*, 375 F. Supp. 456 (D. Nev. 1974) pursuant to which it found that pumping of ground water in the area of concern was jeopardizing the survival of an endangered species because it was lowering the water level below the ledge where the endangered species bred. It found that the United States had shown the public interest lies in the preservation of endangered species. "Congress, state legislatures, local governments and citizens have all recently voiced their expression for the preservation of our environment, and the destruction of the Devil's Hole pupfish would go clearly against the theme of environmental responsibility."[92]

As we entered the 1980s, the rulings began to demonstrate a concern about areas of the state where issued or applied for water rights exceeded the estimated water availability and, during this period, analyses of the public interest criterion began to make significant changes. In Little Fish Lake Valley, a change application from mining and milling to irrigation was denied on the grounds that water levels were declining, water rights exceeded the availability of water in the source, irrigation was not a preferred use and the right sought to be changed had been issued as a temporary use. The State Engineer held that it would not be in the public interest to allow a preferred use to be changed to a non-preferred use within a designated basin as it would adversely affect existing rights. In State Engineer's Supplemental Ruling No. 2776, the State Engineer found that:

> The water law does not specifically define what criteria the State Engineer must follow in determining whether the act of appropriating or changing the point of diversion of existing water rights is "detrimental to the public interest or welfare." The State Engineer therefore must exercise discretion in his interpretation under the express authority granted in law. The State Engineer must, to the extent possible, make a factual determination of all interests involved in any particular appropriation or change of existing rights. It is not unusual that more than one public interest is determined or defined. Some interests may ultimately outweigh others.

In Steptoe Valley, the State Engineer designated the preferred use for industrial purposes and found that:

> The arid conditions that prevail in the state of Nevada dictate that this vital resource be allocated to the most reasonable and economic use and that the public interest and welfare be an integral part of any determination in reaching these decisions. That interest and welfare extends to the protection of the existing rights which is mandated by statute as well as the wants and necessities of the state and local areas. The State Engineer in many cases is simply faced with weighing one public interest against another in reaching a decision especially when competitive beneficial uses are at issue.

Based on that analysis of the public interest, the State Engineer designated the preferred use of water in Steptoe Valley to be industrial, denied senior applications pending for irrigation purposes under Desert Land Entry or Carey Act entries and granted the junior applications of White Pine County for industrial purposes (power plant). The main thrust of White Pine County's testimony and evidence had been directed towards the critical economic conditions faced by the County and the relationship of that economy to the power project. The State Engineer found a vital public interest associated with White Pine County's applications and granted the applications,

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[92] 375 F. Supp. at 460.

which were for a significant quantity of water (25,000 acre-feet annually) with the conditions of a substantial monitoring program and a companion study program. The primary objective of the monitoring program was early detection of any adverse effects of large ground-water withdrawals to satisfy the legitimate concerns of the Protestants. Finally, he noted that Nevada water law allows for a reasonable lowering of the water table at the appropriator's point of diversion and found that should the withdrawal of the large quantity of ground water to support the power project result in some adverse effects on ground-water levels in Steptoe Valley, there would have to be a determination made as to whether that lowering is reasonable. The State Engineer noted the law requires the protection of existing rights, but not the unreasonable protection.

The 1990s saw interpretations very similar to the decades that preceded it. In the Supplemental Ruling on Remand in the Honey Lake case referenced above, the State Engineer set forth for the first time the criteria he found in Nevada water law for assessing whether the use of water as proposed under those applications threatened to prove detrimental to the public interest. But he also made public interest findings on issues that were not identified in that list and made findings of what was in the public interest. He decided that to allocate resources to reasonable and economical uses was in the public interest, so long as other public interest values were not unreasonably compromised or could be mitigated. But he also found that it would threaten to prove detrimental to the public interest to impair the endangered or threatened species in the area or degrade the quality of the water in the Truckee River. He found that even though there would be minimal loss of wetlands that there was an overriding public interest value to put the water to its highest and best use by allowing the water to be exported for municipal use.

In 1992, the State Engineer denied applications that were filed for a large quantity of water for municipal purposes to be used in every populated area in western Nevada on the grounds that it would threaten to prove detrimental to the public interest to grant applications where the applicant had not provided information on its financial ability to construct the project, and had failed to provide information that it had even begun studies to determine whether the water was available, cost to capture the water or whether there was a potential buyer for the water. All which are notably statutory criteria. He also found that it would threaten to prove detrimental to issue permits on applications acquired for the purpose of speculation.

The State Engineer has found that socioeconomic issues, such as decreased property values, loss of county tax base, and unemployment, related to changing 20,000 acre-feet of water from irrigation to wetlands were properly addressed in the required comprehensive planning process rather than under the public interest criterion found in Nevada water law and that the enforcement of land development guidelines was beyond the State Engineer's statutory authority.

In a ruling on appropriating water from the carbonate-rock aquifer, the State Engineer stated that even though it was unknown what quantity of water could be taken out of the carbonate-rock aquifer, there were adequate safeguards in place by the way of monitoring sites to give an early warning before any environmental damage was done or before the pumping decreased the flow in the Muddy River Springs. The State Engineer concluded that to meet the growing demands for electricity in southern Nevada the use of the water as proposed would not threaten to prove detrimental to the public interest. The first decade of the 21st century brought significant new challenges to Nevada. The population had been growing exponentially and fears of power shortages were resonating throughout the Western United States. Addressing these challenges, the State Engineer made his interpretations as to whether the use of water as proposed under an application would threaten to prove detrimental to the public interest. Like his predecessors his rulings mainly focused on the standard statutory criteria and public interest decisions were tied closely to those criteria; however, he also had to balance economic and growth concerns for the state against the environmental issues of concern.

This historical review points to a consistent thread throughout the decisions, that being, violating specific statutory provisions of Nevada's water law threatens to prove detrimental to the public interest. The State Engineers' expressions of the public interest were that it was important for the highest and best use of waters to be made and development of important industries should be encouraged. However, the State Engineer must exercise discretion in his interpretation under the express authority granted in law and must look at all the interests involved as to any particular appropriation and balance them, but that the wants and necessities of the state should be weighed against local interests. The public interest analysis included looking at the benefits of a project, protection of threatened or endangered species, and protection of the quality of water sources, but indicated that water should be allocated to reasonable and economic use, so long as other public interest values will not be unreasonably compromised. Even though some wetlands habitat might be lost there is an overriding public interest value in putting water to its highest and best use by allowing water to be exported for municipal use. The State Engineer is not a land use planner and history has indicated that water resources should be developed, but cautiously, as it would threaten to prove detrimental to the public interest to allow large scale development of water resources to go forward in support of municipal development when the confidence in predictions as to water availability long-term without damaging impacts is low and dire consequences could result. That it is important to encourage the development of the resources to their reasonable and economic use is demonstrated in the legislative policy found in NRS § 540.011(1), which provides that besides protecting existing rights it is also the policy of the state to encourage efficient and non-wasteful use of the state's limited supplies of water resources. In granting water rights in resources where it is not known if there will be impacts, but there is a concern there might be, the State Engineers' decisions have reflected a policy that the water belongs to the public and subject to existing rights may be appropriated, but development of the resources should be done in conjunction with significant monitoring and mitigation, if necessary.

The State Engineer finds the analysis of whether the use of water for a proposed project threatens to prove detrimental to the public interest must be addressed on a case-by-case basis. The State Engineer finds the statutory criterion, like beneficial use, is a dynamic concept changing over time, particularly as the Nevada Legislature provides more guidance as to the issues of importance. As addressed below in the next section of this ruling, since the Honey Lake case, the Nevada Legislature in 1999 provided the State Engineer with the additional statutory criteria found in NRS § 533.370(6) to consider whether the use of water in an interbasin transfer project, such as the one requested here, would threaten to prove detrimental to the public interest.

The State Engineer finds in this case that the Applicant has applied for water that belongs to the public at large. The Applicant has demonstrated a need for the water and a beneficial use for the water and it does not threaten to prove detrimental to the public interest to allow the use of the water for reasonable and economic municipal uses in the service area of the members of the Southern Nevada Water Authority. The State Engineer recognizes the critical nature between the limitations of the Applicant's current water resources and the increasing demands based on projected population growth. The State Engineer recognizes that existing rights must be protected as well as a concern for the wildlife and maintenance of wetlands and fisheries; therefore, the State Engineer finds, as addressed in later sections of this ruling, it would threaten to prove detrimental to the public interest to allow the resource to be developed without significant monitoring and additional study. The State Engineer finds the springs and streams upon which water rights exist and wildlife depend on must be protected. The Applicant has demonstrated the approximate number of persons to be served and the approximate future requirements of water supply. The Applicant has demonstrated the ability to finance the project and has demonstrated a capability to develop large water projects. Also, the Applicant has demonstrated its willingness to significantly monitor its ground-water development. The Applicant has demonstrated the benefit to all of Nevada from the proposed appropriations and under these circumstances the State Engineer finds the proposed use of the water does not threaten to prove detrimental to the public interest as limited in later sections of this ruling.

XXVII.
INTERBASIN TRANSFERS NRS § 533.370(6)

Nevada Revised Statute § 533.370(6) provides that in determining whether an application for an interbasin transfer of ground water must be rejected, the State Engineer shall consider: (1) whether the applicant has justified the need to import the water from another basin; (2) if the State Engineer determines a plan for conservation of water is advisable for the basin into which the water is imported, whether the applicant has demonstrated that such a plan has been adopted and is being effectively carried out; (3) whether the proposed action is environmentally sound as it relates to the basin from which the water is exported; (4) whether the proposed action is an appropriate long-term use which will not unduly limit the future growth and development in the basin from which the water is exported; and (5) any other factor the State Engineer determines to be relevant. The State Engineer finds that NRS § 533.370(6) provides the State Engineer with the guidelines to be used in determining whether the use of water under an interbasin transfer threatens to prove detrimental to the public interest.

XXVIII.
NEED TO IMPORT THE WATER

The State Engineer finds as addressed in Section VI of the Findings of Fact that the Applicant has justified the need to import water from another basin.

XXIX.
CONSERVATION PLAN

Nevada Revised Statute § 533.370(6) provides that in determining whether an application for an interbasin transfer of ground water must be rejected the State Engineer is to consider whether a plan for conservation of water is advisable for the basin into which the water is imported and whether the applicant has demonstrated that such a plan has been adopted and is being effectively carried out. Additionally, some of the Protestants alleged that the approval of the applications would sanction and encourage the willful waste and inefficient use of water in Las Vegas Valley and that the applications should be denied because the per capita water consumption rate for the Las Vegas area is far above that of similarly situated southwestern cities.

In Las Vegas, the role of conservation has been critical to the region's water-planning efforts. In 1990, the local water and wastewater agencies completed an extensive supply and demand projection process that resulted in public realization that the region would run out of water in 15 years even with conservation. The need for conservation was quickly acknowledged by the public and widespread conservation efforts began in the summer of 1991. Creation of artificial lakes was banned, water waste ordinances were adopted, and lawn watering was restricted during the hotter time of the day. To begin the shift to water-conserving rates, local water purveyors switched from flat rates to increasing block rates.

> With the formation of the SNWA in 1991, the first long-term coordinated conservation efforts began among local purveyors. Using 1990 as a base year and building on a recommendation from its integrated resource planning process of the mid-nineties, the SNWA established a goal of 25 percent conservation by 2010. . . . At that time, the SNWA purveyor members also agreed to follow a series of conservation "best management practices" published by the Bureau of Reclamation. . . . Southern Nevada made consistent progress towards it conservation goals through the 1990s . . . In 2002, as drought conditions in the Colorado River Basin became more severe, the SNWA member agencies recognized that a more immediate and actionable community response was necessary. As a result, the conservation strategic planning effort evolved to address drought conditions and ultimately set the stage for development of the SNWA Drought Plan. . . . Following the implementation of the Drought Plan in 2003, conservation and drought saving rebounded with a 23.1 percent saving for that year. A year later, the community surpassed the 25 percent conservation goal set in 1996 – a full six years ahead of schedule. The SNWA anticipates conservation will remain above the 25 percent conservation goal for 2005.[93]

Further activity towards conservation in the Las Vegas Valley has encompassed regulation through land use codes and ordinances to promote a more effective use of water, water pricing, incentive programs, water smart landscape rebate programs, as well as other programs as noted in the 2006 Water Resource Plan.[94] The Integrated Water Planning Advisory Committee puts water conservation at the top of the planning tools for future resources.[95] In the Recommendations Report of the Integrated Water Planning Advisory Committee, additional conservation is strongly supported with opinions only varying on the extent to which conservation should be used as a substitute for the completion of in-state water resource projects.[96]

To address the allegation that the approval of the applications would sanction and encourage the willful waste and inefficient use of water in Las Vegas Valley and that the applications should be denied because the per capita water consumption rate for the Las Vegas area is far above that of similarly situated southwestern cities, the Protestants presented a witness that showed the per capita consumption rate for other southwestern cities. The evidence indicates that the single-family residential per capita daily use in Albuquerque is 125 gallons per day, in Tucson it is 114 gallons per day and in Las Vegas Valley it averages 164 gallons per day. The system-wide per capita consumption in Las Vegas Valley is 227 gallons per day, Tucson 137 gallons per day and

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[93] Exhibit No. 511, p. 17.
[94] Exhibit No. 511, pp. 18-19.
[95] Exhibit No. 516.
[96] Exhibit No. 516, p. 8.

Albuquerque 152 gallons per day.[97] While the system-wide per capita consumption is certainly lower in those cities, these numbers alone do not provide a complete picture of the actions taken by the members of the Southern Nevada Water Authority to promote conservation nor do they present a complete picture of why the use is different, such as tourism, social economic, metrological and ecological factors.

The State Engineer finds a plan for conservation of water is advisable for the basin into which the water is imported and finds the Applicant has demonstrated that such a plan has been adopted and is being effectively carried out; therefore, the protest claims are overruled. The State Engineer finds no evidence supports the protest claim that the approval of the applications would sanction and encourage the willful waste and inefficient use of water in Las Vegas Valley and the protest claim is dismissed. The State Engineer finds that the comparison of per capita consumption of other southwestern cities to that of Southern Nevada is not an accurate comparison due to the factors impacting per capita consumption and the protest claim is overruled.

XXX.
ENVIRONMENTALLY SOUND

Nevada Revised Statute § 533.370(6)(c) provides that in determining whether an application for an interbasin transfer of ground water must be rejected the State Engineer shall consider whether the proposed action is environmentally sound as it relates to the basin from which the water is exported. The words environmentally sound have intuitive appeal, but the public record and discussion leading up to the enactment of NRS § 533.370(6)(c) do not specify any operational or measurable criteria for use as the basis for a quantitative definition. This provision of the water law provides the State Engineer with no guidance as to what constitutes the parameters of "environmentally sound;" therefore, like the criterion "does the use of the water threaten to prove detrimental to the public interest," it has been left to the State Engineer's discretion to interpret the meaning of environmentally sound.

The legislative history of NRS § 533.370(6)(c) shows that there was minimal discussion regarding the term environmentally sound. However, the State Engineer at that time indicated to the Subcommittee on Natural Resources that he did not consider the State Engineer to be the guardian of the environment, but rather the guardian of the state ground water and surface water. The State Engineer noted that he was not a range manager or environmental scientist.[98] Senator James pointed out that by the language "environmentally sound" it was not his intention to create an environmental impact statement process for every interbasin water transfer application and that the State Engineer's responsibility should be for the hydrologic environmental impact in the

[97] Exhibit No. 3064, p. 18.
[98] Minutes of the February 22, 1999, Subcommittee meeting of the Senate Committee on Natural Resources.

basin of export.[99] Additional testimony pointed to the fact that the greatest concern was that there would be enough water left in the basin from which the water was exported to ensure that the basin would remain environmentally viable and that it was important to protect the future environment of basins in the rural communities to ensure water would be available for future growth.[100]

While there are no definitions of what environmentally sound is, there are examples of what environmentally sound is not, such as the Owens Valley project in California. The State Engineer believes that the legislative intent of NRS § 533.370(6)(c) was to protect the natural resources of the basin of origin and prevent a repeat of the Owens Valley while at the same time allowing for responsible use of the available water resources by the citizens of Nevada.

In the State Engineer's Intermediate Order No. 4, the State Engineer addressed the Applicant's motion to dismiss or limit the State Engineer's review of any protest claim that addresses whether the proposed transfer is environmentally sound. The State Engineer noted that the protest claims addressed issues such as threatened and endangered species, destruction of environmental, ecological, scenic and recreational values held in trust for the citizens, and purposes for which the lands are managed under the Federal Land Use Policy and Management Act. In its motion, the Applicant asserted that the State Engineer is not required to duplicate the environmental review that other state and federal agencies are obliged to complete under state and federal law. In Intermediate Order No. 4, the State Engineer found that the legislation was not intended to create an environmental impact process and that care needed to be taken to avoid requirements that would be duplicative of Environmental Impact Statements. The State Engineer found that NRS § 533.370(6)(c) requires the State Engineer to consider environmental issues; however, the perspective he is to focus on is that of hydrologic issues. Therefore, as State Engineers have done with the public interest criterion, the State Engineer turns to the water law to define the parameters of whether the use of the water is environmentally sound for the basin of origin. The State Engineer finds this 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.

Environmental consideration for wildlife is found in NRS § 533.367, which provides that before a person may obtain a right to the use of water from a spring or water that has seeped to the surface of the ground, he must ensure that the wildlife which customarily uses the water will continue to have access to it. While this provision of the water law does not specifically apply to an appropriation of ground water, it is a clear demonstration of the public interest in that the sources of water for wildlife remain accessible and viable.

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[99] *Ibid.*; Minutes of the March 8, 1999, Subcommittee meeting of the Senate Committee on Natural Resources.
[100] Minutes of the April 21, 1999, Subcommittee meeting of the Senate Committee on Natural Resources.

Nevada Revised Statute § 534.020 provides that it is the intention of the Nevada Legislature to prevent the pollution and contamination of the ground water and empowered the State Engineer to take action to prevent that pollution. Pollution of the ground water would be considered to be environmentally unsound; therefore, in allowing for appropriating water, the State Engineer must take into consideration whether the extent of the pumping could draw non-potable water into a drinkable water supply.

Another issue as to whether the use of the water is environmentally sound is the resulting ground-water level decline from the ground-water pumpage. The development of ground water from a hydrologic basin with ET occurs through the capture of the ET by ground-water pumpage and a lowering of the ground-water levels. Nevada Revised Statute § 534.110(4) provides that it is a condition of each appropriation of ground water that the right must allow for a reasonable lowering of the static water level at the appropriator's point of diversion. 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.

Plant communities are always in a natural state of transition given naturally occurring environmental conditions and it is clear that if there was a decline in the ground-water table there would be a change in the existing ground-water dependent plant community. However, the type of plant community change and the time frame over which this transition would occur are unknown and change is not inherently unacceptable. There are many hydrologically related parameters which are part of a viable ecosystem, including the area of vegetative cover and vegetative density in this area. The ecological impact to the ecosystem from the transition of a ground-water dependent ecosystem to a precipitation-dependent ecosystem is unknown. However, while it is evident that rainfall and ground-water dependent plant communities can exist in an area with similar ET and precipitation, there was no evidence or testimony presented which supported the concept that a plant community can transition from a ground-water dependent to precipitation-dependent without significant impacts to that ecosystem.

The State Engineer finds that in consideration of whether the proposed project is environmentally sound there can be a reasonable impact on the hydrologic related natural resources in the basin of origin. The State Engineer finds by requiring the collection of biological and hydrological baseline data, by requiring a significant monitoring and mitigation plan, and by requiring a staged development and associated studies there are sufficient safeguards in place to ensure that the interbasin transfer of water from Spring Valley will be environmentally sound.

XXXI.
LONG-TERM USE BASIN OF ORIGIN

Nevada Revised Statute § 533.370(6) provides that in determining whether an application for an interbasin transfer of ground water must be rejected, the State Engineer shall consider whether the proposed action is an appropriate long-term use, which will not unduly limit the future growth and development in the basin from which the water is exported. Protestants claim the applications should be denied because removal of the water will adversely impact economic activity such as agriculture, power generation and transmission, mineral extraction, manufacturing, tourism and concentration of population. That in modern periods of drought there is insufficient water which creates hardships on cattlemen in that grazing areas do not have sufficient feed, surface waters are insufficient for irrigation and stock watering, water tables are lowered making it more difficult and expensive to pump water, and this effects economic value. If drought creates this many hardships, it is alleged that continual removal of the perennial yield will destroy ranching. Finally, it is alleged that granting the applications in the quantity requested, that is for all the unappropriated water in the basin, will adversely affect agricultural operations in that it will affect the economic value of all farms and ranches, it will destroy the environmental balance thereby destroying grazing lands, wetlands, and farm lands and it will halt all potential agricultural growth.

The Protestants provided a report titled Estimation of Economic Impacts of the Agricultural and Recreational Activities in Spring Valley Area, White Pine County: An Application of Input-Output Analysis.[101] This report does not provide any analysis that addresses whether the proposed action is an appropriate long-term use which will not unduly limit the future growth and development in the basin from which the water is exported. A witness for the Protestants, Mr. Harris, noted that White Pine County has been a boom/bust county and notes that growth is variable and could include ranges.[102] Testimony indicated that one of the main economic engines for White Pine County is the export price of gold along with alfalfa hay and cattle and when you discuss long-term growth and development it must be recognized that you have to look at scenarios, such as the economic impact if gold is $800/ounce vs. $200/ounce.[103] It was indicated that in rural areas, because of this boom/bust cycle, they are trying to diversify their economies to mitigate these

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[101] Exhibit No. 3063.
[102] Transcript, pp. 1802 - 1810.
[103] Transcript, pp. 1816 - 1817.

variabilities, but it is very tough.[104] The testimony indicated that rural areas are very difficult areas in which to do economic forecasts,[105] but there are many different ways to expand the economy of the area, for example, improving telecommunications through broadband.[106]

The Protestants provided testimony and evidence through White Pine County's economic diversification coordinator to address potential future growth in Spring Valley. That evidence included the White Pine County Water Resource Plan, which looks at a 50-year planning process (2006-2056).[107] Of note, was the testimony that indicated historically the economy of White Pine County has been a natural resource economy, that being mining and ranching.[108] After the closing of the Kennecott mine in 1978 and the smelter in 1983, the County in attempting to diversify its economy looked to tourism, which is based on natural resources and outdoor recreation.[109] In recent years, the County has seen growth in summer and retirement homes.[110] Testimony was provided about growth in White Pine County in Steptoe Valley, which indicated that the County did see a growth in population of 3.4 percent, growth in housing, assessed valuation and firms doing business in 2006. Testimony also indicated the County is working on power plant projects and energy projects that require water, such as seed oil crops for biofuels.[111]

Additional testimony directed specifically towards Spring Valley indicates that the economic activity in the valley consists mostly of ranching activity that includes irrigated cropland for alfalfa and livestock production, and recreational use such as hunting and fishing and visits to federal lands and Great Basin National Park. The County Assessor's records indicate that 16.22 percent of the total agricultural property in the county is in Spring Valley with alfalfa production generating $2.6 million dollars annually or 37.94 percent of the total alfalfa hay production in the county. Spring Valley represents 20 percent of the county's cattle production for an economic contribution of approximately $1.38 million dollars annually. The valley accounts for 30 percent of the sheep production in the county and several million dollars of economic activity is generated by recreational activities.[112] The testimony indicated that the future economic growth in Spring Valley would relate to the potential for additional agricultural development, residential

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[104] Transcript, p. 1817.
[105] Transcript, p. 1818.
[106] Transcript, p. 1821.
[107] Transcript, pp. 1723-1725.
[108] Transcript, p. 1728.
[109] Transcript, pp. 1728-1729.
[110] Transcript, p. 1729.
[111] Transcript, pp. 1729-1731.
[112] Exhibit No. 3054.

development and tourism with a potential for mining and related processing. The witness indicated a belief that water is needed to support environmental quality, wildlife populations, and plant communities to maintain scenic beauty so important to outdoor recreational activities.[113]

The testimony and evidence provided indicates from the assessor's records there is 40,406 acres of agricultural property and 3,132[114] acres taxed as single-family residences, but all are not occupied.[115] Of these 3,132 acres many are large parcels that could be divided into five-acre parcels.[116] Of note, the White Pine County Water Plan does not provide any indication of anticipated water needs for future growth in Spring Valley.[117] If all 3,132 acres were divided into 5-acre parcels there would be 626 new single-family residences and, if each was estimated to use the 2.02 acre-feet per acre, which is the annual figure allotted by the State Engineer as the amount for domestic well use, particularly on a larger parcel, then 1,265 acre-feet annually would be needed for future growth.

The Applicant provided testimony that was a review of the Protestants' analysis of the long-term growth of the Spring Valley basin (the Harris Report Exhibit No. 3063) and agreed that the Protestants' witness is probably one of the most knowledgeable people on rural economics in the state of Nevada.[118] The criticism of the Harris Report was that it tended to look at agriculture and tourism related industries in the absence of other activities that may or may not occur in the region. It was making the assumption of impact to industries that presently exist without looking at the other side of the equation, which is what type of additional growth impetus there might be. The Applicant's witness indicated that the Harris Report presupposes there is going to be some factor that results in the agriculture or tourism portion of the economy declining, but does not factor in that the project is a major construction project, and such projects have a tendency to have significant positive impact in terms of employment, wages and related factors. The Applicant's witness agreed with Dr. Harris that far more research is necessary in order to take a look at the entirety of the question.[119]

The Applicant submitted Exhibit No. 528, the Nevada County Population Projections for 2004 to 2024, which was prepared by the Nevada State Demographer's Office for the Nevada Department of Taxation. It predicts that Clark County will have over 2,751,082 people by 2024, and White Pine County will have lost population every year with approximately 1,500 fewer people residing in the county in 2024 then currently reside there in 2004.

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[113] Transcript, p. 1734.
[114] The State Engineer notes later testimony indicated 3,162 acres of private land taxed as single-family residences.
[115] Transcript, pp. 1740-1741; Exhibit No. 3054.
[116] Transcript, p. 1752.
[117] Transcript, pp. 1742-1743.
[118] Transcript, p. 252.
[119] Transcript, pp. 252-254.

Legislative history does not assist the State Engineer in determining the time frame the Legislature was contemplating under this statutory provision, whether it be 10 years, 30 years or 75 years. It was noted that population projections do a good job of predicting the future based on the past, but it is not always an accurate prediction of the future, as has been seen in the inability of Southern Nevada to accurately predict its own population growth. Testimony was provided that disagreed with the demographer figures and called into question the accuracy of their long-term predictions.[120] A number of unforeseen factors could affect future growth in the Spring Valley.

The State Engineer finds a certain quantity of unappropriated water must be left in the basin for future long-term growth, but there is little evidence to support any specific quantity of water. As noted above, if all 3,132 acres of private land were divided into five-acre parcels, this would equate to 626 individual parcels with a domestic use equivalent of 1,265 acre-feet annually needed for the long-term future growth and development of said parcels. However, this does not include other potential future demands such as, but not limited to, commercial, industrial, scenic or recreational uses. There was no substantial evidence or testimony presented at the hearing, which indicated the potential or limit of the future growth within the basin. Therefore, the State Engineer finds that it is reasonable and necessary to leave 10% of the perennial yield of the Spring Valley Hydrographic Basin as unappropriated water for the future growth and development within said basin.

XXXII.
UNAPPROPRIATED WATER

The Protestants allege that the water is not available for appropriation and the quantity requested for appropriation will exceed the safe yield of the area. Mining of ground water is not acceptable and appropriation of this magnitude will lower the water table and degrade the quality of water from existing wells, cause negative hydraulic gradients influences, other negative impacts and adversely affect existing rights and the public interest.

As previously stated, the State Engineer finds the perennial yield of Spring Valley is 80,000 acre-feet annually, committed consumptive use of ground-water rights is 11,128 acre-feet annually, potential future domestic use is 1,265 acre-feet annually, and 10 percent of the perennial yield is 8,000 acre-feet annually. The sum of these existing demands is approximately 20,000 acre-feet annually to meet existing rights and future growth within the basin. Therefore, the State Engineer finds that there is 60,000 acre-feet annually of water available for appropriation and export from the Spring Valley Hydrographic Basin.

[120] Transcript, pp. 1735-1736.

The State Engineer finds that due to the great uncertainty, and no party's ability to quantify impacts with any degree of certainty, caution is warranted as it cannot definitively be said that there will or will not be unreasonable impacts, if those impacts would continue for an unreasonable period of time if pumping were ceased or if any impacts, reasonable or unreasonable, are environmentally sound. The State Engineer finds, in order to gather the necessary information to more accurately predict the effects of pumping, the development of water will occur in stages in conjunction with a significant monitoring and mitigation plan. If unreasonable impacts from the pumping are seen or are likely, curtailment of pumping will be ordered unless the impacts can be reasonably and timely mitigated. The State Engineer finds that prior to the Applicant exporting any ground-water resources from Spring Valley biological and hydrologic baseline studies shall be completed and approved by the State Engineer.

Evidence submitted by the Applicant indicates that the earliest development of the water resources in the five or six basin In-State Resource Importation Project is 2015.[121] Additionally the Southern Nevada Water Authority 2006 Water Resource Plan submitted by the Applicant indicates that the in-state water resources option is anticipated for use to meet long-term water demands beginning in 2017.[122]

The State Engineer finds that staged development and monitoring of biological and water resources in the Spring Valley Hydrographic Basin will be as follows:

- A monitoring and mitigation plan consisting of both biological and hydrological parameters shall be approved by the State Engineer.
- A minimum of five years of biological and hydrological baseline data shall be collected by the Applicant after the approval of the monitoring and mitigation plan and submitted to the State Engineer prior to the Applicant exporting any ground-water resources from Spring Valley.
- The initial staged development shall consist of a minimum ten-year period during which time a maximum of 40,000 acre-feet can be pumped in any year. But over a ten-consecutive year period, the pumping must average at least 35,000 acre-feet annually.
- With the exception of incidental uses related to the project, all ground water pumped during the staged development period shall be exported from Spring Valley.
- During the initial staged development period, the Applicant shall file an annual report with the State Engineer by March 15th of each year detailing the findings of the monitoring and mitigation plan.

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[121] Exhibit No. 516.
[122] Exhibit No. 511.

- During the initial staged development period, the Applicant shall update a ground-water-flow model approved by the State Engineer every five years.
- At the end of the staged development period, the Applicant shall submit the updated ground-water flow model with the data obtained during the staged development period and provide predictive results for 10 years, 25 years and 100 years.
- The State Engineer will then make a determination as to whether the remaining permitted amount may be pumped or additional study is necessary.

XXXIII.
FURTHER STUDY/INADEQUATE SCIENTIFIC INFORMATION

Various Protestants allege that further study is needed because the potential effects are impossible to anticipate and they do not want to render Spring Valley into another Owens Valley, the available scientific literature is not adequate to reasonably assure that the proposed diversions will not impact senior rights and water resources, and in as much as an interbasin transfer project of this magnitude has never been considered, it is impossible to anticipate all possible adverse effects without further information and study. Additionally, this project cannot be properly evaluated without an independent, formal and public reviewable assessment.

The State Engineer finds there is nothing in Nevada water law that requires water resource evaluation by an independent entity, but rather that is the responsibility of the State Engineer; therefore, this protest claim is dismissed. The State Engineer agrees additional study is needed. Additional information will be derived through the collection of both biological and hydrological baseline information, the continued development of the approved ground-water model, the staged development of the water resources and the required monitoring plan.

CONCLUSIONS OF LAW

I.

The State Engineer has jurisdiction over the parties and the subject matter of this action and determination.[123]

II.

The State Engineer is prohibited by law from granting an application to appropriate the public waters where:[124]

A. there is no unappropriated water at the proposed source;
B. the proposed use or change conflicts with existing rights;
C. the proposed use or change conflicts with protectible interests in existing domestic wells as set forth in NRS § 533.024; or
D. the proposed use or change threatens to prove detrimental to the public interest.

The State Engineer concludes, based on the findings, there is unappropriated water for export from the basin, there is no substantial evidence the proposed use will conflict with existing rights, except for those rights on the Cleve Creek alluvial fan, there is no substantial evidence that the proposed use will conflict with protectable interests in existing domestic wells, or the use of the water will threaten to prove detrimental to the public interest; thus, under NRS § 533.370(5), the law mandates the granting of the water rights.

III.

The State Engineer concludes the Applicant provided proof satisfactory of its intention in good faith to construct any work necessary to apply the water to the intended beneficial use with reasonable diligence, and its financial ability and reasonable expectation actually to construct the work and apply the water to the intended beneficial use with reasonable diligence.

IV.

The State Engineer concludes that based on the findings that the Applicant has justified the need to import the water from another basin, that an acceptable conservation plan is being effectively carried out, that the use of the water is environmentally sound as it relates to the basin of origin, and that by limiting the amount permitted for appropriation and leaving a portion of the water in the basin of origin that the use of the water will not unduly limit the future growth and development of the basin of origin. Therefore, there is no reason to reject the applications under NRS § 533.370(6) that are being permitted pursuant to this ruling.

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[123] NRS chapters 533 and 534.
[124] NRS 533.370(5).

RULING

The protests to Applications 54016, 54017, 54018 and 54021 are hereby upheld in part and the applications are hereby denied on the grounds that approval will conflict with existing rights and would threaten to prove detrimental to the public interest. The protests to Applications 54003, 54004, 54005, 54006, 54007, 54008, 54009, 54010, 54011, 54012, 54013, 54014, 54015, 54019 and 54020 are hereby overruled in part and the Applications are hereby granted subject to:

1. Existing rights;
2. Payment of the statutory fees;
3. A monitoring and mitigation program approved by the State Engineer a minimum of five years prior to the export of any water under these permits;
4. A minimum of five years of biological and hydrological baseline data shall be collected by the Applicant and approved by the State Engineer prior to the Applicant exporting any ground-water resources from Spring Valley under these permits;
5. A minimum ten-year period during which time a maximum of 40,000 acre-feet can be pumped in any one year with a ten consecutive-year average of at least 35,000 acre-feet annually;
6. File an annual report with the State Engineer by March 15th of each year detailing the findings of the approved monitoring and mitigation plan;
7. The total combined duty under Permits 54003, 54004, 54005, 54006, 54007, 54008, 54009, 54010, 54011, 54012, 54013, 54014, 54015, 54019 and 54020 shall be limited to 60,000 acre-feet annually, subject to the staged development guidelines and findings of the initial staged development period;
8. If pumpage impacts existing rights, conflicts with the protectible interests in existing domestic wells as set forth in NRS § 533.024, threatens to prove detrimental to the public interest or is found to not be environmentally sound the Applicant will be required to curtail pumpage and/or mitigate the impacts to the satisfaction of the State Engineer.

Respectfully submitted,

Tracy Taylor, P.E.

TRACY TAYLOR, P.E.
State Engineer

Dated this 16th day of
April, 2007.

APPENDIX C

PROTOCOLS

CONTENTS

C.1 Water supply and water quality
C.2 Physical habitat of aquatic ecosystems
C.3 Open water and aquatic vegetation cover
C.4 Macroinvertebrate composition and richness
C.5 Springsnail abundance and distribution
C.6 Fish age/size class structure and distribution
C.7 Northern Leopard Frog egg mass counts
C.8 Cover and composition of aquatic vegetation
C.9 Cover and composition of non-aquatic vegetation
C.10 Vegetation measurements in swamp cedar communities
C.11 Stem elongation in swamp cedar communities
C.12 Training
C.13 Field quality assurance / quality control
C.14 Hazard analysis and critical control points (HACCP)
C.15 Literature Cited

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Chapter 5 describes the target population, sampling design, monitoring sites, and statistical analysis for each indicator. Specific monitoring protocols for each indicator; and protocols for training, safety, and avoidance of transfer of nuisance species are included in this appendix.

The following framework is used for presenting the specific protocols for indicators.

- List of monitoring sites for proposed indicator
- References or Step by step methodology for each measurement.
  - Method
  - Number and location of samples
- Any site-specific changes due to individual site characteristics

Regardless of indicator or method, all data for the monitoring plan will need to be recorded in an efficient and effective manner. Project-specific datasheets, calibration logs, and chain-of-custody forms will be prepared prior to the first sampling effort. Coordination with the data management team (Chapter 7) will be conducted to ensure that these forms correspond to the extent possible and practical with the data entry format developed for the project database. Digital datasheets may be used for certain or all sampling components of the monitoring plan. When hard copies are used, datasheets will be printed on waterproof paper and designed in a user-friendly manner with a designated space for all necessary information. To ensure completeness, once all necessary information has been recorded on the proper datasheet (or digital file) for each site, the person recording the data must initial and date the bottom of the datasheet in a specified field. Prior to leaving the site, the datasheet is then reviewed by the designated crew leader to assure completeness, and signed and dated by that reviewer in a separate field.

C.1 WATER SUPPLY AND WATER QUALITY

Water supply data will be collected for all groundwater-influenced ecosystems, and water quality analysis will be conducted at springs, ponds (Shoshone), and perennial streams (and at northern leopard frog breeding transects in wetlands). Data collection will be conducted at sites selected for monitoring within the IBMA as described in Table C.1-1. Depth to groundwater (local and/or regional), corresponding spring head level (if feasible), discharge (if possible), and water quality parameter information will be collected at springs. Regional depth to groundwater, discharge and water quality will be collected at ponds (Shoshone, where alluvial well discharge rate will be set) and perennial streams. Regional depth-to-groundwater information will be inferred from the nearest monitoring wells for wetlands, meadows, phreatophytic shrublands and swamp cedar woodlands.

Table C.1-1. Water supply and water quality monitoring sites.

Monitoring Site	Depth to Groundwater[1]	Discharge[2]	Water Quality[3]
Stonehouse Spring Complex	Piezometer		BWG
Willow Spring	Piezometer	Flow meter	BWG
Keegan Ranch Spring Complex	Piezometer	Flow meter	BWG
West Spring Valley Complex	Piezometer		BWG
South Millick Spring	Piezometer	Flow meter	BWG
Unnamed Spring 5	Piezometer	Flow meter	BWG
4WD Spring	Piezometer		BWG
Willard Spring	Nearby well		BWG
Swallow Spring	Piezometer	Flume[4]	BWG
Minerva Spring Complex	Piezometer	Flow meter	BWG
Clay Spring - North	Nearby well		BWG
Unnamed 1 – North of Big	Nearby well		BWG
North Little Spring	Nearby well		BWG
Shoshone Ponds	Nearby well	Set discharge rate[4]	NDOW[5]
Big Springs Complex			
Big Spring Creek / Lake Creek	Nearby well	USGS gage[4], flow meter[6]	BWG, TRP[6]
Big Springs	Nearby well	USGS gage[4]	
Stateline Springs		Flow meter	
The Seep	Piezometer		
Blind	Piezometer		
Burbank			
Swamp Cedar Woodland (Middle)	Nearby well		
Swamp Cedar Woodland (South)	Nearby well		
Greasewood/Rabbitbrush	Nearby well (if possible)		

[1] To correlate groundwater elevation in piezometers,to spring head level, staff gauges may be placed in springs depending on site condition and feasibility.
[2] Measured where and when practical.
[3] BWG water quality parameters: dissolved oxygen, temperature, pH, conductivity, turbidity, total nitrogen, total phosphorus, and water temperature. TRP will also be collecting water chemistry measurements at 40 still-to-be determined sites per Exhibit A of the Spring Valley Stipulation.
[4] TRP continuous measurements at Swallow Spring and at Big Springs channels leading to Big Spring Creek / Lake Creek. The BLM plans to set the discharge rate for the alluvial wells that create Shoshone ponds.
[5] Standard water quality sampling conducted by NDOW during fish sampling in the ponds.
[6] TRP gain/loss study on Big Spring Creek / Lake Creek.(BWG will also be collecting stream discharge measurements during biological surveys).

WATER SUPPLY

Piezometers

Will be located at select spring sites (Table C.1-1) and implemented by the TRP (Exhibit A, Spring Valley Stipulation). Continuous data will be recorded with periodic downloads.

Groundwater Monitoring Wells

Groundwater elevation (depth to groundwater) will be measured continuously or quarterly by the TRP in at least 41 monitoring wells spatially distributed across the IBMA in basin fill, carbonate, and volcanic (Fig. 4-2; Chapter 4).

Discharge

Discharge measurements will be taken at select springs and perennial streams during each biological sampling effort (if appropriate and when practical). Continuous monitoring of discharge in Big Springs channels leading to Big Spring Creek will be conducted by the TRP using USGS stream flow measurement protocols (Nolan and Shields 2000), and at Swallow Spring using a flume.

WATER QUALITY

Standard Parameters

Standard water quality parameters will be measured during each biological monitoring effort at the sites referenced in Table C.1-1. Parameters will include:

- water temperature in degrees Celsius (^{o}C)
- dissolved oxygen (DO) in milligrams per liter (mg/l)
- conductivity in microSeimens per centimeter (µS/cm)
- pH, and
- turbidity in N turbidity units (ntu).

A multi-parameter water quality probe (i.e. Hydrolab or similar device) will be used to collect standard parameters. The probe will be placed below the water surface at each of the locations where water is of sufficient depth. If water level is too shallow, water will be collected in a small container (being careful not to splash or create bubbles) and the probe will be inserted into the container of water for measurement of parameters. The number of samples and location of samples is presented in Table C.1-2.

Table C.1-2. Number and location of standard water quality measurements.

Monitoring Site	# of locations	Measurement locations
Stonehouse Spring Complex	3	Spring head complexes sampled for springsnails (3)
Willow Spring	3	East spring head (1), spring brook (1), terminus (1)
Keegan Ranch Spring Complex	3	North spring head (1), North spring brook (1), endpoint (1)
West Spring Valley Complex	3	North spring head (1), associated channel (1), endpoint (1)
South Millick Spring	3	Spring head (1), sampling midpoint (1), sampling endpoint (1)
Unnamed Spring 5	3	Spring head (1), sampling midpoint (1), sampling endpoint (1)
4WD Spring	1	Spring head
Willard Spring	1	Spring head
Swallow Spring	3	Spring head (1), sampling midpoint (1), sampling endpoint (1)
Minerva Spring Complex	5	North spring heads (3), Middle spring heads (2)
Clay Spring-North	3	Spring head (1), sampling midpoint (1), sampling endpoint (1)
Unnamed 1 – North of Big	1	Spring head
North Little Spring	1	Spring head
Shoshone Ponds	4	Within each of the four ponds
Big Springs Complex		
Big Spring Creek /Lake Creek	5	Within each of the five sample reaches
Big Springs	1	Spring head (1)
Stateline Springs	1	Spring head (1)

Correct calibration of the water quality probe is necessary for accurate collection of water quality parameter data. While water temperature measurements (°C) usually do not require frequent calibration when measured with a high quality probe, even a first-rate probe must be calibrated appropriately in order to accurately measure conductivity, pH, and dissolved oxygen concentration.

The multi-parameter water quality probe will be calibrated prior to each sampling trip and then post-calibrated upon completion of the trip. Calibrations will be performed for each parameter according to the manufacturer's guidelines and recorded in a water quality probe calibration log. Each instrument will have its own log with pre- and post-calibration measurements as well as any maintenance and trouble-shooting notes recorded in it. The log will be reviewed periodically to establish instrument accuracy

Nitrogen and Phosphorus

Total nitrogen and total phosphorus will be sampled at springs by a composite grab sample near the spring orifices (Table C.1-3). In the case of multiple spring orifices, the sample will be collected in the same permanent location as the temperature logger. For Minerva, which has multiple locations proposed for temperature loggers, TN and TP will be collected at each location. This results in 17 water quality grab samples per monitoring trip.

Table C.1-3. Number and location of nitrogen and phosphorus measurements.

Monitoring Site	# of locations	Measurement locations
Stonehouse Spring Complex	3	Largest spring head
Willow Spring	3	East spring head
Keegan Ranch Spring Complex	3	North Spring head
West Spring Valley Complex	3	North Spring head
South Millick Spring	3	Spring head
Unnamed Spring 5	3	Spring head
4WD Spring	1	Spring head
Willard Spring	1	Spring head
Swallow Spring	3	Spring head
Minerva Spring Complex	5	North spring head (1), Middle spring head (1)
Clay Spring-North	3	Spring head
Unnamed 1 – North of Big	1	Spring head
North Little Spring	1	Spring head
Big Springs Complex		
Big Springs	1	Spring head (1)
Stateline Springs	1	Spring head (1)

Quality assurance and control for collected water samples will be conducted by making sure that every sample has a documented chain of custody. Once collected, water samples must be passed through a chain of custody that allows them to be documented from field collection through the completion of laboratory analysis. Monitoring the chain of custody of collected water samples provides quality assurance and control for the reliability of the data derived from the samples.

Chain of custody for collected samples will begin in the field, when the collector fills out a form stating the collection date and time, site, station, collector's initials, and container fraction (# of total containers from site). Transfer from field personnel to laboratory personnel will be documented. At the laboratory, the chain of custody will be continued as each sample is given a unique number and the date and time of analysis, tests run, and laboratory analyst's name are recorded. Any comments about the sample by either party will be recorded on the form. Copies of each chain of custody form will be retained by the laboratory.

Water Temperature

In addition to standard parameter measurements, one temperature logger will be placed at each monitoring site, except Minerva and Shoshone Ponds where additional loggers will be placed (Table C.1-4). Temperature loggers will be placed in the deepest part of the spring head, or into the deepest portion of a spring pool (depending upon the spring type). At Minerva, one temperature logger will be placed at a representative spring at each of the north and middle complexes. At Shoshone Ponds, one temperature logger will be placed in each of the four ponds (north, middle, south, and stock). This results in a total of 20 temperature loggers for the monitoring plan. Typical temperature loggers (e.g. TidbiT v2 Temp Loggers, www.onsetcomp.com) cost around $150 and can be set to record at various time intervals allowing for long periods of data collection prior to downloading. This will allow for the collection of continuous temperature information between survey periods. Temperature loggers will be downloaded during each subsequent field event.

Table C.1-4. Number and location of temperature loggers.

Monitoring Site	Number	Measurement locations
Stonehouse Spring Complex	1	Largest Spring head
Willow Spring	1	East Spring head
Keegan Ranch Spring Complex	1	North Spring head
West Spring Valley Complex	1	North Spring head
South Millick Spring	1	Spring head
Unnamed Spring 5	1	Spring head
4WD Spring	1	Spring head
Willard Spring	1	Spring head
Swallow Spring	1	Spring head
Minerva Spring Complex	2	North spring head (1), Middle spring head (1)
Clay Spring-North	1	Spring head
Unnamed 1 – North of Big	1	Spring head
North Little Spring	1	Spring head
Shoshone Ponds	4	Within each of the four ponds
Big Springs Complex		
Big Springs	1	Spring head (1)
Stateline Springs	1	Spring head (1)

C.2 PHYSICAL HABITAT OF AQUATIC ECOSYSTEMS

Physical habitat measures will be collected in all groundwater-influenced ecosystems except for the ponds at Shoshone Ponds (to diminish disturbance to the site) and phreatophytic shrublands. Spring and perennial stream monitoring sites will be characterized by additional suites of physical habitat measures, as described in Table C.2-1. General characterization includes areal extent, open water and aquatic vegetation cover (discussed in Section C.3), spring brook length, fixed station photography, and site condition. More comprehensive physical habitat monitoring will focus on nested target habitat, and will include substrate composition, water depth, water width, and water length. Comprehensive physical habitat monitoring will also consider spring and stream discharge (Section C.1) and general types of aquatic vegetation cover.

Table C.2-1. Physical habitat characterization: spring and perennial stream monitoring sites.

Monitoring Site	General Characterization	Comprehensive (Nested Target Habitat) Characterization
Stonehouse Spring Complex	√	Springsnails, Fish
Willow Spring	√	Springsnails
Keegan Ranch Spring Complex	√	Fish
West Spring Valley Complex	√	Springsnails
South Millick Spring	√	
Unnamed Spring 5	√	Springsnails
4WD Spring	√	
Willard Spring	√	
Swallow Spring	√	
Minerva Spring Complex	√	Springsnails
Clay Spring-North	√	Springsnails
Unnamed 1 – North of Big	√	Springsnails
North Little Spring	√	
Big Springs Complex		
Big Spring Creek / Lake Creek	√	Fish
Big Springs	√	Springsnails, Fish
Stateline Springs	√	Springsnails, Fish

Methods to characterize the basic physical attributes described above for each aquatic system will follow those described in Sada and Pohlmann (2006), in a few cases as modified by BIO-WEST (2007).

Fixed station photography

A permanent benchmark will be established at the head and the terminus of each spring, or near the spring head pool (depending upon the spring type). These benchmarks will serve as permanent photographic stations with photographs being taken during each sampling effort. In most cases, it will be sufficient to take fixed station photographs at the spring head and again at the spring terminus, or determined terminus. Additional permanent photographic stations will be established if necessary. The photo array at each site will consist of the photographer shooting a single photo to the north, to the south, to the east and to the west from both the head and the terminus benchmarks. In instances where this is not possible, a logical place will be used and in all cases a coordinate will be obtained and will serve as the photographic station in subsequent trips. Each frame will be taken in a manner that will include the maximum extent of the spring system as is possible, while identifying (and noting) reference marks within the photograph to line up with during future efforts. Additional photos may be required to fully capture the spring system. In all cases, a GPS point will be taken at all selected fixed stations for future reference.

Areal extent

A GPS unit will be used to measure areal extent. This will be accomplished by the observer walking the perimeter of the body of standing water and recording the area in units of square meters.

Spring brook length

A GPS unit (or tape measure in small springs) will be used to measure the distance from the spring source (fixed point from spring head) to the downstream limit of surface water. This is a measure of the extent of the surface water, not of the physical channel.

Site condition

Qualitatively identify disturbance factors stressing a spring, pond, or stream, and the amount of stress of each factor on the aquatic environment. Determining factors causing stress will be facilitated by looking for evidence of natural and anthropogenic disturbances. Influences of flooding are indicated by location of a spring in the bottom of a gully, presence of a naturally incised channel, and usually limited surrounding vegetation. The presence of pipes, dikes, or spring box indicates modifications for diversion. Abundance of hoof prints and droppings and evidence of grazing indicates ungulate use of a spring. Disturbance may be influenced by multiple factors such as trampling by livestock and diversion into a trough. As describing a certain level of disturbance is highly subjective, it is recommended that a consistent set of individuals make this assessment over time.

Comprehensive physical habitat characterization

Specific to springsnail and fish sampling activities (described in subsequent sections), physical habitat maps will be created at the eight sites listed in Table C.2-2 during each sampling effort.

Table C.2-2. Physical habitat mapping (parameters and location).

Monitoring Site	Parameters	Location
Stonehouse Spring Complex	Springsnails, Fish	Designated sample areas (Figure C-2)
Willow Spring	Springsnails	Entire wetted area (Figure C-1)
Keegan Ranch Spring Complex	Fish	Designated sample area (Figure C-3)
West Valley Spring Complex	Springsnails	Designated sample area – North spring head area
Unnamed Spring 5	Springsnails	Extent of springsnails plus 10 meters
Minerva Spring Complex	Springsnails	Designated sample area at North and Middle complex
Clay Spring-North	Springsnails	Extent of springsnails plus 10 meters
Unnamed 1 – North of Big	Springsnails	Entire wetted area
Big Springs Complex		
Big Spring Creek / Lake Creek	Fish	Each of the five reaches (100 meter lengths)
Big Springs	Springsnails, Fish	Designated sample area
Stateline Springs	Springsnails, Fish	Designated sample area

Physical habitat delineations will be based on the following four main categories: (1) hydro morphological unit, (2) depth, (3) flow, and (4) vegetation. Substrate may also be considered at certain locations, and thus was included in a few of the examples below. Initially, the mapping will be conducted by identifying the types and numbers of hydro morphological units (HMUs) at each study site. HMUs are broad aquatic habitat categories based on gross visual assessment of depth, velocity, and surface turbulence (Parasiewicz 2001). For spring systems selected in the IBMA, four HMUs were identified: Spring head, Channel, Pool, and Wetland/Wet Meadow. Spring heads include the habitat in the immediate area around one or multiple spring orifices. Channels are confined areas of flowing water with the potential for surface turbulence depending on water depth, substrate type, and velocity. Pools are identified as areas with no velocity or surface turbulence, often being formed by channel constrictions that may be natural or anthropogenic. Wetland/Wet Meadows are areas with standing water and emergent vegetation for portions of the year with no distinct channel or pool features.

After initial determination of HMUs at each site, measurements of depth, velocity, and vegetative cover will be taken to further describe each physical habitat. The HMUs will be subdivided by depth (meters), flow (meters/second), and vegetative cover (percentage). The categories for depth, velocity, and vegetative cover will initially be developed by compiling the overall data collected in 2008 and identifying breakpoints. Prior to the first monitoring trip, a habitat subclassification template will be created with physical habitat descriptions defined for each system proposed for mapping. The goal of the template is to provide the professional conducting the work with a process for consistently characterizing habitat conditions at all springs. Once descriptions are defined, a data dictionary for each system will be created within the GPS software program to facilitate future mapping efforts and to ensure consistency among sampling events. Upon completion of the first two years of monitoring, the habitat subclassifications template will be assessed and modified, if necessary to provide specific categories for future monitoring.

All HMUs will be mapped using a Trimble Pro-XH global positioning system (GPS) unit (or similar device) with real-time differential correction capable of submeter accuracy. The Pro XH (or similar device) will be linked to a Trimble Recon Windows CE device (or similar device) with TerraSync software (or similar software) that displays field data as they are gathered which improves efficiency and accuracy. Water depths will be collected using a meter stick or staff gauge. Velocity will be measured using a Marsh McBirney Flo-Mate Model 2000 velocity meter (or similar device).

Fig. C-1 shows an example habitat map at Willow Spring in northern Spring Valley. In this example, there are six designated habitat categories that were based on morphology (spring head, spring brook, pond), aquatic vegetation, open water, and substrate.

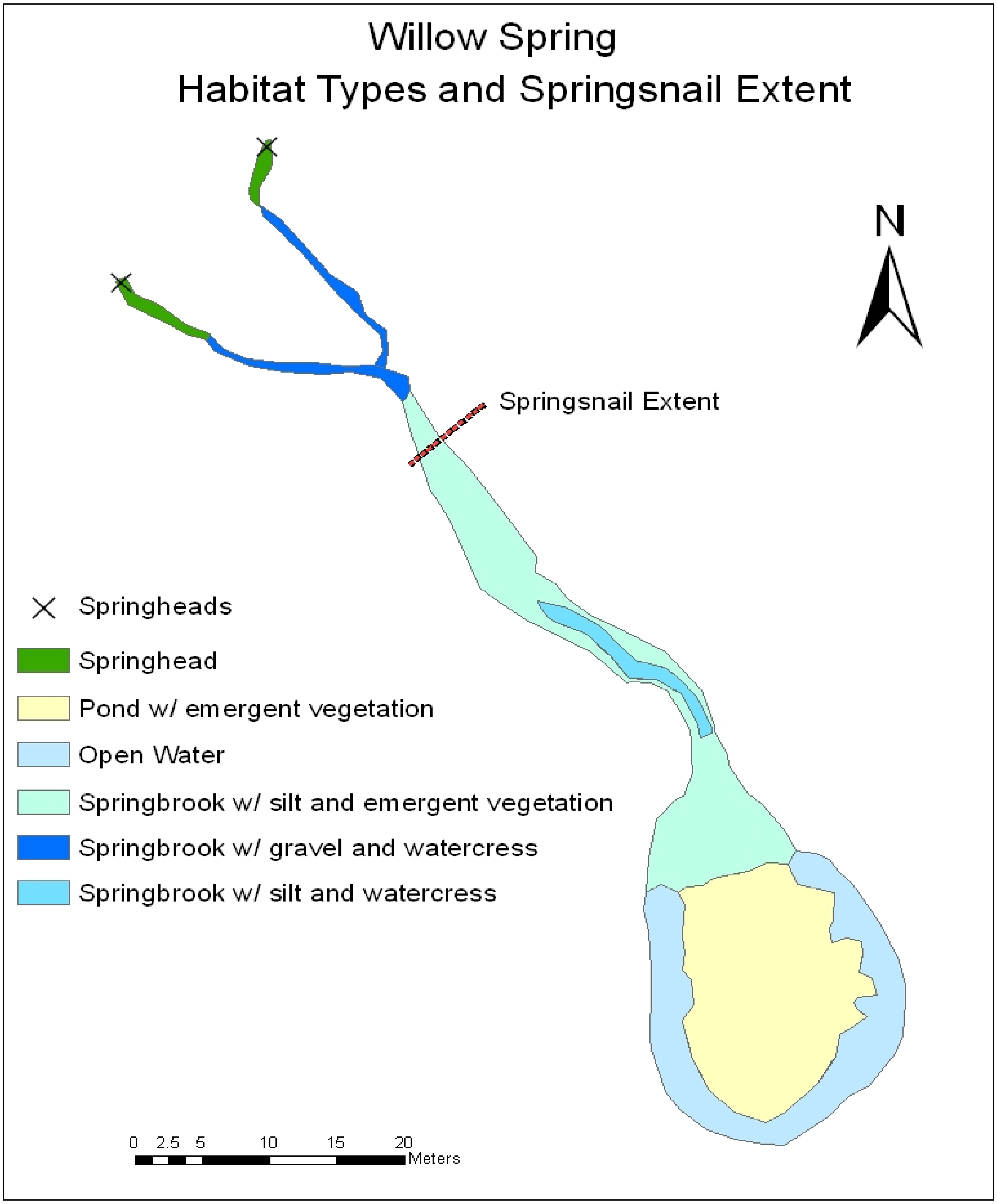

Fig. C-1. Example physical habitat map at Willow Spring.

The extent of springsnail distribution is also portrayed on Fig. C-1. However, as this is a small system, it is proposed that the entire wetted area be mapped during each bi-annual sampling event. Similarly, the extent of wetted area will be mapped at Unnamed 1 – north of Big Spring due to its limited size. As noted in Table C.2-2, Unnamed Spring 5 and Clay Spring-North will be mapped only to 10 meters downstream of the springsnail extent during each bi-annual sampling effort. This is due to the more extended spring brooks that these sites exhibit. Therefore, before physical habitat mapping can be initiated at Unnamed Spring 5 and Clay Spring-North, a biologist must determine the extent of springsnail distribution at these sites.

Also noted in Table C.2-2 is that physical habitat maps for the large springs complexes (Stonehouse, Keegan Ranch, West Spring Valley, and Minerva) will be conducted at designated sample areas representative of their respective complexes. Figs. C-2 and C-3 depict the designated sampling areas for Stonehouse and Keegan Ranch, respectively.

The designated sampling areas for Stonehouse Springs (Fig. C-2) contain multiple spring heads and includes a diversity of habitat types that are representative of the larger complex. Examples of habitat types that might be delineated to assist springsnail and fish sampling efforts at Stonehouse Spring are included in Fig. C-2. Unlike the previous example for Willow Spring, these habitat delineations include a depth (deep, shallow) and a velocity (flowing, slow) component to the descriptions.

Whereas, Stonehouse Springs consist of a massive wet area, Keegan Ranch Spring complex is more defined. This complex has three major spring orifices that flow in confined channels (for the most part) towards a series of ponds/wetlands where the water is pooled. The water then proceeds out of the ponded area to a confined channel that extends in a southeasterly direction (Fig. C-3, lower right corner). The North Spring head, channel, and associated ponds/wetlands were designated as the sample area for the Keegan Ranch complex. This North Spring will represent the entire complex. Examples of some basic habitat types that might be delineated to assist fish sampling efforts at Keegan Ranch Springs are included in Fig. C-3.

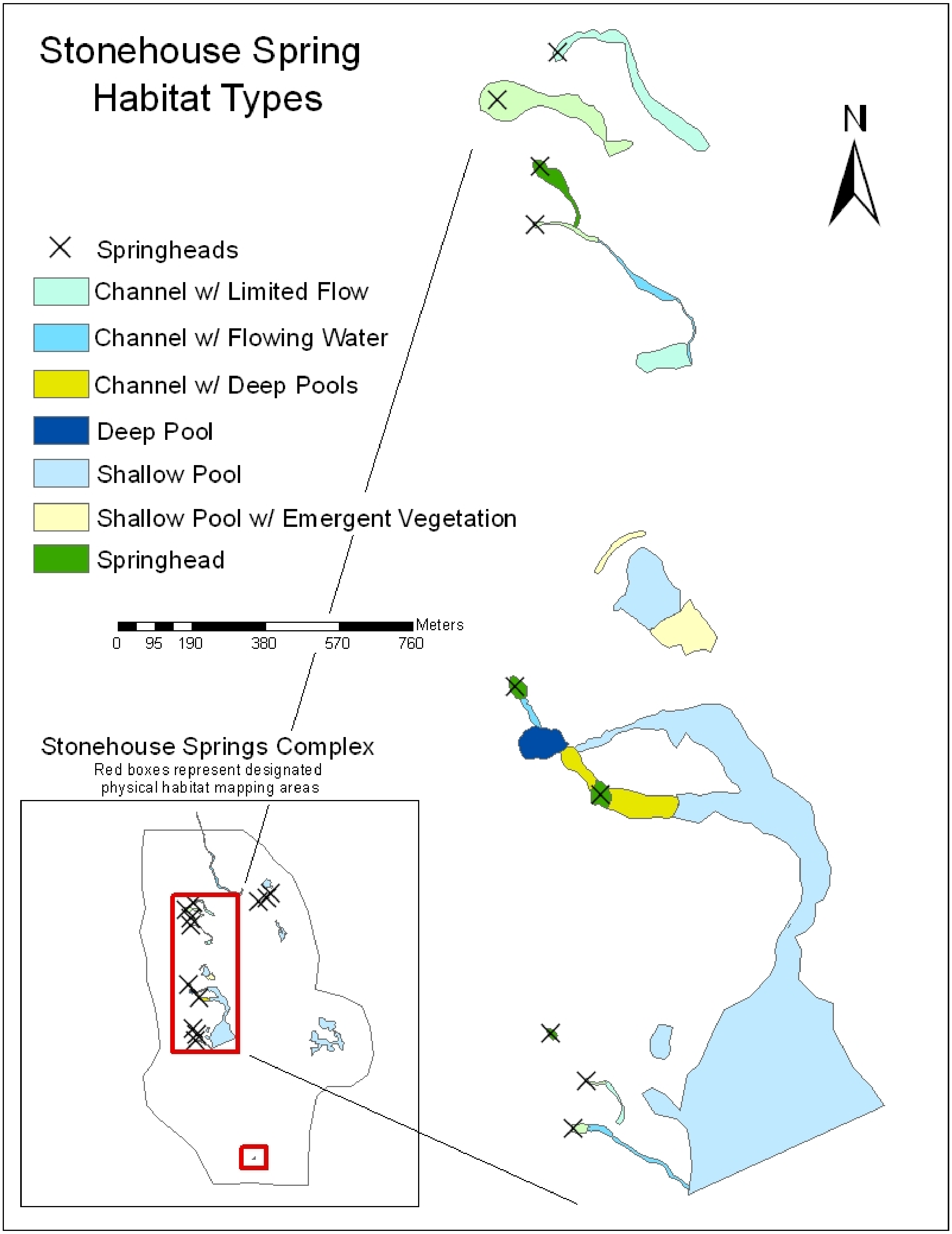

Fig. C-2. Example of physical habitat map of designated sample areas at Stonehouse Spring Complex.

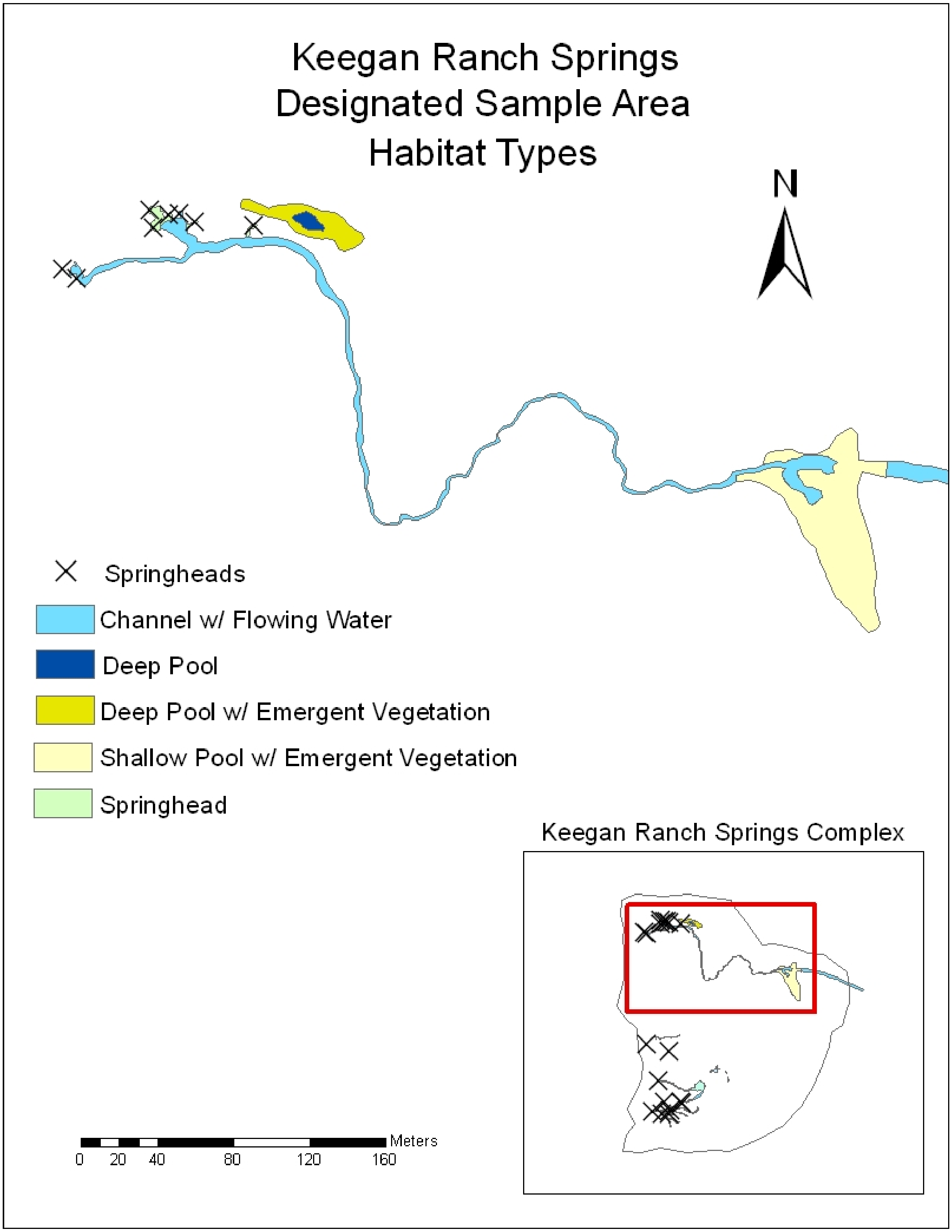

Fig. C-3. Example of physical habitat map of designated sample area at Keegan Ranch Spring Complex.

As discussed in Chapter 4, the West Spring Valley complex is classified as a limnocrene and consists of multiple spring orifices. This complex has a north and south set of springs and associated wetlands that are both representative of the entire complex. Since the flow is not confined, both systems flow outward and create a myriad of habitat types, characteristic of springs, wetlands, and wet meadows. The northern set has slightly more diversity in habitat and thus, is currently selected (temperature logger placement [Table C.1-4] and physical habitat mapping [Table C.2-2]) for this monitoring plan. However, should access not be attainable on this northern set, the southern set will suffice.

Minerva Springs complex is located in southern Spring Valley and consists of a combination of rheocrene and limnocrene springs, and a pond/reservoir. Minerva Springs complex is not as confined as the previously described complexes. It is all interconnected either naturally or via irrigation ditches. The northernmost springs area consists of four defined spring orifices (smaller spring heads are also present) that flow into three confined channels. These channels are immediately dammed with managed culverts to allow flow down the original channel and a separate irrigation channel into which water from all four springs can be diverted. All four spring orifices maintain springsnails, and northern leopard frog was documented in this area. The designated sample area for mapping at the northern Minerva springs area includes the two southern spring heads and associated spring brooks as they extend into an open wetlands area.

The middle Minerva Springs area consists of multiple spring orifices flowing into mostly confined channels and being captured at vary distances downstream by a large irrigation ditch. Large expanses of wetlands and wet meadows are created by these multiple channels providing areas of northern leopard frog habitat. The designated sample area for habitat mapping consists of two spring heads and associated spring brooks. The designated area also includes patches of well-established woody riparian vegetation.

No habitat mapping is proposed for the southernmost area at Minerva which includes the artificial pond/ reservoir.

Physical habitat mapping will be conducted at each of the five Big Spring Complex reaches on an annual basis in association with fish sampling efforts. Physical habitat maps of Big Springs and Stateline Springs in particular will be conducted at designated sample areas in association with springsnail sampling efforts.

The completed physical habitat maps will assist with macroinvertebrate, springsnail, and fish sampling activities.

C.3 OPEN WATER AND AQUATIC VEGETATION COVER

This indicator will be sampled at all springs, perennial streams and wetlands proposed for biological monitoring. In this section (C.3), the term "aquatic sites" is used to refer to the above group of systems.

Permanent line-point transects will be the sampling units for this indicator. In the first year of Pre-Withdrawal monitoring, five (5) permanent transects will be established at each aquatic site included in the Plan, if appropriate. The transects will be located in the following manner. The spatial footprint of the aquatic system will be divided into approximately equal segments along the longest axis of the aquatic system. One transect will be randomly located within each of the segments. Each transect will be sufficiently long to extend across the aquatic system perpendicular to the longest axis of the aquatic system, plus 2 meters past the water edge at both ends of the transect. Each transect will be permanently marked by placing metal stakes at both ends of the transect. Each endpoint will be geo-referenced with a sub-meter accuracy GPS unit. Should the aquatic system expand past the 2-m extensions during the monitoring period, the affected transects will be extended to a point at least 2 meters past the new high-water mark. These will be the same transects as those used to measure Cover and Composition of Aquatic Vegetation (Section C.8). If possible and appropriate, these transects will be continuous with those used to measure Cover and Composition of Non-Aquatic Vegetation in adjacent groundwater-influenced ecosystems (Section C.9).

Data will be collected along each line-transect once per year, during the summer season. This is the period which is expected to correspond to the height of the growing season of the vegetation and the period of lowest water level. If possible, data will be collected from each transect within a 30-day period of when the data were collected from that transect in previous years. Prior to collection of transect data each year, two photographs will be taken at each transect. One photograph will be taken from one transect endpoint and facing toward the second endpoint and the second photograph will be taken from the second endpoint facing toward the first endpoint.

Data collection will be as follows. A tape measure, marked at 1-cm intervals, will be placed between the starting and ending stakes of the transect as close to the water surface as possible. The tape will be stretched such that it is a tight as possible while remaining near the surface of the water. Care will be taken to avoid trampling damage to the beds of the aquatic systems, their banks, and the surrounding vegetation.

Once the tape has been placed, sampling will begin by the observer recording (to the nearest centimeter) the location along the tape at which standing water begins and ends. The observer will then begin collecting data at 1-m intervals along the tape by placing one foot at the 0-meter mark on the tape and the other foot at the 1-m mark and standing directly over the tape with shoulders in a line parallel with the tape. The observer will then count the number of centimeter marks along the tape, between 0 and 1 meters, at which 1) water is present, 2) emergent vegetation is present, or 3) submergent vegetation is present. These three values (centimeter counts) will be entered onto a data sheet for the respective meter of that transect. The observer will then move to the 1-2 m mark along the tape and repeat the process. The observer will continue along the tape, recording the values for each of the three variables, at each 1-m interval until the end stake is reached. This process will be repeated for each transect at the respective aquatic site.

Values for six variables will be calculated from these data for each transect for each sampling period: 1) starting point for standing water, 2) ending point for standing water, 3) amount of emergent vegetation, 4) amount of submergent vegetation, 5) amount of aquatic vegetation, and 6) amount of open water. Amount of emergent vegetation will be calculated as the total number of hits (1-cm marks) at which emergent vegetation was present divided by the total length (in centimeters) of the aquatic system (i.e., ending point for standing water - starting point for standing water). Amount of submergent vegetation will be calculated as the total number of hits at which submergent vegetation was present divided by the total length of the aquatic system. Amount of aquatic vegetation will be calculated as the total number of hits at which either emergent or submergent vegetation was present divided by the total length of the aquatic system. Amount of open water will be calculated as the total number of hits within the aquatic system at which emergent vegetation was not present divided by the total length of the aquatic system.

C.4 MACROINVERTEBRATE COMPOSITION AND RICHNESS

Aquatic macroinvertebrates will be collected at the springs and perennial streams selected for monitoring within the IBMA as described in Table C.4-1.

Table C.4-1 Aquatic macroinvertebrate methodology and location.

Monitoring Site	EPA	Modified EPA	Location
Stonehouse Spring Complex		√	Sampled within designated sample area (Figure C-2)
Willow Spring		√	Entire wetted area
Keegan Ranch Spring Complex		√	Sampled within designated sample area (Figure C-3)
West SpringValley Complex		√	Sampled within designated sample area - North spring head area
South Millick Spring	√		All representative habitats included
Unnamed Spring 5	√		All representative habitats included
Swallow Spring	√		All representative habitats included
Minerva Spring Complex		√	Designated sample areas at North and Middle complex
Clay Spring-North	√		All representative habitats included
Unnamed 1 – North of Big		√	Entire wetted area
Big Springs Complex		√	
Big Spring Creek / Lake Creek			Sampled within each of the five reaches
Big Springs			Sampled within designated sample area
Stateline Springs			Sampled within designated sample area

Aquatic macroinvertebrate sampling

Aquatic macroinvertebrates will be collected systematically from all available instream habitats using the multi-habitat rapid bioassessment protocol that involves 20 total samples composited into one sample (Barbour et al. 1999). The sites checked in Table C.4-1 as "EPA" will be collected specifically as described in Barbour et al. (1999) and highlighted below:

> "A 100-m reach that is representative of the characteristics of the stream should be selected. Draw a map of the sampling reach. This map should include in-stream attributes (e.g., riffles, falls, fallen trees, pools, bends, etc.) and important structures, plants, and attributes of the bank and near stream areas. Use an arrow to indicate the direction of flow. Indicate the areas that were sampled for macroinvertebrates on the map. If available, use hand-held GPS for latitude and longitude determination taken at the furthest downstream point of the sampling reach. Different types of habitat are to be sampled in approximate proportion to their representation of surface area of the total macroinvertebrate habitat in the reach. For example, if snags comprise 50% of the habitat in a reach and riffles comprise 20%, then 10 jabs should be taken in snag material and 4 jabs should be take in riffle areas. The remainder of the jabs (6) would be taken in any remaining habitat type. Habitat types contributing less than 5% of the stable habitat in the stream reach should not be sampled."

The springs checked as "Modified EPA" in Table C.4-1 will use a slightly modified procedure. The slight modification is because these sites already having detailed physical habitat maps. Therefore, instead of visually estimating the proportion of habitat within a reach and using professional judgment to select actual sample sites, the actual proportions will be calculated in the field and the 20 samples sites will be randomly assigned according to proportion. Fig. C-4 provides an overview of the modified approach at Willow Spring.

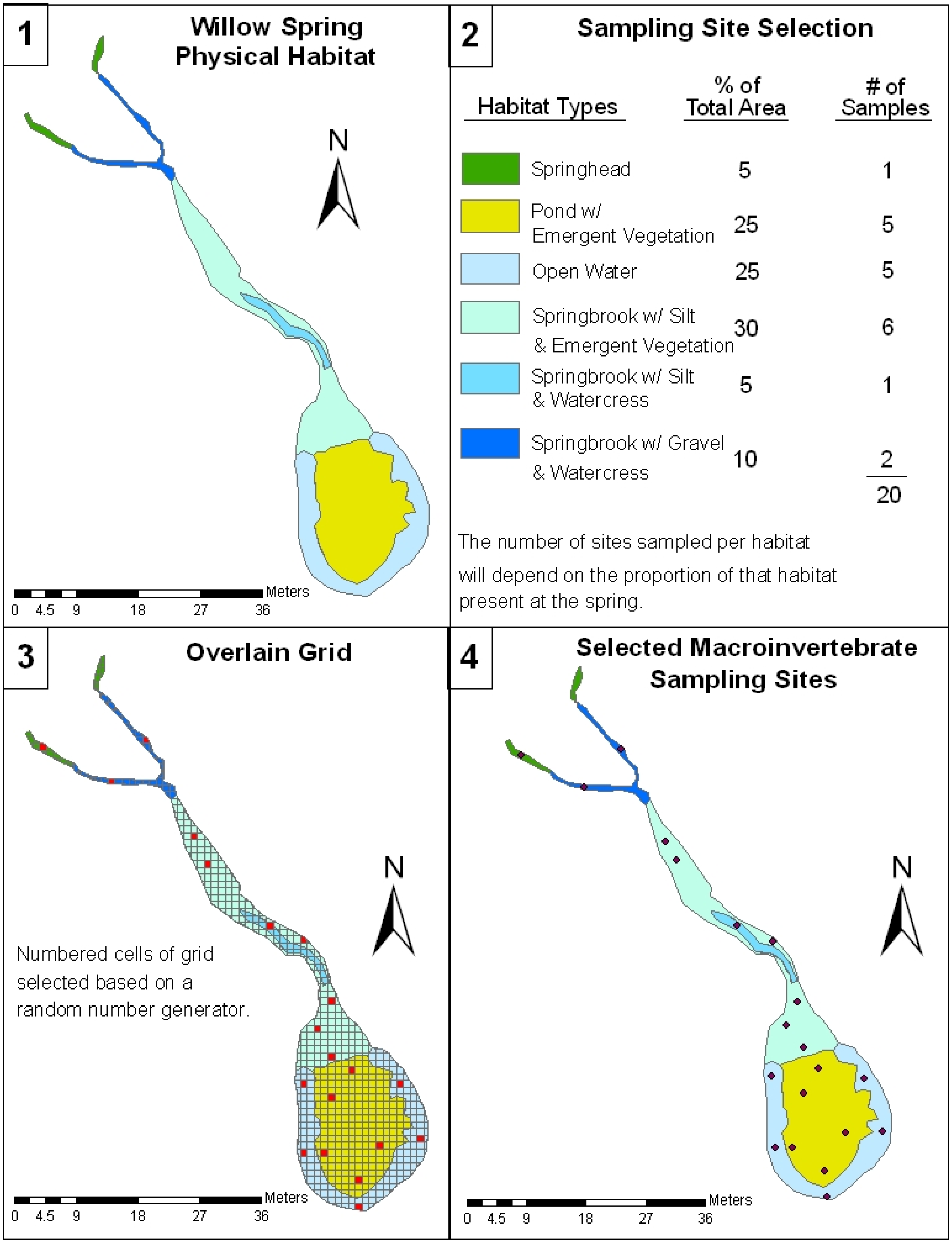

Fig. C-4. Example of aquatic macroinvertebrate site selection methodology at Willow Spring.

In Box 1 (Fig. C-4), the physical habitat was mapped at Willow Spring as described in Section C.2. In Box 2 (Fig. C-4), the delineated habitat types for that trip are listed along with the proportion of habitat, as well as the calculated number of samples based on the 20 sample total. In the field, a 1m x 1m grid will digitally be placed over the habitat map (Box 3, Fig. C-4) with each cell having an assigned number. A random number generator will be used to select the number of the cell chosen for sampling. The GPS coordinates from those points will then be used for actual sample collection (Box 4, Fig. C-4). Using this approach, any bias or inexperience of the sample collector relative to site locations should be removed. Although with proper training this procedure can be very streamlined, this approach of data processing for this modification will take longer than using professional judgment alone. If no advantage to this technique is observed during the first two years of data collection, a switch to the traditional professional judgment approach will be made.

Macroinvertebrate collection will begin at the downstream end of the reach and proceed upstream. A total of 20 roils if using the modified smaller net or 20 jabs if using the standard D-frame net will be taken over the length of the reach. Using the D-frame net with 250-micron mesh in larger springs or streams, a single jab consists of forcefully thrusting the net into a habitat for a linear distance of 0.5 m while a roil is a stationary sampling accomplished by positioning the net and disturbing the substrate for a distance of 0.5 m upstream of the net. In smaller springs, a modified aquarium net (mouth opening of 17cm x 19cm and a depth of 11 cm) with 250-micron mesh netting will be used and an upstream area of approximately 0.25 m will be jabbed or roiled. Within each individual system, only one net size will be used to remain consistent.

In flowing water, samples will be collected by roiling substrates and capturing material that washes downstream into a modified aquarium net (small springs) or D-frame net (larger springs). In lentic waters, jabbing with the modified aquarium net or D-frame dip net will be the method employed. In either case, a total of 20 roils or jabs will be taken from all major habitat types in the reach (Barbour et al. 1999).

The jabs or roils collected from the multiple habitats will be composited to obtain a single sample. After every three jabs, more often if necessary, any collected material will be washed down by running clean spring or stream water through the net two to three times. If clogging does occur that may hinder obtaining an appropriate sample, the material in the net will be discarded and a replacement sample will be collected from the same habitat type but in a different location (back-up locations will also be assigned with the random number generator and grid approach at sites where applicable). Large debris will be removed after rinsing and inspecting it for organisms. All organisms present on the debris will be placed into a sample container. Small debris will be placed directly into the same sample container.

The sample will be transferred from the net to sample container(s) and preserved in enough 95% ethanol to completely cover the sample. Forceps may be needed to remove organisms from the dip net or modified aquarium net. Sample bottles will be labeled indicating the sample identification code, date, spring or stream name, sampling location, and collector name. Additionally, after the ethanol is added, the words "preservative: 95% ethanol" will be added to the outside of the bottle. If more than one container is needed for a sample, each container label will contain all the information for the sample and will be numbered (e.g., 1 of 2, 2 of 2).

The samples will be transferred to the laboratory using appropriate Chain of Custody procedures. Laboratory procedures will follow the general process as developed for bioassessment studies (Barbour et al. 1999). Grids will be randomly selected and organisms collected until 300 organisms have been picked, or the entire sample has been sorted. Applying counts from the number of grids sorted to the remaining grids will allow for estimates of the total number (abundance) of each taxon collected in each sample. All organisms will be identified by a trained taxonomist to the lowest practical taxon. Quality assurance and control (QA/QC) procedures will include a QA sorting on all samples to ensure 90% sorting efficiency. Also, a reference collection will be created, and checked by a different taxonomist to ensure taxonomic accuracy.

C.5 SPRINGSNAIL ABUNDANCE AND DISTRIBUTION

Springsnails will be collected at springs selected for monitoring within the IBMA as described in Table C.5-1.

Table C.5-1 Springsnail monitoring sites and sample locations.

Monitoring Site	Sample Location
Stonehouse Spring Complex	Extent of springsnails in designated sample area (Figure C-2)
Willow Spring	Extent of springsnails
West Valley Spring Complex	Extent of springsnails in designated sample area–(North spring head area)
Unnamed Spring 5	Extent of springsnails
Minerva Spring Complex	Extent of springsnails in designated sample area (North and Middle complex)
Clay Spring-North	Extent of springsnails
Unnamed 1 – North of Big	Extent of springsnails
Big Springs Complex	
Big Springs	Extent of springsnails in designated sample area
Stateline Springs	Extent of springsnails in designated sample area

Springsnail sampling

The monitoring protocol for springsnails specifies that the first activity is to define the longitudinal extent of springsnails in the spring brooks. Once this is determined, a comprehensive physical habitat characterization (as described in Section C.2) will be conducted. Using Willow Spring again as an example, Fig. C-1 back in Section C.2 depicts the physical habitat designations and extent of springsnail distribution. Upon completion of that characterization, up to twenty transects will be placed equidistant from the spring source to the springsnail extent. Transects will not be placed closer than 2.5 m causing some of the smaller spring brooks to have less than 20 transects. At spring brooks with extended springsnail extent, 20 transects will be placed equidistant from the head to the extent. For example, West Valley #1 had a springsnail extent of 71 m in 2008, which would translate into 20 transects spaced every 3.55 meters. Habitat measurements and population estimates will be made within 25 cm^2 (5 cm x 5 cm) quadrats that will be placed at 5 evenly-spaced points along each transect, yielding a maximum of 100 habitat and population sample points along any give spring brook. Transect placement uses a stratified random approach in that as springsnail extent varies, the placement of transects will be adjusted accordingly.

Springsnail density in each 25 cm^2 quadrat will be estimated using a modified surber sampler to collect snails and temporarily remove them from the spring brook. Samples will be conducted from downstream to upstream with estimates being made using depletion techniques (White et al. 1972). During the depletion survey, the contents will be washed into a white plastic tray (or similar container), and the number of springsnails counted. The springsnails will then be returned to the same location.

At the completion of the springsnail survey in a given quadrat, specific habitat data will be collected. Presence/absence of substrate types, algae, and submerged vegetation will be recorded. Substrate types will include course particulate organic matter (COPM), fines, sands, gravel, or cobble (using a Wentworth particle scale analysis, which classifies material as: Fines (<1mm), Sand (1mm – 5mm), Gravel (>5 mm – 80 mm), and Cobble (>80 mm – 300 mm). Size will be defined as the minimum particle size of substrate as measured on a two-dimensional axis, as would pass through a substrate sieve. Submerged vegetation will be recorded to species while algae will be recorded as blue-green algae (cyanobacteria) and filamentous green algae. Percent of the substrate that was shaded (either by riparian or instream vegetation) will also be recorded. Mean water column velocity and water depth will be measured at the center of each quadrat. This procedure will be repeated for each quadrat for a given transect. Standard water quality parameters (temperature, dissolved oxygen, conductivity, and pH) and wetted width will be measured at each transect. GPS points will be taken to mark the transects for comparison with overall physical habitat mapping (Section C.2). Sampling will be conducted no earlier than 1 hour after dawn and no later than 1 hour before dusk to reduce any variability that might be associated with dawn or dusk activities.

Because springsnail species cannot be identified in the field, observed specimens will initially be assumed to be the same as those reported in BIO-WEST (2007) unless additional species are documented in the spring-wide aquatic macroinvertebrate samples described in Section C.4. Furthermore, given that little is known regarding the relative abundances of the various springsnail species within specific sites, if more than one species of springsnail is identified at a site (e.g. Big Springs), it will be assumed that the observed specimens constitute a similar split as represented by the composite aquatic macroinvertebrate sample from that same sampling event.

The springsnail transect approach will require some modification at certain sites. If each site had a well-defined spring head and spring brook, and a distribution of springsnails extending away from the spring orifice (like Willow Spring), little modification would be necessary. However, this is not the case for several of the springs that have springsnails in the IBMA. Of the springs listed in Table C-5-1, Willow Spring, Clay Spring-North, Unnamed 1 – north of Big, and the Big Springs Complex (Big Springs and Stateline Springs) should require little modification.

However, the three large complexes (Stonehouse, West Valley, and Minerva) along with Unnamed 5 will require adjustments to the approach.

As Stonehouse, the four northernmost spring heads within the designated sample area (Fig. C-2) will be combined to form one transect. The reason is that none of these springs have springsnails at any distance away from the spring orifice. In this case, the approach is modified to add replication amongst spring heads. The spring head furthest south in the designated sample area (Fig. C-2) has a defined channel and springsnails extending away from the spring orifice allowing the protocol to be used without modification.

At the West Valley and Minerva complexes, similar modifications to the approach will be necessary to best describe springsnail abundance and distribution. As with Stonehouse, multiple spring heads will serve as replicates, and one channel will have longitudinal transects as described above. At Unnamed 5, springsnails appear to be confined to the spring orifice. In this case, three replicate samples will be collected from the spring orifice area.

The primary objective is to monitor springsnail abundance and distribution within these springs. Understanding the direct relationship of flow to distribution would be ideal. However, ecological systems are not often this simple. The interim step in this relationship is habitat. Therefore, another major objective is to describe habitat to springsnail relationships. By describing these relationships, habitat may be usable in the future as an early indicator.

In summary, spatially located and habitat specific springsnail surveys in the proposed springs as described above should be useful in quantitatively monitoring the relative abundance and distribution of springsnails over time, and describing potential habitat linkages. Using this repeatable approach, long-term trend data will be accumulated over time and any patterns in springsnail abundance or distribution should be evident. Samples will be collected bi-annually at all sites for the initial two years of monitoring. After two years of monitoring, the data collected up to that point will be evaluated to determine if monitoring may be reduced to annual sampling. Additionally, should it appear that the data collection protocol for an individual spring is not suited to address the stated objectives, it will be reevaluated.

C.6 FISH AGE/SIZE CLASS STRUCTURE AND DISTRIBUTION

Fish will be collected at the springs, ponds (Shoshone), and perennial streams selected for monitoring within the IBMA as described in Table C.6-1.

Table C.6-1. Fish monitoring sites, gear and location/notes

Monitoring Site	Gear	Sampled Location
Stonehouse Spring Complex	Minnow traps	Designated sample areas (Figure C-6)
Keegan Ranch Spring Complex	Minnow traps	Designated sample area (Figure C-3)
Shoshone Ponds	Minnow traps	Sampled by NDOW
Big Springs Complex		
Big Spring Creek / Lake Creek	Electrofisher, seines	Five reaches
Big Springs	Electrofisher, seines	Designated sample areas
Stateline Springs	Electrofisher, seines	Designated sample areas

Relict dace – Stonehouse Springs and Keegan Ranch Complex

In order to evaluate the distribution of species within designated sample areas at Stonehouse and Keegan Ranch springs complexes, a systematic, randomized sampling design will be employed. During each sampling trip, a comprehensive physical habitat characterization of the areas depicted in Figs. C-2 and C-3 will be conducted as described in Section C.2. Fig. C-6 depicts an example for selecting sites for fish collection at Stonehouse Springs.

The key steps for relict dace sampling at Stonehouse and Keegan Ranch are as follows:

a. Physical habitat is mapped within designated fish sampling areas. Fish sampling areas for Stonehouse Springs are depicted in lower left corner of Fig. C-6. The habitat map shown on the figure is a magnified view of the northern fish sampling area.
b. Habitats are delineated (upper left corner of Fig. C-6) based on defined categories (see Section C.2 for discussion on habitat classifications)
c. Proportions of each habitat type are calculated in GIS
d. Proportions of habitat are used to guide the number of minnow traps needed (minimum of three per habitat type for replication, maximum of six to limit disturbance)
e. A 1x1 m grid is digitally laid over map of habitat area (bottom right corner of Fig. C-6). Each cell is assigned a number.
f. A random number generator is used to select the placement for trap locations within each habitat type.
g. Standard Gee minnow traps (48 cm long, 22 cm total diameter, 2.5 cm mouth diameter, and 6-mm mesh, baited with dog food) are placed within identified habitat types and allowed to fish for four hours.
    - One smaller mesh size (3mm) minnow trap will be included as one of the traps within each habitat type selected.
    - All traps will be fished during daylight hours for consistency (traps will be set no earlier than one hour after dawn and will be retrieved no later than 1 hour before dusk)
h. Total lengths of the first 25 relict dace from each defined habitat type will be measured; individuals collected in excess of 25 will be enumerated. This number is determined by NDOW to minimize stress to the population.
    - All fish will be held and kept alive during processing, and all will be returned to their point of capture, or as dictated by sampling permits.
    - On-site training will be provided to ensure proper fish handling is being conducted.
i. Upon retrieval of all traps at a location, standard water quality measurements will be taken (one measurement per respective habitat type).

Relict dace sampling at Stonehouse and Keegan Ranch will be conducted twice per year (spring and fall) for the initial two years of monitoring, after which efforts may be reduced to annual sampling if data warrant.

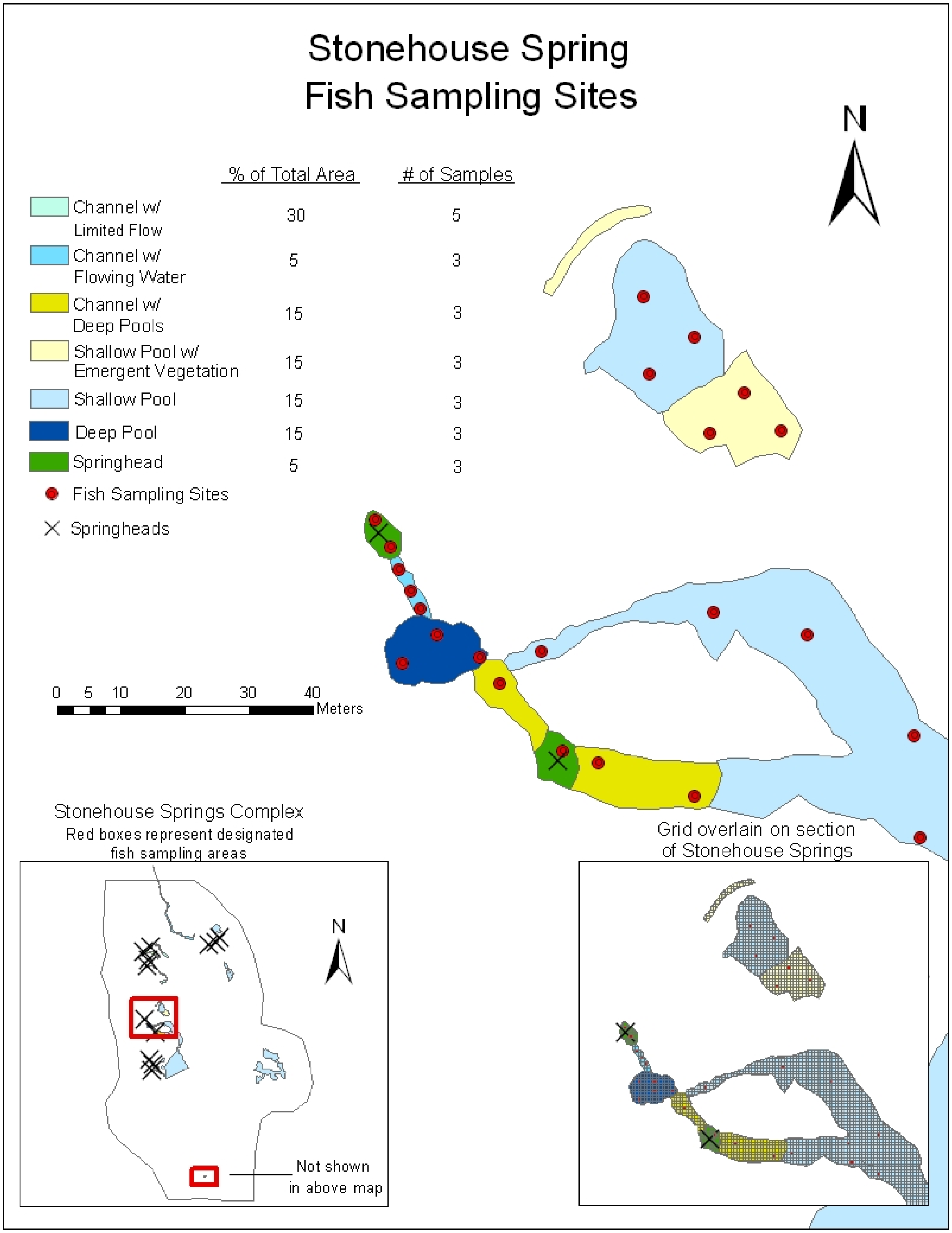

Fig. C-6. Example fish sample site selection methodology at the designated fish sample areas of Stonehouse Spring Complex.

Relict dace – Shoshone Ponds

NDOW samples for relict dace annually at Shoshone Ponds, and thus no additional monitoring is recommended in this plan. NDOW sampling for relict dace at Shoshone Ponds consists of a 2-field day effort (Morrell et al. 2007). On the first day, Gee-Brand Minnow 1/4” mesh traps and exotic 1/8” mesh traps, without bait, are set around the perimeter of the south pond. The traps are allowed to fish 3-4 hours before being pulled. All fish in the exotic traps are measured before being marked. Each fish greater than 30 mm is marked with an oblique clip on the caudal fin before each fish is released. Approximately one week later, Gee-Brand Minnow 1/4” mesh traps are set, without bait, along the perimeter of south pond. Traps are again allowed to fish for 3-4 hours before being pulled. Each fish caught is examined for marks, tallied, and released. Dissolved oxygen, percent saturation and temperature are measured using a YSI Model 55 Dissolved Oxygen Probe. The water quality measurements are made at one location within the south pond. A population estimate for relict dace is calculated using Peterson’s estimator: MC/R. Where M=number of individuals marked, C=number of individuals captured and R=number of individuals recaptured. Approximate 95% confidence intervals are determined using a table appropriate to the Poisson distribution, after the method described in Ricker (1975).

Pahrump poolfish – Shoshone Ponds

NDOW samples for Pahrump poolfish annually at Shoshone Ponds, and thus no additional monitoring is recommended in this plan. NDOW sampling for Pahrump poolfish consists of a 2-field day effort identical to the relict dace effort described in the previous paragraph excepting specific sampling location (different ponds) (Morrell et al. 2007). On the first day, Gee-Brand Minnow 1/4” mesh traps and exotic 1/8” mesh traps, without bait, are set around the perimeter of the north, middle, and stock pond. The traps are allowed to fish 3-4 hours before being pulled. All fish in the exotic traps are measured before being marked. Each fish greater than 30 mm is marked with an oblique clip on the caudal fin before each fish is released. Approximately one week later, Gee-Brand Minnow 1/4” mesh traps are set, without bait, along the perimeter of north, middle, and stock pond. Traps are again allowed to fish for 3-4 hours before being pulled. Each fish caught is examined for marks, tallied, and released. Dissolved oxygen, percent saturation and temperature are measured using a YSI Model 55 Dissolved Oxygen Probe. These water quality measurements are made at one location each within the north and middle ponds, and at the inflow and outflow of the stock pond. A population estimate is then calculated using Peterson’s estimator: MC/R. Where M=number of individuals marked, C=number of individuals captured and R=number of individuals recaptured. Approximate 95% confidence intervals are determined using a table appropriate to the Poisson distribution, after the method described in Ricker (1975).

Utah chub, speckled dace, redside shiner, mottled sculpin, and Utah sucker - Big Springs Complex

As previously discussed, the entire area of Big Springs Complex will not be sampled. Instead, five representative reaches 100 meters long will be selected. These five sampling reaches are: one reach originating from the Big Springs spring head(s), two reaches positioned between Big

Springs and the state line, one reach originating from the Stateline Springs head(s), and a reach positioned between Stateline Springs and Pruess Lake. These reaches were selected to determine the fish community present in each of the distinct habitats available within the Big Springs Complex. Reach size will be standardized as 100 m in length or sufficient to cover all habitat types present within the respective reach. Gear will include a backpack electrofisher (Dingo Model 750/850 backpack electrofisher or Smith Root LR-24 backpack electrofisher, and/or dip nets [34 cm x 30 cm with 2-mm mesh]) and seines (2 m x 4 m x 3 mm), if necessary.

Steps a and b (from relict dace sampling at Stonehouse and Keegan Ranch section above) will be the same for fish sampling at the Big Springs Complex. As all habitat types will be sampled within these reaches, Steps c-f do not apply to the Big Springs Complex. However, fish will be collected within each delineated habitat type and recorded as such. This will allow for an evaluation of habitat preference and fish distribution throughout the reach. As noted in Chapter 5, electrofishing will be the preferred methodology in the Big Springs Complex reaches with supplemental seine hauls if necessary.

Once sampling reaches are established, standard electrofishing techniques will be utilized by block netting the upstream and downstream ends of the reaches. Once blocked, a linear three-pass electrofishing depletion estimate will be performed, however, being careful to hold fish collected within each habitat type within independent containers. This will provide an estimate of the number of each fish species contained within the reach, and will provide a standardized way of evaluating species trends over time. Similar to the minnow trapping described above, the first 25 individuals of each species collected from each habitat type will be measured for total length, with the remainder of the catch being enumerated. By so doing, length frequency and size/age class strength can be monitored over time. CPUE will also be analyzed by reach. Fish sampling efforts within the Big Springs Complex will be conducted annually in late summer/early fall.

C.7 NORTHERN LEOPARD FROG EGG MASS COUNTS

Northern leopard frog sampling will be conducted at springs, ponds (Shoshone), and perennial streams selected for monitoring within IBMA as described in Table C.7-1. The sampling effort will also include areas of wetlands (selected for monitoring within the IBMA) that have standing water adjacent to the spring, pond (Shoshone), and perennial stream survey sites.

The first phase of egg mass monitoring documents use of the groundwater-influenced ecosystem by northern leopard frog. The second phase involves collecting data on egg masses and breeding habitat.

Table C.7-1. Northern leopard frog monitoring sites

Monitoring Site	Phase 1	Phase 2
Stonehouse Spring Complex	√	If present
Willow Spring	√	If present
Keegan Ranch Spring Complex		√
West Spring Valley Complex		√
South Millick Spring		√
Unnamed Spring 5		√
4WD Spring	√	If present
Willard Spring	√	If present
Swallow Spring	√	If present
Minerva Spring Complex		√
Clay Spring-North	√	If present
Unnamed 1 – North of Big	√	If present
North Little Spring	√	If present
Shoshone Ponds		√
Big Springs Complex		
Big Spring Creek / Lake Creek	√	If present
Big Springs	√	If present
Stateline Springs	√	If present

Initial Search and potential frog call recording

Visual encounter surveys will be used to address the question of whether northern leopard frog is using a given spring, pond, or stream site. These surveys will consist of trained biologists walking the perimeter of the spring, pond, or stream and looking for adult frogs, egg masses, tadpoles, or juveniles. The goal of this phase is to identify whether or not northern leopard frogs are using the springs, ponds (Shoshone), or perennial streams, and surrounding wetland areas. Therefore, there is no time constraint placed on the surveys, nor time of day restriction. A comprehensive search of the entire wetted area will be conducted. During year one, weekly visual encounter surveys for frogs and/or egg masses will be conducted at a site where northern leopard frogs are known to occur until presence is determined. This preliminary survey will be conducted for one to four weeks during the breeding season. Once egg masses are detected at that site, visual encounter surveys will be conducted at other sites that have no documented occurrence of northern leopard frog (initial search column in Table C.7-1). The focus of this survey will be on locating breeding adults and/or egg masses. During the fall biological monitoring trip, only a cursory look (e.g., being visually observant while collecting other biological sampling activities) will be conducted for northern leopard frogs.

If after one year, certain sites have areas that visually appear to have high frog potential but no frogs have been observed, a second visual encounter survey will be conducted during the known breeding season (based on actual egg masses present at nearby springs) during Year 2. Additionally, during the peak of the breeding season, a frog recorder will be placed at these sites for a period of 48 hours in an attempt to record northern leopard frog calls. Northern leopard frog is least secretive during the breeding season and, thus, more likely to be observed or audibly recorded during this time. If after this second year of visual encounter survey and after recording activities, no northern leopard frog is detected at a site, frog sampling will be removed from that site.

Egg Mass Counts

Egg mass counts will be conducted at the six documented northern leopard frog sites as well as additional sites where presence has been determined during the Phase 1 surveys (Table C.7-1). For the first two years of egg mass counts, these surveys will entail trips every other week for up to three visits (as necessary) starting in mid-April and extending into May. The surveys are nearly identical to the confirmation visual encounter efforts in that trained biologists will walk the perimeter of the wetted area, but this time the focus is on locating egg masses. The entire perimeter will be walked and survey time recorded as a measure of survey effort. To ensure consistency of data collected by different personnel, different sites, and different years, efforts will be made to ensure that all sites receive a relatively consistent level of visual scrutiny during egg mass searches. To standardize survey efforts, a maximum travel speed when surveying for egg masses of approximately 20 meters per minute will not be exceeded. Abundant egg masses, dense emergent vegetation, and other factors may considerably reduce travel speed, but for consistency of effort, the maximum speed should not be exceeded. Upon completion of the first two years of monitoring it is anticipated that the information acquired will allow the egg mass search area to be reduced to specific habitats where egg masses are likely to occur as opposed to the entire wetted area.

As described in Chapter 4, northern leopard frog eggs are laid in clumps on submerged vegetation slightly below the water surface. Once located, each egg mass will be flagged with a pin flag, and marked with a GPS unit. Once egg masses are located at a given spring, the survey crew will return up to three times at two-week intervals to count any additional egg masses that have been laid. These additional egg masses will be pin flagged, GPS marked with notes regarding time, date, and location. Additionally, the distance from egg mass to edge of water will be recorded. During the final egg survey visit, extent of open water and water quality data will be collected at a breeding habitat line-point transect placed at or near egg mass locations. Vegetation cover and composition data will be collected at this same breeding habitat transect in the summer. Data will be collected as specified in Sections C.3 and C.8 and special effort will be made to avoid disturbance to any egg masses. A temperature logger will be placed in a central location at each permanent transect associated with northern leopard frog breeding habitat assessments.

Following the initial two years of egg mass counts, if the data are supportive, the goal would be to shift to the breeding survey protocols currently implemented by UDWR for Columbia Spotted frog in Snake Valley. This protocol uses a sentinel spring to inform the biologists when the breeding has started during a given year. Then, a one-week period is allowed, after which all springs with known populations are visited and egg masses counted. Counts are conducted in the same manner with egg masses marked by pin flag and GPS, and habitat conditions recorded. The springs are then revisited two weeks later and any additional egg masses laid during that time period are counted. Habitat conditions would then be measured in a similar fashion. The UDWR protocol has proven to be effective in counting approximately 90% of the given egg masses at a much lower effort of time and resources (K. Wilson, pers. comm.). However, UDWR has 14 years of Columbia frog egg mass data to guide and test this protocol modification whereas IBMA egg mass data collection will essentially be initiated with this Plan.

C.8 COVER AND COMPOSITION OF AQUATIC VEGETATION

This indicator will be sampled at all springs and wetlands proposed for biological monitoring. In this section (C.8), the term "aquatic sites" is used to refer to the above group of systems. The target population for this indicator is the vegetation of the aquatic plant communities at each of the aquatic sites. Aquatic plant communities include both emergent and submergent plant communities.

Permanent line-point transects will be the sampling units for this indicator. These will be the same transects used to measure Open Water and Aquatic Vegetation Cover (Section C.3).

Data will be collected along each line-transect once per year, at the same time data are collected for Indicator C.3. Collection of data for both indicators at the same time will minimize sampling impacts to the aquatic ecosystems. For Indicator C.3, presence of emergent and submergent vegetation will be recorded by 1-m increments along the transect by counting the number of 1-cm marks the respective vegetation occurs. The same process will be used for Indicator C.8, but the species will also be recorded at each 1-cm interval and summed by 1-m segments. Both first-hit and multiple-hit data will be recorded by species.

From these data, percent cover will be calculated by species for each community along each transect, on a first-hit and on a multiple-hit basis. Percent canopy cover per species will be calculated by dividing the number of hits (cm marks) recorded for that species within the particular community along a specific transect divided by the width (in centimeters) of that community along that transect. Species composition (relative cover) is calculated by dividing the cover value of a specific plant species in the community by the total plant cover (all species combined) in the same community.

C.9 COVER AND COMPOSITION OF NON-AQUATIC VEGETATION

Cover and composition of non-aquatic vegetation will be sampled in all groundwater-influenced ecosystems with the exception of perennial streams and the ponds at Shoshone Ponds (to diminish disturbance to the site). Protocols for vegetation cover and composition in the swamp cedar woodlands differ; for those protocols see Vegetation Measurements in Swamp Cedar Communities (Section C.10).

The target population is the vegetation of the plant communities at each monitoring site. The sampling units will be line-point transects. Sample size (number of transects) will depend on the spatial extent and heterogeneity of the habitat. Transects will be designed so that plant communities that occur along the transects are represented a minimum of five times per site, if possible. Vegetation maps being prepared by SNWA for springs, wetlands, and meadows will inform transect design. Upon completion of the mapping effort, number and specific locations of transects per community will be determined.

Transects will be established in the first year of Pre-Withdrawal monitoring. Transects will be 100-m long. If the habitat is less than 100-m in width, the transect will extend across the entire width of the habitat. Each transect will be permanently marked by placing metal stakes at both ends of the transect and each endpoint geo-referenced with a sub-meter accuracy GPS unit. If possible and appropriate, these transects will be continuous with those used to measure Cover and Composition of Aquatic Vegetation (Section C.8), as well as non-aquatic vegetation transects in adjacent groundwater-influenced ecosystems to track ecotone changes.

Each transect will be monitored once per year. Sampling will be conducted during the summer season, which is expected to correspond to the height of the growing season and the period of greatest potential water stress. Sampling will be conducted in a manner similar to that for Indicator C.8 and two photographs will be taken at each transect in a similar manner as in Indicator C.8.

A tape with 1-cm markings will be placed between the starting and ending stakes, as close to the ground or water surface as possible, and stretched as tight as possible without moving the tape above the soil or water surface. Care will be taken during tape placement to cause as little damage to the vegetation as possible. Once the tape is in place, the observer will begin collecting data by standing with one foot at the 0-m mark and the other foot at the 1-m mark, shoulders parallel with the tape, and standing over the tape. The observer will make ocular counts of each species that has live vegetative material intersecting a vertical projection of the tape upward from the soil/water surface to the height of the observer. Data (hits) will be counted at 1-cm marks and recorded at 1-m intervals. First-hit and multiple-hit data will be collected by species. Once data is recorded for the first 1-m interval, the observer will repeat the process for each 1-m segment along the transect.

From these data, percent cover will be calculated, by species, for each transect, on a first-hit and on a multiple-hit basis. Percent canopy cover per species is calculated by dividing the number of hits (cm points) recorded for that species along the transect by the length of the transect (in centimeters) multiplied by 100. Species composition (relative cover) is calculated by dividing the cover value of a specific plant species along the transect by the total plant cover (all species combined) for the same transect.

C.10 VEGETATION MEASUREMENTS IN SWAMP CEDAR COMMUNITIES

The three objectives of this indicator are to sample: 1) annual variation in canopy cover of the two plant communities, 2) annual changes in species composition in the two plant communities, and 3) reproductive success of swamp cedars at the two locations. Stem elongation, another indicator for swamp cedar woodlands, is presented in a separate section.

There will be two monitoring sites. These will be the northern and the southern populations of lowland Rocky Mountain juniper (swamp cedars) in Spring Valley. Both juvenile (less than 1-m tall) and mature cedars will be sampled, along with species cover and composition of the understory vegetation.

The sampling unit will be a belt transect (Stoddart et al. 1975:177-178; Bonham 1989:145), 20-m long and 5-m wide. Each belt transect will be permanently marked by placing metal stakes at each corner of the enclosed rectangle and each corner geo-referenced using a sub-meter accuracy GPS unit. Sixteen permanent belt transects will be established in each of the two cedar populations (northern and southern) in the first year of pre-withdrawal monitoring. The spatial extent of the two cedar populations and their associated understory plant communities are being mapped by SNWA. Following completion of the mapping, the 16 belt transects at each site will be stratified-randomly located, with stratification being on the basis of understory vegetation. The number of belt transects placed in each understory community will in approximate proportion to the area within the cedar stand occupied by that understory community. The belt transects will be placed such that the long axis (20 m) runs approximately north-south. A 20-m line transect will be permanently located in each belt transect by placing a metal stake mid-way between the north two corners of the belt transect and the south two corners.

Each belt transect will be sampled once per year, with sampling conducted during the summer season, which is expected to correspond to the height of the growing season and to the period of greatest water stress. Sampling will consist of the following for each transect. The number of juvenile cedar trees will be recorded and their heights measured (to the nearest 1-cm) using a meter stick or range pole. Number of mature cedar trees will be recorded and their circumferences (basal at ground level) measured to the nearest 1-cm using a tape measure. Height of each mature cedar tree will be measured. Canopy cover by species will be recorded along three (3) 20-m long line transects using the same procedure as described for Indicator C.9 (Cover and Composition of Non-Aquatic Vegetation). The three line transects will be the western edge of the belt transect, the center line transect, and the eastern edge of the belt transect.

Moisture status of the surface soil will be noted in each belt transect at the time of sampling. Categories will be dry, moist, wet, and standing water. The appropriate moisture condition category will be recorded for each 1-m segment of the three 20-m transects in each belt transect (west, center, east). If standing water is present, the depth of standing water (to the nearest millimeter) will be measured at 1-m intervals along the line transects.

C.11 STEM ELONGATION IN SWAMP CEDAR COMMUNITIES

There will be two monitoring sites. These will be the northern and the southern populations of swamp cedars in Spring Valley.

The sampling unit will be single branches on individual trees. Four (4) mature cedar trees will be selected from each of the 32 belt transects (16 transects per site) described for Indicator C.10. Ten branches from each sampled tree will be tagged, using colored metal or plastic bands. Tagging will be done in the first year of the pre-withdrawal monitoring at the same time that the belt transects are established. The selected trees will be healthy in appearance and will be selected from different parts of their respective transects. Branches will be selected that have healthy leaves and evidence of recent stem growth. The major growth point (longest stem extension on the branch) will be selected for monitoring and tagged. The tag will be placed at the first juncture of the longest leader to the main secondary branch. The distance from the juncture to the tip of the leader will measured to the nearest millimeter at the time of tagging. The length will be recorded by branch, by tree, and by transect. Trees will be numbered in consecutive order within a transect from south to north.

Each year of the monitoring program, each remaining branch will be re-measured. Re-measurement will be conducting during August-September, toward the end of the growing season to allow for measurement of most of the annual growth produced during the sample year. Natural losses of stems should be expected. The inclusion of ten branches per tree provides some assurance that at least one branch will remain throughout the monitoring period. Sampling will consist of measuring (to the nearest millimeter) the distance from the leader tip to the tagged branch juncture. Changes in leader length between sampling dates will provide a measurement of rate of stem growth.

C.12 TRAINING

It is recommended that all field-based data collection efforts be conducted by qualified, well-trained scientists who are proficient in techniques required for sampling. It is required that the Crew Leader(s) for each respective activity meet(s) this qualification. However, it is recognized that new hires often times do not have site-specific experience or recent graduates do not have extensive field data collection experience, and in both cases, training will be needed in order for these individuals to effectively perform the duties described in this appendix.

Prior to the first sampling effort, all crew members (regardless of experience) will participate in an orientation regarding safety protocols, project area, private property, and overall sampling procedures. During subsequent trips, this orientation will only be provided for personnel new to the project.

On-site training for technical components will be provided to inexperienced crew members by an experienced crew member. Each participating entity will be responsible for identifying personnel that are inexperienced and need training in all or specific areas. If in question, the senior crew leader has the authority to require on-site training, if in his/her opinion the new crew member lacks the specific knowledge and experience to successfully complete the task assigned.

On-site training will consist of the trainee accompanying and observing an experienced crew member for one complete set of sampling (for that component) at a given site. The second time that set of sampling is to be conducted, it will be performed by the trainee with complete oversight by the experienced crew member. The experienced crew member will then discuss the sampling with the senior crew leader and a determination will be made as to whether the trainee will then be allowed to conduct those specific activities without direct supervision or if additional training is necessary.

The experienced crew members will make every attempt within reason to train new personnel. However, should the training become excessive and/or jeopardize the efficiency of the sampling or quality of the data, the senior crew member reserves the right to discuss the continued assistance of the trainee with the supervisor of the respective entity and ultimately SNWA in coordination with BWG.

C.13 FIELD QUALITY ASSURANCE / QUALITY CONTROL

The field QA/QC program is designed to ensure that data of the highest quality are obtained. The collection of representative samples is paramount to a successful time-series program. Samples will be collected and processed by experienced, trained personnel. Annual training will be conducted to ensure that the procedures followed are identical from year to year. Appropriate sampling equipment will be used and will be well-maintained and operationally sound.

C.14 HAZARD ANALYSIS AND CRITICAL CONTROL POINTS (HACCP)

In order to monitor the biotic composition and overall health of sensitive spring systems, field crews must enter those systems and chance negatively impacting the sites. Following a HACCP (Hazardous Analysis and Critical Control Points) protocol works to minimize these possible negative impacts. SNWA (or contractors) in coordination with BWG is especially interested in preventing the translocation of hazardous nuisance and invasive species between sites, and will follow the Nevada Department of Wildlife's (NDOW) protocol for the prevention of such transfers (attached at the end of this section):

The aquatic species that NDOW lists as of special concern are:

- vertebrates: tilapia, cichlids, mosquito fish, guppy, molly, amphibians.
- invertebrates: snails (New Zealand mudsnail, red-rimmed melania), quagga and zebra mussel adults and veliger larvae, Asian clam, crayfish
- plants: eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top
- other biologics (e.g. disease, pathogen, parasite)
- Viral septicemia, Bacterial kidney disease, Bacterial gill disease, ICH, Chytrid fungus (Batrachochytrium dendrobatidis)

Many of the species listed above are not found in IBMA.

The objective is to not allow hazardous species to be transferred via vehicles, equipment, and/or containers. The majority of hazardous species will be removed by storing the equipment and material and allowing it to dry for a sufficient amount of time. However, some invertebrate species may survive storing and drying. Also, it is not always feasible to allow all possibly contaminated material to dry before going to the next site, which risks transferring hazardous species from site to site. NDOW HACCP protocol dictates that possibly contaminated material be inspected visually for hazardous invertebrates and, if such species are found or suspected, be subsequently cleaned, disinfected, dried, or frozen, depending on practicality of each removal method.

For this monitoring program, a visual inspection of all field equipment will be conducted before proceeding to the next site. Additionally, field crews will flush/rinse all equipment (including shoes/boots/waders) with a chlorine solution between monitoring sites. All hazardous species removal will be documented in the field notes/data sheets. Attached are the NDOW HACCP worksheets. The first set relates to the transfer of species but was included because objective 3 specifically acknowledges monitoring. The second set relates to aquatic sampling, primarily by electrofishing.

Nevada Department of Wildlife. HACCP: Hazard Analysis Worksheets.

HACCP Step 1 – Activity Description

<table>
<tr><th colspan="2">Activity Description</th></tr>
<tr><td>Facility: State of Nevada, statewide</td><td>Site: Statewide streams, rivers, lakes and reservoirs.</td></tr>
<tr><td>Project
Coordinator: Jim Heinrich, staff biologist</td><td rowspan="4">Activity:

Transfer of aquatic species (all life stages) for, monitoring, introduction, reintroduction, augmentation, repatriation, refugia initiation, and salvage.</td></tr>
<tr><td>Site
Manager: fishery biologists, all regions</td></tr>
<tr><td>Address:
NDOW 1100 Valley Road, Reno, Nevada</td></tr>
<tr><td>Phone:
775-688-1532</td></tr>
</table>

Project Description i.e. Who; What; Where; When; How; Why
The Nevada Department of Wildlife (NDOW) directly manages all aquatic species of wildlife within the borders of the state. Many times management of these species requires the handling, movement, or transfer of live individuals to and from state facilities, other states, or bodies of water. This process is separate from the state hatchery culture program, but occasionally involves personnel and equipment from these facilities. Movement or collection of aquatic species, typically accomplished by NDOW biologists throughout the state, is required for the following reasons: 1) to receive aquatic species from out-of-state providers to introduce, reintroduce, augment, or repatriate aquatic species; 2) to capture, or salvage aquatic species from one body of water to release into another for introduction, reintroduction, augmentation, repatriation, or population monitoring; 3) to mark or tag individuals for monitoring or research. Many of these efforts are collaborative with county, state and federal partners. Although these activities vary greatly with phyla, species life stage, and purpose, they share the same concerns for accidental ANS transfers.

HACCP Step 2 – Identify Potential Hazards

(to be transferred to column 2 of HACCP Step 4 – Hazard Analysis Worksheet)

Hazards: Species Which May Potentially Be Moved/Introduced
Vertebrates: Tilapia, cichlids, mosquitofish, guppy, molly, amphibians.
Invertebrates: Snails (New Zealand mudsnail, red-rimmed melania), quagga and zebra mussel adults and veliger larvae, Asian clam, crayfish.
Plants: Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, common reed, cattails, white top.
Other Biologics (e.g. disease, pathogen, parasite): Viral septicemia, Bacterial kidney disease, Bacterial gill disease, ICH, Chytrid fungus (*Batrachochytrium dendrobatidis*)
Others (e.g. construction materials, etc.):

HACCP Step 3 – Flow Diagram

Flow Diagram Outlining Sequential Tasks to Complete Activity/Project
Described in HACCP Step 1 – Activity Description
(to be transferred to column 1 of the HACCP Step 4 – Hazard Analysis Worksheet)

Task 1	Obtain transport vehicle/vessel and any equipment or transfer container(s) from NDOW compound/storage area.

⇓

Task 2	Crew with project items travel to transfer site.

⇓

Task 3	Specimens delivered in containers for release at the transfer site are released. Move to Task 6 below.

⇓

Task 4	Specimens delivered to the transfer site or captured on site, to be released elsewhere, are relocated in containers and new transport vehicle/vessel.

⇓

Task 5	Aquatic specimens, and equipment are moved to the stocking site and released.

⇓

Task 6	Work is complete; transport equipment and vehicles return to compound/storage area.

⇓

Task 7	Transport vehicle and any equipment or transfer container(s) are stored.

Task 8	

HACCP Step 4 - Hazard Analysis Worksheet

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards probable? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task 1 Obtain transport vehicle/vessel, and any equipment or transfer container(s) from NDOW compound/storage area.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	No	Gear is stored and dried for an adequate period of time.		
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	Yes	Storage time may not have been adequate to insure complete mortality of these species.	Inspect tanks, boat, trailer, nets, traps, containers (buckets, ice chests, holding tanks), dry, clean, disinfect or freeze if ANS found or suspected.	No
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	No	Gear is stored and dried for an adequate period of time.		
	Others				

Hazard Analysis Worksheet (continued)

Task 2 Crew with project items travel to transfer site.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	No	Gear cleaned and inspected in previous step.		No
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	No	Gear cleaned and inspected in previous step.		No
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	No	Gear cleaned and inspected in previous step.		No
Task 3 Specimens delivered and released at the transfer site. Move to Task 6 below.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly.	Yes	Source of specimens will come from a disease-free source, ANS should not be present	Containers, water and specimens inspected before release.	No
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	Yes	Source of specimens will come from a disease-free source, ANS should not be present	Containers, water and specimens inspected before release.	No
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	Yes	Source of specimens will come from a disease-free source, ANS should not be present	Containers, water and specimens inspected before release.	No
	Viral septicemia, Bacterial kidney disease, Bacterial gill disease, ICH, Chytrid fungus	Yes	Source of specimens will come from a disease-free source, ANS should not be present.	Trained biologists should visually inspect for weak or infected individuals.	No

Hazard Analysis Worksheet (continued)

Task 4 Specimens delivered or captured are transferred to new site.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	Yes	ANS could be collected.	Containers, water and specimens must be thoroughly inspected away from release site, before release.	No
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania), Asian clam, crayfish	Yes	ANS could be collected.	Containers, water and specimens must be thoroughly inspected away from release site, before release.	No
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	Yes	ANS could be collected.	Containers, water and specimens must be thoroughly inspected away from release site, before release.	No
	Others Chytrid fungus	Yes	ANS could be collected.	Trained biologists should visually inspect for weak or infected individuals.	
Task 5 Aquatic specimens, are released at new site.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	No	Controlled in previous task.		
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	No	Controlled in previous task.		
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	No	Controlled in previous task.		

Hazard Analysis Worksheet (continued)

Task 6 Work is complete; transport equipment returns to compound/storage area.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	No	Controlled in previous task.		No
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	Yes	Controlled in previous task, but inspect a second time.	Visually inspect all containers, equipment/gear. Drain containers, live well, bilges. Disinfect or freeze equipment that may hide smaller life stages.	No
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	Yes	Controlled in previous task, but inspect a second time.	Visually inspect all equipment/gear. Drain containers, live well, bilges.	No
Task 7 Transport vehicle and any equipment or transfer container(s) are stored.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	No	Equipment/gear inspected in previous tasks.		No
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	No	Equipment/gear inspected in previous tasks.		No
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	No	Equipment/gear inspected in previous tasks.		No

HACCP Step 5 – HACCP Plan – Aquatic species transfers

HACCP Plan Form

(all CCP's or "yes's" from column 6 of HACCP Step 4 – Hazard Analysis Worksheet)

			MONITORING					
Critical Control Point (CCP)	**Significant Hazard(s)**	**Limits For Each Control Measure**	**What**	**How**	**Frequency**	**Who**	**Evaluation & Corrective Action(s) (if needed)**	**Supporting Documentation (if any)**
Task #1 Equipment, nets, transport containers	Inverts	Visually inspect	Equipment/gear	Visually	Prior to leaving	All Crew	Clean, disinfect, freeze or heat	Field trip notes, data sheets
Task #3 Transport containers	Invertebrates, vertebrates, plants, viral/bacterial	Visually inspect	Containers, water, specimens	Visually	Prior to release	All Crew	Inspect, no release if ANS observed	Field trip notes, planting receipts, data sheets
Task #4 Equipment, transport containers	Invertebrates, vertebrates, plants	Visually inspect	Containers, boats water, specimens	Visually	Prior to release	All Crew	Inspect, no release if ANS observed	Field trip notes, planting receipts, data sheets
Tash #6 Storage: quipment, nets, transport containers	Invertebrates, plants	Visually inspect	Equipment/boat/ gear	Visually	Prior to leaving the area	All Crew	Inspect, disinfect, freeze	Field trip notes, data sheets

Facility: **NDOW, statewide**	**Activity:** **Biological, water or substrate sampling projects**
Address: **NDOW, 1100 Valley Road, Reno, Nevada 89503**	
Signature: **HACCP Plan was followed.**	**Date:**

HACCP Step 1 – Activity Description

Activity Description	
Facility: State of Nevada, statewide	Site: Statewide streams, rivers, lakes and reservoirs.
Project Coordinator: Mark Warren, Staff Biologist	Activity: Survey and monitoring using electro-fishing equipment, including backpack units, shore units, and boats.
Site Manager: fishery biologists, all regions	
Address: 1100 Valley Road, Reno, Nevada	
Phone: 775-688-1532	

Project Description i.e. Who; What; Where; When; How; Why
The Nevada Department of Wildlife (NDOW) conducts electro-fishing operations throughout the state in a variety of aquatic habitats to determine species population trends or collect pesticide/toxicology samples. This includes large reservoirs for game fish populations, a stream survey program directed toward waters that have not been sampled in many years, and surveys for sensitive, threatened and endangered native fish. Surveys are typically completed during the spring and fall months, but scheduling challenges often push sampling into the winter months. Many of these surveys are collaborative efforts with state and federal partners. The NDOW maintains eight, battery powered backpack electrofishing units, 3 boat-shocking units, and a shore sampling unit. Personnel, 18 biologists covering all three regions of the state, undergo extensive NDOW training before allowed to operate these devices. Before each sampling session, safety protocols are reviewed.

HACCP Step 2 – Identify Potential Hazards

(to be transferred to column 2 of HACCP Step 4 – Hazard Analysis Worksheet)

Hazards: Species Which May Potentially Be Moved/Introduced
Vertebrates: Tilapia, cichlids, mosquito fish, guppy, molly.
Invertebrates: Snails (New Zealand mudsnail, quagga/zebra mussel adults and veligers, red-rimmed melania) Asian clam, crayfish
Plants: Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top
Other Biologics (e.g. disease, pathogen, parasite):
Others (e.g. construction materials, etc.):

HACCP Step 3 – Flow Diagram

Flow Diagram Outlining Sequential Tasks to Complete Activity/Project
Described in HACCP Step 1 – Activity Description
(to be transferred to column 1 of the HACCP Step 4 – Hazard Analysis Worksheet)

Task 1	Equipment such as dipnets, backpack electrofishers, buckets, ice chests, holding containers, electrical probes, boots, gloves obtained from storage.

⇓

Task 2	If required, boat and trailer are obtained from storage.

Task 3	Crew with gear travels to sample location.

⇓

⇓Task 4	Crew enters water; samples are collected. Fish are kept or released. Species are frozen, preserved, or dept live. Live specimens are placed in ice chests, buckets or holding tanks.

⇓

⇓Task 5	Crew and gear travels to office/new site.

⇓

Task 6	All gear is stored.

⇓

Task 7	

HACCP Step 4 - Hazard Analysis Worksheet

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards probable? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task 1 Dipnets, backpack electrofishers, buckets, ice chests, electrical probes, gloves, etc. are obtained from storage.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	No	Gear is stored and dried for an adequate period of time.		
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	Yes	Storage time is often not adequate to insure complete mortality of these species.	Inspect dipnets, probes, gloves, buckets, ice chests, holding tanks, probes, etc.	No
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	No	Gear is stored and dried for an adequate period of time.		
	Others				

Hazard Analysis Worksheet (continued)

Task 2 If required, boats and trailers are obtained from storage.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	Yes	If turn-around use time is short, live wells may allow survival of these species.	Inspect, or clean with light chlorine solution.	No
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	Yes	If turn-around use time is short, live wells may allow survival of these species.	Inspect and flush all live wells, bilges, or standing water on dry land, treat hidden areas with light chlorine solution.	No
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	Yes	If turn-around use time is short, live wells may allow survival of these species.	Extend drying time, flush all live wells, bilges, or standing water on dry land.	No
	Others				
Task 3 Crew with gear travels to sample location	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	No	Gear cleaned and inspected in previous step.		
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	No	Gear cleaned and inspected in previous step.		
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	No	Gear cleaned and inspected in previous step.		
	Others				

Hazard Analysis Worksheet (continued)

Task 4 Fish are captured and held in containers. Specimens are released, preserved, frozen, or kept live.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	Yes	ANS species could be collected.	Insure removal of ANS by visually inspecting.	No
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	Yes	ANS species could be collected.	Insure removal of ANS by visually inspecting.	No
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	Yes	ANS species could be collected.	Insure removal of ANS by visually inspecting.	No
	Others				
Task 5 Crew and gear travels to office/new site.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	No			
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	Yes	ANS could be transferred to new site.	Visually inspect a second time all equipment/gear. Drain containers, live well, bilges. Disinfect, dry or freeze equipment.	No
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	Yes	ANS could be transferred to new site.	Visually inspect a second time all equipment/gear. Drain containers, live well, bilges. Disinfect, dry or freeze equipment.	No
	Others				

Hazard Analysis Worksheet (continued)

Task 6 Boat, equipment/gear is stored.	Vertebrates Tilapia, cichlids, mosquito fish, guppy, molly	No	Equipment/gear inspected in previous tasks.		No
	Invertebrates Snails (New Zealand mudsnail, quagga mussel, zebra mussel, red-rimmed melania) Asian clam, crayfish	No	Equipment/gear inspected in previous tasks.		No
	Plants Eurasian milfoil, curlyleaf pondweed, Vallesaria grass, giant salvinia, phragmites, cattails, white top	No	Equipment/gear inspected in previous tasks.		No
	Others				

HACCP Step 5 – HACCP Plan - Electrofishing

HACCP Plan Form

(all CCP's or "yes's" from column 6 of HACCP Step 4 – Hazard Analysis Worksheet)

			MONITORING					
Critical Control Point (CCP)	**Significant Hazard(s)**	**Limits for each Control Measure**	**What**	**How**	**Frequency**	**Who**	**Evaluation & Corrective Action(s) (if needed)**	**Supporting Documentation (if any)**
Task #1 Equipment	Inverts	Visually inspect	Equipment/gear	Visually	Prior to leaving	All Crew	Disinfect, dry	Field trip notes, data sheets
Task #2 boat/trailer	Invertebrates, vertebrates plants	Visually inspect	Boat/trailer	Visually	Prior to leaving	All Crew	Clean, flush, drain, disinfect, dry	Field trip notes, data sheets
Task #4 fish samples	Invertebrates, vertebrates plants	Visually inspect	Equipment/boat/ gear	Visually	Prior to release of captures	All Crew	Inspect, remove foreign material	Field trip notes, data sheets
Tash #5 leave area	Invertebrates, plants	Visually inspect	Equipment/boat/ gear	Visually	Prior to leaving the area	All Crew	Drain, remove foreign material, disinfect	Field trip notes, data sheets
								Field trip notes, data sheets

Facility: **NDOW statewide**	**Activity:** **Electrofishing projects**
Address: **NDOW, 1100 Valley Road, Reno, Nevada 89503**	
Signature: **HACCP Plan was followed.**	**Date:**

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APPENDIX D

LIST OF SCIENTIFIC AND COMMON NAMES

ANIMALS

Scientific Name	Common Name	Lifeform
Anodonta californiensis	California floater	mussel
Antilocapra americana	Pronghorn antelope	mammal
Antrozous pallidus	Pallid bat	bat
Asio flammeus	Short-eared owl	bird
Baetis adonis	Mayfly	insect
Buteo regalis	Ferruginous hawk	bird
Buteo swainsoni	Swainson's hawk	bird
Carassius auratus	Goldfish	fish
Catostomus ardens	Utah sucker	fish
Centrocercus urophasianus	Greater sage grouse	bird
Cercyonis pegala pluvialis	White River wood nymph	butterfly
Circus cyanus	Northern harrier	bird
Cottus bairdi	Mottled sculpin	fish
Dolichonyx oryzivorus	Bobolink	bird
Empetrichthys latos	Pahrump poolfish	fish
Eptesicus fuscus	Big brown bat	bat
Euderma maculatum	Spotted bat	bat
Gambusia affinis	Western mosquitofish	fish
Gila atraria	Utah chub	fish
Gila robusta jordani	Pahranagat roundtail chub	fish
Haliaeetus leucocephalus	Bald eagle	bird
Hesperia uncas grandiose	White River Valley skipper	butterfly
Hesperoperla pacifica	Stonefly	insect
Heterlimnius spp.	Riffle beetle	insect
Ictalurus punctatus	Channel catfish	fish
Icteria virens	Yellow-breasted chat	bird
Lasionycteris noctivagans	Silver-haired bat	bat
Lasiurus blossevillii	Western red bat	bat
Lasiurus cinereus	Hoary bat	bat
Lepidostoma spp.	Caddisfly	insect
Micropterus dolomieu	Smallmouth bass	fish
Micropterus salmoides	Largemouth bass	fish
Microtus pennsylvanicus	Meadow vole	mammal
Moapa coriacea	Moapa dace	fish
Myotis evotis	Long-eared myotis	bat
Myotis lucifugus	Little brown myotis	bat
Myotis thysanodes	Fringed myotis	bat
Myotis volans	Long-legged myotis	bat
Myotis yumanensis	Yuma myotis	bat
Nyctinomops macrotis	Big free-tailed bat	bat
Odocoileus hemionus	Mule deer	mammal
Oncorhynchus mykiss	Rainbow trout	fish
Pacifastacus lenusculus	Crayfish	crustacean
Pipistrellus hesperus	Western pipistrelle	bat

ANIMALS (cont.)

Scientific Name	Common Name	Lifeform
Pomoxis nigromaculatus	Black crappie	fish
Pyrgulopsis Kolobensis	Toquerville springsnail	springsnail
Rana catesbeiana	Bullfrog	frog
Rana pipiens	Northern leopard frog	frog
Relictus solitaries	Relict dace	fish
Rhinichthys osculus	Speckled dace	fish
Richardsonius balteatus	Redside shiner	fish
Salmo trutta	Brown trout	fish
Tadarida brasiliensis	Brazilian free-tailed bat	bat
Thiara tuberculata	Red-rimmed thiara	snail
Uta stansburiana	Common side-blotched lizard	reptile

PLANTS

Scientific Name	Common Name	Lifeform
Agropyron dasystachyum	thickspike wheatgrass	perennial grass
Agropyron spicatum	bluebunch wheatgrass	perennial grass
Allenrolfea occidentalis	iodine bush	shrub
Artemisia arbuscula	low sagebrush	shrub
Artemisia nova	black sage	shrub
Artemisia tridentata	big sagebrush	shrub
Astragalus diversifolius	meadow milkvetch	perennial forb
Atriplex canescens	fourwing saltbush	shrub
Atriplex confertifolia	shadscale	shrub
Atriplex gardneri	Nuttall saltbush	shrub
Atriplex parryi	Parry saltbush	shrub
Atriplex polycarpa	allscale	shrub
Atriplex torreyi	Nevada saltbush	shrub
Bromus tectorum	cheatgrass	annual grass
Carex spp.	sedge	grass-like
Carex nebraskensis	Nebraska sedge	grass-like
Ceratophyllum spp.	coontail	aquatic forb
Chara spp.	stonewort	aquatic macroalgae
Chrysothamnus nauseosus	rabbitbrush	shrub
Chrysothamnus viscidiflorus	green rabbitbrush	shrub
Distichlis spicata	saltgrass	perennial grass
Elaeagnus angustifolius	Russian olive	tree
Eleocharis palustris	creeping spikerush	grass-like
Grayia spinosa	hopsage	shrub
Halogeton glomeratus	halogeton	annual forb
Iva axillaris	sumpweed	perennial forb
Juncus balticus	Baltic rush	grass-like
Juniperus ashei	Ashe juniper	tree
Juniperus monosperma	one-seeded juniper	tree

PLANTS (cont.)

Scientific Name	Common Name	Lifeform
Juniperus osteosperma	Utah juniper	tree
Juniperus occidentalis	western juniper	tree
Juniperus scopulorum	Rocky Mountain juniper	tree
Lactuca scariola	prickly lettuce	annual forb
Lemna spp.	duckweed	aquatic forb
Leymus cinerus	basin wildrye	perennial grass
Leymus triticoides	creeping wildrye	perennial grass
Melilotus officinalis	yellow sweetclover	biennial forb
Nitrophila occidentalis	alkali pink	perennial forb
Phacelia parishii	Parish's phacelia	annual forb
Phragmites australis	common reed	perennial grass
Poa secunda	Sandberg bluegrass	perennial grass
Populus spp.	cottonwood	tree
Potamogeton spp.	pondweed	annual or perennial aquatic
Potentilla fruticosa	shrubby cinquefoil	shrub
Rorippa nasturtium-aquaticum	watercress	perennial forb
Salicornia spp.	pickleweed	perennial forb
Salix spp.	willow	shrub or tree
Salsola kali	Russian thistle	annual forb
Sarcobatus vermiculatus	greasewood	shrub
Scirpus spp.	bulrush	grass-like
Scirpus pungens	common threesquare	grass-like
Spartina spp.	cordgrass	perennial grass
Spiranthes diluvialis	Ute ladies'-tresses	perennial forb
Sporobolus airoides	alkali sacaton	perennial grass
Suaeda torreyana	seepweed	shrub
Tamarix spp.	saltcedar	tree
Tetradymia spp.	horsebrush	shrub
Typha latifolia	cattail	grass-like
Utricularia spp.	bladderwort	perennial aquatic

APPENDIX E

CONCEPTUAL MODELS

CONTENTS

E.1 Introduction
E.2 Purpose and Intent
E.3 General Conceptual Model
E.3.1 Water
E.3.1.1 Water Supply
E.3.1.2 Water Loss
E.3.1.3 Water Balance
E.3.1.4 Water Quality
E.3.2 Climate Change
E.3.3 Plant Communities
E.3.3.1 Resource Requirements
E.3.3.2 Stressors
E.3.4 Animal Communities
E.3.4.1 Resource Requirements
E.3.4.2 Stressors
E.4 Specific Conceptual Models
E.4.1 Springs
E.4.1.1 Maintenance Factors
E.4.1.2 Disturbance Patterns
E.4.1.3 Relationship of Conceptual Model to Monitoring Plan
E.4.2 Ponds (Shoshone Ponds)
E.4.2.1 Maintenance Factors
E.4.2.2 Disturbance Patterns
E.4.2.3 Relationship of Conceptual Model to Monitoring Plan
E.4.3 Perennial Streams
E.4.3.1 Maintenance Factors
E.4.3.2 Disturbance Patterns
E.4.3.3 Relationship of Conceptual Model to Monitoring Plan
E.4.4 Wetlands
E.4.4.1 Maintenance Factors
E.4.4.2 Disturbance Patterns
E.4.4.3 Relationship of Conceptual Model to Monitoring Plan
E.4.5 Meadows
E.4.5.1 Maintenance Factors
E.4.5.2 Disturbance Patterns
E.4.5.3 Relationship of Conceptual Model to Monitoring Plan
E.4.6 Phreatophytic Shrublands
E.4.6.1 Maintenance Factors
E.4.6.2 Disturbance Patterns
E.4.6.3 Relationship of Conceptual Model to Monitoring Plan
E.4.7 Swamp Cedar Woodlands
E.4.7.1 Maintenance Factors
E.4.7.2 Disturbance Patterns
E.4.7.3 Relationship of Conceptual Model to Monitoring Plan

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E.1 INTRODUCTION

Ecosystems are complex assemblages of interacting biota that are influenced by and are influencing their associated abiotic environments. Although ecologists understand much about the components of various ecosystems and how ecosystems function, a complete understanding of composition, structure, and function is lacking for most, if not all, naturally-occurring ecosystems.

An ecological model is an abstraction of some part of an ecological system. The models can be of a number of types, ranging from simple to complex. Models are used for a number of purposes, but in all cases the purpose of the model is to attempt to explain some aspect of the ecological system, such as how the system functions, how it relates to other ecological systems, or how it changes over time. Regardless of the type of model or the specifics of an application, a primary purpose of all ecological models is that they should increase our understanding of the ecological systems to which are applied.

All scientific models have a conceptual basis. There is a logic associated with how the model is constructed and this logic is associated with how the system is thought to function, mathematical or statistical methods of identifying relationships, or perceived associations among components. In general, the more correct the conceptual model (i.e., the more closely the model assumptions reflect their analogs in the physical ecosystem) the more useful the model.

The conceptual models presented in this appendix should be considered as a work in progress. We assume that we do not fully understand the multitude of ecological relationships associated with these ecosystems, and will modify the conceptual models as additional information and a better understanding become available. Furthermore, the conceptual models discussed in this chapter provide the foundation for this Plan but, by design, stop short of describing the complexity of biological interactions within and among these groundwater-influenced ecosystems, and are not site-specific. As detailed biological information is collected on these ecosystems, additional levels of detail will be added and site-specific conceptual models may be developed.

Conceptual models can play a role in increasing our understanding of the groundwater-influenced ecosystems and informing our monitoring efforts. Conceptual models provide a short-hand method of presenting the state of our understanding of these systems, focusing the thought processes of those working on the systems and communicating the status of our understanding to others. Their development also encourages translation of the monitoring data into a better understanding of the ecology of these target ecosystems. In this way, a tremendous scientific opportunity presents itself in the biological monitoring effort being conducted in the IBMA. Lastly and perhaps most importantly, conceptual models will help us focus our monitoring efforts, identify those areas where further study may be warranted, and interpret the monitoring results in the context of the groundwater development project.

E.2 PURPOSE AND INTENT

The purpose of this appendix is to present a summary of our understanding of the ecology of the aquatic and wetland ecosystems in the IBMA in the form of conceptual models. The seven types of groundwater-influenced ecosystems that are included in the biological monitoring plan are presented in this appendix: springs, ponds (Shoshone), wetlands, perennial streams, meadows, phreatophytic shrublands, and swamp cedar woodlands. Only information that is relevant to the monitoring sites in the IBMA is included in the conceptual models.

The conceptual models are presented in two sections: General Conceptual Model (Section E.2) and Specific Conceptual Models (Section E.3). In the general conceptual model section, overall broad-scale environmental processes that are common to all of the groundwater-influenced ecosystems are presented. The specific conceptual model section does not repeat this information, emphasizing instead the more unique attributes of the specific groundwater-influenced ecosystems.

For the specific conceptual models, simple models are first presented that include the more general aspects of each of the groundwater-influenced ecosystems. These simple models are then expanded by discussing the factors most important in maintaining these ecosystems. Maintenance of the ecosystem is considered to be the continuation of the present condition of the ecosystem. Next, the models are expanded to discuss major factors that produce disturbance patterns typically seen in these ecosystems. Disturbance is herein considered to be an ecological factor that has the potential of changing at least one primary characteristic of the ecosystem, compared to the state of the ecosystem under maintenance conditions. Within the disturbance subsection, we discuss how we expect the ecosystems to respond to various environmental stressors, including long-term natural stressors, groundwater withdrawal, and other anthropogenic stressors. Finally, we include flow-chart diagrams that illustrate how components of the conceptual models relate to the monitoring plan. These parsimonious diagrams are not meant to demonstrate complete conceptual models. Instead, the intent is to show how primary drivers and stressors discussed in the conceptual models relate to the KEAs and indicators to be monitored for each groundwater-influenced ecosystem in the IBMA (Chapter 4), and therefore are presented within the context of the groundwater development project and the biological monitoring plan.

E.3 GENERAL CONCEPTUAL MODEL

The purpose of Section E.2 is to present those conceptual aspects common to all of the individual groundwater-influenced ecosystems included in this Plan. The general conceptual model in its most basic form consists of water supply and characteristic biota. If the water supply is maintained, within certain (and largely currently unknown) limits, the biota is likely to persist. For springs, ponds (Shoshone), wetlands, and streams, the water supply must be sufficient to maintain the required depths and flow rates. For meadows, cedars, and shrublands, the water supply must be sufficient to maintain the necessary amount of groundwater to supplement precipitation to supply the required amount of soil moisture needed to sustain these ecosystems.

E.3.1 WATER

E.3.1.1 WATER SUPPLY

There are four sources of water to these ecosystems 1) groundwater flowing to the surface, 2) surface flow of water, 3) subsurface groundwater, and 4) precipitation (Fig. E-1). Groundwater may flow to the surface in the form of springs or seeps. Subsurface groundwater may be available to the ecosystems when the water table is sufficiently shallow that it, or its capillary fringe, is in contact with the plant root systems. Surface flow can occur as stream flow, overland seepage from springs and ponds, and as runoff following heavy rain events or snowmelt.

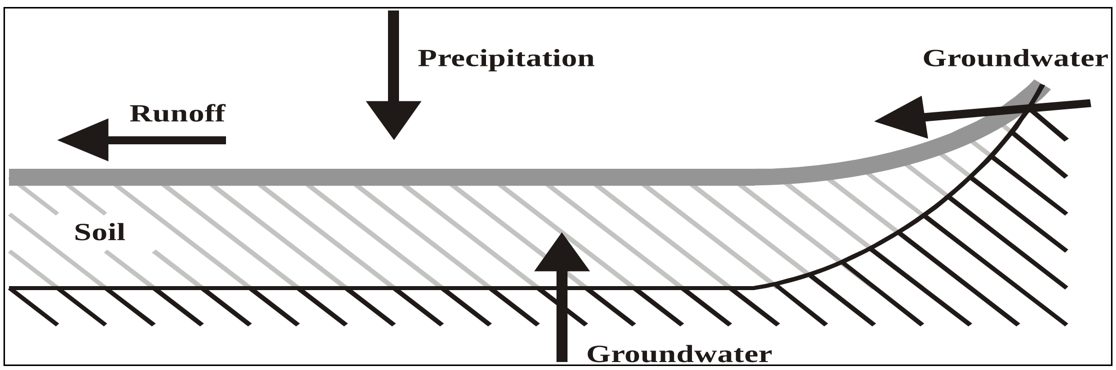


Fig. E-1. Sources of water to groundwater-influenced ecosystems.

Flow rates from all four sources may vary both seasonally and annually. In general, variability in supply rate is least for groundwater flow (springs and seeps) and greatest for precipitation and surface runoff. Flow rates from springs and seeps are dependent on the head pressure of the portion of the aquifer supplying the spring or seep. These rates are determined in a complex manner related to water supply and transport patterns in the various parts of the aquifer. In part, the supply in the aquifer is dependent on the annual inputs into the aquifer from precipitation (mostly snowmelt) in the adjacent mountains. However, because of potentially complex geology, there may be substantial lag times between seepage into the aquifer from snowmelt and changes in flow rates of the springs and seeps.

Surface flow from groundwater occurs as stream flow and as overland seepage from springs and ponds. Stream flow rate is largely dependent on amount of snowmelt in higher elevations and outflow from springs, minus losses from the stream (e.g., channel loss, evapotranspiration, water diversion). These two primary water sources have very different seasonal and annual rates of variability. Spring flow is less variable than snowmelt. Stream flow from snowmelt depends on the amount of snow received that year, how fast temperatures increase in the spring (melt rate), how dry the stream channel was prior to and during early runoff, and the amount of upstream diversions. In most years, the perennial stream flow will be highest in the late spring and lowest in fall and winter. During fall and winter, the flow rate will be determined largely by the rate of outflow from springs.

Surface flow to meadows, and at times to cedars and phreatophytic shrublands, is determined by outflow rates from wetlands associated with springs and seeps, from seasonal surface flow from snowmelt, from seasonal rise in water table, and from episodic surface runoff from infrequent heavy rain events. Outflow rates from wetlands are the least variable of the four water sources to meadows. Rates are somewhat lower in summer because of increased evapotranspiration from the wetlands. For example, a cattail (*Typha latifolia*) community in Arizona transpired 54 cm of water October through March compared to 209 cm April through September (McDonald and Hughes 1968) and an irrigated saltgrass (*Distichlis spicata*) meadow near Winnemucca, Nevada transpired 2.7 cm in April compared to 3.1 cm in July (Grosz 1972). The other three surface water sources to meadows (snowmelt, water table rise, and surface runoff) are highly variable both seasonally and annually.

Fluctuations in depth to groundwater can be substantial in shallow groundwater systems. Low-elevation sites in the Owens Valley, California have relatively shallow water tables that are recharged by mountain snowmelt runoff, primarily from the Sierras. At 8 control sites (not impacted by groundwater pumping) with a mean depth to water (DTW) of 2.6 m, mean annual DTW varied by an average of 1.0 m over an average of 8 years (McLendon 2006). DTW varied seasonally at these sites by as much as 1.1 m within a 12-month period. In shallow-groundwater (< 1 m DTW) sedge-bluegrass meadows in central Nevada, mean growing-season DTW can vary by 25-40 cm between years (Martin and Chambers 2001) and DTW can vary seasonally by as much as 0.7 m on shallow-groundwater (0.9-1.6 m DTW) saltgrass flats in Ruby Valley, eastern Nevada (Miller et al. 1982).

Precipitation varies considerably, both annually and seasonally, in arid and semiarid regions, and the variability typically increases as total annual precipitation decreases (Fogel 1981, Le Houerou 1984). This variability is ecologically important as it affects ecosystem diversity and productivity (Brown et al. 1997; Williams and Ehleringer 2000; Schwinning et al. 2002), and long-lived desert plants are especially sensitive to infrequent but intense extremes in precipitation (Turner 1990). Long-term data from two sites will serve to illustrate this variability in precipitation in the Great Basin region.

The 132-year (1875-2006) average annual precipitation for Salt Lake City, Utah is 40.3 cm. The driest year on record (1979) received 21.7 cm (54% of mean) and the wettest year (1983) received 71.7 cm (177% of mean) (Fig. E-2). Over the 132 years of record, annual precipitation exceeded the long-term average by 20% or more in 21 years (16%) and was 20% or more below average in 26 years (20%). Spring (March-May) is the wettest season (14.6 cm) and summer (June-August) is the driest (5.9 cm) (Fig. E-2). On average, 36% of annual precipitation occurs during the spring, compared to less than 15% during the summer.

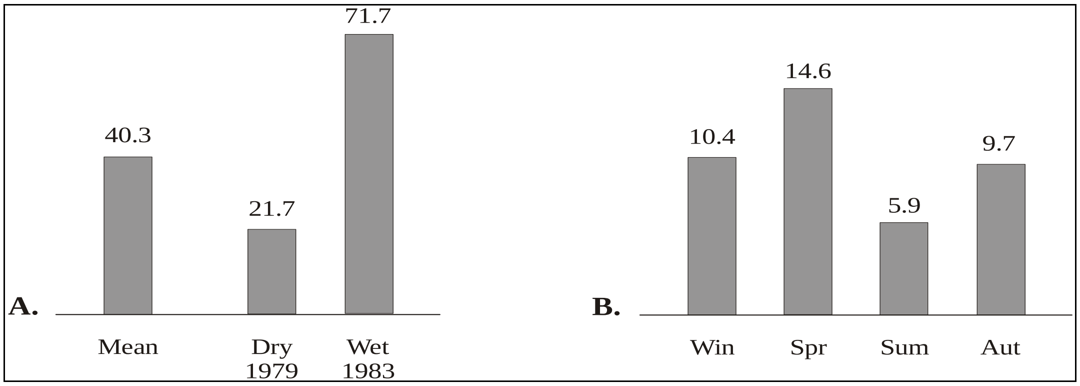


Fig. E-2. Annual and seasonal precipitation (cm) at Salt Lake City, Utah. A. Long-term (1875-2006) mean, driest, and wettest annual totals. B. Seasonal means (Winter = Dec-Feb, Spring = Mar-May, Summer = Jun-Aug, Autumn = Sep-Nov).

Independence is located in the Owens Valley of California, on the southwestern edge of the Great Basin Desert and the northern edge of the Mojave Desert. The 124-year mean annual precipitation for Independence is 13.0 cm (Fig. E-3). These data cover the period 1866-2005, with data missing for 1877-1892. The driest year on record for Independence was 1929 (2.1 cm = 16% of average). There have been three other years in which the total annual precipitation was less than 2.5 cm, the latest being 1990. The wettest year on record was 1867 (54.9 cm = 422% of average). The second-wettest year was 1969 (40.1 cm = 308% of average). Over the 124 years of record, annual precipitation exceeded the long-term average by 20% or more in 37 years (30%) and was at least 20% below average in 53 years (43%).

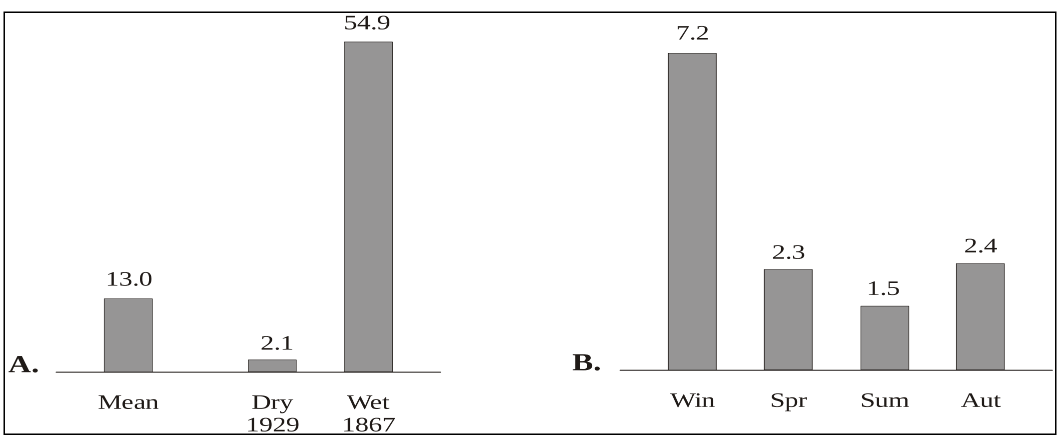


Fig. E-3. Annual and seasonal precipitation (cm) at Independence, California. A. Long-term (124 years) mean, driest, and wettest annual totals. B. Seasonal means (Winter = Dec-Feb, Spring = Mar-May, Summer = Jun-Aug, Autumn = Sep-Nov).

Comparing the two sites, annual precipitation is more variable at Independence than at Salt Lake City. At Independence, annual precipitation deviated 20% or more from the long-term average in 90 out of 124 years compared to 46 out of 127 years at Salt Lake City. Seasonal differences in average precipitation are also greater at Independence than at Salt Lake City. The amounts of precipitation received seasonally at Salt Lake City are relatively constant (Fig. E-2). In contrast, over half (56%) of the average annual precipitation at Independence occurs in the winter (December-February) and only 25% occurs in the spring and summer (March-August) (Fig. E-3).

Relative amounts of precipitation received seasonally (percent of annual precipitation received by season) at Independence also vary substantially (Table E-1). Winter (December-February) precipitation averaged 38% of the annual total during the 1930s, but increased to 70% during the 1960s (Table E-1). The amount received during the summer increased steadily from less than 3% of annual total in the 1940s to 10% in the 1980s, and then has decreased again in the last 15 years (Table E-1).

Table E-1. Percent of annual precipitation received by season and by decade at Independence, California from 1900 through 2005.

Season	00-09	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	00-05	Overall
Winter	52.9	64.1	38.2	55.5	58.1	59.3	69.9	49.0	48.2	57.2	53.6	56.1
Spring	25.0	18.5	19.3	15.5	16.4	17.6	7.5	22.1	19.9	23.1	10.7	17.8
Summer	5.8	8.5	10.0	11.9	2.8	4.7	8.1	8.6	9.9	7.0	5.7	7.3
Autumn	16.3	8.9	32.5	17.1	22.7	18.4	14.5	20.3	22.0	12.7	30.0	18.8

Winter = December-February; Spring = March-May; Summer = June-August; Autumn = September-November

While annual and seasonal precipitation patterns at Salt Lake City indicate variability, there is no consistent change in pattern over the period of record (1875-2006). This is not the case at Independence. Annual precipitation at Independence averaged 12.24 cm between 1866 and 1956, a period with 75 years of data. Between 1957 and 2005 (49 years), it averaged 13.94 cm, or an increase of 10.5%. During two periods (1900-1939 and 1940-1989), each lasting 4-5 decades, summer precipitation increased in proportion to total annual precipitation, then suddenly decreased (Table E-1). Long-term precipitation data (110-152 years) from some other sites in the western United States (Albuquerque, El Paso, Fort Collins, Reno, San Antonio, Santa Fe, Tucson) also show an increase in precipitation during the past 50 years, while data from other sites show no such increase (Amarillo, Cheyenne, Salt Lake City).

These precipitation data from Salt Lake City and Independence strongly illustrate two points. First, precipitation varies both annually and seasonally, and the magnitude of this variability varies from site to site. Second, precipitation patterns, as well as amounts, are changing at some sites but not at others. Analysis of long-term data records is the only way these variations can be determined and quantified. Because there are no long-term (100 years or more) precipitation data for sites in the IBMA, the long-term data sets that do exist must be studied and the results related to those sites without such long-term data. In addition, the dynamic aspect of precipitation amounts and patterns must be recognized and accounted for in ecological monitoring programs, especially those in arid and semiarid regions. The importance of such studies increases even more as we attempt to account for effects of climate change (Section E.2.5).

E.3.1.2 WATER LOSS

There are five major ways in which water is lost from the groundwater-influenced ecosystems 1) export, 2) outflow, 3) percolation, 4) evaporation, and 5) transpiration (Fig. E-4). Export is the direct removal of water from the system for human use, such as irrigation and stock watering.

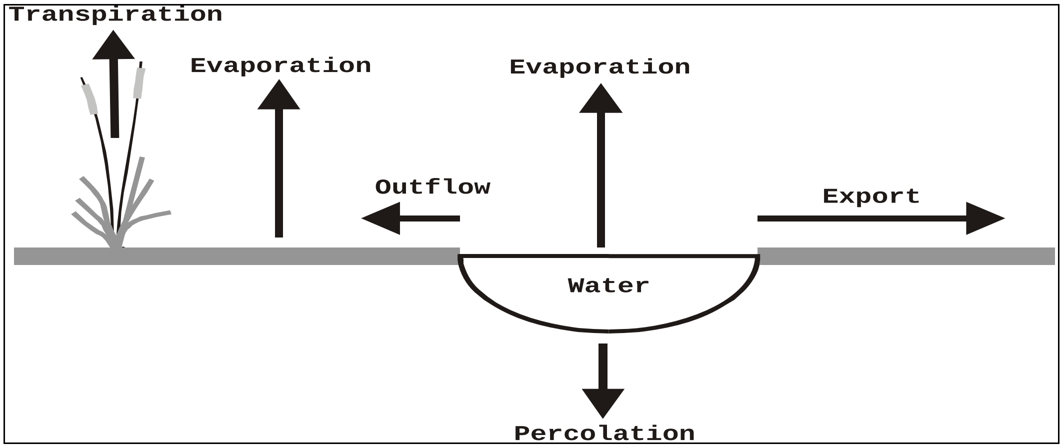


Fig. E-4. Sources of water loss from groundwater-influenced ecosystems.

Outflow occurs whenever the storage capacity of the system is exceeded. It is the natural process of water flowing downstream, either in a defined channel (streamflow) or as seepage over a surrounding area of lower topography. The outflow rate can be relatively constant, as in the case of a constant-flow spring supplying water to an associated stream, or it can be variable. Variable rates are common with seasonal springs and seeps, seasonal rises in shallow groundwater, snowmelt, and surface runoff from storm events.

Percolation rate is largely a function of the soils and geology of the substrate underlying the ecosystem. The rate of downward movement (percolation) of water is determined by the rate of water movement at the interface between saturated and unsaturated substrates. At this interface, the rate-determining layer may be the overlying saturated layer or the underlying unsaturated layer. If, for example, the overlying saturated layer is a clay and the underlying unsaturated layer is a sand, the rate of water movement from the saturated clay into the sand will be slower than the rate of movement through the sand. Conversely, if the overlying layer is a sand and the underlying layer is a clay, the percolation rate into the clay will determine the rate of movement. If the underlying substrate is rock, the rate of water movement will be determined by the number and size of cracks (vertical and horizontal) in the rock, the amount of residual water contained in the cracks, and the size of the openings into which the water-carrying cracks and fissures eventually open.

Percolation rate through soil is a function of the soil texture, bulk density, and water content. Water flows through unsaturated sands rapidly (2-20 cm per hour), but very slowly through clay (< 0.2 cm per hour) (Kohnke 1968:31). A higher bulk density (e.g., compacted clay) results in a slower percolation rate. Muck (combination of organic matter and fine mineral particles) accumulations at the bottom of ponds slow the percolation rate because these materials fill the larger cracks and pore spaces and they form a dense mat covering the underlying mineral surface. The slower the rate of water movement through the wetland system, the more likely there is for muck to accumulate. Water loss from percolation through a muck-covered pond bottom overlying a saturated clay substrate is likely to approach zero. Conversely, water loss from percolation through a sand-gravel bottom overlying a relatively thick gravel-sand substrate may be on the order of 2-3 m per day until the substrate becomes saturated.

Evaporation includes the loss of water to the atmosphere from a free-water surface and from the upper layers of the soil. The rate of evaporation depends on the amount of energy available at the water surface. Therefore, rates are lower in winter and on cloudy days and higher in summer and on sunny days. Rates are also influenced by the relative humidity at the evaporating surface, therefore rates increase as wind speed increases because the wind reduces the thickness of the water vapor layer (increasing the gradient) between the water and the atmosphere (boundary layer effect). Examples of evaporation rates from free-water surfaces in Nevada and Arizona are presented in Table E-2.

Table E-2. Evaporation rates (cm per month) from free-water surfaces at Winnemucca, Nevada and Yuma, Arizona (data from Grosz 1972 and McDonald and Hughes 1968).

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Nevada	na	na	na	13.8	22.1	22.5	29.6	26.3	19.5	10.7	na	na	
Arizona	10.4	14.5	19.9	27.2	37.4	36.6	37.5	33.5	26.6	17.9	11.4	9.4	282.3

Nevada data are 5-year averages (1968-72).
Arizona data are 4-year averages (1963-66).

Evaporation of soil water occurs only from the surface layer of the soil (Foth and Turk 1972:88), generally to a depth of 20 to 50 cm (Daubenmire 1967:114; Sorenson et al. 1991:13; Dawson 1993:469; Zencich et al. 2002:11). For soil water below the surface layer to be evaporated, it must first be moved to the upper layer, most commonly by capillarity or hydraulic redistribution. On vegetated sites, capillarity is not an effective means for moving soil water to the surface layer when the plants are active because the water must first pass through the root zone. Roots take up water faster than water can move through the root zone by capillarity (1-5 mm per day). Coarse-textured soils have particularly low evaporation losses because these soils have too little capillary lift to supply the surface with water (Kohnke 1968:35). This does not suggest that soil water loss through evaporation is always minimal, because if most precipitation events are relatively small and therefore soil water rarely infiltrates below 30 cm, evaporation can be the primary means of soil water loss.

Transpiration is the primary means by which most soil moisture is extracted from a soil (Dobrowolski et al. 1990). In its simplest terms, transpiration is evaporation through plants. The amount of water lost by transpiration is a function of several factors, including the amount of water available to the plant roots, the relative humidity of the air around the plant canopy, air temperature, amount of solar energy striking the plant leaves, and the type and amount of vegetation. A number of these factors vary temporally, both seasonally and annually, and spatially across the landscape. Consequently, transpiration rates vary substantially both temporally and spatially. Transpiration is typically low during the cool season, under relatively dry conditions, and when vegetation is sparse, and high during the warm season, when water is abundant, and when vegetation is dense.

The term evapotranspiration (ET) is often used to include both evaporation and transpiration losses from an ecosystem. Typical ET values in arid ecosystems can vary considerably, even for the same type of vegetation (Table E-3). In arid and semiarid systems where groundwater is not available to the vegetation, ET often approximately equals the amount of precipitation stored as soil moisture (Table E-4). In systems where groundwater is available to the vegetation, ET generally exceeds annual precipitation and can even exceed annual pan evaporation rates. ET can be a major source of water removal from western basins, accounting for as much as 80% of the annual water budget (Chimner and Cooper 2004).

Table E-3. Examples of annual evapotranspiration (ET) reported for vegetation in groundwater-influenced arid ecosystems.

Vegetation	Location	ET (cm)	Reference
Cattail	S Arizona	262	McDonald and Hughes 1968
Sedge	S Wisconsin	72	Lott and Hunt 2001
Baltic rush	E Nevada	73	Miller et al. 1982
Baltic rush-saltgrass	Nevada	93	Laczniak et al. 1999
Meadow-grassland	C Nevada	68	Welch et al. 2007
Saltgrass	E Nevada	68	Miller et al. 1982
Saltgrass	N Nevada	51	Grosz 1972
Saltgrass-sacaton[1]	E California	107	Duell 1990
Saltgrass-sacaton[1]	E California	85	LADWP/ICWD 1986
Saltgrass-sacaton[2]	E California	15	LADWP/ICWD 1986
Saltgrass-sacaton[2]	E California	63	Duell 1990
Sacaton	E California	83	Duell 1990
Sacaton	S Arizona	27	Scott et al. 2000
Greasewood	E Nevada	10	Miller et al. 1982
Greasewood	C Nevada	24	Nichols 1994
Greasewood	C Nevada	30	Welch et al. 2007
Greasewood	N Nevada	41	Grosz 1972
Greasewood-shadscale	E Nevada	28	Miller et al. 1982
Greasewood-saltgrass	E California	39	Duell 1990
Rabbitbrush	N Nevada	48	Grosz 1972
Rabbitbrush-greasewood	E Nevada	28	Miller et al. 1982
Rabbitbrush-saltgrass	E Nevada	28	Miller et al. 1982
Rabbitbrush-saltgrass	E California	33	LADWP/ICWD 1986
Rabbitbrush-saltgrass	E California	47	Duell 1990
Rabbitbrush-sacaton	E California	61	Duell 1990
Rabbitbrush-sagebrush	E Nevada	22	Miller et al. 1982
Rabbitbrush-wildrye	E Nevada	35	Miller et al. 1982
Nevada saltbush-sacaton	E California	82	Duell 1990
Cottonwood	S California	122	Lines 1999
Willow dense woodland	S California	127	Lines 1999

[1] Depth to groundwater = 0.6 m
[2] Depth to groundwater = 2.6 m

Table E-4. Examples of annual evapotranspiration (ET) reported for vegetation in arid ecosystems dependent on precipitation (PPT) only.

Vegetation	Location	ET (cm)	PPT (cm)	Reference
Big sagebrush	E Nevada	30	30	Miller et al. 1982
Big sagebrush-wheatgrass	SE Washington	15	36	Cline et al. 1977
Big sagebrush-bluegrass	SW Idaho	36		Flerchinger 1996
Big sagebrush-rabbitbrush	NW Nevada	6	15	Obrist et al. 2003
Low sagebrush	SW Idaho	27	35	Wight et al. 1986
Saltbush	W Utah	20		Evans et al. 1981
Shadscale	E Nevada	12	30	Miller et al. 1982
Winterfat	E Nevada	15	30	Miller et al. 1982
Cheatgrass	NW Nevada	8	15	Obrist et al. 2003
Cheatgrass	SE Washington	11	16	Hinds 1975
Cheatgrass	SE Washington	8	31	Cline et al. 1977

E.3.1.3 WATER BALANCE

The primary factor affecting the integrity of wet ecosystems in arid and semiarid regions is their water balance. This is determined by subtracting the total water loss (export, outflow, percolation, evaporation, and transpiration) from the total water input (groundwater flowing to the surface, subsurface groundwater, precipitation, and surface flow) plus the storage water:

$$\text{net change} = (\text{storage water} + \text{water input}) - \text{water loss}.$$

Water balances are commonly calculated on an annual basis, but seasonal (and shorter-term) balances are also important ecologically.

Most often, inputs do not equal losses at all time steps. Over multiple time steps (e.g., several years), the system may be in approximate equilibrium, but this is rarely the case over shorter periods of time and may not be the case over longer periods of time. Losses to ET, for example, are strongly season-dependent. Rates are low in the winter and high in the summer. Inputs from precipitation (Fig. E-3) and overland flow may also be strongly seasonal, with high inputs during spring and inputs progressively decreasing through summer and autumn (Smith et al. 1991). Depth to groundwater in native meadows in Nevada can fluctuate by 70-80 cm during a single growing season (Miller et al. 1982, Martin and Chambers 2001). Flow rates from springs and seeps may be seasonal because of changes in hydrologic heads resulting from seasonal dynamics of snowmelt into the supplying aquifer.

E.3.1.4 WATER QUALITY

The quantity of water supplied to aquatic ecosystems is not the only important factor influencing their integrity. Water quality is also important. There are numerous water quality variables, both chemical and physical, that are important. These include temperature, dissolved oxygen (DO) content, pH, salinity, turbidity, and nutrient concentrations (especially of nitrogen and phosphorus). Water quality, like water quantity, varies both temporally (seasonally and annually) and spatially (horizontally and vertically). Diurnal cycles can also be important from a water quality standpoint. Animal and plant species have ranges for optimal and tolerance conditions to extremes in water quality.

Changes in water quality variables are driven by both abiotic and biotic factors. Air temperature affects water temperature and water temperature can affect DO levels. Flow rates may vary seasonally and flow rates can affect water quality altering the amount of water in the system, and therefore affecting dilution, concentration, and physical removal (flushing) of particles from the wetland system. At low flows for example, concentrations of some components may increase. Surface flow of runoff water following snowmelt or heavy rains can input large quantities of sediments into the wetland (Belnap et al. 2005), thereby increasing turbidity, salinity, and nutrient concentrations. Water movement, either laterally (flow) or vertically (temperature gradients), increases DO content. Conversely, DO content decreases as water stagnates.

Biotic factors also influence water quality. As vegetation increases, there is an increase in vegetation structure. Vegetation structure functions as a filter causing suspended materials to come out of suspension as the water moves over and around the vegetation and the particles drop to the bottom of the water column because of a decrease in water velocity. An increase in vegetation also decreases the depth of light penetration, increases the amount of organic matter entering the system, and alters habitat heterogeneity for aquatic organisms. There are a number of abiotic-biotic feedback mechanisms that become important. Increased nutrient inputs into the wetland may result in an increase in plant productivity which may result in an increase in sediment loading and a decrease in water depth. The increase in organic matter and decrease in water depth may result in an increase in water temperature and detritus decomposition rate, which results in an increase in available nutrient content in the sediments.

E.3.2 CLIMATE CHANGE

Climate, in particular precipitation and temperature, is a primary factor affecting ecosystem composition, structure, function, and dynamics. These attributes which define an ecosystem are not static, but vary somewhat as factors that control their responses fluctuate. The amount of variation in each attribute is a characteristic of the ecosystem, as is its tolerance to the amount of variation in each controlling factor such as climate. As long as the variation in the controlling factor remains within its tolerance limits, the attributes of the ecosystem remain within their characteristic ranges. When the variation in a controlling factor exceeds the tolerance limit of the ecosystem, major shifts occur in the ecosystem attributes.

Climate is not static; it changes over time. Short-term changes are part of the pattern that defines the climate of a region. These short-term changes include diurnal and seasonal changes, and they fluctuate to various degrees. Some days are warmer or colder than others within the same season, and some years are colder or warmer or wetter or drier than others. In general, ecosystems are adapted to these short-term fluctuations, although extremes in precipitation and temperature (e.g., drought, long periods of cool wet weather, unseasonable or extremely hard freezes in warmer climates) can cause major stress resulting in at least short-term changes in ecosystem attributes.

In addition to these inherent short-term climatic fluctuations, major shifts in climatic patterns also occur. These major shifts have potentially extreme effects on ecosystem characteristics, in some cases altering the ecosystems such that their attributes change sufficiently to result in shifts to different ecosystems. Major shifts in climatic patterns are what constitute the subject of climate change.

Climatic patterns in many regions, including the Great Basin, may be relatively stable for periods on the order of centuries, and then relatively rapidly (e.g., decades) change sufficiently to cause major changes in the ecosystems of the region. The distinction between climate change and fluctuations within a relatively stable climatic pattern may be difficult to determine at the time it is occurring, except when comparing recent conditions to long-term patterns. Droughts are good examples of this challenge.

A drought is a prolonged period (generally multi-year) of substantially below average precipitation. While occasional droughts are common in the western United States, climate change would be indicated by a long-term decrease in annual precipitation. Many parts of the western United States have been in drought at least since about 2000, and this drought has been severe in some regions. For example, for the Upper Colorado River Basin the current drought is the most severe drought observed from 1923 to present, but it is only about the tenth most severe in the past 500 years based on reconstructed precipitation patterns (Timilsena et al. 2007).

For the drought to indicate a shift in climate (i.e., climate change), there must be a corresponding shift in long-term precipitation patterns. Long-term precipitation data (110 years or more) from 12 locations in the inter-mountain and southwestern United States show decadal fluctuations in mean annual precipitation, and data from eight of the 12 locations indicate an increase in precipitation over the past 50 years. Data from the remaining four locations do not indicate either an increase or decrease (Section E.2.1). This mixed pattern of an increase in precipitation at some locations and no net change at others is consistent with current projections of precipitation response to climate change in this region (Brown and Thorpe 2008a).

Data from a variety of sources (e.g., tree rings, pollen records, rat middens, isotope ratios, and ice core layer thicknesses) have provided a substantial amount of information from which past climate change patterns have been identified. From these data, it is clear that major climatic shifts have occurred repeatedly in temperate regions since the end of the last Ice Age. These long-term shifts have been a major factor defining the ecosystems and their changes in the Great Basin Region (Tausch et al. 2004), as well as many other parts of the world, and recognition of these effects is fundamental to understanding long-term dynamics of these ecosystems. For example, the Great Basin Region, as well as much of the rest of the western United States, underwent a 2000-year period of increasing aridity beginning about 2,600 years ago, during which woodlands in the Great Basin Region declined and shrubs such as greasewood increased (Tausch et al. 2004). Then about 650 years ago a period known as the Little Ice Age began and conditions became wetter and cooler. Pinyon-juniper woodlands, grasslands, and wetlands increased in extent. Vegetation patterns were very different during this period compared to vegetation patterns that currently exist, especially in relation to pinyon-juniper and sagebrush types (Tausch et al. 2004). The Little Ice Age conditions lasted until about 150 years ago, and then the climate shifted again, with aridity again increasing.

There is no basis to believe that these types of climatic change that have occurred in the past are no longer occurring. What is less clear, however, is how these typical climate change patterns may be affected by industrial-age human activities. Regardless of the cause, we are in a period of global climate change. Temperatures in some areas are warming and precipitation patterns in many regions may be shifting. Of equal ecological importance may be the facts that 1) the variability in both temperature and precipitation is increasing in many regions (Chambers and Pellant 2008) and 2) combinations of changes in temperature and precipitation likely cause nonlinear responses in ecosystems (Ibanez et al. 2007, Zhou et al. 2008). These changes are likely to have significant impacts on ecosystems in many regions of the world, including the IBMA. It is important to understand that these changes are taking place and to attempt to determine what effects the changes may have on the ecosystems of the IBMA. Failure to do so will result in 1) under-estimating the amount of ecological stress the ecosystems are being subjected to and 2) improperly attributing impacts of land management practices, including groundwater withdrawal.

Precipitation is a major source of water to the ecosystems of the IBMA (Section E.2.1). This is true for both direct input of precipitation to the ecosystems and as the source of groundwater recharge, originating as precipitation received in the adjacent mountains. Any significant change in precipitation, either annually or seasonally, will likely result in significant changes to the ecosystems of the IBMA. Recent projections of climate change impacts in the southern and central Great Basin region include an increase in winter precipitation, with either no increase or a decrease in summer precipitation (Brown and Thorpe 2008a; Chambers and Pellant 2008). Changes in seasonal patterns of precipitation, with or without changes in annual amount, may alter the composition of plant communities in the Great Basin (Gebauer et al. 2002; Schwinning et al. 2005; West et al. 2008). Increases in winter precipitation over a 30-year period have been associated with major shifts in abundance of both plant and animal species in the Chihuahuan Desert (Brown et al. 1997).

Precipitation patterns in the Mojave Desert region are strongly influenced by global-climate fluctuations of sea-surface temperature and atmospheric pressure operating on two time scales, one defined by the Southern Oscillation and the other by the Pacific Decadal Oscillation (Hereford and Webb 2001). Hydrologic variability in the western United States, based on tree-ring data over the past 500 years, is strongly correlated with climate variations from both the Pacific [Pacific Decadal Oscillation (PDO)] and Atlantic [Atlantic Multidecadal Oscillation (AMO)] Oceans (Hidalgo 2004). Both the PDO and the AMO are strongly influenced by variations in their respective sea surface temperatures. These sea surface temperatures exhibit both short-term (ca. 10 years) and long-term variations (500-1000 years). A 3,000-year reconstructed surface temperature record has been constructed for the Sargasso Sea in the Atlantic Ocean (Keigwin 1996). Based on those data, temperatures (50-year average) were about 2^{o} C above present levels 2,600 years ago and then decreased by 3.5^{o} C over a period of 800 years, increased by 2.5^{o} C over the next 800 years (ca. AD 1000), and then decreased during the Little Ice Age by 2^{o} C (ca. AD 1600). Since the Little Ice Age minimum, temperatures have increased by about 1.3^{o} C over the past 400 years. The "mega-drought" that took place in the southwestern United States around 1600 (Hidalgo 2004; Timilsena et al. 2007) occurred about the same time as the Little Ice Age minimum temperatures. In general, the period AD 1500-

1900 was much drier in the southwestern United States than the last 100 years, the last 100 years being much wetter than the long-term average (Timilsena et al. 2007).

The ecological impacts of climate change may be even more affected by changes in temperature than in changes in precipitation. Temperatures in the Great Basin may increase by 1-3^{o} C by 2050, with increases occurring in both summer and winter (Brown and Thorpe 2008a). This is about twice the average temperature rise that the region experienced over the last 100 years (Chambers and Pellant 2008). In comparison, average surface temperature throughout the Northern Hemisphere decreased by about 1.1^{o} C between AD 1000 and 1400 (Zielinski et al. 1994). The postulated shift in temperatures over the next 40 years will therefore be greater than what has occurred during the last two millennia and will occur much more rapidly.

Temperature affects ecosystems in numerous ways, but three are of primary importance in the IBMA. First, temperature, along with photoperiod, affects the length of the growing season. Higher temperatures are likely to result in longer growing seasons for plants and longer activity periods for animals. Longer growing periods are likely to result in higher primary productivity, provided that other resources do not become more limiting. A longer growing season will result in higher water use by the plant communities, provided adequate water is available. If adequate water is not available, the longer growing season is likely to increase water stress on those plant communities that are not drought-tolerant. Therefore, ecologically there is a strong feedback linkage between temperature and water.

Increased temperature may also affect the plant communities through changes in competitive advantage of the various plant species. A primary way in which may occur is through the photosynthetic pathway. There are three major photosynthetic pathways in plants: C_3, C_4, and CAM. The CAM pathway is most common in succulents. Most of the species in the IBMA utilize either the C_3 or C_4 pathways, with some dominant species using the C_3 pathway (e.g., greasewood, rabbitbrush, big sagebrush, winterfat, wildrye, Baltic rush, spikerush, most sedges) while others use the C_4 pathway (e.g., saltbushes, alkali sacaton, saltgrass). In relation to temperature and water-use efficiency, C_3 species generally have a competitive advantage at lower temperatures and C_4 species at higher temperatures. Therefore, as temperature regime changes, the competitive relationship among many of the plant species in the IBMA will change. If the temperature change is sufficiently large, C_4 species currently in the IBMA may increase and C_3 species may decrease, and C_4 species currently occurring to the south of the IBMA, such as creosotebush (*Larrea tridentata*) may establish in the IBMA. And because the animal communities are dependent on the plant communities, there will likely be a change in animal communities also, in addition to any direct impacts on the animal species from the change in temperature regime.

The third primary way in which a change in temperature regime is likely to affect the ecosystems in the IBMA is through evapotranspiration (ET). As temperature increases, ET increases. If adequate water is present to the plants, the net result will be an increase in water loss to the atmosphere (Sections E.2.2 and E.2.3). This will mean that less water will be available for other uses, including both intra-IBMA water diversions and groundwater withdrawal, or there will be increased stress to the ecosystems. If adequate water is not present, because less precipitation is being received or because of intra- or inter-IBMA water export, the ecosystems will undergo increased water stress.

Climate change is occurring and will likely continue to occur in the near future. Although there is a great amount of uncertainty associated with what the ecological effects of climate change on specific ecosystems will be (Ibanez et al. 2007, Brown and Thorpe 2008a, West et al. 2008), and the effects may not be what might be expected (Adler and HilleRisLambers 2008, Zhou et al. 2008), there will be effects. The combination of long-term directional shifts, increased short-term variability, and expected and unexpected interactions among factors may change the fundamental properties of many ecosystems (Brown and Thorpe 2008b). These changes will likely alter at least some of the attributes of the groundwater-dependent ecosystems in the IBMA, although which attributes and how much are currently unknown. In order to determine attributability of possible impacts from groundwater withdrawal, it will be imperative that the effects of climate change, to whatever degree they occur, be understood. It is possible that these climate change effects, both naturally caused and anthropogenic, may be so substantial that management concepts based on historical range of variability, natural range of variability, and ecological sustainability may no longer be adequate (Millar et al. 2007).

E.3.3 PLANT COMMUNITIES

On a very broad scale, plant dynamics can be modeled as a function of maximum potential growth rate, modified by resource supply and stress tolerance. Each species has a maximum potential growth rate. This is the rate at which growth can occur under optimum conditions. However, optimum conditions are rarely encountered in nature. Actual conditions tend to be less than optimum because of limitations in supply of some resource or because of the effect of one or more stress factors.

Plants have requirements for many types of resources. Some resources are required in relatively large amounts and some in only minor amounts, and some resources tend to become limiting to plant growth more often than others. Plants are also subject to numerous stressors and some of these are of sufficient intensity to limit plant growth within the IBMA. Some of the more common limiting resources and stressors are discussed in the following two subsections. These resources and stressors are major factors controlling the dynamics of the ecosystems being monitored in the IBMA. It will be important to understand their role as control factors in order to properly attribute the potential effects of groundwater withdrawal on the changes that may occur in these ecosystems over time.

E.3.3.1 Resource Requirements

Plants have both optimum and tolerance levels for various resources. Tolerance levels can be maximum levels, minimum levels, or both. These are the minimum levels that a species requires or the maximum level it can tolerate before adverse effects are manifested in the plant. Whereas optimum levels are generally related to maximum potential performance (e.g., growth rate), tolerance levels are generally associated with maintenance levels. Maintenance levels are those levels of resources that the plant requires to maintain a minimum level of physiological function.

Resource-use efficiency of many resources varies by the relative abundance of that resource to the plant. It is the amount of a resource used by the plant to produce one unit of the measured plant response (e.g., biomass produced, photosynthetic rate). For some resources (e.g., nitrogen and water), use-efficiency decreases as the supply of the resource increases. This is sometimes referred to as luxury consumption. The efficiency at which a plant utilizes a particular resource may also be affected by the supply of another resource. For example, some species are more water-efficient when adequate levels of nitrogen are available to the plant than when nitrogen supply is low.

Resource-use efficiency is not synonymous with productivity. A plant may be very efficient in utilizing a resource, especially when the resource is in short supply, but the resource may be in such short supply that the overall production level is low. This frequently occurs in arid regions in relation to water availability. Many species adapted to arid conditions have higher water-use efficiencies at low moisture levels than at high levels. For example, precipitation-use efficiency (% canopy cover per 1 cm precipitation) in rabbitbrush (*Chrysothamnus nauseosus*) communities in the Owens Valley of California is twice as high when annual precipitation is less than 10 cm than when precipitation is greater than 20 cm per year (1.46 and 0.75, respectively; McLendon et al. 2008a). While water-use efficiency is higher at low moisture levels, productivity is still lower. At 6 cm of precipitation the rabbitbrush community in the Owens Valley would have 8.8% canopy cover, compared to 18.8% cover at 25 cm.

Plants require a large number of resources. Those most commonly limiting to growth include water, nutrients, energy, and space. Oxygen in the rooting zone is another important resource potentially limiting plant performance in wet environments or in very dense soils.

Water is required for metabolic processes within the plant, maintenance of turgor, transport of nutrients and photosynthates, and transpiration. The amount of water required varies by species and by environmental conditions. Water-use efficiency varies more than 10-fold among plant species found in the Great Basin and growing under various conditions. Most species adapted to wet environments can not tolerate dry conditions for any extended period (days to weeks). In contrast, upland species are adapted to conditions where the soil is relatively dry most of the time, with moisture becoming available only for limited periods following rainfall or snowmelt. Between these two extremes are species that inhabit sites that form a moisture gradient from moist most of the year to dry most of the year. Some of the species of these intermediate habitats can tolerate wet conditions for extended periods, but can also tolerate dry conditions for shorter periods. Other species can tolerate moist conditions, but not wet (saturated) conditions. Species of the intermediate habitats require higher moisture levels than the upland species, at least to achieve moderate growth levels. This additional moisture is supplied by surface runoff, subsurface drainage, or groundwater. Various root architectures, tolerances to soil moisture levels, and preferential use of precipitation- and groundwater-derived moisture contribute to the relative competitive success among these species.

Plants require nutrients for production of new tissue and for various physiological processes. Nitrogen is a nutrient often found in low amounts in arid soils. It is supplied primarily in precipitation, by decomposition and mineralization of organic matter, by transport in surface and subsurface flows of water from adjacent communities, and by microbial fixation in the soil and in roots of some plants. Groundwater may be lower in nitrogen content than is precipitation, and consequently nitrogen may be more limited in systems that are largely dependent on groundwater than systems receiving most of their water from surface flow or precipitation. A number of water-limited arid and semiarid ecosystems may also be nitrogen-limited as evidenced by increases in plant productivity when nitrogen is applied in the absence of additional moisture (Fisher et al. 1988; McLendon and Redente 1991; Paschke et al. 2000; McLendon et al. 2001).

Low nutrient levels are important in determining the dynamics of plant communities but high nutrient levels can also be ecologically important. As levels of plant-available nitrogen and phosphorus increase in soil or water, productivity of the associated plant communities tends to increase. However, this productivity increase is not uniform among plant species. Species adapted to conditions where resources are limited, or where stress levels are high, tend to be relatively slow-growing. Conversely, species adapted to conditions of high-resource availability tend to be relatively fast-growing. Under conditions of resource limitation, including nutrients, the slower-growing species tend to dominate a site because they tend to be more efficient users of the limited resources, have more internal storage capacity for the resources, and have more symbiotic relationships with other species (McLendon and Redente 1994). As resources become more available, faster-growing species can more readily achieve their high growth potential. As these species grow, they also utilize larger quantities of other resources, thus depleting supplies to the slower-growing species. Competitive advantage then shifts to the faster-growing species, they begin to dominate, and abundance of the slower-growing species decreases.

In aquatic ecosystems, high nitrogen loads can lead to high production of aquatic plants and algal blooms. High plant productivity can decrease light penetration into the water column, increase the amount of decaying organic matter, and decrease the oxygen content of the aquatic system. In terrestrial ecosystems, increased nitrogen availability can increase the amount of early-successional species, especially annuals, and decrease the productivity of late-successional species.

The energy source for most plants is sunlight. Light is generally not a limiting factor in most arid and semiarid regions, but it can be in two general cases. The first case is in aquatic systems. Light penetration decreases in the water column as depth of water increases, plant coverage increases, and turbidity increases. As the plant communities increase in structure, productivity, and spatial extent, more of the water column and more of the water surface is covered by leaves. This decreases the amount of light filtering into the lower layers of the water column, which alters both the biological and the temperature regimes of these lower levels. Turbidity (water opacity due to particle suspension) can increase because of increases in sediment transport into the wetland, increased productivity of the plant community, and increased activity of the animal communities (both aquatic and terrestrial).

The second case where light intensity can be important in arid ecosystems is shading. As the upper canopy increases in coverage and density, less light penetrates to the lower levels. This can affect the temperature and moisture regimes of the lower levels (especially the soil surface) and the growth of understory species. Soil microbial processes are important in the proper functioning of arid as well as more mesic ecosystems. Soil microbial processes are influenced by soil temperature and soil moisture, especially in the surface soil layer. Seed germination in many species is also affected by the temperature and moisture content of the surface soil and by adequate light intensity. Dense meadows are one example where shading probably has a significant influence on community dynamics. Shrub islands are another example. Juniper, sagebrush, and rabbitbrush communities in the Great Basin often accumulate litter beneath the canopies of the mature trees and shrubs. Soil temperatures are lower and moisture content is higher under the canopies than in the adjacent open spaces. Productivity and composition of both the plant and microbial communities are very different beneath the canopies than in the open spaces (Rickard et al. 1973; Dobowolski et al. 1990; Comstock and Ehleringer 1992; Smith et al. 1994; McLendon 2001). The altered light, moisture, and nutrient regimes characteristic of the organic matter accumulations under the shrubs can also affect establishment patterns of associated species (Owens et al. 1995). Much of the diversity in the mid- and late-successional communities is associated with these sub-canopy micro-communities.

Space is a resource in the sense that it is required by plants. If a site is occupied by a plant, it is unavailable to another plant unless the other plant can either displace the first plant or grow under, on, or above the first plant. Therefore to properly understand spatial heterogeneity and spatial dynamics in plant communities, especially in arid ecosystems, both aboveground and belowground volumes should be considered.

E.3.3.2 Stressors

Ecological stress refers to the condition where the ecological or physiological condition of the organism or system is less than its potential because the supply of at least one essential resource is below or above its optimum level. Most species and most ecosystems are under stress most, if not all, of the time. Indeed, plants in natural environments are subject to multiple stresses and conditions that reduce their potential growth (Mooney et al. 1991:xiii). These are the conditions under which these plant communities developed and continue to exist. The distribution patterns of species across the landscape are the result of the interaction of differences in the environmental tolerances of the various species and the heterogeneity of the environment (Daubenmire 1968:3).

Soil moisture is the most important stressor, as it relates to distribution and productivity of plant communities throughout the Great Basin (Comstock and Ehleringer 1992), including the IBMA, and most arid and semiarid regions in general (Brown et al. 1997). Both extremes of soil moisture are important: abundance and deficit. Wetland communities exist because of saturated soils and standing water. Oxygen content is limited in saturated soils, and most terrestrial species can not tolerate saturated soils. To upland species, the abundant water supply found in wetlands is an ecological stress that exceeds their tolerance levels. The species that do dominate these wet sites can tolerate saturated soils. Within the wetland systems, there is a spatial distribution of species based primarily on their tolerance to depth of water. The peripheral species, such as Baltic rush and saltgrass, can tolerate saturated soils for long periods, but can not tolerate long-term submergence of their leaves and stems. The next zone contains species that can tolerate continuously saturated soil but can not tolerate submergence. The difference between these species and those that dominate the Baltic rush-saltgrass periphery is that these species can grow taller, hence they can tolerate deeper water than can Baltic rush and saltgrass. As depth of water increases to the point that these taller species would be submerged most of the time, a zone may occur that is dominated by species that are rooted in the substrate, but that can tolerate continual submergence. These species can dominate as long as sufficient light and carbon dioxide reaches their stems and leaves. The next zone is dominated by free-floating species. Low light intensity and the inability to take up carbon dioxide become the primary stress factors causing the shift from emergent species to submerged, rooted species and the free-floating species.

Low soil moisture is the opposite stressor. Species on these sites either avoid or tolerate dry periods. Plant species may tolerate low moisture conditions by reducing transpiration or by becoming dormant. A common means of reducing transpiration is a reduction in leaf area.

Some species have roots in contact with groundwater or its capillary fringe. These species can utilize this source of water when the moisture in the upper soil horizon is depleted. In some cases, groundwater usage increases, thereby replacing the soil moisture that is no longer available (Schwinning et al. 2002). In other cases, the species continue to use the same amount of groundwater they used when also using soil moisture. When this happens, the groundwater is used for maintenance and growth slows or stops until new precipitation-derived moisture becomes available.

Low nutrient availability is a common stressor in many ecosystems. This is especially true for nitrogen availability. Low nitrogen availability favors species with lower tissue nitrogen concentrations, greater internal retention of nitrogen, slower growth rates, and increased symbiotic relationships (e.g., nitrogen-fixing bacteria). These characteristics are more common in late-successional species than in early-successional species. Low nitrogen availability is a major factor causing secondary succession, late successional species tending to be better stress-tolerators than are early-successional species (McLendon and Redente 1992).

Temperature is an important factor influencing plant distributions and dynamics. Both high and low temperatures are important ecologically. High temperatures increase water usage and can adversely affect physiological processes in plants. Low temperatures also affect plants through water relations and physiological processes. Initiation of growth and growth rate are temperature dependent in many species. In other species, initiation of growth is dependent on photoperiod. In both cases, changes in temperature regime (e.g., later freezes, earlier spring warm-up) can affect the plants either positively or negatively. Species that begin growth earlier in the spring than their associated species may have greater access to soil moisture resulting from snow melt and spring rains, but may also be more vulnerable to late freezes. A longer growing season may also favor slower-growing species more than faster-growing species, but may also increase annual water requirements.

Wind is a climatic factor that affects plants primarily through moisture relations. As wind speed increases, the thickness of the humidity gradient between the stomates and the atmosphere decreases. This increases the transpiration rate of the plants, resulting in greater water usage. If the plant continues to transpire and water supply can not keep up with water loss, tissue desiccation can occur.

Fire is another common stressor in arid and semiarid regions. The effect of fire is greater on species that have large proportions of their perennial biomass and their tissues from which new growth occurs aboveground. These include most woody plants. Grasses have most of their perennial tissue and most of their growing points near or below ground. Therefore, grasses tend to be more tolerant of fire than are shrubs and trees. Over the past 100 years or so, fire has not been a major ecological factor in the IBMA. However, the importance of fire may increase in the future as a result of climate change and possible alterations of land management practices. Some projections are that fire frequency and extent are likely to increase in shrublands and lower elevation woodlands in the Great Basin if climate changes in the anticipated manner (Chambers and Pellant 2008).

Herbivory is a selective stressor, both in relation to plant species and to plant parts. Most herbivores, native or domestic, are at least somewhat selective in the plants that they consume. Cattle, horses, and elk tend to be primarily grass-eaters. Sheep and deer prefer forbs, but also browse heavily on many species of shrubs and, for sheep especially, grasses. Herbivory stresses those plants which are eaten but not those that are not. Therefore, under heavy herbivory, preferred species tend to decrease in abundance and non-preferred species tend to increase. At low levels of herbivory and when the plants are not overly stressed by other factors (such as drought or fire), grazed plants may increase in vigor compared to ungrazed plants.

The effects of changes in water regime on plant dynamics in the IBMA can not be taken in isolation. Water balance is a major factor, probably the primary factor, influencing plant community dynamics in the area. But it is not the only factor. Without considering potential effects of these other factors, incorrect assumptions may be made relative to the potential impacts of change in water regime.

E.3.4 ANIMAL COMMUNITIES

Animal population dynamics are ordinarily based on extent and quality of suitable habitats. In arid lands, habitats are distinguished primarily by the species composition of the plant community, whether in aquatic, semi-aquatic, or terrestrial systems. Plants provide much of the physical structure of the habitat (e.g., nesting sites and materials, perching sites, and physical cover), food for herbivores, habitat for prey, and drinking water for some but not all animal species.

Areas with extremes in physical conditions, such as the aridity of most parts of the Great Basin, tend to have both low total productivity and lower species diversity in both plants and animals.

Lower total primary productivity necessarily limits total secondary production in animal populations. This effectively excludes many animal species for which there is not enough food to support viable populations. Fewer plant species available means fewer options for herbivorous animals and therefore lower herbivore abundance and species richness. Fewer herbivores also means fewer predators to prey upon them. Low total productivity and diversity implies that the loss or gain of single plant or animal species can have a disproportionate effect on community composition and ecosystem dynamics.

Because water-associated communities such as streams, riparian corridors, wetlands, and meadows are uniquely productive and rich in potential habitats in the Great Basin Desert, they play a disproportionately important role in providing suitable habitat for animal species. Because these systems are so limited in spatial extent, animal species that are dependent on them are similarly constrained in their numbers and distribution. Wetland ecosystems in the IBMA provide habitat for aquatic plants and animals, a water source for terrestrial animals, and a source of food and cover for amphibians, birds, and mammals. Some of these aquatic habitats in the IBMA host endemic fishes and macroinvertebrates.

E.3.4.1 Resource Requirements

Relatively low productivity in arid regions results in food being an especially limiting resource for most animal species. Although some ecosystems such as permanent ponds, streams, and wetlands may be highly productive, these systems are very limited in spatial extent and often quite isolated. All resources must be sufficient not just for survival of individuals, but also to provide for a breeding population and for reproduction and rearing of young. This applies obviously to food supplies, whether plant materials such as leaves or seeds for herbivores, as well as to animal prey for predators.

There are a wide range of strategies adapted by animals for survival in areas with relatively low primary productivity such as the Great Basin. Animal species that are present and active year-round must be both hardy and flexible to deal with seasonal fluctuations in food, water, and cover availability. Other species are only seasonally active, usually during the plant growing season, and at other times of the year will hibernate (e.g., some rodents), estivate (e.g., many amphibians), or enter diapause in egg, larval, or juvenile stages (most insects).

Some animal species migrate seasonally to take advantage of seasonally-available resources. These would include many bird species present during the growing season, but also some species such as elk that descend from higher to lower elevations for winter grazing. All habitats utilized by migrants are potentially limiting to their population dynamics, especially in regard to successfully rearing young and obtaining winter forage. Although migrants may ordinarily make good use of special resource opportunities for each habitat they inhabit during the year, they are also sensitive to the vagaries in all of the habitats they utilize.

Although some animal species require drinking water in all seasons, and others can take advantage of it when available, many species in arid lands do not require drinking water. These species instead can efficiently metabolize the water content of their food as their sole water source. These adaptations are most evident in species with limited mobility or small size, such as insects and spiders, reptiles, and rodents. Those species that require drinking water are for the most part either highly mobile (e.g., birds and large mammals) or restricted in distribution to be near water-associated ecosystems such as streams and wetlands. Still other species only require water during certain life stages, especially for reproduction (e.g., amphibians and some reptiles) and early life stages (e.g., many aquatic insects).

Cover is important for all animal species in temperate or colder climates. Shelter must be adequate for protection from temperature extremes, inclement weather, and predators during the entire time the animals are present, even during inactive periods such as hibernation. Although animals such as birds and some mammals utilize available woody plants for cover, specific shrub and tree species are often well-spaced individually and limited in distribution across the landscape. Access to cover is also commonly restricted by territorial behavior, especially in birds and mammals.

In many areas of the Great Basin, burrowing is a common strategy for cover among all animal types, including all vertebrates and invertebrates, and in terrestrial and aquatic ecosystems. However, not all areas are suitable for burrowing as a viable cover strategy. Burrowing requires suitable subsurface materials for digging and structural integrity. While rocky substrates may have cracks and crevices that must be utilized "as is", many sandy soils are too friable to maintain the burrow shape, or too susceptible to collapse during precipitation events. Burrows are often highly visible with low vegetation cover, and therefore susceptible to discovery by predators, especially where there is a higher density of burrows in desirable substrates. Temporary burrowing is a different type of burrowing activity that is commonly practiced by some species. In these cases, the animals burrow into friable soil to escape harsh environmental conditions or predators.

The aquatic biota of the groundwater-influenced ecosystems are regulated by chemical, biological, and morphological characteristics (van der Kamp 1995). From a chemical standpoint, water temperature, dissolved oxygen, conductivity, pH, carbon dioxide, and other components influence the biological communities in these systems. These communities typically have a spatial component with composition changing as one progresses downstream. Spring source species do not occupy downstream habitats where temporal fluctuations in water quality or quantity are pronounced (Erman 1992) and endemic macroinvertebrates are usually more abundant near spring sources (Hershler 1998). This is very evident in springsnail populations within the IBMA (BIO-WEST 2007). Additionally, communities with permanent water sources include more species and individuals than ephemeral sources. The physical habitat of a groundwater-influenced ecosystem is another major factor affecting the aquatic flora and fauna, as well as the riparian vegetation. The quantity and consistency of water affects the aquatic vegetation and riparian zones, creating differences in available habitat structure and function.

The complex interactions of chemical and physical components on plant and animal physiology cause groundwater-influenced ecosystems in the Great Basin to be biologically distinct (Sada et al. 2001). The environmental characteristics described above shape the distribution of aquatic and riparian species along a continuum of habitat from a spring source to its terminus or expanded aquatic habitat (e.g., pond, wetland, meadow). For instance, stoneflies, caddisflies, and amphipods occur mostly in stronger currents over gravel substrate, while nematodes and many dragonflies occur where environmental fluctuation is often greater, flow velocities lower, and substrate smaller (Sada et al. 2001). Springsnails within the IBMA typically prefer flowing water over gravel substrate, with pockets of aquatic vegetation (BIO-WEST 2007).

Biological interactions also shape the aquatic communities present in these ecosystems. Food availability, life-cycle habitat requirements, predation and competition are all factors that contribute to the ecological balance. Fish within these systems typically feed on aquatic macroinvertebrates and algae. Springsnails feed on algae found on aquatic vegetation and on the substrate. Amphibians can filter suspended plant material or feed on algae or detritus during the larval stage and feed on a variety of insects, mollusks, and arachnids as adults.

Fishes, macroinvertebrates, and amphibians are groups of aquatic or semi-aquatic organisms that can be used as environmental indicators in groundwater-influenced ecosystems because they offer a signal of the biological condition of the system. Fish are good indicators of aquatic ecosystem conditions because they live in the water all their life, differ in their tolerance to amount and types of water quality and quantity changes, are easy to collect with the proper equipment, and typically live for several years. Aquatic invertebrates, also called benthic macroinvertebrates, make good indicators of aquatic ecosystem conditions because they live in the water for most of their lives, stay in areas suitable for their survival, have limited mobility, often live for more than one year, and are integrators of environmental condition. Mollusks, in particular springsnails, may prove to be excellent indicator species within the perennial springs of the IBMA. Amphibians can also serve as indicators because they inhabit aquatic ecosystems for the early stages of their life cycle and as such must frequent these systems as adults to sustain viable populations. Specific biological interactions between these potential indicator species and their aquatic and riparian habitat requirements are discussed in detail in Chapter 5.

E.3.4.2 Stressors

Stressors for most animal populations are often factors which are detrimental to availability of resources, including food, drinking water for some species, and cover (plants and physical features). Adequate resources must extend uninterrupted across the entire period of use of each habitat by each animal species. Even for those animal species that avoid seasons with low resource availability by hibernating or migrating, sufficient resources must be available during the active seasons to supply metabolic needs during the entire year. Because productivity in arid lands can be highly seasonal, often in response to seasonal precipitation, stresses during dry periods can have year-round effects on food availability for all animals.

Resources must also be consistently available and sufficient across years for short-lived species to survive and reproduce, and for many long-lived species to survive in order to later reproduce in years without such resource limitations. Animals which might be well-suited for “average” climatic and productivity years may therefore be eliminated by the occasional “bad” years. Many animal species that are adapted for surviving worst-possible conditions may not be well-adapted to taking advantage of years with high-resource availability. Therefore, the presence and abundance of most animal species may not reflect overall resource availability in the recent past.

Arid lands often have considerable variability in precipitation from year to year (Figs. E-2 and E-3), which can lead to a variety of stresses on resources for plants and animals. Water is a limiting resource for most plants in arid lands, and therefore indirectly for all animals as the base of the food chain. Water stress resulting from drought can reduce or eliminate plant productivity for herbivores, and thereby for predators feeding on these herbivores. Water stress can be induced either by reduction in total precipitation or by a shift in seasonal precipitation patterns.

Arid lands are prone to droughts extending across multiple years. Such droughts can be particularly harmful to short-lived animals as well as those higher up on the food chain. Recovery of such animal populations after severe droughts is often dependent on colonization from areas far removed from the drought area. Droughts are particularly destructive of aquatic animals. Substantial loss of water from drought or other hydrological disruption in "permanent" streams and ponds can mean loss of much of the animal community. Even loss of water for a short duration can be fatal for much of the gill-bearing animals such as fish, immature amphibians (e.g., tadpoles), and many crustaceans and insects. Because such habitats are usually very limited and isolated in arid lands, recolonization of lost species from other areas can be very difficult or impossible for some species. Even if droughts do not eliminate permanent water entirely, concentrated use of available water resources by large wild and domestic herbivores can severely damage habitats by trampling, over-grazing, and addition of excessive nutrients in urine and manure.

Surprisingly, years of good productivity resulting from better than normal precipitation can also indirectly result in less than optimal conditions for animal populations later on. Good years can result in highly successful reproduction and possible over-population in subsequent "average" years. In arid systems, too many individuals in a species can mean over-exploited and inadequate resources for all individuals. The result may be a decline in populations below average numbers.

Populations of native aquatic species in springs and streams in the western United States have, in many instances, either been reduced or extirpated as a result of aquatic invasive species (Miller et al. 1989, Hershler 1998). Because the native aquatic species in many of the western United States springs and streams evolved without severe competition and with essentially no aquatic predators, they are not equipped to sustain themselves when faced with high levels of competition or predation (Sigler and Sigler 1987). Invasive aquatic species in the western United States range from crayfish (usually *Pacifastacus lenusculus*) and red-rimmed thiara (*Thiara tuberculata*) which are some of the most commonly introduced invertebrates, to vertebrate species introduced for biological control [western mosquitofish (*Gambusia affinis*)], to aquarium fish such as goldfish (*Carassius auratus*) and mollies (*Poecilia* spp.), to species introduced for sport such as rainbow trout (*Oncorhynchus mykiss*), largemouth bass (*Micropterus salmmoides*), and bullfrogs (*Rana catesbeiana*)(Sada et al. 2001).

An increasingly important indirect stressor for animals in many arid regions in the western United States is establishment of exotic plant species such as cheatgrass (*Bromus tectorum*), halogeton (*Halogeton glomeratus*), knapweeds (*Centaurea* spp.), saltcedar (*Tamarix* spp.), and Russian olive (*Elaeagnus angustifolius*). Most of the exotic species found in the IBMA have low forage value for both wildlife and livestock and compete with more productive native species. Saltcedar is a vigorous invader of riparian zones in arid lands, rapidly excluding native woody vegetation such as willows and cottonwoods and altering the understory plant community. Although not currently found in large amounts in the IBMA, saltcedar has the potential for expanding its range within the area. Animal species (including a number of song birds) adapted to the native plants for food and cover are adversely affected by this loss. Few animals can successfully make use of saltcedar for food or cover. Further, because saltcedar is a heavy user of soil water, its establishment cause substantial reductions in flowing and standing water, thereby adversely affecting aquatic animals.

Cheatgrass and Russian thistle (*Salsola kali*) are other examples of non-native plants in the IBMA. They are very efficient in their use of water and therefore potentially highly productive in arid lands. These annual species can produce large fuel loads in upland areas adjacent to riparian zones and wetlands in good precipitation years, leading to the elevated risk of wildfires. The rapid growth rates of these annual species, with the corresponding high use of site resources (Section E.2.6.1), allow them to dominate disturbed sites to such an extent that re-establishment by native perennial species becomes difficult.

It is important to note that aquatic communities are influenced by many biotic and abiotic factors (e.g., shelter, food, water quality, flow). Within the Great Basin, the most notable disturbance factor is the destruction of habitat via modification (Sigler and Sigler 1987). This may include modification resulting from groundwater withdrawal, irrigation, impoundment, grazing, or combinations thereof. If water levels are reduced, aquatic habitat is often impacted. Similarly, the interruption or termination of spring flow can lead to negative impacts to aquatic resources. Impoundments caused by irrigation diversions or for livestock watering also modify existing habitat, often with detrimental consequences to the established native fauna and flora. Modification of aquatic habitat by livestock trampling also can be detrimental to endemic aquatic plant and animal species. Another major disturbance factor is the establishment of non-native species in these aquatic ecosystems. Because of the nature of Great Basin water dynamics, the endemic biological resources utilizing these groundwater-influenced ecosystems have evolved with little to no competition and with limited predation (Sigler and Sigler 1987). Consequently, native aquatic species within the Great Basin may be poorly equipped to survive when forced to co-exist with the competition and predation components imposed by non-native species (Sigler and Sigler 1987). Other concerns with introductions of non-native species include parasitism and hybridization.

Disease is a potentially major stressor to animal populations, the impacts of which often increase as the animal populations are stressed by other factors. Predation can also be a major stress factor affecting animal populations. Normal levels of predation are an integral part of the natural balance within ecosystems. However, abnormally high levels of predation, either short-term or long-term, can be detrimental to the prey populations, and eventually to the predators also. Some animal species exhibit natural population cycles, with very high numbers in some years followed by low numbers. These population cycles can have a ripple effect throughout the ecosystem, resulting in a strong impact on numerous associated species, including species competing with, preying on, or being preyed on by the cyclic species.

E.4 SPECIFIC CONCEPTUAL MODELS

E.4.1 SPRINGS

A spring is a body of water that is fed by the emergence of groundwater to the surface. Springs in the IBMA can be categorized into mountain block, range-front, and valley-floor springs (Fig. E-5). Mountain block springs in the IBMA are high-altitude springs that occur from localized recharge encountering low-permeability zones or structural features. Range-front springs occur at the base of mountain ranges where recharge water from the mountains encounters range-front faults or low-permeability materials. Valley-floor springs reflect the groundwater elevation on the valley floor, where recharge water from the mountains moves toward the center of the valley and is discharged in low-permeability zones and at points of low elevation. Because impacts from groundwater withdrawal are unlikely in the mountain block springs of the IBMA due to a lack of hydrologic connectivity with areas of potential pumping (pers. comm., TRP), the Plan and the remainder of this appendix focus on range-front and valley-floor springs.

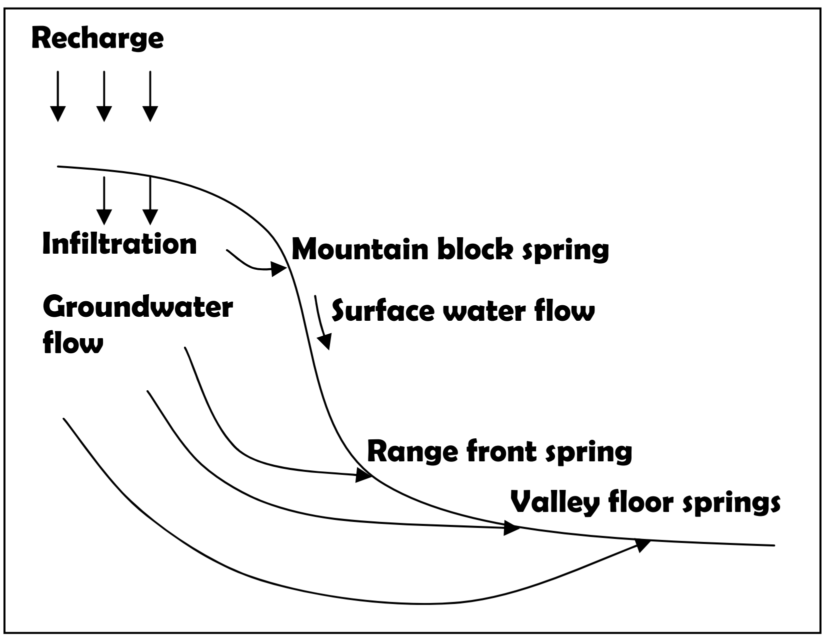


Fig. E-5. Typical spring hydrology in the IBMA.

Groundwater flowpaths that feed springs are determined by the configuration and relative transmissivity of aquifers (permeable, water-bearing underground layers) and aquitards (impermeable layers adjacent to aquifers), and by the hydraulic gradient. Flowpaths occur at local, intermediate, and regional scales based on length and depth (Welch et al. 2007). Local flowpaths are characterized by shallow alluvial aquifers, travel relatively short distances, and terminate at lower-volume springs where discharge tends to fluctuate with precipitation. These localized flowpaths are characteristic of mountain block springs. Intermediate flowpaths typically originate in upland recharge areas and discharge at moderate-volume range-front and valley-floor springs. Regional flowpaths are characterized by deep carbonate aquifers, typically originate in montane recharge areas, travel over long distances across hydrographic basins, and discharge at larger springs and wetlands (Welch et al. 2007). Regional springs are less seasonally influenced and provide a more stable aquatic environment (Sada et al. 2001). There are no regional warm springs in the IBMA.

A typical spring in the Great Basin can form a closed pond with no outflow, a pond with a stream outflow, or the headwaters for a stream. In high gradient locations such as mountain-sides, the spring flow is likely to produce a high-gradient stream with little or no standing water. The ecosystems that develop along such streams are usually limited to riparian vegetation rather than in-stream vegetation because of flow energy and scouring. In flat terrain such as valley floors, it is more likely that the spring will produce a pond, a meandering stream, or a wetland. In such systems, standing water is extremely important and considerable macrophytic and riparian vegetation can develop. While this section encompasses spring ponds, other ecosystem types that can develop in association with springs are discussed in the Perennial Streams (E.3.3) and Wetlands (E.3.4) sections.

Springs are often classified by morphology into several distinct type categories including rheocrene (spring that discharges into a defined channel), limnocrene (spring that discharges into an open pool before a defined channel), and helocrene (spring without an open pool and comparatively shallow and dry). Within the IBMA all three morphological spring types are represented, but rheocrene and limnocrene are more prevalent. In each spring type, standing water is a key component to the aquatic flora and fauna present at that site.

At the valley-floor springs, there is often a pronounced zonation of vegetation from the spring orifice, channel, or terminus pond edge to the open water (Fig. E-6). Cattails, sedges (*Carex* spp.), rushes (*Juncus* spp.), and similar species are common on the edges of valley-floor springs.

Water supply and water quality are both critical components to the ecological sustainability of springs in the IBMA. Because groundwater depths may change slowly over time, flow rates of some springs can be fairly constant within and among years. Any variability will depend greatly on the subsurface hydrology, but especially up or down-slope position of the spring. Because the primary source of groundwater in the Great Basin is snow melt, subsurface flows tend to be more seasonal higher up in elevation and on high slopes.

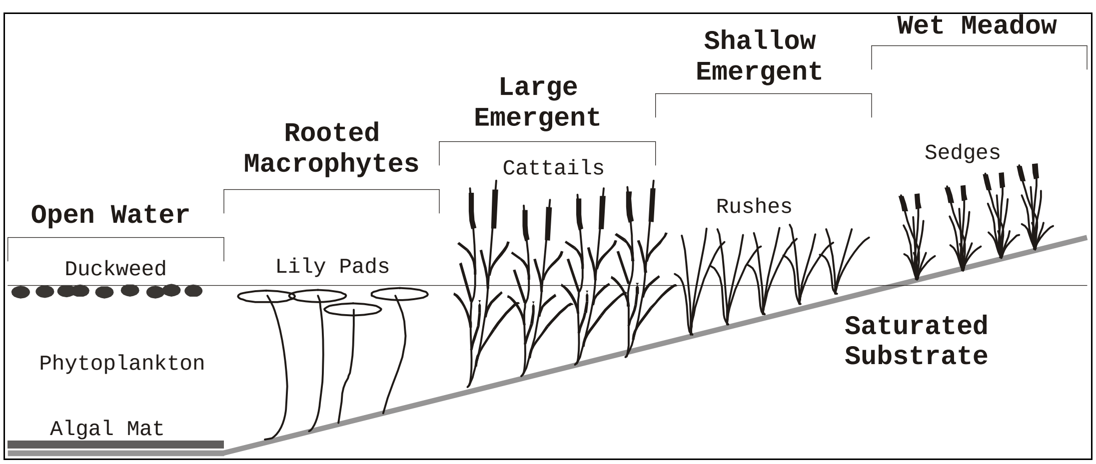


Fig. E-6. Typical vegetation zones surrounding valley-floor springs.

Spring water can carry a significant load of dissolved inorganic constituents. These are mobilized from the different substrate strata that the groundwater flows through before emerging at the spring. Mobilization of inorganic material such as metals and salts in groundwater depends on a number of factors, including original source water chemistry, age of the spring, volume of flow, residence time in material-bearing substrates, pH, alkalinity, and other water chemistry factors. Water quality parameters such as water temperature, dissolved oxygen, pH, and conductivity also play key roles in the formation of aquatic plant and animal communities within springs.

Physical and chemical characteristics are major factors influencing spring-fed riparian and aquatic plant and animal communities (van der Kamp 1995, Sada and Pohlmann 2006). Most spring environments are less variable in their physical and chemical characteristics than other aquatic habitats (e.g., streams, rivers, lakes, etc.), causing comparatively low within-spring variability in population sizes and assemblage structures (van der Kamp 1995). Typically, environmental variation within a spring is lowest near the source and greater downstream, which often causes the composition of source and downstream communities to be quite different (Hayford et al. 1995, Herschler 1998). Crenobiontics (species that live only in springs [e.g., springsnails]) appear to be specifically adapted (Sada and Pohlman 2006) for these spring environments. Many additional factors such as food availability, reproduction, predation, competition, and migration of species along a spring brook can influence the abundance of aquatic organisms (Varza and Covich 1995). Morphology also influences aquatic biota as species that inhabit rheocrenes prefer flowing water and species in limnocrenes are more closely related to species that occupy lakes and ponds (Sada 2000).

E.4.1.1 Maintenance Factors

The primary driver in springs in the IBMA is precipitation. Precipitation in arid lands can be highly variable among years, so that there is the potential for considerable variation in groundwater flows over time, depending on the location of the particular spring along the groundwater flow pathway.

The primary maintenance factor for springs is the maintenance of groundwater flows to the spring site. It is unlikely that the subsurface geology in the pathway from the higher elevation recharge areas to the valley aquifers would change, barring a large seismic event (i.e., an earthquake and fault slippage). It is much more likely that disruptions would be due to changes in precipitation in the recharge zones, or drops in the groundwater level up-gradient from the spring.

Precipitation also influences the amount of overland flow that is directly input into the springs. This flow would supplement the groundwater flow that typically sustains the majority of standing and flowing water in these springs. The amount of standing water is also a maintenance factor that influences the water quality and aquatic flora and fauna that inhabit each spring. The areal extent of standing water along with climate affects the amount of evaporation that occurs at these springs.

E.4.1.2 Disturbance Patterns

Springs in the Great Basin have been subjected to many stressors – physical, chemical, and biological – since European settlers entered the region. Surface water and groundwater diversion and/or withdrawal, incompatible livestock grazing, and invasive plants and animals have all played roles over time in the IBMA. Most of the springs within the valley floor or range front have been, or are currently, disturbed by diversion or livestock use, and several springs have substantial amounts of livestock trampling, as well as piped, ponded, or excavated spring heads (BIO-WEST 2007).

Natural stressors also exist. Drought is a major contributor to ecological variability within the IBMA. Changes in precipitation patterns can involve total annual volume and/or seasonality. A decrease in total annual precipitation in recharge areas at higher elevations would result in a decrease in total groundwater flow into and out of the entire system. Whether there would be a change in depth to groundwater or spring flow at any particular location would depend on the subsurface geology.

A decrease in groundwater discharge in any spring would result in a reduction of stream flow or standing water, depending on the ecosystem configuration. This would probably result in a reduction in habitat extent and total productivity. An increase in total precipitation would probably result in increased spring flows at most locations, and possibly the appearance of new springs. Up to some point (flooding has the opposite affect) this would result in the expansion of aquatic habitats associated with each spring. Springs which were associated with closed pond systems might then produce enough flow to overflow from the pond, creating new stream habitat.

Changes in groundwater flows might also result in changes in water quality. For example, an increase in groundwater flows might result more stable water temperatures, higher levels of dissolved oxygen, and potentially more nutrients. However, an increase in turbidity might instead occur as the expanded flow passed through new subsurface strata where previously stationary materials were then wetted and mobilized.

Seasonality of precipitation is also important in that snow melt at higher elevations is currently the primary source of groundwater recharge. Snow melt usually results in slower infiltration than in rainfall events. Therefore, a shift in precipitation from winter snows to warm season rainfall, for example, might result in more of the total precipitation going into runoff than into infiltration. This would result in reduced groundwater recharge and an increase in seasonal surface runoff. Any number of seasonal shifts might occur, each one resulting in different allocations of total precipitation to groundwater recharge and runoff. This combined with potential changes in total precipitation volume could produce any number of recharge and runoff scenarios, far too many to be considered exhaustively here.

The initiation of groundwater withdrawal can have significant effects on springs, depending on the locations of wells relative to the springs, as well as subsurface geology and flow patterns. If a well is located near a spring, and there are no controlling geologic features between them, an increase in depth to groundwater can result in significant reduction or cessation of spring flow.

A well located up-gradient from a spring might also reduce down-gradient flow sufficiently to reduce or eliminate spring flow. Conversely, a well located down-gradient from a spring would have less or no impact on spring flow. As mentioned earlier, changes in groundwater flow resulting from changes in precipitation could have any number of effects on water chemistry and quality in spring flows. The same possibilities could result from changes in flow resulting from groundwater pumping.

Surface water diversions can also significantly alter existing habitat conditions. If water levels are reduced, aquatic habitat is often impacted. Similarly, the interruption or termination of spring flow can lead to negative impacts to aquatic resources. Impoundments caused by irrigation diversions or for livestock watering also modify existing habitat.

Incompatible livestock grazing can also modify existing habitat, often with detrimental consequences to the established native fauna and flora. Modification of aquatic habitat by livestock trampling also can be detrimental to endemic aquatic plant and animal species.

Another major disturbance factor is the establishment of non-native species in these aquatic ecosystems. Woody plants such as salt cedar (Sala et al. 1996; Devitt et al. 1997, 1998; Shafroth et al. 2000) have a high transpiration demand and the rapid growth rate of this species has resulted in reductions and even elimination of surface spring flows in some western states. Although these have not established in aquatic systems in the IBMA, the potential for establishment does exist. Nonnative aquatic animals, in particular bullfrogs and crayfish also pose a significant threat to springs within the IBMA. Other concerns with introductions of non-native species include parasitism and hybridization.

E.4.1.3 Relationship of Conceptual Model to Monitoring Plan

Fig. E-7 depicts how primary drivers and stressors presented in the conceptual models relate to KEAs and indicators to be monitored at springs in the IBMA (Chapter 4). This parsimonious diagram is not meant to demonstrate a complete conceptual model, but rather how components of the conceptual models relate to the Plan.

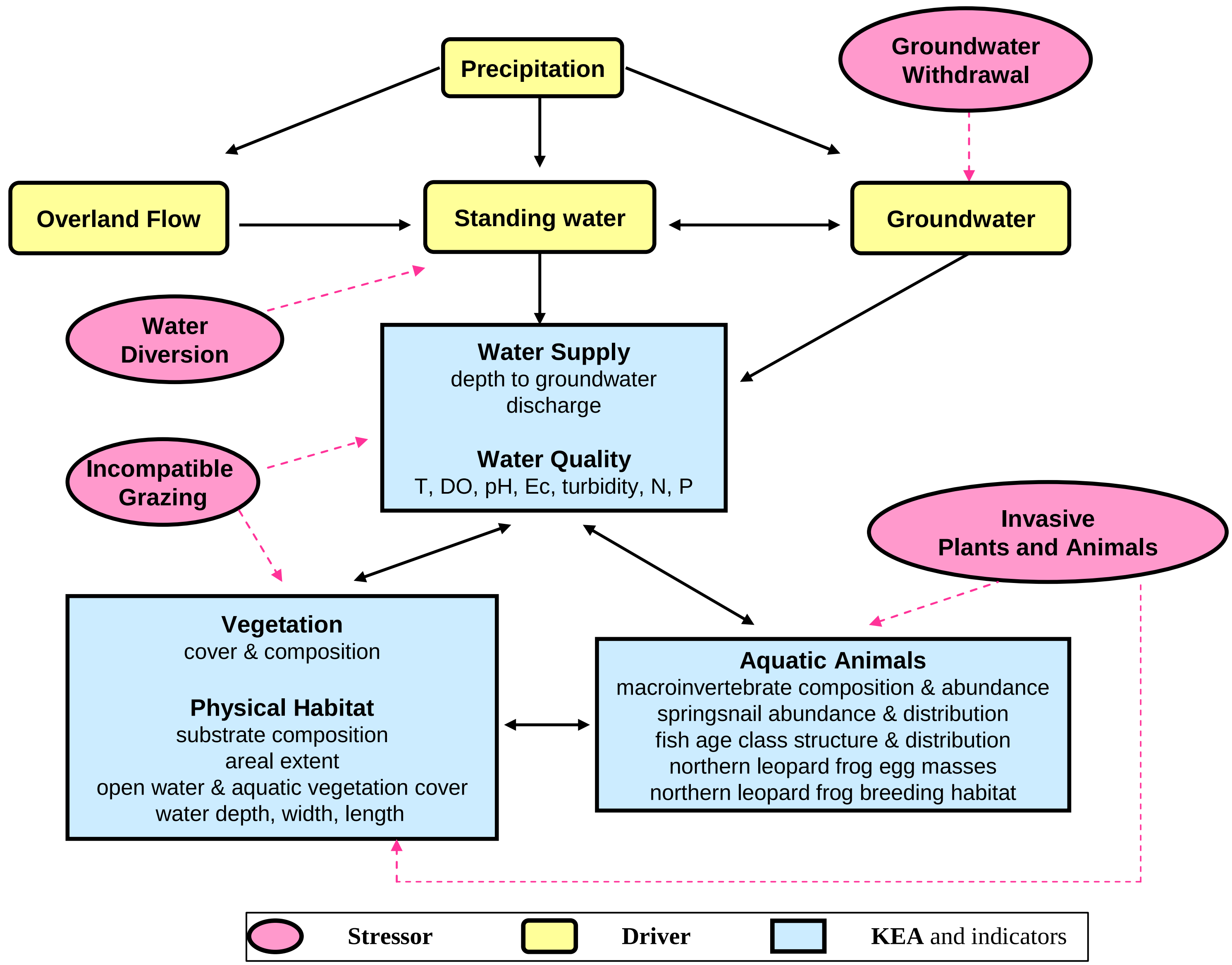


Fig. E-7. Relation among primary drivers, stressors, and KEAs and indicators to be monitored at springs in the IBMA.

E.4.2 PONDS (Shoshone Ponds)

Section 4.2 addresses the unique case of Shoshone Ponds. The classic definition of a pond is a small, shallow, body of standing water with abundant rooted and floating macrophytic vegetation (Welch 1952). While spring systems may create ponds that meet this definition, springs systems as a whole are addressed in Section E.4.1 and therefore are not discussed here. The IBMA also has "playas", which are temporary ponds that are often filled with seasonal runoff. Playas can be classified as "dry" playas which are filled exclusively by surface runoff, and "wet" playas which occur over areas of high groundwater and can accumulate some moisture from upward movement of groundwater in the springtime when water tables are their highest. In either case, however, the soil properties of playas make for limited permeability. While there is groundwater discharge in the form of evaporation in the Spring Valley playas, because the majority of water present is due to surface water runoff (pers. comm., TRP), the Plan and the remainder of this appendix do not address playas. Therefore, this section is dedicated entirely to Shoshone Ponds.

Shoshone Ponds classifies as a permanent pond but is a unique ecosystem due to its creation history and purpose. Shoshone Ponds consists of multiple "ponded" environments, however it was artificially created and water is maintained by a number of artesian wells. Historically, the area was used as a camp for the Civilian Conservation Corps (CCC) in the 1930s. In 1970, the BLM designated Shoshone Ponds as part of the Shoshone Ponds Natural Area. The area is characterized by a series of six artesian wells and is currently managed by the BLM as a native fish refuge. Currently, one artesian well feeds a series of three man-made ponds within a fenced enclosure while an additional well feeds another pond to the north. The three ponds within the enclosure are commonly referred to as the North, Middle, and South Ponds and the remaining pond is known as the Stock Pond.

Shoshone Ponds maintain the hydrological components of permanent ponds but are fed by artesian wells rather than natural groundwater interaction (Fig. E-8).

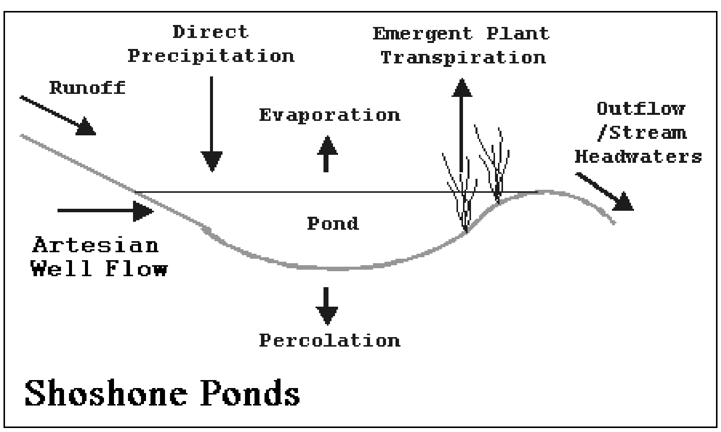


Fig. E-8. Shoshone Ponds hydrology.

Just as soil characteristics are a key factor in determining the plant community type in terrestrial systems, bottom substrate characteristics are important in determining vegetation types, productivity, and water quality in ponds. Shoshone Ponds has developed soft bottoms from sediment loads transported from surface runoff, from wind-blown dust and dirt, and from plant material in different stages of decomposition. Within the fenced enclosure portion of Shoshone Ponds, the dense vegetation around the edges can filter out and trap much of the runoff sediment before it reaches the ponds themselves. However, this vegetation also produces substantial organic debris which settles to the bottom, producing fine silt and a constant food supply for bottom animals. The most common growth forms include macroalgae (e.g., *Chara* spp.) erect aquatics (e.g., pondweeds *Potamogeton* spp.), filamentous algal mats, and tall emergents [e.g., cattail (*Typha* spp.) and bulrush (*Scirpus* spp.)].

Nutrients do not tend to be limiting resources for primary production in artesian-fed ponds. Artesian-fed ponds build up organic materials in the bottom sediments over time, so that nutrients are available for rooted vegetation at the onset of the growing season. These nutrients are usually re-suspended in the water column during the winter by wind action, and therefore are available to phytoplankton as well in the early growing season.

Anaerobic conditions can develop in the bottom sediments of artesian-fed ponds as a result of decomposition of organic material, especially near rooted vegetation such as cattails, rushes, and sedges, less so out in the open water. The water column itself can become oxygen-depleted if elevated water temperature in summer and high nutrient availability results in excessive water column productivity of phytoplankton.

Shoshone Ponds vegetation is greatly influenced by the basin configuration, the source of water (runoff and artesian well), and constant flow volume. Aquatic vegetation such as pondweed, coontail (*Ceratophyllum* spp.), and duckweed (*Lemna* spp.) can also develop high densities in artesian-fed ponds, providing food supply and structure for a wide range of aquatic animals.

Shoshone Ponds is associated with surrounding wetlands and meadows. This occurs as a result of the outflow from the Stock Pond and direct artesian well flow that creates overland flow into the wetland. Shoshone Ponds was specifically designed as a refugia for fish. However, it also attracts resident and migratory water-associated birds and wildlife and supports northern leopard frogs.

E.4.2.1 Maintenance Factors

The artesian well system is the most important maintenance factor for Shoshone Ponds. Although overland runoff can contribute to the overall hydrology, well flow maintains the constant level in these artificially created structures. Decreased inflows resulting from changes in volume of water being supplemented to these ponds would have similar impacts to those discussed in the Springs section relative to decreases in precipitation patterns or from increases in groundwater depth.

E.4.2.2 Disturbance Patterns

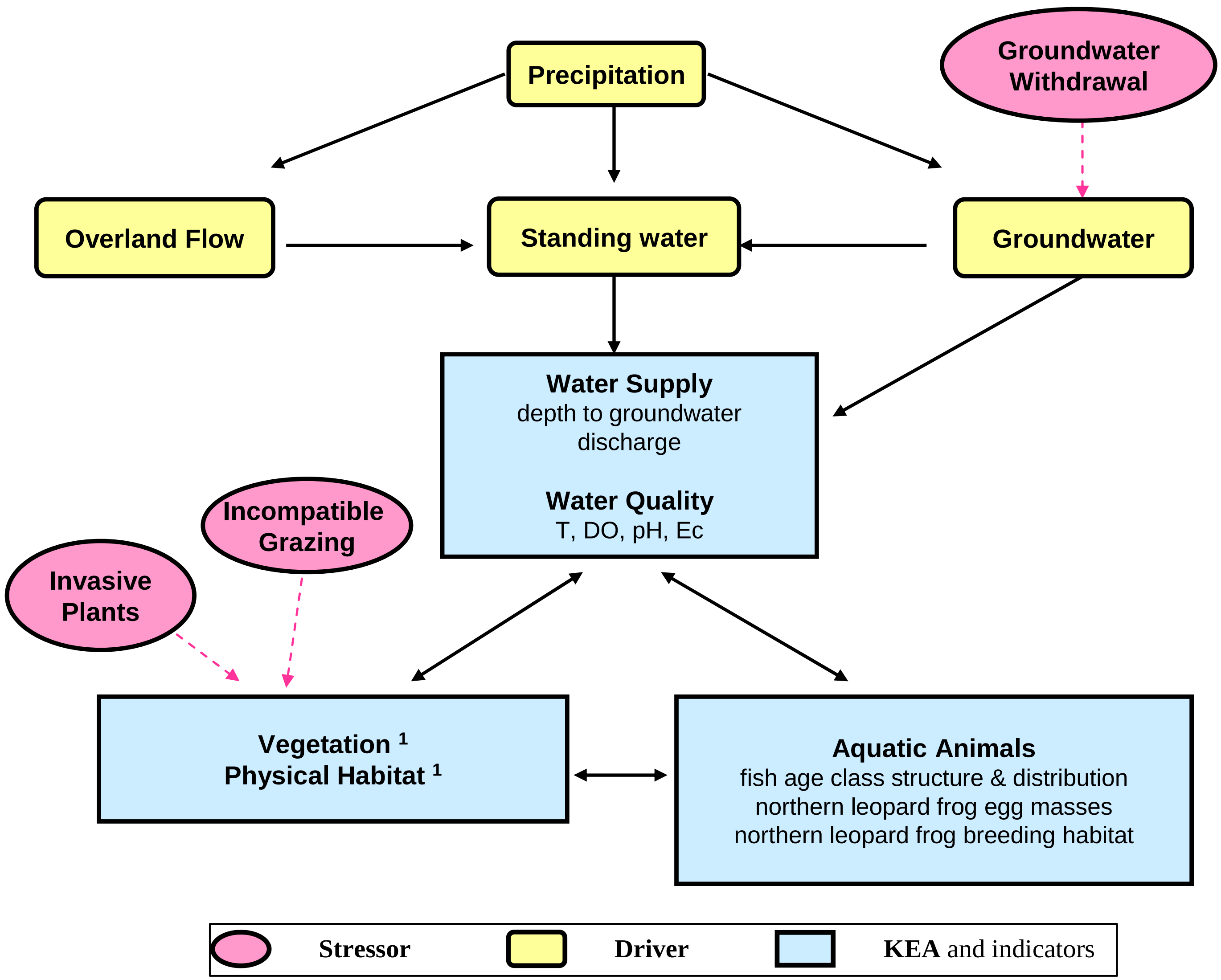
Reduction of inflows to Shoshone Ponds as a result of changing management practices of well operation, changing precipitation patterns, or groundwater withdrawal would likely result in reduction in total habitat area as the ponds decreased in volume, and water quality might change as runoff water became more important to overall hydrology. Total cessation in inflow would result in either a change from permanent to temporary pond ecosystems if significant runoff inflows filled the basin at least seasonally, or to arid land vegetation if little or no runoff was captured. However, this is highly unlikely as the purpose of these artificially created basins are for fish refugia.

Impacts from incompatible grazing are another potential disturbance factor at Shoshone Ponds. Runoff patterns can be altered by cattle trails which funnel runoff water rapidly across bare ground into the ponds, resulting in potentially more and dirtier runoff. There is also the potential for perforating the pond bottom substrate by cattle hooves, which would accelerate infiltration of pond water into subsurface layers. The water can also be fouled from urine and manure inputs, as well as anaerobic sediments stirred up into the water column as animals wade through the pond. Increased nutrient inputs can also result in night-time depletion of oxygen by aquatic algae and bacteria in any season of the year. Large animals can trample aquatic vegetation, suppressing productivity and disturbing habitat for many aquatic (e.g., insects and crustaceans) and terrestrial (nesting and migratory birds) animals. Trampling can also directly kill many organisms such as fish fry, amphibians, and nestling birds. Currently, the North, Middle, and South Ponds are fenced off to prevent livestock access.

Another disturbance factor could be the establishment of invasive plant and animal species at Shoshone Ponds. Non-native aquatic vegetation currently exists at Shoshone Ponds. Although invasive aquatic animals do not currently inhabit Shoshone Ponds, the introduction of invasive species could be destructive to the purpose of the refugia.

E.4.2.3 Relationship of Conceptual Model to Monitoring Plan

Fig. E-9 depicts how primary drivers and stressors presented in the conceptual models relate to KEAs and indicators to be monitored at Shoshone Ponds in the IBMA (Chapter 4). This parsimonious diagram is not meant to demonstrate a complete conceptual model, but rather how components of the conceptual models relate to the Plan.



[1] Vegetation and physical habitat are chosen KEAs, but are not being monitored in order to limit disturbance.

Fig. E-9. Relation among primary drivers, stressors, and KEAs and indicators to be monitored at Shoshone Ponds in the IBMA.

E.4.3 PERENNIAL STREAMS

Streams are small flowing-water systems of a wide range of types. The flow can be year-round ("perennial" or permanent), seasonal ("ephemeral"), or "intermittent" (Minshall et al. 1989). Stream systems considered and subsequently dismissed from inclusion in the Plan were mountain block originating streams, ephemeral streams, and intermittent streams. In coordination with the TRP, the BWG based dismissal of these ecosystems on the assumed low likelihood of direct or indirect impacts by SNWA groundwater withdrawal within Spring Valley. Mountain block originating streams are fed by mountain block springs and/or snowmelt and, in the cases where the potential exists to extend into the valley floor, these streams are typically diverted for agricultural purposes. Ephemeral and intermittent streams were not included because flow pattern limits their use for impact determination. Additionally, these streams are predominantly driven by surface water runoff and precipitation related events. Big Spring Creek / Lake Creek is the one perennial stream complex in the IBMA that met the criteria for inclusion in the Plan.

Source water for all streams will almost always include some surface runoff from precipitation events in the nearby watershed. Other water sources can include springs or seeps, snow melt, or overland flow. Perennial streams in arid lands usually have springs in the headwaters, outflows from spring-fed ponds, and/or groundwater seeps along the channel as their primary water sources. The portion of total stream flow arising from groundwater in any form is called "base flow". Base flow can be relatively constant year-round, but can vary seasonally as recharge rates vary with seasonal precipitation and snow melt (Elliott et al. 2006).

One important feature of perennial streams is the transition among habitat features along the course. Streams have a variety of segment types, including pools, riffles, runs, and glides (Hawkins et al. 1993). Many plant and animal species tend to occupy specific segment types. However, all segments share common water quality and overall stream flow attributes, so that disturbances in one segment are likely to have impact in that and all lower segments.

Water chemistry in perennial streams reflects quality in the source water and anthropogenic impacts. Permanent spring-fed streams (such as Big Springs Creek) usually have high water quality and clarity, while temporary streams that are dependent on runoff can often have significant loads of sediments. In-stream macro-vegetation is usually dependent on sufficient sediments being present for rooting. Even in low-gradient, low-velocity streams, macro-vegetation is often restricted to stream banks and sand/sediment bars in pools and inner sides of stream bends.

Periphytic algae and complex stream-bottom microbial communities are important primary producers in slower-velocity streams with significant hard surfaces. These are important as the base of the food chain for aquatic animals such as insects, snails, and juvenile and forage fishes. Riparian vegetation is usually greater in lower-gradient, lower-velocity streams where water has sufficient time to infiltrate into soils along the channel. Typical riparian vegetation along Big Springs Creek / Lake Creek are more similar to that in meadows, with sedges and rushes, grasses associated with wet soils, and some larger woody hydrophytes intermingled with upland plant species.

Perennial streams typically support numerous small invertebrates which are important in the food chain as grazers on periphyton and decomposing vegetation, as well as providing food for vertebrates. Perennial streams in the Great Basin are not usually large, so the associated animals are usually small, including forage fishes (minnow-like) and amphibians. Where appropriate emergent and riparian vegetation are present, perennial streams can provide habitat for a wide range of birds and mammals.

E.4.3.1 Maintenance Factors

The key maintenance factor for perennial streams is ensuring continued water inputs, whether from springs, groundwater, pond outflow, snow-melt, or runoff, or some combination of these. Important characteristics of these inputs are flow rate, total volume, seasonality, sediment content, dissolved nutrient and other material content, and temperature. Both hydrology and water quality are important maintenance factors.

Precipitation also influences the amount of overland flow that is directly input into perennial streams. This flow would supplement the spring flow that typically sustains the majority of flowing water in these streams. The amount of stream flow is also a maintenance factor that influences the water quality and aquatic flora and fauna that inhabit a perennial stream. The areal extent of stream flow along with climate affects the amount of evaporation that occurs in these systems.

E.4.3.2 Disturbance Patterns

Springs are the major water source for Big Spring Creek / Lake Creek, so disruption of groundwater flow to these springs could alter hydrological patterns. Complete disruption of spring flows, even for a short-duration event, might be sufficient to eliminate animals such as fishes, immature amphibians (i.e., tadpoles), and many gill-breathing insects and crustaceans. Further, the arid climate might result in rapid drying of the stream channel even for a brief interruption of flow, possibly eliminating many water-dependent plants, algal mats, sediment-burrowing animals (i.e., various worms), and some microorganisms.

Changes in precipitation patterns can also affect perennial streams. Groundwater flows in the Great Basin are primarily dependent on snow melt. A change in the seasonality of precipitation from winter to other seasons might result in reduction in snow fall and groundwater recharge. Even if the same annual precipitation volume was maintained, it is likely that a greater proportion would go into runoff rather than recharge, thereby reducing groundwater flows and possibly permanent stream inputs, although this might lead to more flows in seasonal and intermittent streams. Even though a reduction in stream flows might not immediately eliminate water dependent species such as fishes, it is possible that severe droughts that occur at frequencies of multiple decades could eliminate flows entirely for the duration of the drought.

Groundwater withdrawal can have significant effects on perennial streams that are fed by spring flow, depending on the locations of wells and the springs, as well as subsurface geology and flow patterns. An increase in depth to groundwater or hydraulic head at a source spring could result in reduction or even cessation of spring flow, ultimately decreasing overall stream flow.

Just as seen with changes in precipitation, changes in spring flow resulting from groundwater pumping could affect stream water chemistry and quality.

In many parts of the Great Basin, perennial streams have been diverted for agricultural and other uses. In many cases, some stream flow may continue down the original channel; however the amount of flow may be greatly reduced by the diversions. This reduced flow can at times alter the dynamics of the stream system and result in a highly modified ecosystem. Surface water diversions are common practice in the Big Spring Creek / Lake Creek system.

Just as seen with springs, physical disturbance from incompatible grazing and trampling can be severe in perennial streams if not carefully managed. It is widely contended that grazing itself is not damaging of stream and riparian areas, but what is detrimental is livestock over-grazing (Briggs 1996). Excessive nutrient inputs from cattle urine and manure are not as damaging as in ponds because of flushing by stream flow, except when deposited and accumulated, especially during low- and no-flow periods when limited dilution potential exists. Spring-fed and stream aquatic and riparian systems are also directly impacted by livestock, where excessive use of a waterbody results in trampling that can decrease riparian and aquatic diversity (Fleischner 1994). Trampling and grazing of in-stream, bank, and riparian vegetation can be severe if no provision is made for rest and recovery by livestock exclusion. Trampling can also compact soils, disturb stream bottom conditions, and increase sediment transport and deposition from bare ground and cattle trails.

Excessive runoff loadings of sediments and pollutants (herbicides) can bury existing plant and animal communities. Agricultural practices along the Snake Valley floor have the potential to affect Big Spring Creek / Lake Creek via both sediment input from erosional processes and herbicides from crop development. Culverts can also become impediments to fish movements during periods of heavy sedimentation.

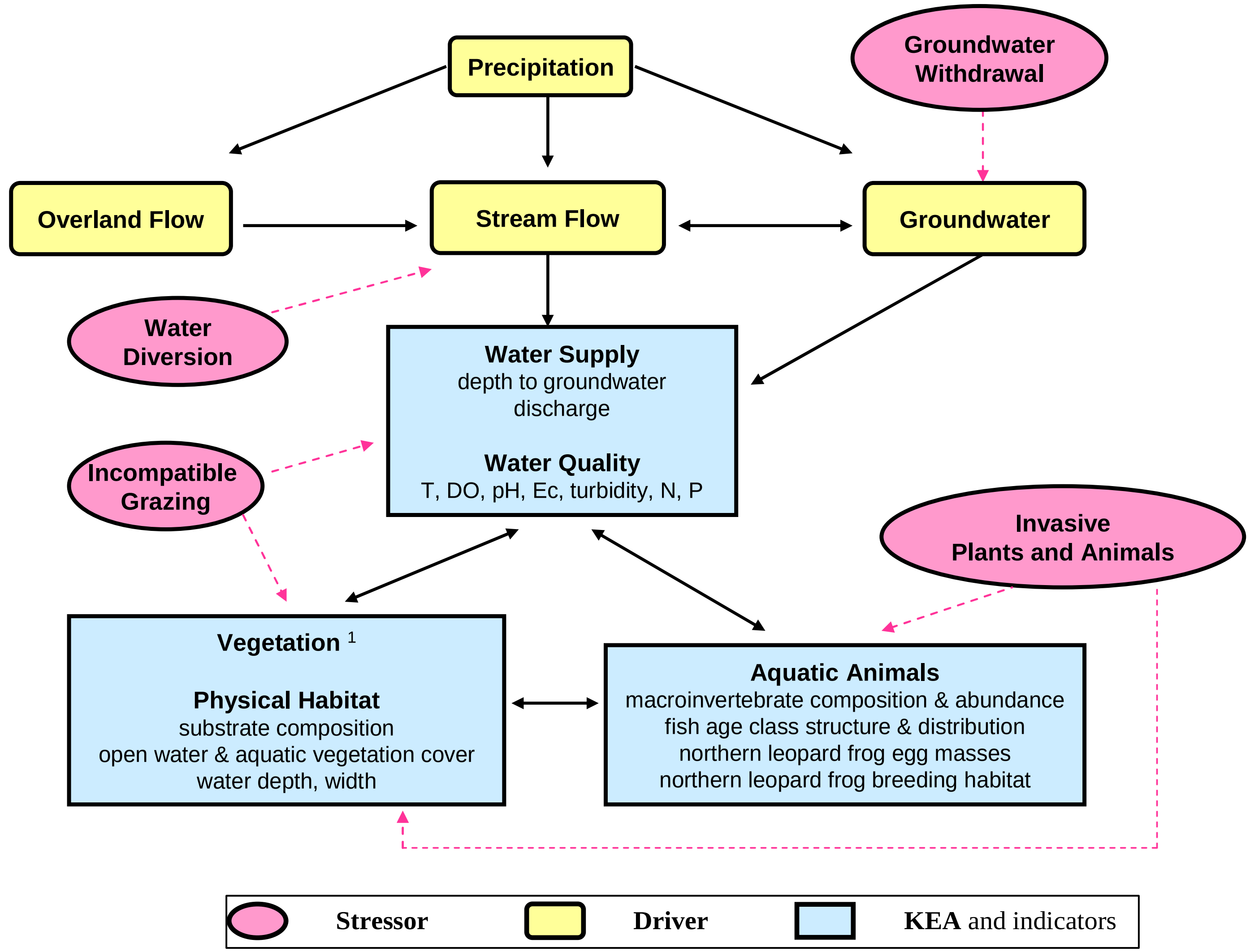
Populations of native aquatic species in springs and streams in the western United States have, in many instances, either been reduced or extirpated as a result of invasive species (Hershler 1998, Miller et al. 1989). Since the native aquatic species in many of the western U.S. springs and streams evolved without severe competition and with essentially no aquatic predators, they are not equipped to sustain themselves when faced with high levels of competition or predation (Sigler and Sigler 1987). As discussed in Chapter 4, a number of non-native game fish species have been introduced into Big Springs Creek / Lake Creek over the course of the past 60 years in an attempt to establish a sport fishery. Fortunately for the native fisheries, these attempts have been unsuccessful. Current invasive aquatic animal species such as the bullfrog and crayfish still pose disturbance threats to Big Spring Creek / Lake Creek. Invasive woody species such as saltcedar (Pruess Lake) and Russian olive (Big Spring Creek / Lake Creek) are particularly problematic along perennial streams (Hubert 2004). These can rapidly grow into dense thickets, crowding out native vegetation, and transpiring large volumes of stream and subsurface water. In some locations, these woody species have essentially eliminated spring inputs and channel flow for formerly perennial streams.

Fire can be another hazard to stream riparian vegetation because of the high density of litter and standing dead material in fall and winter (Knight 1994). Dense marshy plants, mature and senescing stands of woody plants, and especially dense stands of exotic saltcedar and Russian olive can produce highly flammable loads at the end of the growing season, which may occur as early as mid-summer in dry years. Intense burns under these conditions can eliminate native woody vegetation, and provide opportunity for invasion and further dominance by exotics. Although the potential exists for future occurrence, fire has not been a primary disturbance factor in Snake Valley in recent times.

Because perennial streams in arid lands tend to be small and isolated, recovery from physical disturbance can be slow. Effects of physical disturbances such as floods, unusually large sediment pulses, and even fire tend to affect all segments below the original disturbance site, and even some above if they are thereafter isolated from the lower segments. Sources for extirpated species such as fishes and woody plants may be some distance away, upstream or downstream, so that recolonization may take some time.

E.4.3.3 Relationship of Conceptual Model to Monitoring Plan

Fig. E-10 depicts how primary drivers and stressors presented in the conceptual models relate to KEAs and indicators to be monitored at the perennial stream in the IBMA (Chapter 4). This parsimonious diagram is not meant to demonstrate a complete conceptual model, but rather how components of the conceptual models relate to the Plan.



[1] Vegetation cover and composition will not be monitored in Big Spring Creek/Lake Creek, but will be monitored in Big Springs Complex springs. Aquatic vegetation cover (indicator for Physical Habitat) will be monitored in the stream.

Fig. E-10. Relation among primary drivers, stressors, and KEAs and indicators to be monitored at the perennial stream in the IBMA.

E.4.4 WETLANDS

Wetlands are areas with soils that are saturated to the surface most of the time. They support vegetation that is dominated by rooted species that require high levels of soil moisture most of the year. Wetlands often have standing water for long periods of time and may have standing water year-round. If so, the depth of standing water is less than that for ponds. Ponds have substantial amounts of open water (no vegetation extending above the water surface) or, if not open water, then substantial amounts of the water surface covered by free-floating aquatic plant species. Wetlands can have areas of open water and areas supporting free-floating aquatic plant species, but if so, these are relatively minor components of the entire wetland area. Most of the area covered by a wetland is dominated by emergent species (plants rooted in the soil and with leaves or stems extending above the water surface) whereas ponds have emergent vegetation only on a portion of their spatial extent, generally confined to the shallower edges.

In the IBMA, most wetlands occur in 1) areas adjacent to spring ponds where outflow from the ponds saturates the soil and often results in shallow standing water, 2) areas where groundwater reaches the surface because of a high water table (either permanently or seasonally), and 3) areas of outflow or subsurface flow (tailwater) from water diversions, heavily irrigated areas, or streams. The larger spring complexes and many of the medium-sized springs and seeps support adjacent wetlands. As surface elevation increases slightly, the soil surface and upper layers of the soil profile become saturated less often and the vegetation shifts from wetland vegetation to meadow vegetation (Section E.3.5). Wetlands in the IBMA therefore generally occupy the intermediate topographic position between springs and the somewhat higher and drier meadows.

Because wetlands are transitional between aquatic and meadow communities, they share some plant species with both of these other types. Within the wetland, these species are often distributed in response to differences in micro-topography, with some confined to lower and wetter areas (those species also associated with the edges of the aquatic communities) and some confined to higher and drier micro-sites (those species also associated with wet meadows). Species in the IBMA that are generally associated with the wetter sites, and which require some standing water for most of the year, include cattail, spikerush, common reed (*Phragmites australis*), bulrush, and cordgrass (*Spartina* spp.). The slightly drier areas are typically dominated by Baltic rush, sedges, cinquefoil (*Potentilla* spp.), wildrye (*Elymus* spp.), bentgrass (*Agrostis stolonifera*), and slender wheatgrass (*Elymus trachycaulus*). Where woody species are present, the most common are willows and Wood's rose (*Rosa woodsii*).

Wetlands have restricted water flow-through, therefore sediments and nutrients can accumulate to produce highly productive ecosystems. Because of the high productivity of wetland vegetation, the food chain is often dominated by a group of animals feeding on sediments, plant litter, and associated decomposing microorganisms, including insects, crustaceans, snails, and variety of benthic worms. Fishes tend to be limited in productive wetlands by shallow depths, seasonally high and low temperature extremes, low dissolved oxygen, and possibly high salinities (Gammonley 2004). This lack of fish predators can result in excellent breeding habitat for many amphibians such as frogs (*Rana* sp.). Wetlands can provide excellent but isolated habitats for water-dependent vertebrates. Wetlands in the Intermountain west are used by more than 140 species of wetland-dependent and wetland–associated birds. Many of these species do not nest in Nevada, but may use wetlands in the Great Basin as feeding areas during migrations. Wetlands can also provide winter forage for domestic and large native herbivores such as pronghorn antelope and mule deer (*Odocoileus hemionus)*.

Wetlands in the IBMA, as in most arid lands, despite their limited spatial extent, are extremely important ecologically because of their high productivity, high species richness, and their importance to many terrestrial animals.

E.4.4.1 Maintenance Factors

The primary maintenance factor for wetlands is the hydrologic cycle. The period of inundation and time of year are significant factors in determining the biotic community that exists in each wetland. Some wetlands, or portions of wetlands, are wet only during the growing season rather than year-round. This seasonal wetting pattern is likely to be important for maintaining these systems. It is also possible that a change to permanent wetting for such wetlands would result in shifts in species composition towards those species that are intolerant of substrate drying at any time.

Because of the inherent high productivity of wetlands, nutrient dynamics are usually robust. Although sediment inputs from blown dust and runoff can be readily utilized, these are not usually required for adequate nutrient cycling. Temporary drying does not usually cause significant nutrient losses from the system because substrates and roots are ordinarily well-protected by above-ground vegetation biomass, even by dead standing vegetation.

Some of the wetlands in the IBMA are artificial or their spatial extent has been expanded artificially by agricultural practices. Artesian wells, stock watering facilities, diversion ditches, and irrigation have resulted in the creation of wetlands where none existed before these developments, or in some cases these developments have substantially increased the extent of previous natural wetlands. Activities that result in a permanent or seasonally-permanent supply of surface water to areas of relatively level topography in the IBMA are likely to create artificial wetlands. Over time, these artificial wetlands can assume characteristics very similar to natural wetlands.

Invasion by woody plants is a major factor in meadow communities and maintenance of meadow communities requires some ecological factor or set of factors to restrict shrub invasion (Section E.3.5.1). Woody plant invasion is not as much of a factor in the IBMA wetlands as it is in the meadows, because the saturated soils and standing water conditions in the wetlands restricts the establishment of most shrub species.

E.4.4.2 Disturbance Patterns

Potential impacts of groundwater development in valleys where wetlands are found include 1) Interruption of the source of water for the wetland (springs in many cases in the IBMA) and, 2) lowering of the water table when there is connectivity between the aquifer being developed and the wetland. The potential for groundwater development to affect a particular wetland is dependent upon the specific hydrogeology of that wetland and its juxtaposition with production wells. Permanent or even temporary lowering of the water table in wetlands can result in shift of the wetland vegetation to that more typical of meadows. Species adapted to standing water or saturated, anaerobic soils would give way to those tolerant of temporarily saturated soils but better adapted to fully-aerated soils. This transition can be rapid because of high productivity and high water requirement of most wetland plant species. Changes in precipitation patterns that affect groundwater recharge and subsurface flow might also affect groundwater inputs, resulting in similar impacts on wetland vegetation.

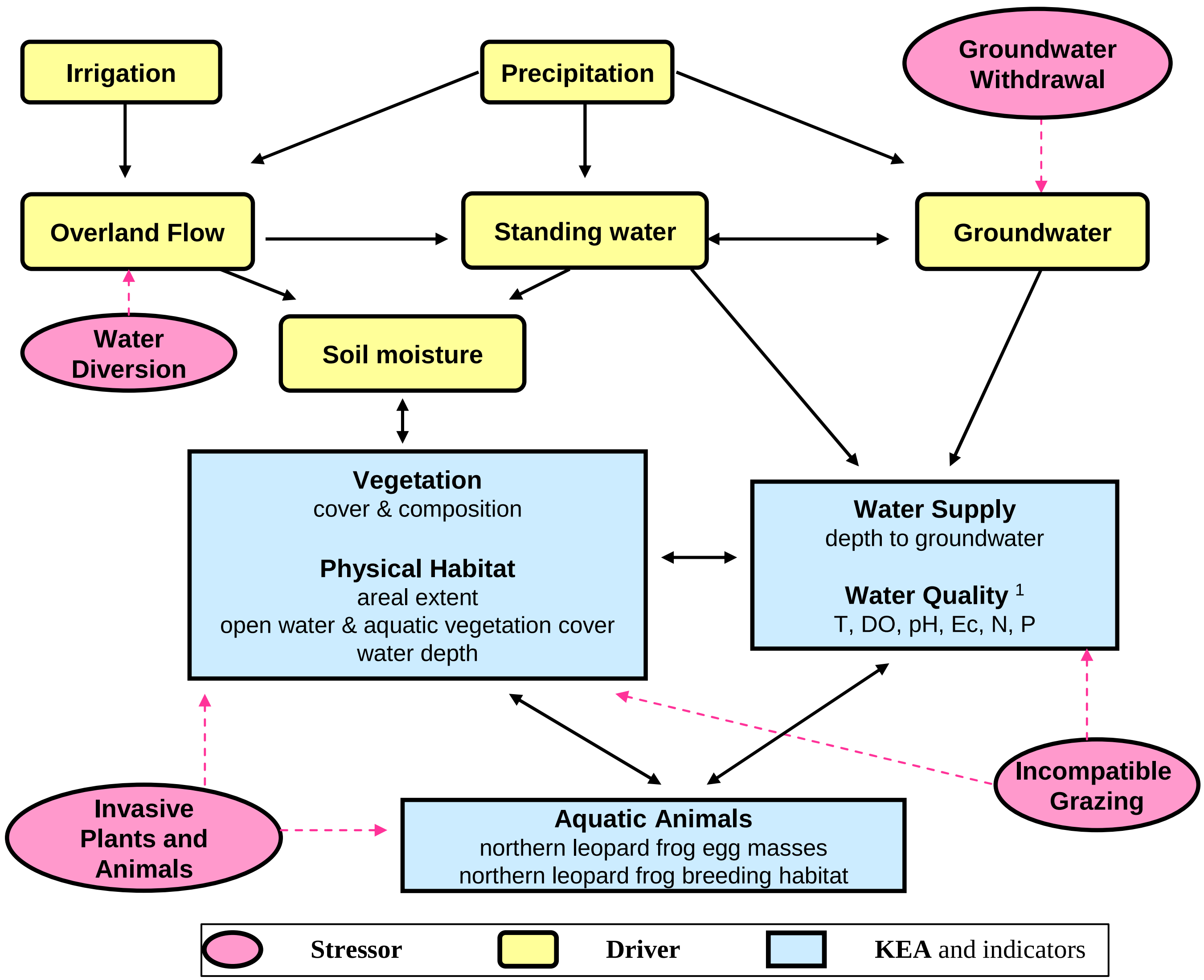
Wetland vegetation can be very resilient to temporary physical disturbance and moderate pollutants inputs because of high productivity. Wetlands are also relatively tolerant of moderate sediment deposition because of abundant water and high productivity. However, extreme sediment deposition can fill standing water areas, block drainage channels, and otherwise alter hydrological dynamics to the potential detriment of some areas within the wetland. Developments that might alter the hydrologic conditions of the wetlands, such as road construction or alternation of water diversion structures, could have major detrimental impacts to the wetlands.

Physical disturbance from trampling and improper grazing by domestic livestock can be destructive of wetland vegetation (Niemuth et al. 2004). Grazing of wetland vegetation can be destructive to palatable species, resulting in community composition shifts, particularly as a result of intensive winter grazing. Because of the high productivity of wetland vegetation and the presence of abundant water in most periods for plant growth, heavy utilization by grazing animals can occur during dry periods when surrounding vegetation becomes less palatable. Trampling is also destructive of vegetation, bottom sediments, and wildlife such as nesting birds. Cattle paths established in wetland vegetation can also alter hydrological processes, increase predator access, and reduce preferred cover types for different animal species.

Fires are not frequent in the IBMA. However, their frequency could increase in the future as a result of climate change or changes in land management practices. If fire frequency increases, it can become a major disturbance factor in the wetlands of the IBMA during periods when the wetlands are in their driest condition. Fire can be very destructive to wetlands during dry periods or droughts when there is considerable fuel loads of dead, dry vegetation. The heat of the fire can further dry out substrates and even kill exposed or buried roots. Different plant species can have different sensitivities to fire, so that single or repeated fires may cause significant shifts in marsh species composition.

E.4.4.3 Relationship of Conceptual Model to Monitoring Plan

Fig. E-11 depicts how primary drivers and stressors presented in the conceptual models relate to KEAs and indicators to be monitored at wetlands in the IBMA (Chapter 4). This parsimonious diagram is not meant to demonstrate a complete conceptual model, but rather how components of the conceptual models relate to the Plan.



[1] Wetland water quality will be monitored at frog breeding habitat transects only.

Fig. E-11. Relation among primary drivers, stressors, and KEAs and indicators to be monitored at wetlands in the IBMA.

E.4.5 MEADOWS

Meadows are grasslands (communities dominated by grasses or grass-like plants) that have saturated soil within the rooting zone in most or all months of the year. If standing water occurs, it is for only part of the growing season. Meadows tend to have relatively high cover values (generally greater than 30%) and in the IBMA are typically dominated by saltgrass (*Distichlis spicata*), Baltic rush (*Juncus balticus*), alkali sacaton (*Sporobolus airoides*), or wildrye (*Leymus triticoides* or *L. cinerus*), either singularly or in combination. Micro-topography is important in determining the spatial structure of these meadows (Fig. E-12). Lower microsites are wetter and higher microsites are somewhat drier. These differences result in a topographic mosaic within the meadow, with Baltic rush and wildrye more abundant on the lower and wetter sites, saltgrass on the intermediate, and sacaton on the higher and drier sites.

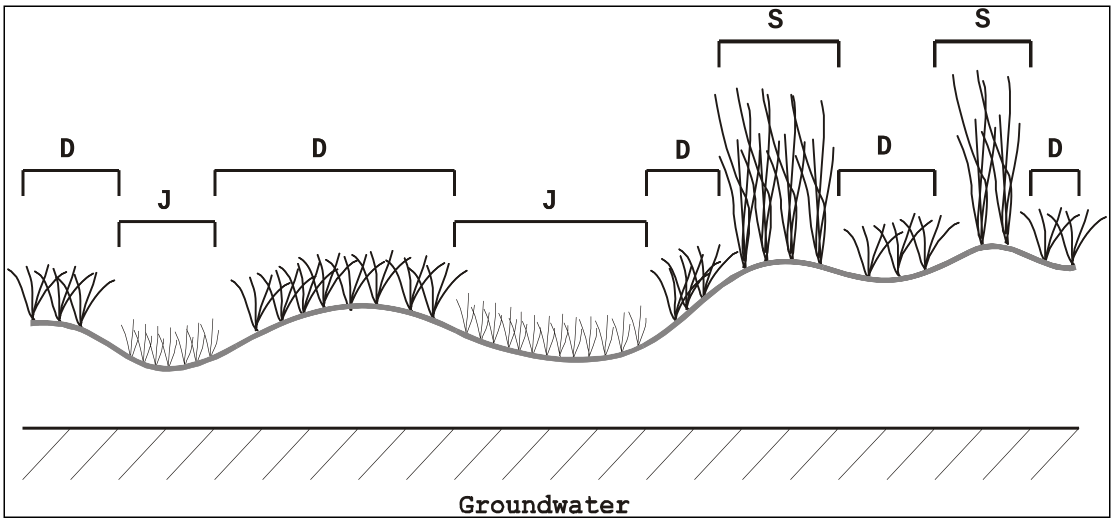


Fig. E-12. Typical distribution pattern of dominant species in meadow communities in response to micro-topography (D – saltgrass, J – Baltic rush, S – alkali sacaton).

If surface runoff is a major source of water to the meadow, the soils may be saline, with highest salt accumulations in the lower portions of the meadow. The high soil salinity results from the concentration of salts in runoff water which accumulates in depressions and then evaporates, leaving the salts on the soil surface. Areas of very high salt concentration are typically either barren or dominated by halophytes such as iodine bush (*Allenrolfea occidentalis*), seepweed (*Suaeda torreyana*), and alkali pink (*Nitrophila occidentalis*). Salinity levels decrease as micro-topography increases, and these slightly higher areas are dominated by saltgrass (Fig. E-13).

E.4.5.1 Maintenance Factors

Two factors are of prime importance in the maintenance of meadows, high soil moisture and perturbations sufficiently frequent to exclude dominance by shrubs.

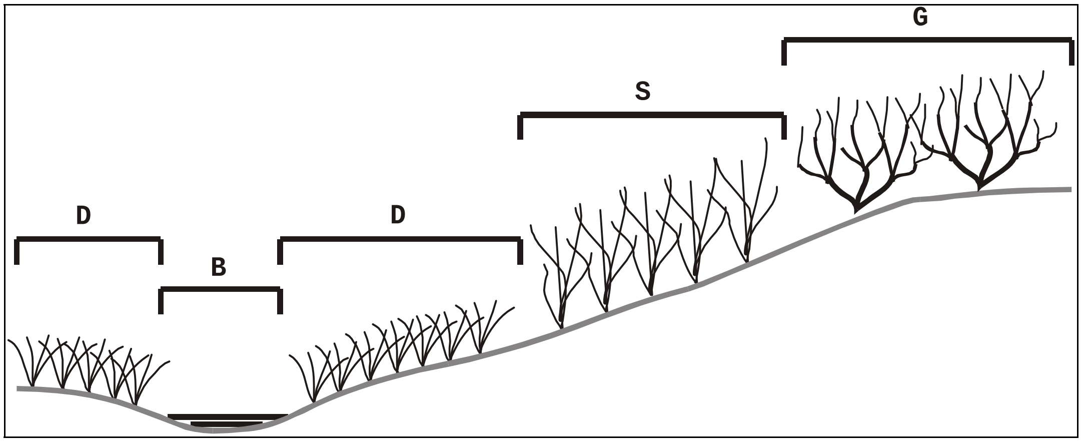


Fig. E-13. Typical toposequence where saline runoff water periodically accumulates in lower depressions (B – barren, D – saltgrass, S – alkali sacaton, G – greasewood).

Great Basin meadows tend to have groundwater at depths of 1-2 m (Miller et al. 1982; Nichols 1994; Martin and Chambers 2001; Welch et al. 2007; Mata-Gonzalez et al. 2008), but they also exist on sites where depth to groundwater is 3-6 m (Duell 1990; McLendon et al. 2008a). Saltgrass and Baltic rush are meadow species generally assumed to be dependent on groundwater within about 2 m of the soil surface (Miller et al. 1982; Sorenson et al. 1991; Nichols 1994). However, recent studies have shown that both species can produce high cover values where depth to groundwater is greater than 2 m (60% cover of saltgrass at DTW = 3.2 m and 70% cover of Baltic rush at DTW = 2.7 m; Mata-Gonzalez et al. 2008). In the Owens Valley of California, an isotopic study of water use indicated that saltgrass utilized primarily shallow soil moisture rather than groundwater during May-September, even though groundwater was available at a depth of 2 m (Goedhart et al. 2008). Water-balance calculations in sacaton and saltgrass communities in the Owens Valley also indicate that high levels of cover of these grasses occur at groundwater depths of 2-6 m (McLendon et al. 2008a).

Therefore, meadows in the Great Basin are not dependent on shallow groundwater (less than 2 m), but do require more available water than is supplied by direct precipitation. This additional soil moisture can be supplied from two sources (Fig. E-14). Groundwater is one source. Groundwater might be supplied from a shallow water table (less than 3 m), with the water table remaining within the rooting zone most of the year. In this case, the plants would have access to groundwater either directly or by capillarity. Alternatively, there might be a fluctuating water table, with groundwater rising within 2-3 m of the surface often enough to supply the necessary supplemental water to the roots. The second source of additional water to meadows is overland flow, which can occur as 1) surface runoff following snowmelt and heavy rainstorms, 2) outflow from springs, seeps, wetlands, or streams, or 3) artificial irrigation. Many of the meadows in the IBMA exist because of irrigation, either by direct application of irrigation water or by seepage from irrigation ditches carrying water to other locations. Regardless of source (groundwater or overland flow), these meadows require more soil moisture than can be supplied by precipitation alone. Common ET rates for these meadows are on the order of 60-90 cm per year (Table E-3), or 2-5 times the average annual precipitation.

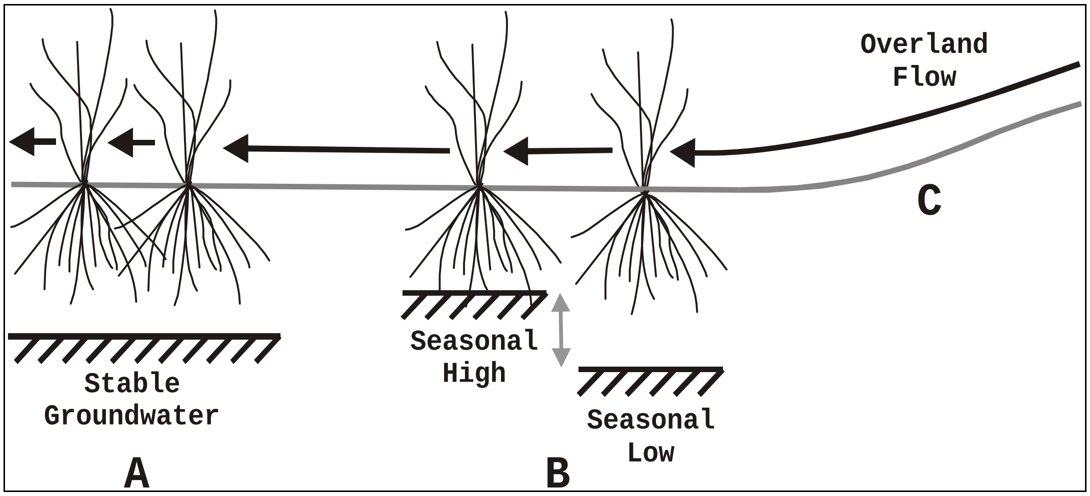


Fig. E-14. Potential sources of additional soil moisture to meadow communities (A – Shallow Groundwater, B – Fluctuating Water Table, C - Overland Flow).

The second factor required to maintain these meadows is perturbations frequent enough to keep shrubs from becoming dominant. A basic concept in successional ecology is that, in the absence of disturbance, systems tend to increased structure (Peet 1992:126; Smith 1992:324). Over time in most systems, there is an increase in woody plants (Fig. E-15). In the Owens Valley for example, shrub cover has increased in meadow communities where depth to groundwater has remained relatively constant (i.e., not affected by groundwater pumping). Over a 16-year period, shrub cover increased by an average of 53% at two sites with an average depth to groundwater of 2.0 m. At a third site, shrub cover (Nevada saltbush) increased more than 500%, from 5% to 31% cover (McLendon et al. 2008b). For grassland communities to remain grasslands, there must be a factor, or set of factors, that shifts competitive success from woody plants (shrubs) to grasses or grass-like plants (Fig. E-16). Fire is one such factor. Woody plants are more vulnerable to periodic fires than are grasses because, unlike woody plants, grasses have very little of their perennial biomass located aboveground. Haying operations can also reduce shrub establishment because the mowing associated with haying removes much of the aboveground perennial biomass of shrubs. In contrast, most of the tissue giving rise to new growth in grasses is located near or below the soil surface.

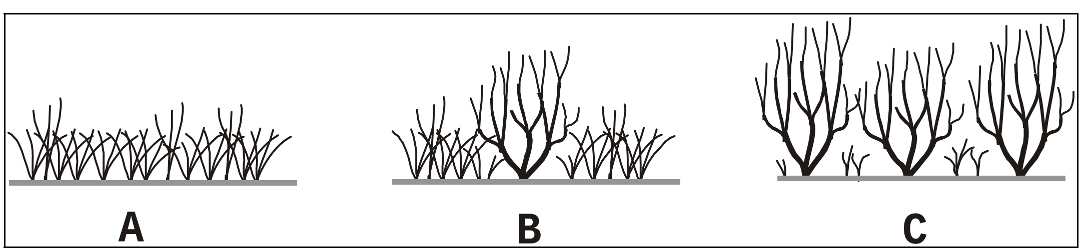


Fig. E-15. Successional communities on meadow sites in the absence of shrub-excluding factors (A – Grass Meadow, B – Grass-Shrub Meadow, C – Shrubland).

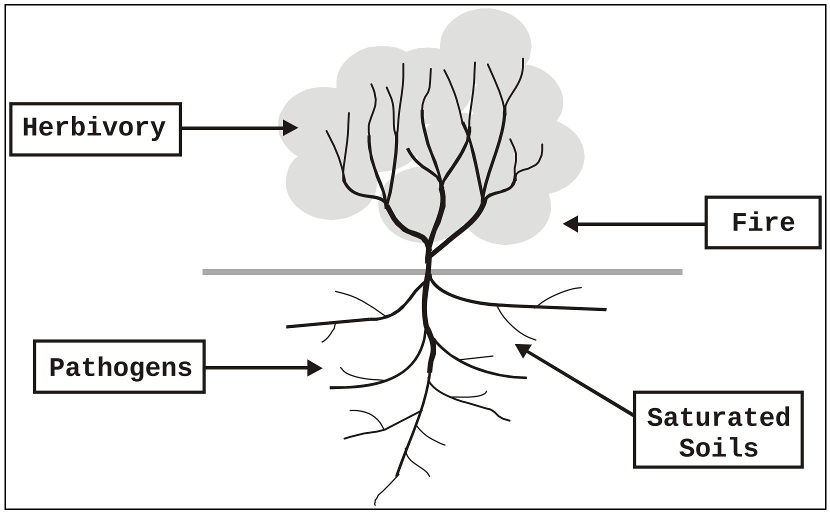


Fig. E-16. Factors that could reduce shrub abundance in meadows.

Another factor generally favoring grasses over shrubs is soil saturation. As groundwater rises nearer the surface, soils become saturated and oxygen content decreases. Roots of non-tolerant species die from anoxia (Naumburg et al. 2005). The meadow grasses and grass-like species may be able to tolerate saturated soils for longer periods than some shrub species. Big sagebrush (*Artemisia tridentata*) and green rabbitbrush (*Chrysothamnus viscidiflorus*) are relatively intolerant of saturated conditions (Ganskopp 1986). However, other shrub species such as greasewood (*Sarcobatus vermiculatus*), shrubby cinquefoil (*Potentilla fruticosa*), rubber rabbitbrush (*Chrysothamnus nauseosus*), and Nevada saltbush (*Atriplex torreyi*) are more tolerant (Miller et al. 1982; Ganskopp 1986; Groeneveld and Crowley 1988; McLendon et al. 2008a). Although greasewood is often associated with high water tables, it does not tolerate flooding for long periods (6 months, Groeneveld and Crowley 1988) and requires at least 25-30 cm of unsaturated soil for most of the year (Ganskopp 1986; Nichols 1994).

Saturated soils therefore apparently favor the herbaceous meadow species over even those shrubs that are more tolerant of saturated conditions. However, some shrub species will tend to invade the meadows even if the sites are saturated for up to six months. Therefore, saturation as a single-factor may not maintain the meadow communities. Saturation may slow the invasion of woody plants, and when combined with other factors such as fire may be partially responsible for the maintenance of the meadow communities.

High-soil moisture conditions may also increase the potential for attacks of pathogens on the roots of plants less tolerant of wet conditions. There has been a wide-spread decrease in the abundance of some shrub species (e.g., big sagebrush and shadscale) in the Great Basin over the past 20 years and it has been suggested that this might be related to above average soil moisture (Dobrowolski et al. 1990).

Herbivory is another factor that is likely to be important in the dynamics of the meadow communities. Most grasses are well-adapted to herbivory, but sustained overgrazing tends to decrease their abundance and increase the abundance of shrubs. However, under some conditions, herbivory may favor the meadow grasses. During the earlier stages of shrub invasion into the meadows, shrubs are smaller and less abundant than in later stages. Their smaller size (less mature) and the fact that they are growing on sites with more abundant moisture may increase their palatability, compared to more mature individuals of the same species growing on drier sites. These conditions might increase their use by sheep and native herbivores, especially during dry periods and during winter. Although these levels of herbivory are not likely to be sufficiently high to totally exclude the shrubs from the meadow communities, they may contribute to the success of the grasses. Conversely, sustained over-grazing by grass-eating herbivores is likely to decrease the vigor of the grasses and increase the rate of shrub invasion.

In summary, the meadow communities in the IBMA require more moisture than is normally supplied by precipitation falling directly on the meadow site. This additional moisture may be supplied by either groundwater or surface flow. The soils of most of the meadows are not saturated throughout the entire profile most of the year. As the depth of the unsaturated soil increases, the probability of shrub invasion increases. Without fire or some other means of shrub reduction, these meadows may become shrub-dominated communities over time.

E.4.5.2 Disturbance Patterns

Groundwater withdrawal might affect the meadow communities in two ways. First, it could increase depth to groundwater (i.e., lower the water table) where there is connectivity between the shallow aquifer and the developed aquifer. Although many plant communities in arid and semiarid regions with access to groundwater preferentially utilize precipitation derived soil moisture when it is available (e.g., Smith et al. 1991; Dawson and Pate 1996; Schulze et al. 1996; Zencich et al. 2002; Snyder and Williams 2003; Chimner and Cooper 2004; Goedhart et al. 2008), use of groundwater often becomes critical when other sources of water are depleted. Secondly, groundwater withdrawal might decrease overland flow to the meadows by reducing spring flow and/or the depth of water in adjacent wetlands.

If groundwater is within the rooting zone of the meadow community, a decrease in the water table would likely alter the community in three primary ways (Fig. E-17). First, productivity and cover would decrease. Meadow communities in the Owens Valley utilize both groundwater- and precipitation-derived water and the amount of groundwater usage decreases as depth to water (DTW) increases (McLendon et al. 2008a). When DTW is 2 m or less, sacaton meadows use an average of 50-80% groundwater, but this usage decreases to 35-50% when DTW is 2.0-5.5 m and to about 15% when DTW is greater than 5.5 m. Canopy cover of the meadows also decreases as DTW increases. When DTW is 2 m or less, cover averages 35-45%, and decreases to 10-25% at 2-8 m DTW.

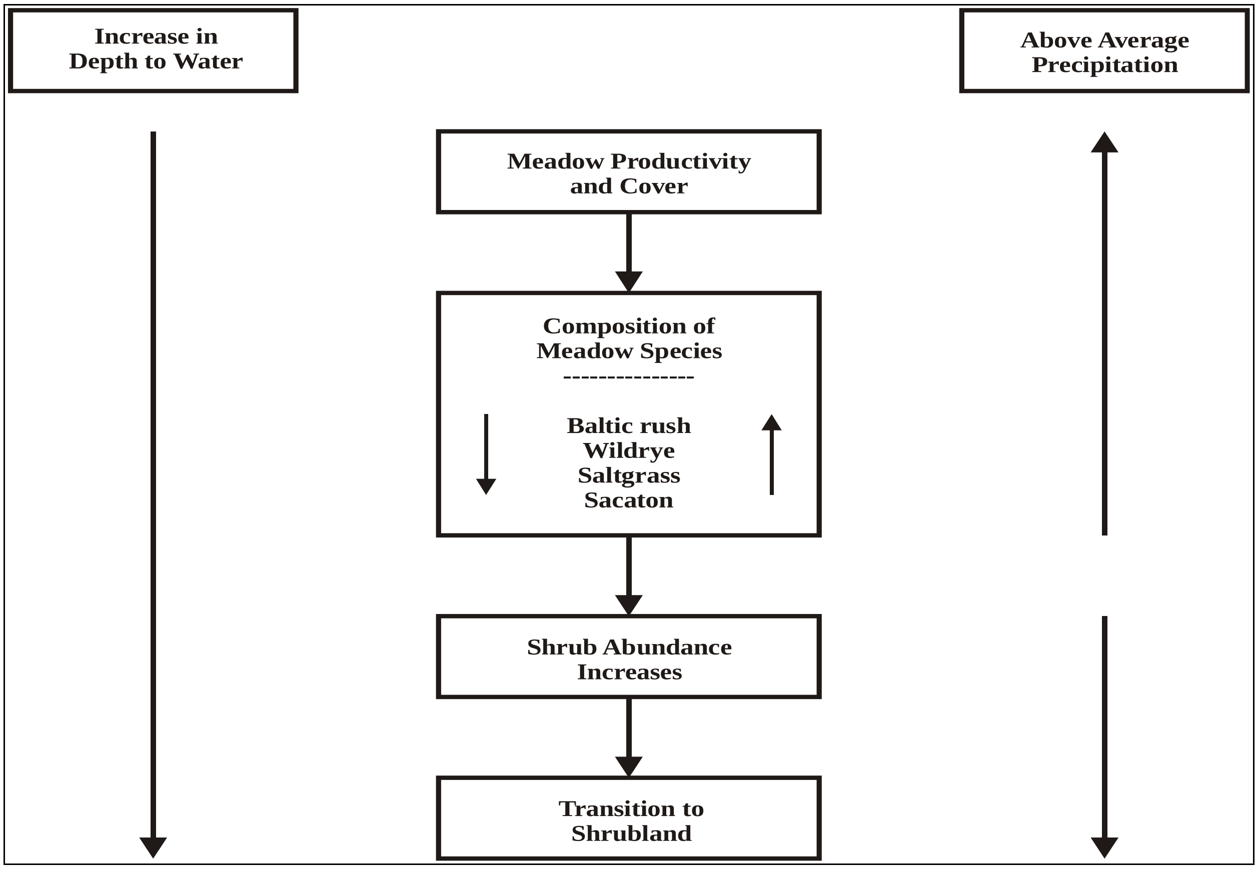


Fig. E-17. Probable impacts of an increase in depth to water on the dynamics of meadow communities and the potential alternate pathway in years of above average precipitation.

Secondly, species composition would likely shift. Cover of Baltic rush and wildrye would decrease and saltgrass cover would initially increase. Baltic rush is more dependent on a higher water table than is saltgrass. As the water table continued to decline, cover of saltgrass would begin to decrease and cover of sacaton would increase. Saltgrass utilization of groundwater is about 30% higher than that of sacaton (McLendon et al. 2008a), so saltgrass would be impacted more by a lowering of the water table than would sacaton.

The rate at which the decrease in cover of the meadow community and the shift in species composition would occur would be dependent, in part, on the amount the depth to water increased and the amount of precipitation received during and following the drawdown (Sorenson et al. 1991). Meadow communities in the Owens Valley remain productive (40% cover) in wet years (29 cm), even when groundwater is relatively deep (5.9 m)(McLendon 2006). In addition, both sacaton and saltgrass preferentially use precipitation instead of groundwater (McLendon et al. 2008a). Therefore the effects of a groundwater decline on meadow communities could be offset, at least temporarily, if precipitation was above average.

Finally, the community would likely eventually shift from a meadow to a shrub-dominated community. There are a number of factors that can cause a meadow to shift to a shrubland, and a declining water table is one. In general, shrubs have deeper root systems than grasses. Therefore shrubs can potentially extract water from deeper sources than can grasses (Dodd et al.

1998; Schwinning et al. 2002; Scott et al. 2006). Hence, as depth to groundwater increases, shrubs should have a competitive advantage over grasses. However, this is not a simple relationship. For example, sacaton has a deep root system and can utilize some groundwater from depths up to at least 6.5 m (McLendon et al. 2008a). When groundwater was at depths of 6.0-6.5 m, groundwater-supported cover was higher in sacaton-dominated communities in the Owens Valley than in Nevada saltbush-dominated communities, about equal to that in rabbitbrush-dominated communities, but lower than that in greasewood-dominated communities (McLendon et al. 2008a).

The relationship between change in depth to water and change in vegetation is complex. Great care should be given to the issue of attributability when attempting to understand vegetation dynamics. This is especially true in the case of increases in shrub abundance in meadow communities. Meadow communities can shift to shrub communities without a change in depth to groundwater and this shift can occur rapidly. One control site that has been monitored in the Owens Valley for almost 20 years illustrates this point (McLendon 2006; McLendon et al. 2008a). In 1989-1991 the plant community was a meadow community dominated by saltgrass (30% cover) and sacaton (8% cover), with 2% cover of Baltic rush. There were no shrubs along the permanent monitoring transect. Nevada saltbush began in invade in 1992 (4% cover). Nevada saltbush became the dominant species on the site (28% cover) in 1995. In 2004, Nevada saltbush cover was 47% and saltgrass and sacaton had declined to 8% and 4%, respectively. Depth to groundwater averaged 3.4 m in 1990-91, and decreased (water table became higher) to 3.0 m in 1992 when shrub invasion began. Between 1992 and 2006, depth to groundwater averaged 1.9 m. In this case, shrub invasion of a saltgrass meadow occurred in conjunction with a decrease in depth to groundwater. The shift from meadow to shrubland was not caused by livestock grazing either, because the site was fenced to exclude grazing.

Once shrub abundance increases to some threshold level, the transition to a shrubland will probably occur even if higher water levels are restored or high precipitation is received. Once these threshold levels have been reached, the meadow communities can be restored only if methods are applied that vigorously decrease shrub abundance. Examples include fire, mechanical brush control, and flooding. If the abundance of the herbaceous meadow species becomes sufficiently low following transition to shrubland, reseeding or other methods of propagation of the herbaceous species will also be required following reduction of shrub abundance.

E.4.5.3 Relationship of Conceptual Model to Monitoring Plan

Fig. E-18 depicts how primary drivers and stressors presented in the conceptual models relate to KEAs and indicators to be monitored at meadows in the IBMA (Chapter 4). This parsimonious diagram is not meant to demonstrate a complete conceptual model, but rather how components of the conceptual models relate to the Plan.

E.4.6 PHREATOPHYTIC SHRUBLANDS

The primary example of groundwater-influenced shrublands in the IBMA are the greasewood (*Sarcobatus vermiculatus*) communities. Other shrubs, such as shadscale (*Atriplex confertifolia*), rabbitbrush (*Chrysothamnus nauseosus*), and various species of saltbush (*Atriplex canescens, A. gardneri, A. parryi, A. torreyi*) are also commonly found on lowland sites, often in areas with relatively shallow groundwater. Most shrublands are more productive and have greater canopy cover when in contact with groundwater, but most other shrublands are also common on upland sites, albeit at lower productivity levels. Greasewood communities will be used as the typical example of groundwater-influenced shrublands in this section, but it is recognized that shrublands dominated by other species may also be important.

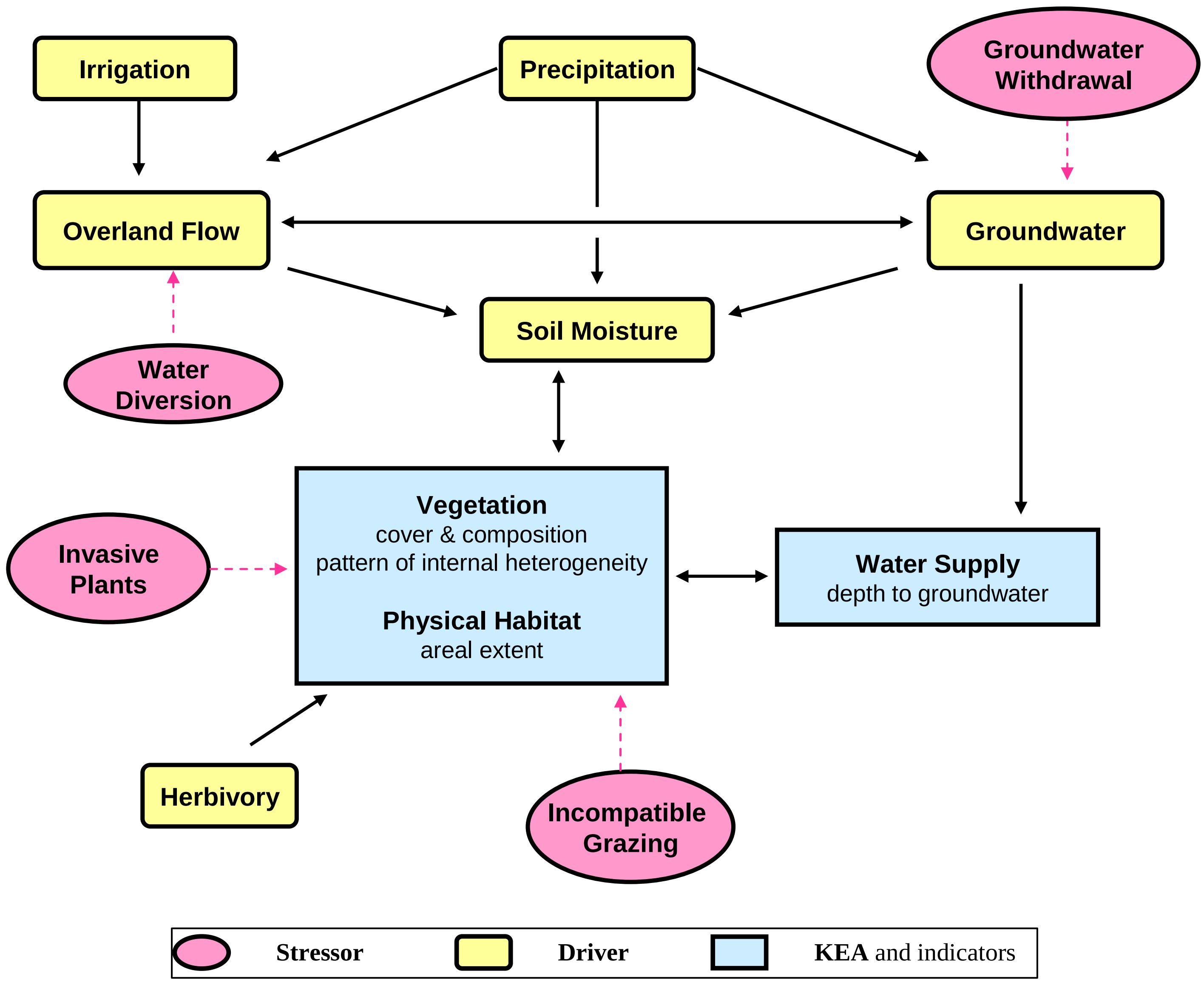


Fig. E-18. Relation among primary drivers, stressors, and KEAs and indicators to be monitored at meadows in the IBMA.

E.4.6.1 Maintenance Factors

Greasewood communities are one of the most common shrublands on lowland sites with shallow groundwater throughout the Great Basin. They generally occur along a toposequence between meadow (typically saltgrass) communities where groundwater nears the surface and shadscale, rabbitbrush, and sagebrush communities upslope (Miller et al. 1982; Sorenson et al. 1991; Comstock and Ehleringer 1992; Nichols 1994; Chimner and Cooper 2004). Although greasewood is most abundant on these lowland sites (DTW at 4 m or less; Miller et al. 1982, Sorenson et al. 1991), individual plants and small populations can also occur on upland sites, indicating that greasewood is not entirely dependent on shallow groundwater. Thus, greasewood is a facultative phreatophyte, not an obligate phreatophyte. Greasewood can occur in near monoculture stands, but it is commonly the dominant species in these communities with rabbitbrush, shadscale, and Nevada saltbush as common sub-dominants (Table E-5).

Table E-5. Canopy cover (%) and aboveground biomass (g/m^2) in greasewood communities in the western Great Basin.

Species	Battle Mountain NV		Owens Valley CA	
	Cover	Biomass	Cover	Biomass
Greasewood	4.8	19.9	7.6	30.2
Rabbitbrush	1.8	19.8	0.8	3.2
Nevada saltbush	0.0	0.0	1.8	11.4
Shadscale	0.0	0.0	0.7	3.0
Horsebrush	0.0	0.0	0.4	0.7
Other shrubs	0.1	0.0	0.7	3.1
Saltgrass	2.7	12.2	1.4	9.7
Thickspike wheatgrass	1.0	3.1	0.0	0.0
Alkali sacaton	0.7	0.0	1.8	5.2
Other grasses	0.5	0.0	0.0	0.0
Sumpweed	3.7	14.4	0.0	0.0
Prickly lettuce	1.5	0.1	0.0	0.0
Sweetclover	0.4	0.0	0.0	0.0
Other forbs	0.1	0.6	0.5	2.0
TOTAL	17.3	70.1	15.7	68.5

Nevada data = mean of 4 sites (McLendon 1998, unpublished data)
California data = mean of 7 sites (McLendon 2007)

The same two primary hydrologic factors that are important in supplying supplemental water to meadows (shallow groundwater and overland flow) are also important determinants for greasewood and similar facultative phreatophytic shrublands. However, whereas the meadows can tolerate groundwater to the surface and even prolonged surface flooding, the shrublands can not. Greasewood, for example, can tolerate flooding for short periods (less than 6 months; Groeneveld and Crowley 1988), but it requires a minimum of 25-30 cm of unsaturated soil during most of the year (Ganskopp 1986; Nichols 1994). When groundwater is very shallow (e.g., 0.3 m), an increase in depth to groundwater results in an increase in greasewood cover because of the increase in depth of the unsaturated zone (Sorenson et al. 1991:33; McLendon 2005, 2008). Many of the lowland depressions that accumulate surface runoff water also tend to have saline and sodic soils, at least in the surface horizons. Greasewood is relatively tolerant of saline and sodic conditions (Miller et al. 1982; Chimner and Cooper 2004).

A primary difference between the hydro-ecology of these shrubland sites and the associated meadow sites is that the shrublands can utilize deeper groundwater than can most meadow communities. In general, shrubs have deeper root systems than grasses (Schenk and Jackson 2002), which allow them to utilize groundwater at greater depths than the meadow communities. Greasewood roots can extend to depths of at least 5.5 m (ICWD/LADWP 1989) and is found in lowland sites where groundwater is as much as 11 m deep (Nichols 1994). If greasewood is utilizing groundwater at 11 m and its roots extend to 5.5 m, groundwater would have to be lifted by capillarity at least 5.5 m. This height for capillary rise is unlikely. Theoretically, capillary rise in clay soils can be as much as 15 m (Kohnke 1968:20). In practice however, it is not likely to result in such substantial heights because of the very slow rate of rise in clay soils. Capillary rise has been reported to be nearly 2 m in sandy clay loams (Chimner and Cooper 2004) and as much as 3.5 m on clay loam soils (Cook and O'Grady 2006). A capillary rise of 3.5 m and a rooting depth of 5.5 m would place the maximum depth at which groundwater might be accessible to greasewood at about 9.0 m. Data from the Owens Valley indicate that greasewood communities can access groundwater (including possible capillary rise) at depths of 8.0-8.5 m (McLendon et al. 2008a).

As depth to groundwater increases, use of groundwater by greasewood decreases as does canopy cover of greasewood (unless the water table is very shallow). Nichols (1994) estimated groundwater usage by greasewood communities in Nevada as a function of depth to groundwater. When depth to groundwater was less than 2 m, the estimated ET rates in greasewood communities were 19-31 cm per year. Welch et al. (2007) reported similar rates of 25-33 cm in Spring and White River Valleys. ET decreased to 10-22 cm per year when DTW was 3-4 m and 6 cm when DTW was 8.4 m (Nichols 1994). Grosz (1972) measured ET from tanks planted to rabbitbrush and to greasewood near Winnemucca. In these constructed systems with abundant moisture, ET rates for greasewood also decreased with increasing DTW, with 56 cm of ET at 1.5 m DTW, 40-43 cm at about 2.0 m, and 33 cm at 2.5 m (Table E-6).

Table E-6. Evapotranspiration (May-October) in relation to depth to water (DTW) and canopy cover from constructed saltgrass, rabbitbrush, and greasewood microcosms, Winnemucca, Nevada (Grosz 1972).

Saltgrass			Rabbitbrush			Greasewood		
DTW (m)	Cover (%)	ET (cm)	DTW (m)	Cover (%)	ET (cm)	DTW (m)	Cover (%)	ET (cm)
0.7	100	51.1	1.6	51	49.5	1.5	47	56.1
			1.9	72	57.2	1.9	48	40.4
						2.3	57	43.4
2.5	34	22.1	2.5	64	39.1	2.5	20	33.0

Data from the Owens Valley also indicate that groundwater use by greasewood communities decreases as depth to groundwater increases, although the Owens Valley data also indicate that groundwater use by greasewood (and other groundwater-influenced communities) is also affected by the amount of precipitation received. When groundwater was at 2-4 m, the community used 65-75% groundwater, compared to 10-30% when DTW was 6-8 m (McLendon et al. 2008a). When DTW was less than 3 m, the greasewood communities averaged 10-15% canopy cover, depending on amount of precipitation received (Table E-7). When DTW decreased to 3-4 m, cover decreased to 7-13%, a reduction of about 30%. At 5-7 m DTW, cover decreased to 5-8%, and decreased to 3-5% when DTW reached 8.0-8.5 m. Cover values at 8.0-8.5 m DTW were about one-third their values when DTW was less than 3 m. This is consistent with the data from Nichols (1994), where ET at 8.4 m DTW was 20-33% of ET when DTW was less than 2 m.

Table E-7. Effect of depth to groundwater (DTW) and annual precipitation (PPT) on canopy cover of greasewood in 3 greasewood communities in the Owens Valley, California.

Dry Years (PPT < 12 cm)		Average Years (PPT 12-20 cm)		Wet Years (PPT > 20 cm)	
DTW (m)	Cover (%)	DTW (m)	Cover (%)	DTW (m)	Cover (%)
2.3-2.6	10.6	2.6-2.9	13.3	2.3-2.7	15.2
3.1-3.7	7.1	3.4	9.6	3.0-3.3	12.6
4.4	5.1				
4.8-5.3	5.1	4.8-5.8	6.9	5.2-5.3	5.1
6.1-6.6	4.9			5.7-6.2	7.0
7.2-7.4	5.5	7.0-7.7	6.6	7.0-7.2	7.6
				7.6-7.9	6.8
8.5	3.0	8.0-8.5	5.0	8.2-8.5	2.6

Data were pooled from 3 permanent monitoring sites that supported greasewood communities (McLendon 2006, with updates for 2005 and 2006). Data were collected over 18 years. Depths to water varied by year and therefore each PPT regime did not contain the same number of observations or the same precise ranges in DTW.

The data in Tables E-6 and E-7 indicate that canopy cover of greasewood decreases as depth to groundwater increases. This is not synonymous with cover of greasewood communities decreasing with a decrease in depth to groundwater. The two would be synonymous if the community was a monoculture of greasewood. However, most greasewood communities also contain other shrubs, as well as herbaceous species (Table E-5). Data from the study by Nichols

(1994) in Nevada indicate that canopy cover of greasewood communities is not affected by depth to groundwater until below 5.5 m (Table E-8). Data from McLendon (2008a) also indicate that canopy cover of greasewood communities remains relatively high when depth to groundwater is 4 m or less, and then declines to 7-10% between 4 m and 8 m. Canopy cover then declines to about 5% below 8 m. The stability, as measured by canopy cover, in greasewood communities in response to increasing depth to groundwater above 4 m (McLendon et al. 2008a) or 5.5 m (Nichols 1994), and again between 4 and 8 m (McLendon et al. 2008a), is probably the result of increases in cover of associated species offsetting decreases in cover of greasewood (Fig. E-19).

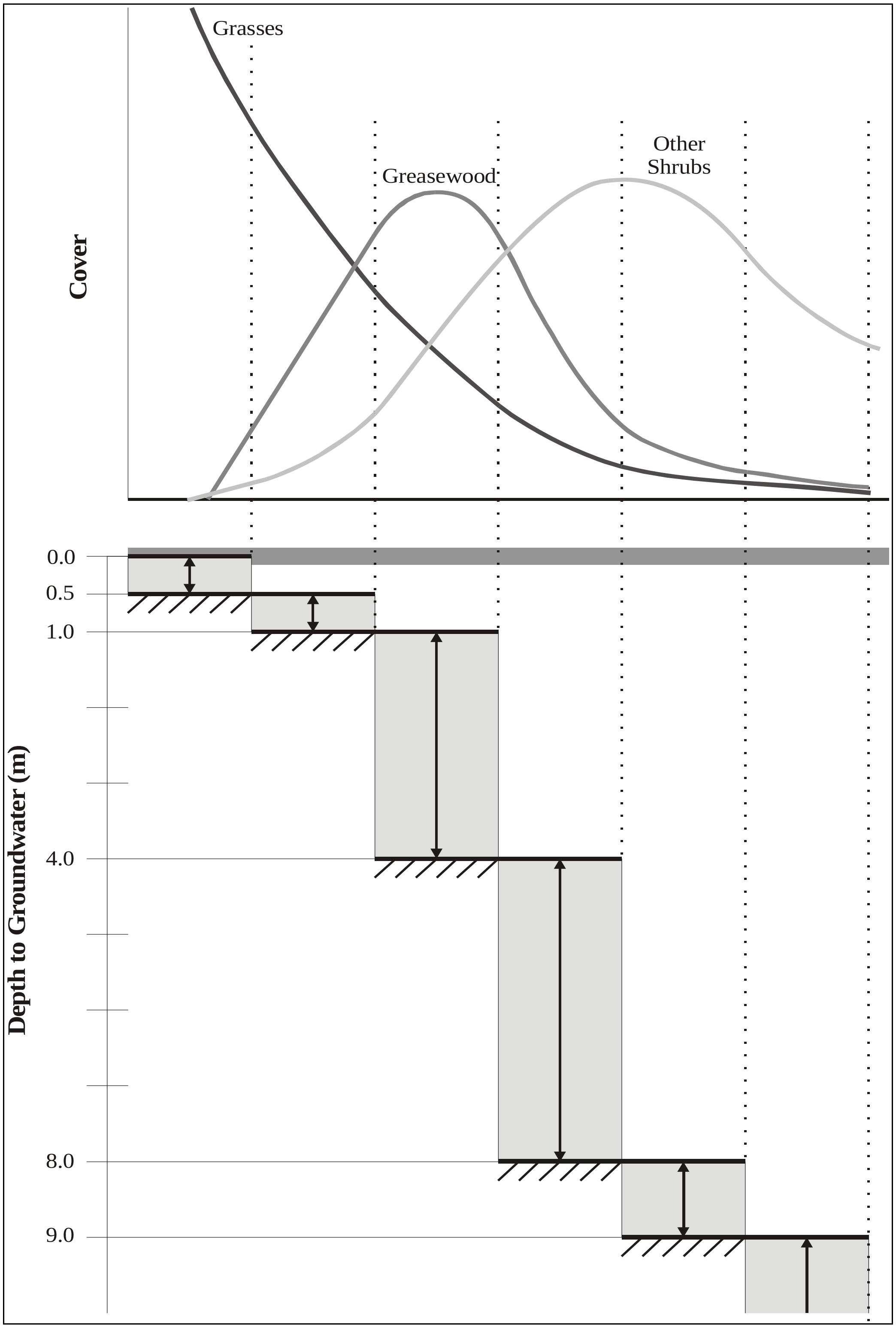


Fig. E-19. Generalized relationship between depth to groundwater and changes in cover of grasses, greasewood, and other shrubs under average precipitation. Arrows indicate the ranges in depth to groundwater causing the respective changes in plant cover values.

Table E-8. Relationship of canopy cover of greasewood communities to change in depth to groundwater (DTW).

Nichols (1994)		McLendon et al. (2008a)	
DTW (m)	Cover (%)	DTW (m)	Cover (%)
1.7	25	2-3	35
1.8	22	3-4	22
2.7	23	4-5	8
4.9	25	5-6	10
5.5	23	6-7	7
6.4	13	7-8	9
		8-9	5

Data from Nichols (1994) are for 6 sites in Nevada, each sampled on one occasion.
Data from McLendon et al. (2008a) are means of 3 sites in California, sampled annually for 16-20 years.

Results from these three studies indicate that cover of greasewood communities is likely to decrease as depth to groundwater increases, but that the communities would continue to exist even if the linkage between groundwater and their roots (including capillary fringe) was severed (Fig. E-19). This observation is supported by the fact that these species occasionally occur on upland sites where groundwater is too deep to affect the plants. This is true for greasewood and is especially true for rabbitbrush. Rabbitbrush is one of the most widespread species in the Great Basin region (Anderson 1984) and is abundant on both lowland and upland sites. Therefore groundwater is not required for the existence of productive rabbitbrush communities, but rabbitbrush is able to exploit groundwater when it is available, with a corresponding increase in productivity. Productive greasewood communities are more dependent on groundwater (or surface runoff) than rabbitbrush, but they are not totally dependent on shallow groundwater. Canopy cover of understory vegetation, primarily grasses and forbs, and the composition of the various understory species are also likely to change as depth to groundwater increases (Fig. E-19). However, change in grass cover and composition is also affected by grazing by both livestock and wildlife.

In summary, greasewood communities occur on sites receiving runoff or outflow or on sites with relatively shallow groundwater. Greasewood does not tolerate saturated conditions in the upper 50 cm of the soil profile for long periods of time (ca. 6 months). Greasewood can utilize groundwater to depths of about 9 m, with canopy cover decreasing as depth to water increases. If groundwater is deeper than 9 m, greasewood becomes entirely dependent on precipitation or surface runoff. Under these conditions, greasewood canopy cover is likely to be about 2-5%, depending on the amount of precipitation received. Greasewood communities are not as sensitive to changes in depth to groundwater as is greasewood itself because of groundwater-use patterns of the associated species. In general, total canopy cover of these communities will not likely to be strongly affected by an increase in depth to groundwater until DTW exceeds 4-5 m, at which point total canopy cover will probably decrease by about 50-75%. Total canopy cover will likely remain at these levels until DTW exceeds 8-9 m. At that point, total canopy cover is likely to decrease to the level that can be supported by precipitation and the accumulation of surface runoff.

E.4.6.2 Disturbance Patterns

Groundwater withdrawal may affect these shrublands in the same two ways it is likely to affect meadows: a reduction in overland flow and an increase in depth to groundwater. Both ways would primarily affect the shrublands by reducing the amount of water available to the plants.

Precipitation-use efficiency data from the Owens Valley indicate that groundwater-affected shrub communities (greasewood, rabbitbrush, and Nevada saltbush) require an average of about 1.1 cm of annual precipitation to produce 1% canopy cover in most years (McLendon et al. 2008a). Data from Nichols (1994) indicate that greasewood communities in Nevada transpire 0.7-0.8 cm of groundwater per 1% canopy cover, per year. Assuming that these communities also used 15-20 cm of precipitation per year, precipitation-use would add another 0.6-0.8 cm per 1% canopy cover, for a total annual water use of about 1.3-1.6 cm per 1% canopy cover. Therefore, these shrublands require about 1.0-1.5 cm of water per 1% canopy cover. Less water is required if it is precipitation-derived and more is required if it is groundwater-derived.

The time required for the effects of an increase in depth to groundwater to be discernable will depend, in large part, on what the depth was prior to the increase and how fast the increase in DTW occurs. If DTW remains 4 m or less, there is not likely to be any decrease in total canopy cover of the shrub community (Fig. E-19). Over time, there may be a shift in species composition, with greasewood and shadscale decreasing in abundance and rabbitbrush and saltbush (primarily Nevada and fourwing) increasing.

Rabbitbrush, Nevada saltbush, and alkali sacaton all have greater reported maximum rooting depths (6.2, 5.8, and 6.2 m respectively) than greasewood (5.5 m)(ICWD/LADWP 1989). Therefore, as DTW increases, these three species may be able to extract more water than greasewood. However, maximum rooting depth would not be the only root factor that might affect water supply to the plants as depth to groundwater increased. Efficiency of hydraulic lift may also be important. Greasewood is more effective in supplying water to upper soil layers through hydraulic lift than is rabbitbrush, and fourwing saltbush is intermediate between the two (Sperry and Hacke 2002). Greater hydraulic lift efficiency might favor greasewood over rabbitbrush as depth to groundwater increased until depth to groundwater approached the maximum rooting depth of greasewood. Rabbitbrush is more sensitive to a declining water table under conditions of low precipitation than either greasewood or Nevada saltbush (Sorenson et al. 1991), and hydraulic lift efficiency might be a factor. Once the maximum rooting depth of greasewood was reached, groundwater would become unavailable to greasewood except as it was transported to upper soil layers via hydraulic lift by deeper-rooted species. Therefore at deeper depths to groundwater, rabbitbrush and fourwing saltbush would have competitive advantage over greasewood and shadscale in relation to moisture supply (Sperry and Hacke 2002).

Rabbitbrush has a faster growth rate than greasewood (Dodd and Donovan 1999), which should provide rabbitbrush with a competitive advantage as moisture becomes limited, especially if the moisture occurs primarily in pulses (e.g., rainfall and runoff events)(Gebauer and Ehleringer 2000; Gebauer et al. 2002; Huxman et al. 2004), because the faster-growing plants should also take up soil moisture faster than slower-growing plants (Fernandez and Reynolds 2000). The replacement of greasewood and shadscale by rabbitbrush and various saltbush species might not be as much a displacement process as a replacement process, e.g., greasewood might decline in abundance because of deeper groundwater and rabbitbrush might not be affected initially and therefore would increase in abundance relative to greasewood.

Once depth to groundwater was below 4 m, total canopy cover would likely decrease. The major shrub species would likely remain as parts of the plant community, but at lower densities and cover values. The rate of groundwater decline would also have an effect on the species composition of the community, which would have an effect on productivity. If the decline occurred fairly rapidly (e.g., 1-5 years) the community would likely remain a greasewood community during this period because there would be insufficient time for the associated shrub species to increase in abundance enough to become site-dominants. If so, and depth to groundwater declined to below 8-9 m, total canopy cover would decrease to 5% or less.

If depth to groundwater remained below 4 m, the abundance of shrubs other than greasewood and shadscale would likely increase over time. Rabbitbrush and Nevada saltbush require 5-10 years to become site dominants (Harniss and Murray 1973; McLendon and Redente 1990, 1991, 1994; Stevenson et al. 2000; McLendon 2006). As groundwater becomes less important in the maintenance of the plant community, the community would shift to greater dependence on precipitation-derived soil moisture. Eventually, a new community composition and productivity would be achieved that would be similar to those currently on the uplands. Important species would include rabbitbrush, big sagebrush, green rabbitbrush, black sage (*Artemisia nova*), winterfat (*Eurotia lanata*), and hopsage (*Grayia spinosa*). Total canopy cover would be on the order of 20-30%.

Another factor affecting the existence of greasewood communities is soil salinity. Soil salinity can change as both the relative and absolute amounts of overland flow and groundwater change. Groundwater withdrawal and changes in land management and amount of precipitation received can alter these hydrological dynamics and therefore the potential salinity level of the soil. Greasewood is relatively tolerant of saline and sodic conditions. As depth to groundwater increased and surface runoff decreased, salts in the upper profile would still be present. At low precipitation levels (e.g., less than 25 cm), it is unlikely that these salts would be transported to lower soil horizons by percolation of soil moisture. Therefore, the species that might replace greasewood on these sites would also need to be tolerant to relatively high salt concentrations. Branson et al. (1988) summarized data on salinity tolerances of 31 plant species of the western United States. Shadscale, fourwing saltbush, Nevada saltbush, and saltgrass were reported to be more salt-tolerant than greasewood, and rabbitbrush, big sagebrush, and alkali sacaton were reported to be similar to greasewood in their salinity tolerance. However, when the salinity of the soils on which each species occurs is used as the measure salinity tolerance, shadscale is as tolerant (Branson et al. 1988) or less tolerant (Miller et al. 1982; Comstock and Ehleringer 1992) than greasewood. Big sagebrush generally occurs on soils that are less saline than those supporting greasewood (Miller et al. 1982; Branson et al. 1988; Comstock and Ehleringer 1992), but this may be a response to soil texture and soil drainage as much as it is salinity. Big sagebrush tends to occur on coarser-textured soils than does greasewood (Comstock and Ehleringer 1992) and big sagebrush is particularly sensitive to flooding (Ganskoff 1986).

Change in species composition that might occur in response to changes in depth to groundwater is a complex issue that would be influenced by a number of factors (Fig. E-20), one of which is drought-tolerance. At least under some conditions, rabbitbrush is less drought-tolerant than greasewood, shadscale, fourwing saltbush, and Nevada saltbush (Branson et al. 1988; Dileanis and Groeneveld 1989). However, drought-tolerance is a complex attribute in plants, affected by a number of factors including soil texture. Although soil texture affects plant-moisture relationships in a general manner, the relative impact can vary substantially among species. Rabbitbrush and shadscale transpiration rates are strongly affected by soil texture, with lower rates on fine-textured soils, but transpiration rates of greasewood and fourwing saltbush are affected relatively little by soil texture (Sperry and Hacke 2002). A higher transpiration rate on fine-textured soils would suggest greater water uptake by greasewood under these conditions, and might provide enough competitive advantage to greasewood as soil moisture decreased to at least slow its replacement by rabbitbrush as groundwater declines. Greater drought-tolerance and higher hydraulic conductivity in greasewood might provide substantial competitive advantage to greasewood over rabbitbrush on fine-textured soils, especially where groundwater remained available to both species. Faster potential growth rate and a deeper root system would favor rabbitbrush, especially on coarse-textured soils or where groundwater became unavailable to both species.

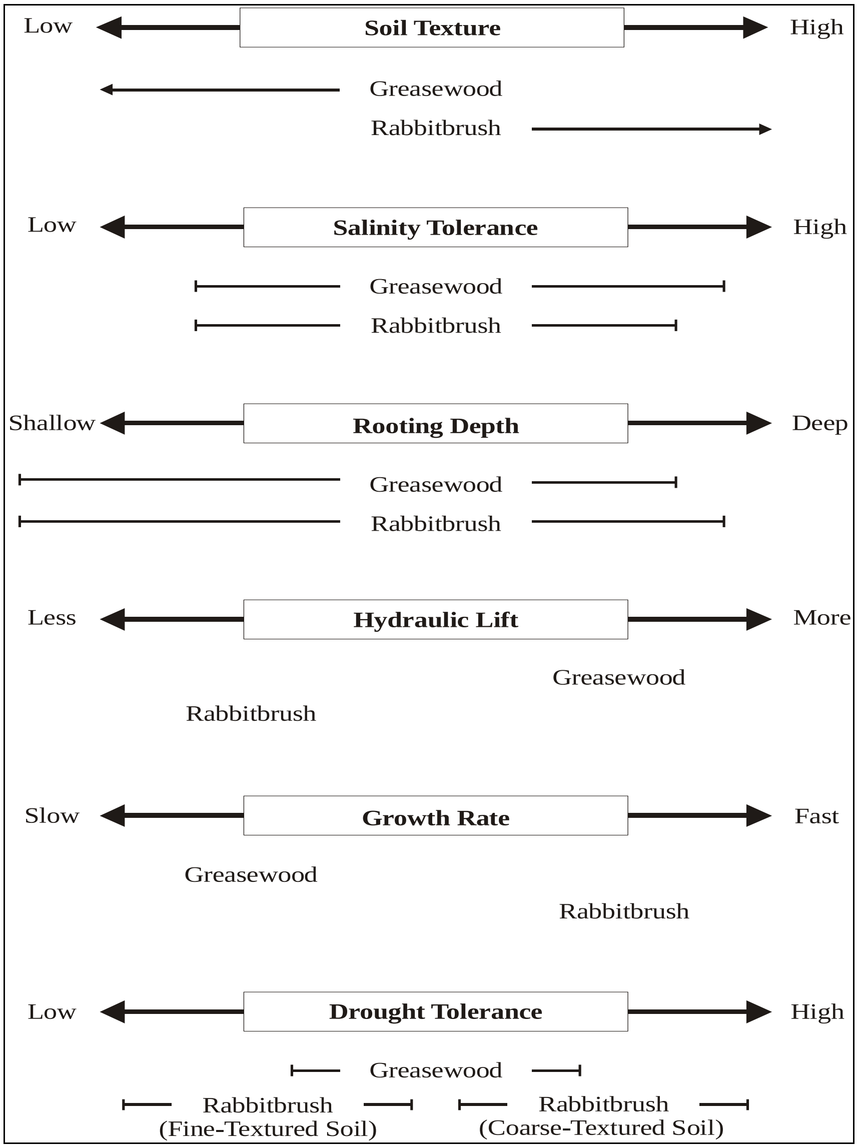
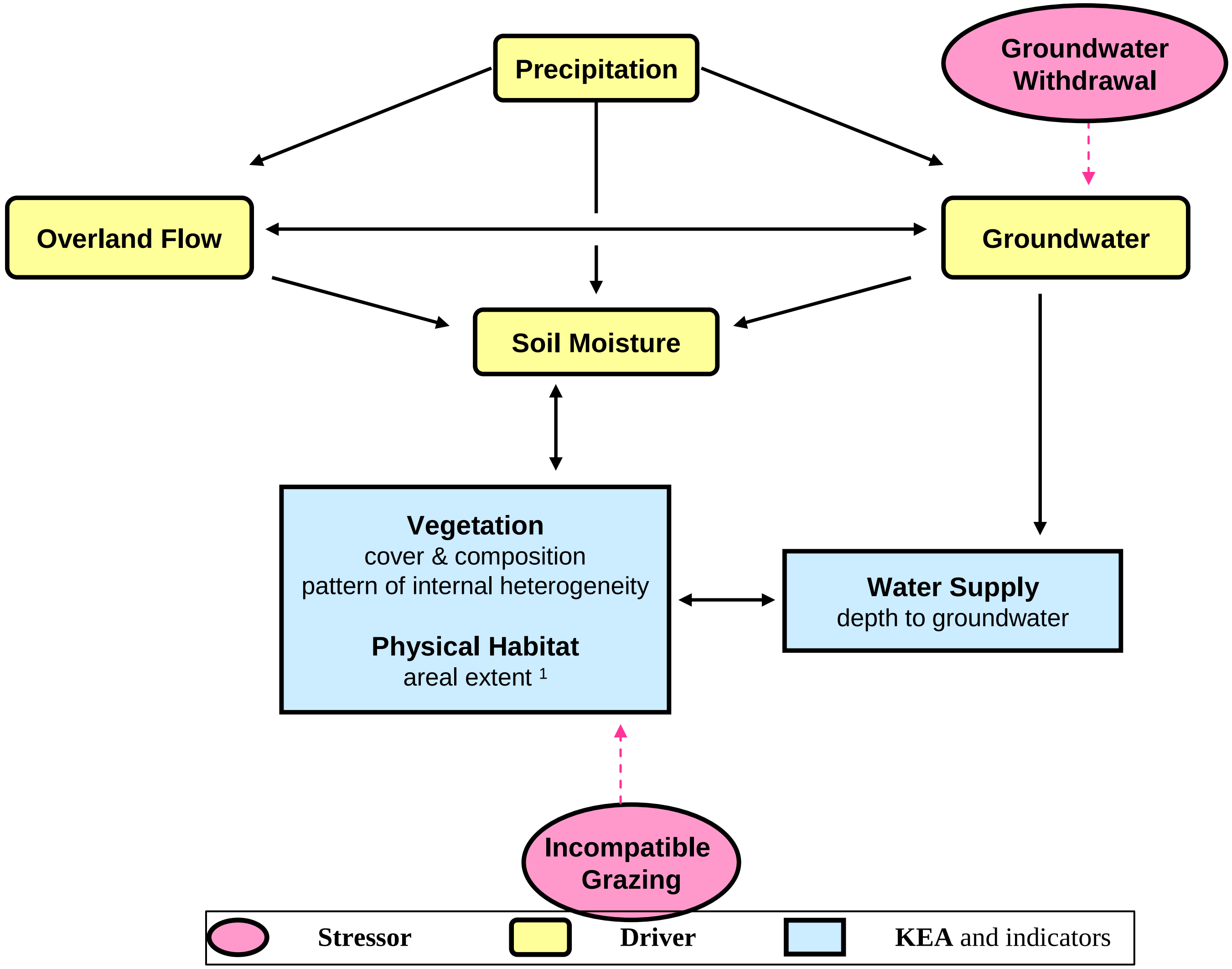


Fig. E-20. Comparison of responses of greasewood and rabbitbrush to some ecological factors that might affect change in species composition as depth to groundwater increases.

E.4.6.3 Relationship of Conceptual Model to Monitoring Plan

Fig. E-21 depicts how primary drivers and stressors presented in the conceptual models relate to KEAs and indicators to be monitored at phreatophytic shrublands in the IBMA (Chapter 4). This parsimonious diagram is not meant to demonstrate a complete conceptual model, but rather how components of the conceptual models relate to the Plan.



[1] Remote sensing may be used to monitor areal extent in the future.

Fig. E-21. Relation among primary drivers, stressors, and KEAs and indicators to be monitored at phreatophytic shrubs in the IBMA.

E.4.7 SWAMP CEDAR WOODLANDS

Swamp cedars is a term applied to populations of Rocky Mountain juniper (*Juniperus scopulorum*) that occur in Spring Valley on lowland sites at elevations lower than commonly associated with the species.

E.4.7.1 Maintenance Factors

Rocky Mountain juniper is the most widely-distributed western juniper that grows to tree size and is found on a wide variety of soils and topographic locations (Fowells 1965). The lower end of the precipitation range to which it is adapted is about 30 cm (Fowells 1965; Van Haverbeke 1980), and so its presence at lowland sites in Spring Valley requires supplemental moisture. The source of this supplemental moisture is most likely a perched water table, deeper groundwater, spring flow, or a combination. Water supply to a perched water table would likely be from subsurface drainage from higher elevations through sands, gravels, and cracks and fissures in the underlying rock. Surface runoff following snowmelt or high rainfall events could also contribute to higher soil moisture if the runoff was retained within the juniper community. A perched water table would require a largely impervious layer below the rooting zone. This most likely would be either a clay hardpan or a subsurface "micro" basin in the underlying rock.

The existence of a hardpan, rather than access to shallow groundwater, seems to be the most likely explanation for the mechanism responsible for providing the junipers with an increased water supply. These junipers occur in isolated populations, each covering a relatively small area (4-6 km^2). If shallow groundwater was the primary source for the additional water, it seems logical that the populations would cover larger areas of the valley floor. The small areas covered suggest a localized factor causing higher available moisture. A hardpan would be such a factor.

The root architecture of the swamp cedars is unknown. However, some assumptions can be made based on root architectures of other western juniper species. For example, most (52-95%) of the roots of western juniper (*J. occidentalis*) occur in the upper 50 cm of the soil profile (Young and Evans 1986). If this is also true for the Spring Valley cedar populations, a high concentration of roots in the upper soil layer would allow them to effectively utilize moisture from a perched water table without being overly harmed by poor soil aeration resulting from saturated lower profiles. If the hardpan was at a depth of 2-5 m and the soils were loams or clay loams, the perched water could easily be drawn to the upper soil layers (e.g., 1-2 m) by capillarity. Juniper roots could then access this water without having to be exposed to saturated conditions.

Some juniper species have maximum rooting depths that allow them to access water at substantial depths. Ashe juniper [*J. ashei*; a species that occurs in New Mexico, Texas, and northern Mexico (Correll and Johnston 1970)] can root to at least 8 m (Jackson et al. 1999) and one-seeded juniper (*J. monosperma*) has been reported to root as deep as 24 m (Tierney and Fox 1987). Rocky Mountain juniper is a relatively long-lived species (250-300 years), with one tree in Utah being over 1000 years old (Fowells 1965). Hardpans are not likely to be totally impervious to roots over these lengths of time. Therefore, some roots probably penetrate the hardpan. Initially, this might be through small cracks, fissures, or thin inclusions of coarser-textured materials. Over time, root expansion might lead to larger cracks in the hardpan. Such cracks would not necessarily cause the hardpan to become ineffective in retaining soil water. Percolation through these relatively thin cracks and fissures would be slow, allowing ample time for the juniper to extract most of the water being held in the soil above the hardpan.

If depth to groundwater was near the lower surface of the hardpan and within the maximum rooting depth of the juniper, some groundwater would probably be available for use by the trees. Although the root biomass in contact with this deeper water source might be very small, this source might be an important source of water to the trees, especially during the driest periods (Smith et al. 1991; Jackson et al. 1999, 2000; Snyder and Williams 2003).

The lower limit of the precipitation regime generally associated with Rocky Mountain juniper is 30 cm (Fowells 1965; Van Haverbeke 1980), or about 10 cm more than the average annual precipitation occurring in Spring Valley (16-23 cm; Welch et al. 2007). This provides an estimate of the minimum amount (10 cm) of additional moisture required by these lowland juniper populations.

Another approach to estimating water requirements of the swamp cedar populations is to use ET rates of juniper populations in other areas. Utah juniper populations near Milford, Utah, Blanding, Utah, and Tooele, Utah had estimated annual ET rates of 15.3, 19.4, and 47.9 cm respectively (Gifford 1975; McLendon et al. 2000). Dense stands of Ashe juniper in higher rainfall areas of central Texas have annual ET rates of 44-69 cm (Dugas et al. 1998; Jackson et al. 1999; Wu et al. 2001; McLendon et al. 2001; McLendon and Coldren 2005). Annual ET rates for the swamp cedars are likely to be less than those of the dense juniper stands in Texas (44-69 cm) and near Tooele, Utah (48 cm), but possibly higher than the rates near Milford and Blanding, Utah (15-19 cm). An annual ET rate of 30-35 cm is about mid-way between the lower ET values from central Utah and the higher values from northern Utah and Texas. This value of 30-35 cm agrees well with the 30 cm estimate based on precipitation range as an estimate of the minimum annual water requirement of the swamp cedars.

Water-use efficiency of Utah juniper (*J. osteosperma*) near Reno is not different between populations growing on drier sites (20 cm annual precipitation) and those on more mesic sites (26 cm) but productivity rates are different (Delucia and Schlesinger 1991). If the same relationships hold for Rocky Mountain juniper, water requirements and ET rates may be comparable among lowland and upland populations, when adjusted for differences in canopy cover, productivity, and climatic conditions.

E.4.7.2 Disturbance Patterns

The two most likely sources of supplemental water to the swamp cedar populations are 1) a perched water table caused by an underlying hardpan and 2) high groundwater. At least 10-15 cm of supplemental water (i.e., in addition to the amount received by direct precipitation) is likely to be required annually to support the juniper populations (previous paragraph).

If the primary source of the supplemental water is a perched water table, this water most likely accumulates over the hardpan from 1) surface runoff following snowmelt or high rainfall events or 2) subsurface drainage from higher-elevation sites. Groundwater withdrawal is not likely to affect either of these sources unless the amount of surface runoff or subsurface drainage is dependent on depth to water along the supply pathway between the juniper populations and the higher-elevation sources, and groundwater withdrawal substantially increases the depth to groundwater along the supply pathway (Fig. E-22). If the primary source of the supplemental water is groundwater, groundwater withdrawal would affect the junipers as it increases depth to groundwater.

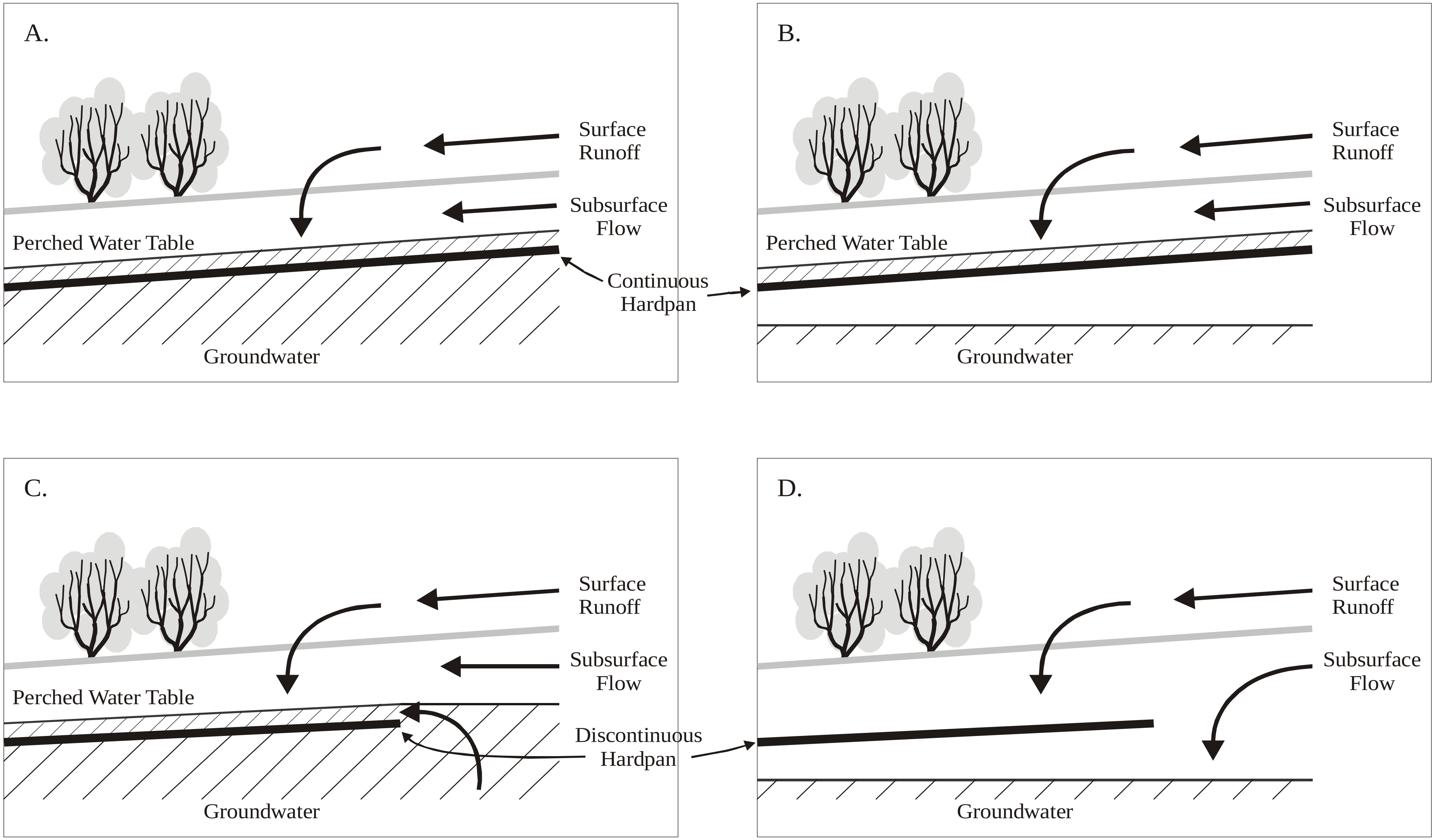


Fig E-22. Schematic illustrating possible effects of an increase to depth to water on a perched water table that overlays a hardpan. A. Continuous hardpan with shallow groundwater. B. Continuous hardpan with lowered groundwater. C. Discontinuous hardpan with shallow groundwater. D. Discontinuous hardpan with lowered groundwater.

The expected impact to the junipers of reduced supplemental water would depend on the amount, duration, and frequency of the reduction. There is likely a minimum amount of water required to maintain the vigor of the established trees. It is also likely that there is a minimum amount of water required for growth to occur, and this minimum amount for growth is higher than the minimum amount for survival. A lower supply of water in one year might result in lower growth during that year, but might be compensated for by a greater amount of water in the following years. As long as sufficient water is supplied over time to achieve the necessary average growth rates, the vigor of the existing trees should be met. If however, the amount decreases below the amount required for maintenance, tissue death will likely occur. The trees would not likely to die in one year, unless the amount of water was very low, but accumulated tissue loss over time will eventually result in death of the trees.

Short-term reductions (e.g., one year or less) in water supply should have less of an effect than longer-term reductions. Rocky Mountain juniper is adapted to semiarid conditions, including occasional droughts. In its more common habitats, there are years in which precipitation is much below average. If these low-precipitation periods are relatively short, there is minimal impact on the trees. A similar pattern might be expected for the lowland populations.

Precipitation levels, as contrasted with runoff or subsurface flow, are also important in the water balance for these populations. Other species of juniper preferentially use precipitation-derived soil moisture over groundwater or deep soil moisture (Flanagan et al. 1992; Williams and Ehleringer 2000). If this is also true for the swamp cedars, supplemental water would be less important in wet years than in dry years. Consequently, groundwater withdrawal (if it affects these sites) would have less of an impact on the populations in wet years than in dry years.

Changes in water diversion practices might also affect the cedar populations. This might occur as a change in amount of water being supplied directly to site or a change in amount of water being transported in nearby diversion structures that may supply water to the cedars by leakage from the diversion ditches. Potential impacts to the cedars from change in water diversion are not limited to a reduction in water. If sufficient additional water is supplied to these sites, flooding may occur. These cedars do not appear to be tolerant of long-term soil saturation as evidenced by the death of both mature and immature cedars along the fringes of their current populations in areas currently subjected to flooding.

Plant-water requirements are often different for seedlings and saplings than for mature plants (Donovan and Ehleringer 1992, 1994). One example is that deep soil moisture may benefit established plants with deep root systems, but not newly emerged seedlings which are just beginning to develop their root systems. As a seed germinates, the root extends first and begins to grow downward before the stem and leaves emerge. Among other things, this functions to allow the seedling to reach a more dependable source of soil moisture before water loss by transpiration begins. As soon as the leaves emerge, transpiration begins and the plant requires a major supply of water. In general, the larger the seed, the deeper the root can grow (utilizing stored carbohydrates in the seed) before stem and leaf emergence. Rocky Mountain juniper seeds are not large. Therefore, there must be an adequate supply of soil moisture at moderate soil depths (10-20 cm) or the seeding to continue to survive and grow. In many arid and semiarid environments, seedling establishment does not occur uniformly among years. Instead, seedlings tend to establish during wet periods (Turner 1990). As seedlings grow, there can be substantial competition for soil moisture between the seedling and other plants, including established plants of the same species. Assuming that a majority of the roots of Rocky Mountain juniper are located in the upper 50 cm of the soil profile, there is likely to be substantial competition for moisture between roots of established plants and seedlings in all but the wettest periods. As a result, surface-derived moisture (either rainfall or runoff) is likely to be most beneficial to seedling establishment. Deeper soil moisture may benefit the seedlings once they develop deeper roots, but initially they are likely to be dependent on shallow soil moisture (Donovan et al. 1993).

Both of the populations of swamp cedars that occur in the IBMA have various understory plant communities associated with them. These understory communities range from wetland and meadow communities to shrubland communities that are dominated by species characteristic of adjacent upland sites. This heterogeneity in understory communities is likely the result of differences in depth to groundwater caused by changes in microtopography. Because of this probable relationship between microtopography and depth to groundwater, changes in understory composition may provide an indication of changes in depth to groundwater that would be manifested earlier than changes in the swamp cedars themselves. However, other factors are also likely to affect the composition of the understory species and must be accounted for when attempting to assign changes in understory composition to change in depth to groundwater. Grazing is one such factor that is likely to have a substantial impact on compositional changes in the understory vegetation.

E.4.7.3 Relationship of Conceptual Model to Monitoring Plan

Fig. E-23 depicts how primary drivers and stressors presented in the conceptual models relate to KEAs and indicators to be monitored at swamp cedar woodlands in the IBMA (Chapter 4). This parsimonious diagram is not meant to demonstrate a complete conceptual model, but rather how components of the conceptual models relate to the Plan.

Please see Chapter 9 for Literature Cited.

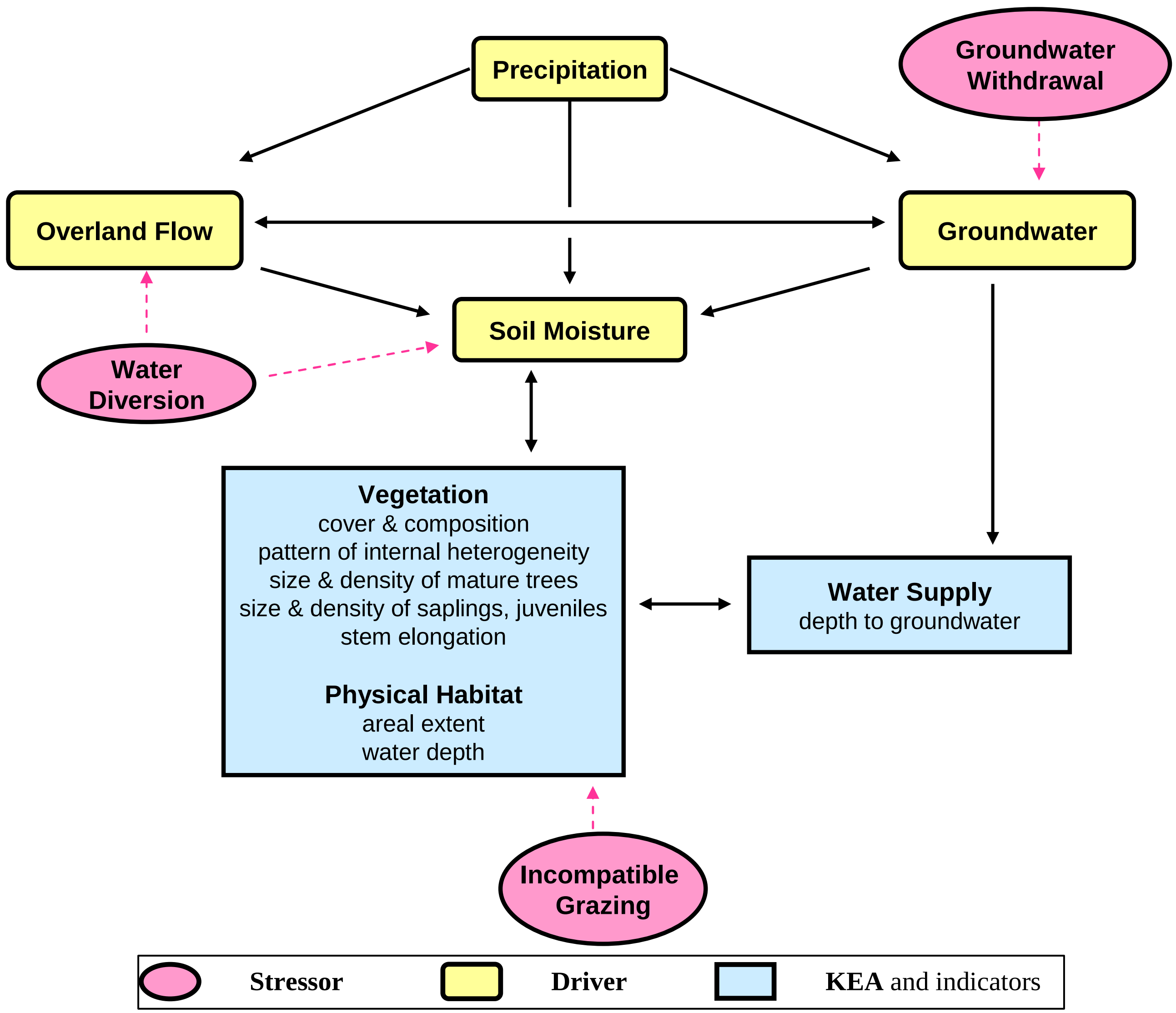


Fig. E-23. Relation among primary drivers, stressors, and KEAs and indicators to be monitored at swamp cedars in the IBMA.