Final Report

Inventory and Rapid Assessment of Southern New Mexico Springs

Assistance Agreement No. #00F736-01-0C (FY2014)

May 2019

Figure 1. San Francisco Warm Springs near Luna, NM

New Mexico Environment Department

Surface Water Quality Bureau

Wetlands Program

Project Goals and Objectives

This Project is a continuation of the development of wetlands rapid assessment methods geared towards New Mexico arid land wetlands with a focus on springs within EPA Ecoregion 23 (Arizona and New Mexico mountains) in southwestern New Mexico. New Mexico Rapid Assessment Method (NMRAM) metric development data and floristic quality data were collected from spring locations principally in Grant and Catron counties in 2018.

The Project was designed to expand rapid assessment methods for New Mexico springs. Springs have long been identified on topographic maps but are not well characterized as far as basic attributes much less condition. And, considering that all wetland types in New Mexico, including springs, are considered "waters of the state" (20.6.4 NMAC) and subject to both water quality protection and regulations, the Surface Water Quality Bureau recognized the need to have both a preliminary inventory of springs and develop a framework to assess their condition. The rapid assessment metrics that were developed evolved from a handful of existing spring rapid assessment protocols but were tailored to the specific needs of the project. For example, most existing spring assessment protocols rely heavily on biological species richness metrics which require advanced education and training in entomology and botany. However, species richness in spring ecosystems is typically a function of spring type and how geomorphologically intact the spring is. By developing metrics to quantify aquifer functionality and geomorphic process, some of the biological indicators became simplified and were more rapidly applied. This project also pioneered a new way of considering condition 'stressors' from being merely a footprint of degradation, to include them as part of the processes that impairs condition and are therefore included in the overall condition scoring process.

Through this project six major objectives were accomplished. 1) Data collection and analysis for 68 springs in Ecoregion 23 including the development of NMRAM for Springs Ecosystems in Southwestern New Mexico Field Guide and Manual (Springs NMRAM) https://www.env.nm.gov/surface-water-quality/wetlands-rapid-assessment-methods/ , 2) Formation of a Technical Advisory Committee which met two times to provide input to NMRAM development, 3) a training for agency employees and the general public in how to apply the Springs NMRAM (Technical Transfer), 4) Two "Wetland Roundtables" were hosted by this project with education and outreach for northern New Mexico (Santa Fe roundtable) and southern New Mexico (Las Cruces roundtable), 5) Staff members from SWQB attended springs symposia and trainings to improve our in-house expertise on spring ecosystems, and 6) The construction of a geodatabase for springs throughout New Mexico that compiled sources from many different agencies and publications.

Project Outcomes

- This project visited and inventoried 68 springs, many of which had never been surveyed or catalogued even at the most basic level. Level 1 type data to include photographs, geographic locations and spring discharge is almost non-existent even for the majority of mapped springs in New Mexico. As hydrologic features on a landscape that can be highly

responsive to both climate patterns and anthropogenic forces, springs are a fantastic 'early warning tool' to understand how wetlands and surface waters are being impacted.

- The project created a database for spring locations throughout New Mexico. It is likely the most comprehensive attempt to compile all the existing data for spring locations and condition to date.

- This project creates a tool for evaluating the condition of southwest New Mexico's springs in comparison to a level of human disturbance and that is relevant to New Mexico. In semi-arid areas like New Mexico, spring ecosystems are often the only nearby source of water and consequently have a long legacy of human development and impacts. Yet, they are also some of the most biologically diverse and important spots on the landscape.

- The Springs NMRAM fills a critical piece of an integrated and comprehensive approach to wetlands protection by SWQB and its partners. Springs are very often the headwaters for all surface waters in New Mexico and the condition at the source of the stream sets a trajectory for the entire stream reach.

- The Springs NMRAM can be used to identify reference standard springs in need of special protection, and those that are particularly impacted and those that can be restored.

- As future wetlands subclasses are described and assessed, an iterative monitoring program linked to water quality assessments by watershed will continue to be developed and will increase the capacity and understanding of ecological linkages, natural variability and changes that result from human activities.

- Springs data collected under this project are included in the Springs Stewardship Institute on-line database along with other springs data from throughout the Southwest increasing access to stakeholders and decision makers to improve their knowledge and understanding of wetlands issues. Future versions of Springs NMRAM will ensure inclusion of Springs data in an integrated Surface Water Quality Information Database (SQUID) at SWQB, and along with other wetlands assessment data will be available for inclusion in CWA Section 305(b) reports.

- Maintaining the Wetlands Roundtable to include meetings especially designed and planned for the Northern as well as the Southern parts of New Mexico, establishes and solidifies new partnerships, increases the capacity of the Wetlands Program to reach a variety of stakeholders with relevant and up-to-date information and data-sharing regarding wetlands in New Mexico.

- The project also trained several agency staff and NGO representatives on the importance of springs, their physical and biological characteristics, the stressors that imperil their function and techniques to restore spring function and health.

Figure 2. Unnamed Spring near Reserve, NM

Figure 3. McCain Spring near the Tyrone copper mine south of Silver City, NM

Project Location

The project was located within EPA Ecoregion 23—Arizona and New Mexico Mountains, and more specifically Grant and Catron counties (Figure 4). The majority of field work was conducted on the Gila and Apache National Forests, with additional work on private lands and state-owned lands.

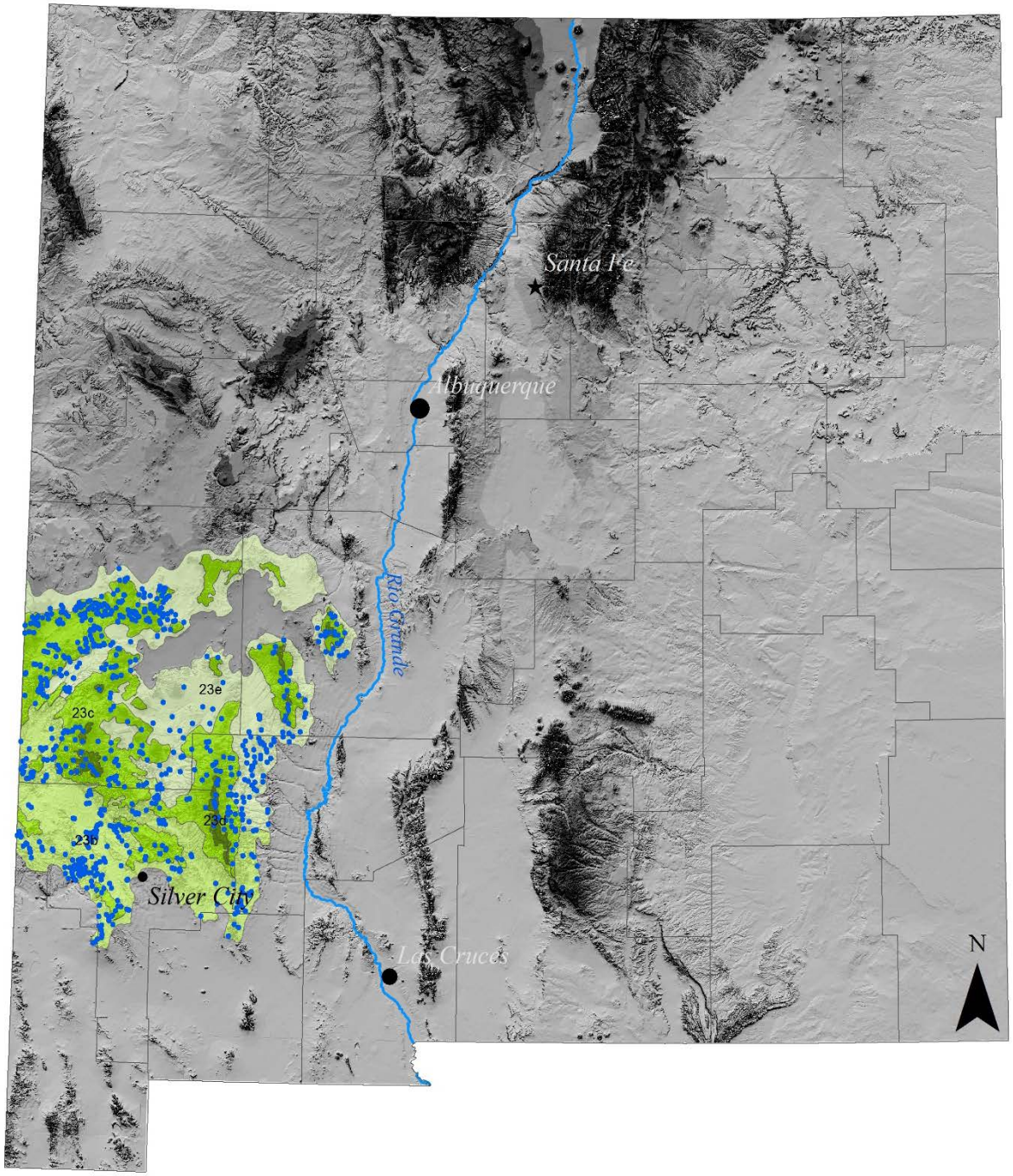

Figure 4. Project area in southwest New Mexico. Green features are Ecoregion 23 and blue dots are mapped springs

Original Timeframe

The Notice of Award on the Cooperative Agreement CD #00F736-01-0C was issued on May 27, 2014. The project was amended for a no cost extension on May 10, 2016, extending the project termination date to May 31, 2019. The stated goals and objectives of the project remained the same, as well as the key project Tasks.

Partners Involved

The Museum of Northern Arizona-Springs Stewardship Institute (MNA-SSI) was the principal contractor in partnership with SWQB Wetlands Program in developing the Springs NMRAM. The natural resource staff at the Gila National Forest were integral in providing information about spring condition and location data which greatly facilitated an efficient use of field time by crews.

SWQB staff were involved in every aspect of the project and co-authored the Field Guides and data collection worksheets along with MNA-SSI (co-authors: Larry Stevens, Jeri Ledbetter, Alek Mendoza, Ed Schenk, John Moeny, Susan Styer, Emile Sawyer, Maryann McGraw). The project included an advisory committee whose members are listed below:

Name	Affilitation
Abe Springer	Hydrologist, Northern Arizona Univ.
Alek Mendoza	MNA-SSI
Amanda Gehrt	Reserve Ranger District Biologist
Bob Sivinski	Retired NM state botanist
Carolyn Koury	Gila National Forest Hydrologist
Charles Enos	Gila River Indian Community
Daniel Trujillo	NMDGF aquatic invertebrate biologist
Dave Menzie	Retired geologist
Donna Stevens	Upper Gila Watershed Alliance
Ellen Soles	NPS I&M program, Grant County SWCD
Emile Sawyer	NMED/SWQB wetlands program
Harley Shaw	Retired wildlife biologist
Jeri Ledbetter	MNA-SSI
John Moeny	SWQB Project Officer
Joneen Cockman	Safford Buraeu of Land Management
Larry Stevens	MNA-SSI
Laura Crossey	Geologist, University of New Mexico
Livia Crowley	USFS Cibola Forest Hydrologist
Malia Volke	NMDGF aquatic ecologist
Maryann McGraw	NMED/SWQB wetlands program
Nathan Newcomer	NM Wilderness
Susan Styer	SWQB Project Officer
Wendell Hahn	Rancher and retired fire ecologist

The project also benefited from independent review of the datasheets and assessment metrics by Glenn Rink—contract botanist and geologist from Flagstaff, AZ. Glenn Rink was also part of the inventory and data collection team which also included:

Name	Affilitation
Alek Mendoza	MNA-SSI
Ed Schenk	MNA-SSI
Emile Sawyer	NMED/SWQB wetlands program
Glenn Rink	Far Out Botany
Gloria Hardwick	MNA-SSI
Jeri Ledbetter	MNA-SSI
John Moeny	SWQB Project Officer
Joneen Cockman	Safford Buraeu of Land Management
Larry Stevens	MNA-SSI
Maryann McGraw	NMED/SWQB wetlands program
Stephanie Wacha	MNA-SSI
Susan Styer	SWQB Project Officer
Wendell Hahn	Rancher and retired fire ecologist

Northern Wetlands Roundtable (December 11, 2018) Presenters:

- Kerry Jones, National Oceanic and Atmospheric Administration
- Paul Tashjian, Audubon New Mexico
- Josh Hall, Santa Fe National Forest
- Deanna Cummings, US Army Corps of Engineers
- Collin Haffey, Rio Grande Water Fund
- Gwen Kolb, US Fish and Wildlife Service
- Christopher Rustay, Playa Lakes Joint Venture
- Ryan Besser, US Bureau of Land Management
- Jan-Willem Jansens, Ecotone Landscape Planning

Southern Wetlands Roundtable (November 7, 2018) Presenters:

- Jason Laney, National Oceanic and Atmospheric Administration
- Norm Gaume, P.E. (ret.)
- A.T. Cole, Pitchfork Ranch
- Este Muldavin, Natural Heritage New Mexico
- Justin Riggs, US Army Corps of Engineers
- Mike Gaglio, High Desert Native Plants
- Beth Bardwell, Retired Audubon New Mexico

Each Wetland Roundtable includes sponsors who provide refreshments and other support. Sponsors for the two roundtables for this project were:

- The Upper Pecos Watershed Association
- Santa Fe Fly-Fishing School
- Tetra-Tech

Project Funding

The original Federal amount was $349,907 with $130,863 in non-federal matching funds. The final federal amount spent was $306,003.11, and the final match amount achieved was $142,457, resulting in a 45.6% match against the federal amount spent. See semi-annual reports for details.

Major Project Highlights and Chronology

- SWQB Wetlands Program was awarded federal assistance for this project. Signatures on the Cooperative Agreement between NMED and EPA were completed on May 27, 2014.
- John Moeny, SWQB Silver City Office, is the Project Officer for this project.
- The project officer drafted a presentation for the southern wetlands roundtable which was presented by SWQB staff member Susan Styer at the November 2015 event.
- During the spring and summer 2017, the Project Officer began assembling existing data for spring locations and any past survey work within the project area.
- In January of 2018 a contract between NMED and the Museum of Northern Arizona-Springs Stewardship Institute was finalized with a noticed to proceed dated January 17, 2018.
- A project kick-off meeting between SSI and SWQB staff was hosted on-line by SSI on January 17, 2018. At the meeting, SWQB delivers a compiled database of springs and spring assessment literature to MNA-SSI for them to incorporate into a New Mexico wide database.
- A draft list for members of the advisory committee (AC) meeting was compiled by NMED and SSI, in advance of the first AC meeting scheduled for May 2018.
- A draft Quality Assurance Project Plan (QAPP) was written by SSI, edited by NMED and submitted to NMED's quality assurance officer for review. This QAPP was accepted by the EPA on March 21, 2018 clearing the way for data collection in the spring and summer of 2018.
- A draft Manual and Field Guide Outline was submitted to NMED by SSI for review and comment.
- In May 2018, Maryann McGraw, Wetlands Program Coordinator (WPC) and the Project Officer traveled to Flagstaff Arizona to meet with MNA-SSI and review the draft manual and field guide. This meeting also discussed scheduling and expectations by both parties to complete the project in a very compressed timeframe.
- In early June 2018, the Project Officer attended the two-day Springs Science Symposium in Flagstaff, Arizona.
- In June 2018, SWQB staff members Susan Styer and Emile Sawyer attended a week-long Springs Inventory and Monitoring training in Flagstaff, AZ. This course was presented by the MNA-SSI.
- On June 19th and 20th, the Advisory Committee (AC) held its first meeting in Silver City. The meeting included a presentation by the Project Officer detailing the "why" and "where" of the project, with the MNA-SSI presenting on springs ecology, biodiversity, types of springs, inventory and monitoring, assessment and other related topics. The AC consisted of 12 members of scientific, governmental and environmental groups. They advised the SWQB and MNA-SSI on potential spring locations for surveying, private land issues and owners, and provided critical feedback for the in-development field guide and manual.
- The data collection team, in addition to several members of the AC, completed the pilot study during the third week of June 2018. Seven spring sites were visited that represented a range of elevations, land use histories and conditions from poor to excellent. Based on the results from this first round of field work, the MNA-SSI incorporated changes into the evolving field guide and manual.

- The data collection team completed their second trip during July 2018. This trip focused on 'front-country' springs that were easily accessible by vehicles. This allowed for efficient data collection across a broad range of landforms, spring types, condition classes and land use histories. Over twenty springs were visited during this trip, although as is typical, many of the mapped springs were either dry or completely mis-mapped and non-existent.
- In August 2018 MNA-SSI completed the pilot study report and springs classification report. The springs classification report detailed the types of springs known to exist in New Mexico including the relative proportion of those spring types that had been encountered during the pilot study and first data collection trip in July.
- MNA-SSI updated their on-line springs database to include sites visited during the two field trips.
- The data collection team spent 7 days in September 2018 completing the second round of data collection and metric testing. The team split into two sub-teams, with one team collecting data from springs in the Gila Wilderness, while the second team collected springs data in front country locations. The Gila Wilderness team was able to visit several very high-quality springs which improved the metric scoring. Prior to this trip, few, if any springs, had rated in excellent condition, but the wilderness setting provided the opportunity to find springs that were undeveloped and mostly intact biologically. Still, many of the wilderness springs ranked poorly despite their land use protections.
- In November and December 2018, the two wetland roundtables were held in Las Cruces and Santa Fe.
- During the winter of 2018/2019, MNA-SSI and the SWQB worked in concert to continue to write and develop the Springs NMRAM Field Guide and Manual.
- The final geodatabase of spring locations and associated spatial data was delivered to SWQB in March 2019.
- In March 2019, MNA-SSI presented 90% complete versions of the Field Guide and Manual to SWQB for review.
- In April 2019, the second AC meeting was held in Silver City. Committee members were given presentations on the preceding year's field work, and the draft NMRAM documents. Going through each metric one by one with the committee allowed SWQB and MNA-SSI to get feedback on wording and content prior to completing the documents. Several committee members had useful suggestions which were incorporated into the final documents.
- Also in April 2019, the NMRAM for Springs training was held in Silver City. Attendees had a brief period of classroom introduction and education then went into the field to complete an assessment on two springs. The two springs spanned a range of condition and land use types with one spring managed by the Nature Conservancy and the second a previously developed spring on Forest Service lands.
- MNA-SSI revised the Field Guide and Manual to incorporate AC and SWQB suggestions and edits.
- Fillable, interactive data sheets were completed and submitted to SWQB in May 2019.
- The final 100% Field guide and Manual were presented to SWQB in May 2019.
- Supplies and field gear were purchased in May 2019 to allow SWQB staff members to complete spring assessments in the future.
- The agreement terminated on May 31, 2019.

Figure 5. Members of the Advisory Committee at the second meeting in April 2019

Field Guide Summary

There are 19 assessment questions are designed to aid the inventory team in documenting the site condition according to consistent, repeatable criteria. Questions are classified into five basic categories: Aquifer Function and Water Quality, Geomorphology, Geographic Context, Habitat, and Biota. Higher scores equate to better condition of that factor or resource.

Aquifer Function, Water Quality

This metric asks three questions that are related to the apparent condition of the aquifer and water table, short-term climatic conditions, and quality of groundwater at the source.

A. Water table

Question: *Is there evidence that the water table is dropping, and the aquifer is failing to produce natural quantities of water for the springs ecosystem? For example, is woody vegetation (e.g., cottonwood, tree willow, other woody phreatophytes) showing evidence of mortality or declining health? Is woody upland vegetation encroaching? Or is an area now dry that was apparently previously groundwater supported? Is there an abandoned well or windmill? Any of these can indicate a declining water table.*

Incontrovertible detection of water table change requires analysis of well log data, and also may be indicated through groundwater modeling; however, depletion of shallow aquifers is often detected by surface vegetation and abandoned water extraction equipment and con-

veyance, such as pipes or irrigation ditches. For a rapid assessment, evidence of these elements is sufficient to indicate water table depletion.

B. Surface water quality

Question: *What is the quality of water after it emerges onto the surface? Is there visual, olfactory, or other evidence of contamination (e.g., feces, strong odor, unusual color)?*

Water quality is widely assessed using EPA standards for conductivity and contaminants, but this standard is not necessarily appropriate for evaluating the ecological condition of New Mexico springs. Natural springs waters in the Southwest often exceed EPA standards for safe drinking water, in many cases supporting highly adapted organisms. Therefore, we have selected indicator variables that are regionally appropriate and readily detected during a field site visit.

C. Springs flow

Question: *Is there evidence that the springs flow has been altered through human actions, such as wells, diversions, or capping?*

This question is critical to understanding the extent to which flow, a critical characteristic of springs ecosystems, has been altered. Springs flow measurement is a standard practice during inventory; however, credibly answering the question may require flow monitoring information that is only rarely available.

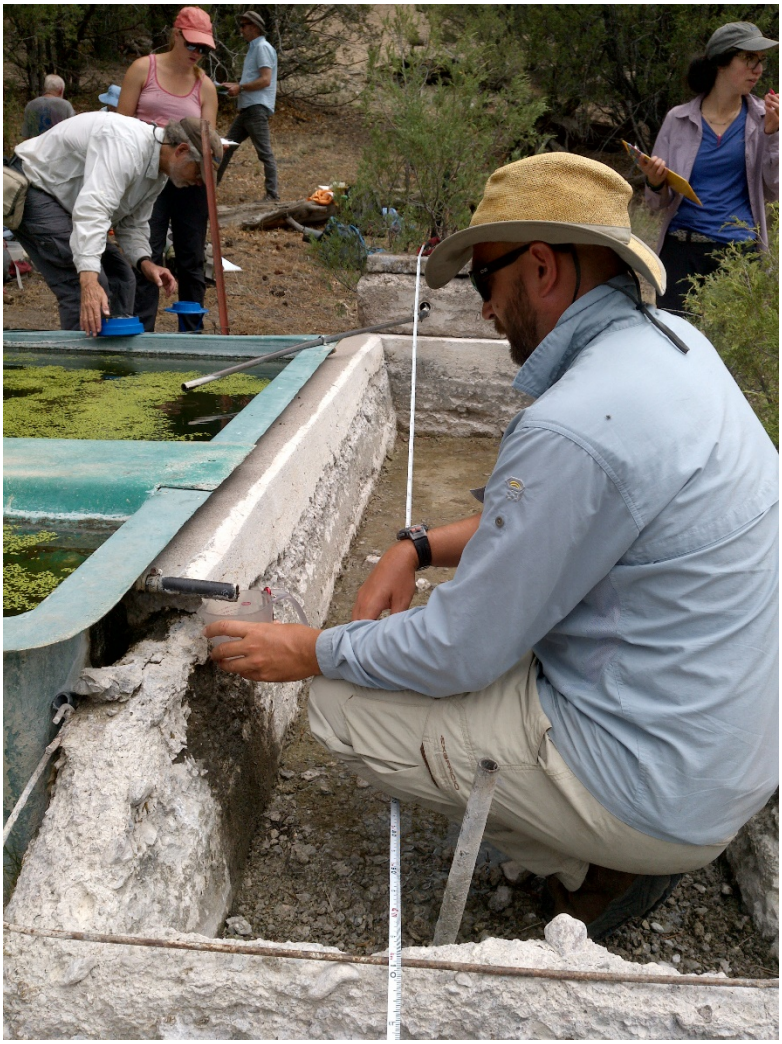

Figure 6. Ed Schenk from MNA-SSI measuring spring flow at a developed spring near Quemado, NM

Geomorphology

This metric asks questions related to the natural geomorphic integrity of the springs ecosystem. Scores will vary from 1.0 (highly altered) to 4.0 (pristine), using half decimals. It consists of 4 topics: Natural Geomorphic Diversity, Soil Integrity, Natural Physical Disturbance, and Natural Fire Regime.

D. Natural Geomorphic Diversity.

Question: *Are the expected microhabitats for this springs ecosystem type present, and/or are additional natural microhabitats or anthropogenic microhabitats present? Are geomorphic processes negatively influenced by human activities at the springs?*

The array of microhabitat array at a springs ecosystem influences its functionality, which species can exist there, as well as overall ecosystem biodiversity. For example, plant species richness is

positively related to the number of microhabitats present (Springer et al. 2014; Sinclair 2018), and such patterns also are expected for both invertebrates and vertebrates.

E. Soil Integrity

Question: *To what extent are the soils, if present, altered due to anthropogenic influences? Natural soils can be affected by trampling, paving, trailing, vehicle tracks, fire pits, and other factors. What percent of the natural soils have been affected by these impacts?*

Soil integrates climate, geology, vegetation, land use, and time, and therefore is an excellent indicator of site alteration.

F. Natural Physical Disturbance

Question: Is the site subject to its natural geomorphic disturbance regime, including flooding, rockfall, mammalian herbivore influences, or other natural disturbances? Fire disturbance is considered in the next question.

Each springs type is subject to natural disturbances, which influence geomorphology, biodiversity, and goods and service.

G. Natural Fire Regime

Question: *Is the springs ecosystem subject to its natural fire disturbance regime? Has a past fire negatively affected the springs ecosystem? Has fire suppression created unnaturally dense vegetation, threatening the springs with a catastrophic burn?*

Some springs types, such as gushets, may be somewhat buffered from wildfire impacts, but most can be strongly affected. Fire can influence bedrock geomorphology, allochthonous soil, water, and nutrient delivery (especially in rheocrene springs), habitat, biota, and goods and service. Like other forms of disturbance, the impacts of fire can vary in intensity, and can vary in relation to timing, magnitude (intensity), duration, and frequency, all of which can be altered by upstream or upslope conditions, climate change, livestock grazing intensity, and other processes. Upper elevation springs may sustain the same fire frequency as the surrounding upland forests. In contrast, fire may preferentially burn low elevation springs, which support enough plant life to result in extensive litter fall.

Figure 7. Ed Schenk and Glenn Rink surveying Bead Spring in the Gila Wilderness. This spring had been burned twice in the last 6 years.

Geographic Context

The following questions relate to the level of isolation and size of the springs ecosystem. These intrinsic site characteristics reflect the ecological importance of the springs ecosystem and are likely to influence stewardship prioritization, but they do not reflect the condition and are therefore not counted in the assessment scoring. It consists of 3 questions—Isolation from other springs, Isolation from other perennial water sources, and habitat size.

H. Isolation from other springs.

Question: *How isolated is this springs ecosystem from other reported springs?*

The distance to the nearest springs ecosystem influences many ecological dynamics, including how important a springs ecosystem is within the adjacent landscape, as well as whether or not the springs can serve as a genetic stepping stone, versus a sink for biological diversity.

Figure 8. Faywood Cienega-- a type of Helocrene (pool forming) spring that is highly isolated from other nearby springs.

I. Isolation from perennial sources

Question: *How isolated is this springs ecosystem from the nearest perennial water body, such as a stream or lake?*

Flora and fauna populations occupying springs that are connected to, or in the vicinity of other perennial bodies of water may have enhanced gene flow and lower likelihood of supporting endemic species. Springs near other bodies of water may sustain higher rates of invasion by

non-native crayfish, predatory game fish, bullfrogs, and other non-native species, and therefore such springs may be at greater risk due to high levels of habitat connectivity.

J. Habitat size

Question: *How large is this springs ecosystem?*

Aridland springs function as islands of wetland habitat surrounded by arid uplands. The well-known species-area relationship in insular biogeography effectively describes the conceptual relationship between habitat area and species richness for sessile species. Strong positive relationships between springs size and springs plant species have been documented by Springer et al. et al. (2014), Ledbetter et al. (2016), and Sinclair (2018). Conversely, very large springs are typically attractive to recreation users or to developers of water resources and consequently size may be negatively correlated to condition.

Habitat

The following questions relate to the capacity of the springs and its associated microhabitats to support native species and natural ecosystem processes. Habitat area, quality, productivity, and diversity strongly influence springs ecosystem ecology and biota, and anthropogenic degradation of springs habitat reduces the extent and importance of those ecological variables. The category covers 3 sub factor questions concerning Microhabitat Quality, Native Plant Cover and Native Foodweb Dynamics.

K. Microhabitat quality

Question: *What is the condition of the microhabitats associated with the site? Consider the overall habitat quality in each of the microhabitats and the intensity of all apparent anthropogenic impacts.*

Human activities can influence some or all microhabitats at a springs ecosystem. For example, intensive livestock use may cause pedestal formation, feces deposition, erosion, or other impacts on wetland microhabitat surfaces. Construction of roads, springboxes, or berms, as well as pollution can degrade microhabitat quality.

L. Native Plant Cover

Question: What is the proportion of native to non-native plant cover?

Documentation of plant cover by species in seven strata (aquatic, non-vascular, ground cover, shrub cover, mid-canopy, tall canopy, and basal cover) will be accomplished during the inventory and assessment and will reveal not only the extent of non-native plant cover by stratum, but also the wetland status and the ecological structure of the springs ecosystem, with relevance to wildlife habitat availability.

M. Native Foodweb Dynamics

Question: *What is the condition of the natural food web at this springs ecosystem?*

Trophic structure, as indicated by the presence of vegetation, primary consumers, and secondary or top consumers (predators), indicates that ecosystem functionality at a site is high.

Biota

Floral and faunal species biodiversity is an important topic in stewardship discussions about springs. The presence of just one or two invasive species can irreversibly change the spring condition and habitat. Similarly, the presence of species of concern can be important for management decisions and prioritizing restoration sites. This category includes six questions relate to native and exotic plants and animals.

N. Native vs. non-native plant species:

Question: *What is the proportion of native plant species?*

Springs function as biodiversity hotspots, supporting many rare, endemic, and some endangered species, as well as a host of non-springs-dependent and upland species. Thus, springs have inordinately high levels of species packing and biodiversity.

O. Presence of noxious weed species

Question: *How many plant species from the New Mexico's Noxious Plant Species list are present?*

New Mexico noxious plant species are widely recognized for exerting deleterious impacts on many aspects of the state's ecosystems and economics.

P. Natural plant demography

Question: *Is the population structure (demography) of woody vegetation appropriate to the site? For example, is the springs ecosystem becoming unnaturally dominated by woody plant species (e.g., conifer, Russian olive, Siberian elm, tamarisk) or invasive wetland species (e.g., Typha or Phragmites), as evidenced by the presence of multiple life stages (e.g., seedling, sapling, mature plants)? Upland woody shrubs or trees encroaching onto the site can reveal an unnatural transition due to human activity or disturbance*.

Observation of encroachment of woody species, die-back of wetland plant species, or demographic skewing indicates that a springs ecosystem is under stress from water table subsidence.

Q. Sensitive species presence

Question: *Did surveyors identify any sensitive plant or animal species?*

Identification of rare, endemic, sensitive, threatened and/or endangered species at springs may trigger management responsibilities and actions.

R. Proportion of native animal species

Question: *What is the proportion of native invertebrate and vertebrate species?*

Detection of non-native animal species is needed to evaluate the risks they pose to the site.

S. Number of non-native animal species

Question: *How many non-native aquatic and terrestrial animal species are present? For example, to what extent are nonnative mollusks, crayfish, bullfrogs, and game or aquarium fish species present?*

Non-native animal species can exert negative impacts on native species and ecological processes, degrading the springs ecosystem. One caveat: not all animal species occupying a springs ecosystem are likely to be detected during a single site visit. Therefore, this score is expected to be refined with multiple visits. Detection of non-native faunal species is needed to evaluate the risks they pose to the site.

Stressor Checklists. Stressor checklists are found in the New Mexico Rapid Assessment Method for Springs Ecosystems in Southwestern New Mexico Field Guide. These checklists include six broad categories of impacts: Flow Regulation/Hydrologic Alternation, Soil/Geomorphic Alteration, Animal Impacts, Recreation Impacts, and Land Use impacts. Each item within the category is rated with a 1- 4 scale with Absent being "1" and Intense scoring "4". Each category gets a sub-score based on the total value of all stressor categories. A high score denotes many stressors within that category.

One of the important discoveries made during the field work is that a single stressor can have an outsized impact but not be reflected in the total score. For example, in Animal Impacts, "Livestock grazing, browsing, defecating, or trampling" is one of five potential impacts. If the impact from Livestock is rated as "Intense" but no other animal impacts are observed, the Impact by Animals category score may appear very low—yet the actual effect at the spring may be quite obvious and severe. To account for these dilutive effects, observers can select a multiplier of "low, medium or high" for the stressor category to more heavily weight those impacts.

Data Collection Worksheets. Interactive PDF versions of the data collection worksheets are included in the electronic versions of field guide. The electronic versions will do the computations and scoring automatically, while the hard copy paper versions obviously require human scoring.

Manual. The Manual justifies condition scoring and ranking based on analyses and literature review of relevant spring and ecological data.

List of Major Deliverables

- Contract between NMED and the MNA-SSI
- First Advisory Committee meeting invitation, agenda, sign-in sheet and meeting notes
- Project Quality Assurance Plan
- Pilot Study data and interpretation
- ArcGIS Database containing all known or mapped springs in New Mexico
- Visits to 68 springs with data collection from 48 of those
- Second Advisory Committee meeting agenda, sign-in sheet and presentations
- NMRAM for Springs training agenda and notes
- Final Version of NMRAM for Spring Ecosystems in Southwestern New Mexico Field Guide
- Final Version of NMRAM for Spring Ecosystems in Southwestern New Mexico Manual
- Final Version of fillable PDF datasheets
- Semi-Annual and Final Reports

- Wetland Roundtable agendas and presentations for Northern and Southern roundtables
- Hard-bound copies of NMRAM for Spring Ecosystems in Southwestern New Mexico Field Guide and Manual and uploaded Version 1.0 to the SWQB website.

Figure 9. Emile Sawyer (NMED) and Larry Stevens (MNA-SSI) surveying a Rheocrene spring near Silver City, NM

Lessons Learned

This project developed the first NMRAM for spring ecosystem wetlands in southwestern New Mexico. While springs are relatively small features of the landscape, they can be incredibly complex in terms of their hydrogeology, land use history, and interactions between the physical and biological environments. Often, they are very stable features of the landscape with little to no impacts from humans. Take, for example, Hanging Garden spring type. These springs form in locations where groundwater emerges at contact points or weakness in bedrock. They are typically on vertical faces and consequently are protected from nearly all ground-based disturbance like wildlife, livestock, roads, trails, etc. Contrast that with Rheocrene spring types where the water discharges at the bottom of a drainage. These springs are subject to frequent disturbance in the form of flooding, and consequently never develop the rich species diversity one encounters in a Hanging Garden. Creating a single rapid assessment that could meaningfully evaluate the condition of these two disparate spring types took many long discussions and experimentation with the metrics by field crews.

Having the benefit of completing visits to over 60 springs in the project area, we now know which spring types are the most common in the landscape. The most common spring types included Rheocrene (n = 28) Hillslope (n=27) and Helocrene or pool forming springs (n=8). Future efforts to refine the NMRAM for Springs should probably focus on Hillslope springs as they are both very common and often highly impacted by development, recreation, wildlife or other stressors.

We also learned that the public had a great interest in this project and wetland science and conservation in general. This was expressed at the two wetland Roundtables held during this project and the Advisory Committee meetings and training. Springs are fascinating to most people and this project allowed NMED to bring a greater awareness of how they function, the stressors that degrade their condition and management tools to conserve them.

Technical Transfer

Agencies, Cooperators and local stakeholders have been invited to trainings to promote the understanding and use of NMRAM for Springs and spring rapid assessments in general. During the training held in April 2019, a diverse ground of scientists, college professors, environmental groups and agency staff from across New Mexico learned about the development of the NMRAM for Springs and applied it to two springs in the project area. While the training was largely to benefit the attendees, the MNA-SSI and NMED also received valuable feedback from the participants on how to improve the NMRAM. An SWQB presentation on spring types was given at the NM Wetlands Roundtable in 2015 providing an introduction to springs and spring types to many of the attendees. The MNA-SSI provided excellent and informative presentations to the Advisory Committee which in turn allowed the participants to have a greater understanding of springs and spring types and allowed them to provide meaningful feedback during the rapid assessment development.

EPA Feedback Loop

The EPA was very supportive in all aspects of this project. Due to some unforeseen complications with securing a contractor, the project required a contract extension which allowed the project to be completed as designed without sacrificing valuable field time during the summer 2018.

Future Activity Recommendations

- SWQB Wetlands Program proposes to continue to refine this 1.0 Version of the NMRAM for Spring Ecosystems in Southwestern New Mexico, continue to integrate Springs data in SQUID, and to test and expand its utility beyond the original project area.
- Use the NMRAM for Spring Ecosystems and our current set of data to continue to engage the public and agencies about the significance of springs wetlands, the importance of springs assessment and monitoring, and to promote greater stewardship and protection of springs.
- Integrating Springs NMRAM data into "SQUID" the state's water quality database, would facilitate easier data sharing between NMED and agencies or the general public.
- Currently the USFWS is interested in finding sites suitable for expanding the range of listed wetland plant species in New Mexico. They are using our NMRAM data to find possible locations. We hope to partner with more agencies that might find excellent uses for Springs NMRAM.

Figure 10. Attendees at Springs NMRAM training identifying wetland plants