WATERSHED BASED PLAN

FOR THE MORA RIVER

UPPER CANADIAN PLATEAU

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Watershed Based Plan for the Mora River – Upper Canadian Plateau 13-D

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AMA	Agricultural Management Assistance
AU	Assessment Unit
BASINS	Better Assessment Science Integrating point & Non-point Sources
BISON-M	Biota Information System of New Mexico
BMP	Best Management Practice
BSIP	Biological Sampling Index Period
COOP	Cooperative Observer Program
CRP	Conservation Reserve Program
CWA	Clean Water Act
DOT	Department of Transportation
EPA	Environmental Protection Agency
EPT	Ephemoptera Plecoptera Trichoptera
EQIP	Environmental Quality Incentives Program
FBI	Family Biotic Index
GIS	Geographic Information Systems
GPS	Global Positioning System
HPWA	Hermit's Peak Watershed Alliance
HSPF	Hydrologic Simulation Program - Fortran
HUC	Hydrologic Unit Code
HWY	Highway
LA	Load Allocation
MGD	Millions of Gallons per Day
MOS	Margin of Safety
MRM	Management & Restoration Measure
MUSYM	NRCS Soil Number
NAWCA	North American Wetlands Conservation Act

NEPA	National Environmental Policy Act
NLCD	National Land Cover Database
NM	New Mexico
NMED	New Mexico Environment Department
NMDGF	New Mexico Department of Game and Fish
NMHU	New Mexico Highlands University
NMOSE	New Mexico Office of the State Engineer
NMRAM	New Mexico Rapid Assessment Method
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
PLJV	Playa Lakes Joint Venture
QAPP	Quality Assurance Project Plan
RBRA	River Behavior and Recovery Assessment
RFP	Request for Proposals
SMC	San Miguel County
SNOTEL	Snow Telemetry
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
SWCD	Soil and Water Conservation District
SWMM	Storm Water Management Model
SWQB	Surface Water Quality Bureau
SWREGAP	Southwest Regional Gap Analysis Project
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TNC	The Nature Conservancy
TP	Total Phosphorus
TSS	Total Suspended Solids
US	United States
USDI	United States Department of Interior
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UWC	United World College
WASP	Water Quality Analysis Simulation Program
WBPMR	Watershed Based Plan for the Mora River-Upper Canadian Plateau
WLA	Waste Load Allocation

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EXECUTIVE SUMMARY

Purpose. This Watershed Based Plan for the Mora River-Upper Canadian Plateau (WBPMR) helps to guide land management and restoration efforts in the lower Mora Watershed from 5 miles west of Rio Mora National Wildlife Refuge to the former USGS gage east of Shoemaker, NM including the subwatersheds of the lower Sapello River and Wolf Creek. Because of the large size of the entire Mora Watershed and distinctly different ecological and cultural circumstances, this plan only addresses the lower portion of the Mora River Watershed.

Guidance in this plan relates to activities that directly affect overall watershed condition and more specifically as they pertain to decreasing stream nutrient concentrations so they meet state standards. This plan's impetus is the Federal Clean Water Act Section 319(h) Nonpoint Source Grant that provides funding through the New Mexico Environment Department. Future 319 on-the-ground improvement grants, among other sources, will then help provide the support to put this plan into action.

State standards are based on the Total Maximum Daily Load (TMDL) which identifies the Mora River, as nutrient impaired. It was determined that the Mora River from Highway 434 to the USGS gage east of Shoemaker does not support its designated marginal coldwater aquatic life use. In order to support that designated use, Total Nitrogen should not exceed 0.38 mg/L and Total Phosphorus should not exceed 0.03 mg/L.

This planning effort examined the current condition of the lower Mora River to identify specific causes and sources of degradation and recommend efforts that can help restore healthy conditions. This plan focuses on management and restoration that reinstates watershed functions related to anchoring and rebuilding healthy soil ecosystems, encouraging soil and underground water infiltration, reestablishing riparian vegetation and buffer strips and purifying water in natural wetlands since these functions contribute most significantly to stream nutrient regulation, offer ecosystem services related to other important watershed values and are most controllable by human activities.

Findings. Nutrient impairments in the Mora River were substantiated with data collected in the summers of 2014 and 2015. Additionally, overall compromised stream conditions were identified with NMRAM, geomorphology and benthic macroinvertebrate surveys. GIS assessments and BASINS modeling identified and confirmed the scope and geographic range of Total Phosphorus and Total Nitrogen impairments. High nutrient loads and overall compromised stream conditions were identified to be caused by streambank erosion, stream channel incision, rangeland grazing, drought-related impacts, loss of riparian habitat, loss of wetlands, mass wasting and agriculture. Almost all impaired river in the Lower Mora is on private land with the exception of Rio Mora NWR. Activities that contribute to degradation of riparian vegetation and stream channels include livestock grazing, residential development, stream channel modifications, agricultural fields, roads and railroads. Social circumstances that contribute to the current impaired conditions of the Mora River are a lack of understanding about what constitutes a healthy stream and riparian area, a lack of community support to assist landowners in valuing and maintaining healthy stream conditions and inadequate financial support in our economically depressed area to implement sound land management measures.

Planned Measures. To remedy degraded conditions of the lower Mora River Watershed, both improved land management and restoration of degraded conditions are needed. This plan offers guidance, assistance and tools to landowners and land managers to develop watershed-sensitive land management practices and restoration activities for their rangeland, agricultural land, residential and riparian areas. A comprehensive suite of measures is presented that approaches watershed work from a holistic perspective, recognizing the interconnected nature of all watershed elements.

Restoration and management measures address root causes of watershed degradation that impact water quality and land health. All measures strive to reduce bare ground and reinstate abundant and diverse plant communities in upland and riparian areas with a focus on resilient native plants. They rebuild healthy soil ecosystems that enable the watershed's sponge to function and sequester and regulate nutrient movements by improving water infiltration and limiting erosion. They do this by providing carefully planned livestock management, coupled with specific tools like fencing, water development, herding and rangeland improvements. Improvements to agricultural activities that maintain year-round plant cover like no-till and cover cropping systems and use regenerative farming practices are offered. Improved management benefits both landowners and watersheds.

Management and restoration measures also address impacts from existing infrastructures by ensuring adequate buffers between infrastructure and water courses. Roads that affect drainage systems and soil erosion are planned for redesign and reconstruction with watershed processes in mind. Restoring and supporting natural systems like wetlands and beaver communities that perform water purification and numerous watershed ecosystem services with little intervention are offered.

In order to offer the incentives and technical and financial support needed to act on these measures, conservation, planning and regulatory tools such as Conservation Easements, Wetland Mitigation Banks and financial assistance programs from various government agencies are recommended. The development of recommended riparian/stream buffers and best management practices would provide clear guidance for land use planning efforts. Work with County, State and Federal agencies to improve on regulatory or non-regulatory guidelines to support management and restoration measure are also complementary efforts. As a high priority, landowners need the tools to understand and implement efforts with educational opportunities that explain specific techniques that are practically implemented. Direct one-on-one work with landowners is likely to be most successful.

Future Plans. The Hermit's Peak Watershed Alliance plans to submit a variety of grant proposals, including EPA 319 on-the-ground improvement grants, to put into action the planned activities described in this document. This Watershed Based Plan developed a sixteen year, phased approach to restoring healthy stream conditions and reducing nutrient loadings in the lower Mora River and its tributaries. . It is a plan that conducts the necessary education and outreach, accomplishes on-the-ground management and restoration measures, monitors progress and puts into place sustainable community support systems that will carry on into the future.

The lower Mora Watershed is fortunate to have a number of other strong entities that will help put this plan into action either independently or collaboratively. Those key collaborators include the Rio Mora National Wildlife Refuge, Tierra y Montes and Mora- Wagon Mound Soil and Water Conservation District, the High Plains Grassland Alliance, the Fort Union Ranch and a number of private landowners; all who share the vision of sound watershed stewardship.

SECTION 1: INTRODUCTION

After over 180 years of modern man using the land in the lower Mora Watershed it is time for reflection. In this moment of pause we must assess the condition of that resourceful landscape and determine a future course of action that rebuilds ailing land features important to maintaining our supply of clean and abundant water. We must take the opportunity to restore degraded conditions and refine our relationship with the land, soil, water, plants, animals and with ourselves. This Watershed Based Plan for the Mora River-Upper Canadian Plateau (WBPMR) is just that pause.

The lower Mora Watershed has been well used since the 1830's and was a vital piece of the pioneering and settling of northern New Mexico. Located along the Santa Fe Trail it was the home of Fort Union, the adult entertainment hub at Loma Parda, and livestock range supporting thousands of cows and sheep that fed expanding populations and later stimulated by the Atchison Topeka and Santa Fe Railroad.

The Santa Fe Trail and a spider web of road ruts have turned to deep arroyos, once productive rangeland has become bare ground from overgrazing and a water drainage system including the Mora River is far from the verdant green, wetland zone that pioneers found. As we move into a new era, finding a new balance that enables the restoration of degraded conditions and future sustainable use of the land in the lower Mora Watershed, and throughout New Mexico, is the aim of this plan.

Our watersheds offer the fundamental resources that have sustained us through history and hopefully into the future – water, food and space. Our attentiveness to restoring and maintaining the health of those watersheds must be revived if communities are to remain viable and prosperous into an uncertain future. We must continue to improve land management practices and restore degraded areas in order for the land in our watersheds to function for the benefit of people and all other living organisms that are part of our land community.

Producing cold, clean and abundant water is perhaps the most significant ecological service offered by the land in our watersheds. Restoring and then maintaining the land's ability to perform its watershed functions without cumbersome, expensive and often ineffective (in the long run) infrastructure is the goal of this plan. If our watersheds are healthy, they can collect, store, filter and transport water throughout the landscape, supporting local and distant inhabitants. If they are not healthy, they cannot perform those functions and problems that can be avoided, such as excessive flooding, desertification and polluted water arise.

With a holistic approach, this WBPMR strives to paint a picture of the lower Mora Watershed landscape, assess its ability to perform watershed functions needed to sustain life, identify issues that require attention and drive its restoration and improved management in a direction that allows us to keep profitably using that landscape into the future. This plan attempts to offer the tools and insight to refine our relationship with the land, providing tangible on-the-ground work that is needed and identifying the resources to do that work.

Impetus and Development

The specific impetus for developing this *Watershed Based Plan for the Mora River – Upper Canadian Plateau* (WBPMR) is the provision of high quality water needed to support both human and non-human communities both locally and downstream. Beyond this specific driving force, this plan recognizes the far-reaching benefits of holistic and comprehensive watershed restoration and management so strives to improve and support the entire lower Mora Watershed system.

Currently, water quality in the lower Mora River does not meet state standards; it contains higher nutrients, Nitrogen and Phosphorus, than it should to support its natural ecosystems and our human uses. This water quality impairment has been evident since 2004 and is still in effect as of 2016. This impairment is due to the manner in which the landscape has been used and degraded over time. And water quality issues are usually indicative of unhealthy conditions across the watershed. This plan hopes to reverse that.

With support and guidance of the Clean Water Act, this WBPMR strives to present a vision and a practical implementation plan for restoring and maintaining health in the lower Mora Watershed that will improve and sustain its ability to produce high quality water that we all require. This vision and plan also strive to be holistic knowing that all components of a watershed are interconnected, and in order for one component, namely water, to be sustainable in the long run, all other elements must be healthy and operating synergistically.

This Watershed Based Plan is specifically funded by the Nonpoint Source Grant supported by Section 319 of the Federal Clean Water Act (referred to as 319). Funds are provided by EPA and administered locally through the New Mexico Environment Department, Surface Water Quality Bureau. This plan is guided by the Nine Key Elements (US Environmental Protection Agency, 2008) of a sound watershed plan (see Appendix A. Nine Key Elements of a Watershed Based Plan).

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The precursor to the CWA was enacted in 1948 and was called the Federal Water Pollution Control Act; the Act was significantly reorganized and expanded in 1972. "Clean Water Act" became the Act's common name with amendments in 1972. CWA is administered by the US Environmental Protection Agency and coordinated in New Mexico by the NM Environment Department (NMED). Under the CWA, EPA has implemented pollution control programs such as setting wastewater standards for industry. Water quality standards for all contaminants in surface waters are also set by EPA (http://www2.epa.gov/laws-regulations/summary-clean-water-act). CWA supported funding is then made available to states for various local water quality supported endeavors.

Since this plan guides the technical and regulatory processes related to water quality standards, there are many sections that contain technical information that may not be useful or understandable by people not intimately involved in that bureaucracy. The Management and Restoration Measures section (see Management and Restoration Measures to Support Load Reductions) offers the essential guidance to landowners for improving land and watershed health so provides the crux of this plan from a landowner perspective. For lay people, the Executive Summary and the Management and Restoration Measures sections may contain adequate information to understand the water quality related aspects of this plan.

Water quality related terminology used in this plan conforms to that used by EPA and NMED and key

Water Quality Impairment – Determined when a water body does not support the designated uses due to one or multiple pollutants from point or nonpoint sources. Designated uses for a particular body of water are uses specified in state or tribal water quality standards regulations, whether or not they are being attained. Examples of designated uses include marginal coldwater aquatic life, irrigation, recreation, or livestock watering.

Causes of Impairment – Pollutants or stressors that prevent a water body from supporting the designated uses. For example, temperature, dissolved oxygen, nutrients, or e.coli.

Sources of Impairment – Activities that may contribute pollutants or stressors to a waterbody. For example, rangeland grazing, septic systems, loss of riparian habitat, or road/bridge runoff.

TMDL –Total Maximum Daily Load (TMDL) is a regulatory document which describes the value of the maximum amount of a pollutant that a water body can receive while still meeting water quality standards.

The geographic area addressed by this WBP is the lower Mora River Watershed within the EPA Level IV Ecoregion of the Upper Canadian Plateau, covering the Mora River and its tributaries from approximately 5 miles west of Rio Mora National Wildlife Refuge and east to the former USGS gage east of Shoemaker (see Map 1). This area of the Mora Watershed is a sub-watershed of the Mora Watershed (Hydrologic Unit Code (HUC) 11080004) and is located in northeastern New Mexico. The project area watersheds encompass approximately 477 mi^2 and include an approximately 36.6 mile long impaired section of the lower Mora River, along with approximately 130.1 miles of perennial and intermittent tributaries.

This Watershed Based Plan (WBP) was developed with a strong scientific foundation resulting from numerous on-the-ground investigations and augmented with remote sensing technology using GIS (Geographic Information Systems). Next, that objective understanding was combined with cultural and social information to produce a plan that is well rooted in the realities of the communities and available resources of this large area.

This document presents background information and results of our scientific and social investigations and then combines that information to identify issues and measures to address those issues in order to restore and maintain health in the lower Mora Watershed. This WBPMR takes a holistic watershed perspective ensuring that all parts of the watershed are supported, natural and human. However, there is a focus on water quality because this plan is driven by the Clean Water Act and its funding sources.

This document is meant to guide improved watershed management and restoration; it is not designed to serve as a scientific treatise. Significant work and past experience has gone into developing this document. However, not all citations are included in the text since it was felt that they would be cumbersome and would detract from the application of this plan. The references section and the Literature Review document provide the principal sources of information for further investigation.

This WBP was developed by the Hermit's Peak Watershed Alliance (HPWA), a locally based 501(c)(3) nonprofit organization that strives to improve the health of local watersheds including the Gallinas, Tecolote, Sapello and lower Mora. Since 2011, HPWA has completed a Watershed Based

Plan for the Upper Gallinas Watershed, the first phase of its implementation and is beginning the second phase, all with CWA 319 funding. Also in the Gallinas Watershed, HPWA is currently carrying out a major river and floodplain restoration project funded under NMED's River Stewardship Program. This WBPMR will begin work in the lower Mora River Watershed and its tributaries including the Sapello River. Beyond watershed planning and on-the-ground watershed restoration work, HPWA offers various education programs to landowners, land managers and the general community to improve our collective understanding of watershed health and approaches to restore it. See www.hermitspeakwatersheds.org for copies of this plan, past plans, reports and educational materials.

Watershed Definition, Functions, Characteristics and Processes

A watershed is a region of land that drains into a particular body of water such as a river or a lake. Rain or snow that falls anywhere in that watershed eventually flows to that water body. Watersheds are defined hierarchically with large watersheds (e.g. the Canadian River Watershed) broken down into smaller sub-watersheds (e.g. Mora River, Sapello River) as tributaries to the larger ones.

Water within a watershed may travel overland as surface water (in rivers or ephemeral drainages) or flow underground as groundwater either in soils or deeper in the aquifer. A watershed includes all the natural and manmade elements that occur within its boundary: rocks, soil, topography, water, plants, animals, humans and their developments.

According to John Wesley Powell a watershed is:

> *"that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community."*

Watersheds naturally function as water conduits, storage reservoirs and water treatment plants. They receive precipitation then carry that water into surface and underground storage areas where it can be stored for weeks, months, or centuries. While passing over surface areas, drainages and wetlands or in underground areas, watersheds capture and filter debris, sediments and pollutants so the resultant water is clean enough to use and is delivered to people in a relatively consistent manner. Through surface obstacles (e.g. plants, rocks, logs, meandering rivers, wetlands) and underground storage areas, watersheds regulate the rate and quantity of water flow that moves through the system and is delivered to downstream areas.

Watersheds function to:

- capture, store, filter and transport water;
- regulate water flow under and on the surface over space and time;
- mitigate natural disturbances such as floods, drought and fire;
- rebound after natural disturbances and human uses;
- produce and support topographic features, soil structures, vegetation and wildlife that aid in watershed functions;
- produce natural resources (water, timber, forage, space) of value to humans.

These watershed functions, also known as ecological services, rely on intact and diverse ecological structures and processes to function optimally and sustainably. Important watershed characteristics (structures) or configurations are:

- soil structure and composition that enables water to infiltrate;
- appropriately shaped drainages (i.e. hydrogeomorphology that is appropriate for the size and type of drainage);
- obstacles that slow and capture water flow and encourage infiltration (e.g. vegetation, rocks, logs, topography);
- the ability of drainages to overflow onto their floodplains (referred to as floodplain connectivity);
- intact and abundant wetlands;
- intact and diverse upland, floodplain and riparian vegetative cover.

Numerous ecological processes occur and must occur within watersheds in order to maintain their functionality and characteristics. The rate and distribution of these processes occur in balance when watersheds are functioning at their best. These processes are:

- natural disturbances like fire, flood, drought, wind;
- erosion and redistribution of inorganic materials (soil and rock);
- dynamic adjustments of drainage channels through aggradation and degradation;
- plant community dynamics in response to disturbances and subsequent plant community succession;
- dynamic animal communities that adjust to changes in the landscape and plant communities through birth, death and movement.

The above ecological functions, characteristics and processes are complex and dynamic and would require volumes to fully cover without even mentioning the complexity of human-related functions, structures and processes. However, attempting to acknowledge and to some degree accommodate the diversity and dynamics of watersheds must be a part of a WBP that has a good likelihood of being effective at restoring and maintaining these complex systems.

Goals and Objectives

The purpose of this WBPMR is to lay a common foundation for approaching restoration and improved management of the lower Mora Watershed from a water quality and overall watershed health perspective in order to guide funding and on-the-ground activities. It hopes to support all entities that work on the land and offer a watershed health perspective to their work. This plan will also drive implementation of management and restoration measures that can be funded with Clean Water Act related grants as well as other programs.

The specific goal of this plan is to reduce nutrient loads and improve water quality in the lower Mora River and its tributaries. To accomplish this, we have developed a *Watershed Based Plan for the Mora River – Upper Canadian Plateau* which assesses the conditions that have lead to the current impairment and to clearly identify actions needed to restore the functionality of nutrient impaired reaches resulting in measurable improvements in water quality and enhanced watershed health.

The primary emphasis of this Watershed Based Plan is to identify projects that will lessen the nutrient impairment as first identified by the 2004-2006 §303(d) /§305(b) list (NMED SWQB, 2004) and by the Total Maximum Daily Load (TMDL) for the Mora River (USGS gage east of Shoemaker to Hwy 434) (NMED SWQB., 2007). Beyond that focus, watershed actions to restore and maintain the broad scope of watershed functions are addressed. In accordance with the EPA's Healthy Watersheds Initiative, this project acknowledges that waters and aquatic ecosystems are interconnected in the landscape. In assessing conditions and establishing remediation plans, this project took a comprehensive look at the watershed to the extent possible. It also emphasized landowner and community education on the importance of healthy streams and overall watershed health.

While water quality is the focus of this planning effort it has been approached with a holistic perspective knowing that ……

> "*It is increasingly recognized that ecosystem health is integral to human health and unless healthy rivers (and their watersheds) are maintained through ecologically sustainable practices, societal, cultural, and economic values are threatened and potentially compromised.*" (Brierley, 2005)

This WBPMR is founded in the nine elements of watershed based plans drawing from the EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters, 2005, and the EPA Healthy Watersheds Initiative National Framework and Action Plan, 2011 for guidance and protocol. We believe the nine planning elements substantially improve the quality of the plan and its likelihood of implementation success in the future.

Planning Approach and a Guide to this Document

This WBP is based on a scientific watershed condition assessment, informal discussions with residents and stakeholders, consultations with watershed restoration specialists and a review of literature. This base of information is then used to document and substantiate causes and sources of the water quality impairment. Goals are set for nutrient load reductions in order to meet the recommended Total Maximum Daily Load (TMDL) as set by NMED. Management and Restoration Measures that should be implemented to remediate the water quality impairment and accomplish the TMDL are presented to guide future on-the-ground work. An overall strategy for prioritizing this work, seeking funding and partners for its support and monitoring its outcomes is then presented.

Because of the large size of this project area (477 sq. miles) it was necessary to choose focus areas. Due to the project's two year time frame, the limited monitoring and assessment budget and a lack of access to some property, it was decided to focus field data collection on the main stem of the Mora River with only limited attention to Sapello River and other tributaries. The reason for this focus area is that the main stem of the Mora is the only nutrient impaired reach within this large project area. As a consequence there are notable gaps in the treatment of certain geographic areas of the lower Mora Watershed; those gaps, and recommendations for filling them are:

- *Sapello River* – A sediment (rather than nutrient) impairment, distinct social characteristics and considerable observed river degradation necessitate closer investigation and unique planning for this area. We recommend separating the entire Sapello Watershed, which would include the headwaters of the Sapello River, into a separate Watershed Based Planning area.

- *Wolf Cr. and Dog Cr.* - Both of these streams are intermittent and sampling flow and nutrients proved to be difficult as flow was irregular. Future monitoring on these streams should be attempted dependent on flow conditions.
- *East of Shoemaker* – While the impaired section of the Mora River ends 5 miles east of Shoemaker, the project area for the WBP extends to the HUC boundary approximately 12 miles downstream from the impaired Assessment Unit (AU). No roads or developments exist in this area of the lower Mora River which prevented access. As the impaired section of the stream has no road access for assessment and future treatment and degraded conditions are expected to be minimal, no future action is required.

The organization of this planning document follows the planning process that occurred over the course of this two year project. Each Section of this WBP presents the results of a planning step as described below.

SECTION 1. INTRODUCTION – Presents the purpose, impetus and funding source for this project, an explanation of watershed functions, characteristics and processes, goals, and objectives and describes a vision for the lower Mora Watershed.

SECTION 2. WATERSHED DESCRIPTION – A collection of background information that is readily available to describe a variety of environmental and social characteristics of the watershed including its: geography (location, watershed hierarchy, drainage system and hydrology), ecology (geology and soils, wetlands, plant communities, wildlife communities) and human culture (history, demographics, landownership, land use).

SECTION 3. WATERSHED ASSESSMENT – An assessment of the current environmental and social conditions of the watershed required to determine remediation needs and approaches.

Environmental Assessment - An assessment of current on-the-ground condition consisted of:

1. Nutrient Assessment Level 1 and 2 including collecting river samples for nitrogen and phosphorus analysis, collecting periphyton for chlorophyll *a* analysis and collecting sonde data (pH, turbidity, dissolved oxygen, specific conductivity and temperature).
2. Riparian and instream condition using the NM Rapid Assessment Method (NMRAM), (version 2.0) for Montane Rivers.
3. Geomorphology using a Rosgen Level II assessment.
4. Macroinvertebrate survey as an additional water quality indicator.
5. River Visual Assessment.
6. Watershed modeling – bare ground, hydrologic, sediment and nutrient.

Social Conditions Assessment - An assessment of social conditions was also accomplished. Landowners and stakeholders in the lower Mora Watershed were identified and interviewed to better understand the social climate and landowner/land manager culture, perspectives, goals and constraints. This understanding was used to establish realistic approaches to changing land management and doing restoration work with a good likelihood of local support. Informal discussions were held with willing landowners and stakeholders, written questionnaires were circulated and public meetings were held to solicit further input. Draft copies of the Watershed Based Plan were circulated to interested landowners and stakeholders for their comments and input. Beyond this social condition assessment, 19 (see Table 17) education and outreach events occurred to share information and become better acquainted with local residents.

SECTION 4. PLANNING ELEMENTS – The crux and organization of the plan is largely set by an EPA developed guide for Watershed Based Plans as described in the Nine Key Elements (see Appendix A. Nine Key Elements of a Watershed Based Plan). They include the following subsections:

Causes and Sources of Nutrient Impairment – The type of impairment (Causes) and the general reasons for that impairment (Sources) are described and substantiated by data collected during this planning project. The Causes and Sources were further explained by information provided in the TMDL as well as information acquired from stakeholder interviews, field monitoring assessments and GIS and modeling assessments.

Nutrient Load Reductions – Total Nitrogen and Total Phosphorus loading rates for the Mora River were calculated using the EPA modeling program BASINS (Better Assessment Science Integrating Point and Nonpoint Sources). After pollutant loading rates were established, load reductions for Management and Restoration Measures (MRMs) were calculated using STEPL (Spreadsheet Tool for Estimating Pollutant Loads). Load reductions were calculated based on the land use, acreage and the efficiency of the MRM. Efficiencies of MRMs were based on STEPL, BASINS and a literature review.

Management and Restoration Measures to Support Load Reductions – Using a review of current literature, consultation with watershed restoration specialists and experienced stakeholders, field data collection, interviews with landowners and past experience in other watersheds, management and restoration measures for reducing the nutrient impairment and improving overall watershed functions were assembled. Those measures address both recommended changes in land management and needed restoration activities. They address the identified causes and sources of impairment and are related to nutrient load reduction goals set in the plan.

Financial and Technical Assistance Needed – Based on Management and Restoration Measures needed to meet load reductions that were identified in the previous section, a budget was developed to estimate the amount of funding needed to implement this WBP. The types of technical support needed to carry out MRMs and how that technical support might be provided is then detailed.

Education and Outreach – A strategy for education and outreach needed to promote and inform landowners about watershed management and restoration techniques, opportunities and resources is presented.

Implementation Strategy and Schedule – A strategy for prioritizing and funding the implementation of management and restoration measures is proposed to offer an approach to accomplishing on-the-ground work. A description of partners that could be involved in this implementation is presented.

Measurable Milestones of Implementation – Quantitative and qualitative measurable milestones that will be used to gauge progress on implementing planned activities are presented.

Criteria for Evaluating Load Reduction Achievements – A set of criteria to determine whether load reduction goals are being met over time and progress is achieved toward meeting water quality standards.

Monitoring Program – A long-term strategy for monitoring progress toward meeting the nutrient load reductions after on-the-ground projects are accomplished was developed to evaluate the effectiveness of implementation efforts and modify future implementation approaches.

A Vision for the Lower Mora Watershed

Our vision for the lower Mora River Watershed is that the land (rocks, soil, water) and its inhabitants (plants, animals, people) are healthy and capable of producing and sustaining the ecological services that the watershed can provide within its natural capacity. This vision is based on a desire to support all living organisms and the non-living components in a balanced and mutually beneficial manner. It is also based on employing natural systems and well managed land uses to provide ecosystem services and natural resources without a reliance on expensive and difficult to maintain man-made infrastructure.

More specifically, our vision is for an intact and fully functional lower Mora River Watershed that has the following characteristics:

- Upland soils harbor vibrant ecosystems, support productive plant growth and are free of excessive erosion allowing them to sequester carbon, infiltrate, store and filter water, prevent local desertification and fuel upland plant and animal ecosystems.

- Natural areas in uplands are covered with abundant, diverse and productive vegetation enabling water infiltration, storage and purification and anchoring soils to prevent erosion while fueling both abiotic and biotic ecosystem processes.

- Human use areas in uplands are managed to maintain abundant, year round plant cover enabling water infiltration, storage and purification, anchoring soils to prevent erosion, maintaining soil health and supporting human and animal residents of the watershed.

- Riparian areas and floodplains are dominated by abundant and diverse native vegetation providing rivers and streams with shade, filtering sediments and nutrients, anchoring soils to prevent erosion, offering rich fish and wildlife habitat and travel corridors and providing a beautiful, moist area for humans to enjoy.

- Wetlands occur in all locations where they can be hydrologically sustained and complement human land uses providing the services of water storage, water purification, disturbance mitigation, fish and wildlife habitat and beautiful areas in our arid environment.

- Rivers and streams are well connected to their floodplains enabling them to accommodate floods, buffer downstream areas from flood damages and store and slowly release flood waters to maintain flows during dry periods.

- Instream characteristics mimic natural conditions so that drainages can slow water flow, maintain or enhance water quality, balance aggradation and degradation processes, prevent erosion, help spread water to floodplains and provide fish and wildlife habitat.

- Fish and wildlife, especially keystone species, occur in viable, self-maintaining populations as part of sustaining all ecosystem processes and offering enjoyment and sustenance to human inhabitants.

- Humans live comfortably and in a balanced manner in the lower Mora Watershed using and stewarding the natural resources (water, soil, rock, plants and wildlife) for their mutual benefit.

SECTION 2: WATERSHED DESCRIPTION

To provide a picture of the lower Mora Watershed and its physical and social context, a description of the geography, ecology and cultural history follows.

Geography

Location

The Mora Watershed – Upper Canadian Plateau project area is located within the Mora Watershed in northeastern New Mexico. The project area is within both Mora (60.5%) and San Miguel (39.5%) Counties. The project area is bounded by the Turkey Mountains and Black Mesa to the north, the creston to the west, the Great Plains to the south and canyon lands to the east. The villages of Sapello and Golondrinas are located near the southwest and west boundaries, respectively. The village of Watrous on I-25 is approximately in the center of the project area. The elevation descends from 8,500′ on Black Mesa and the Turkey Mountains to 5,900′ at the eastern downstream edge of the watershed. The project area begins approximately 50 miles downstream of the Mora River headwaters.

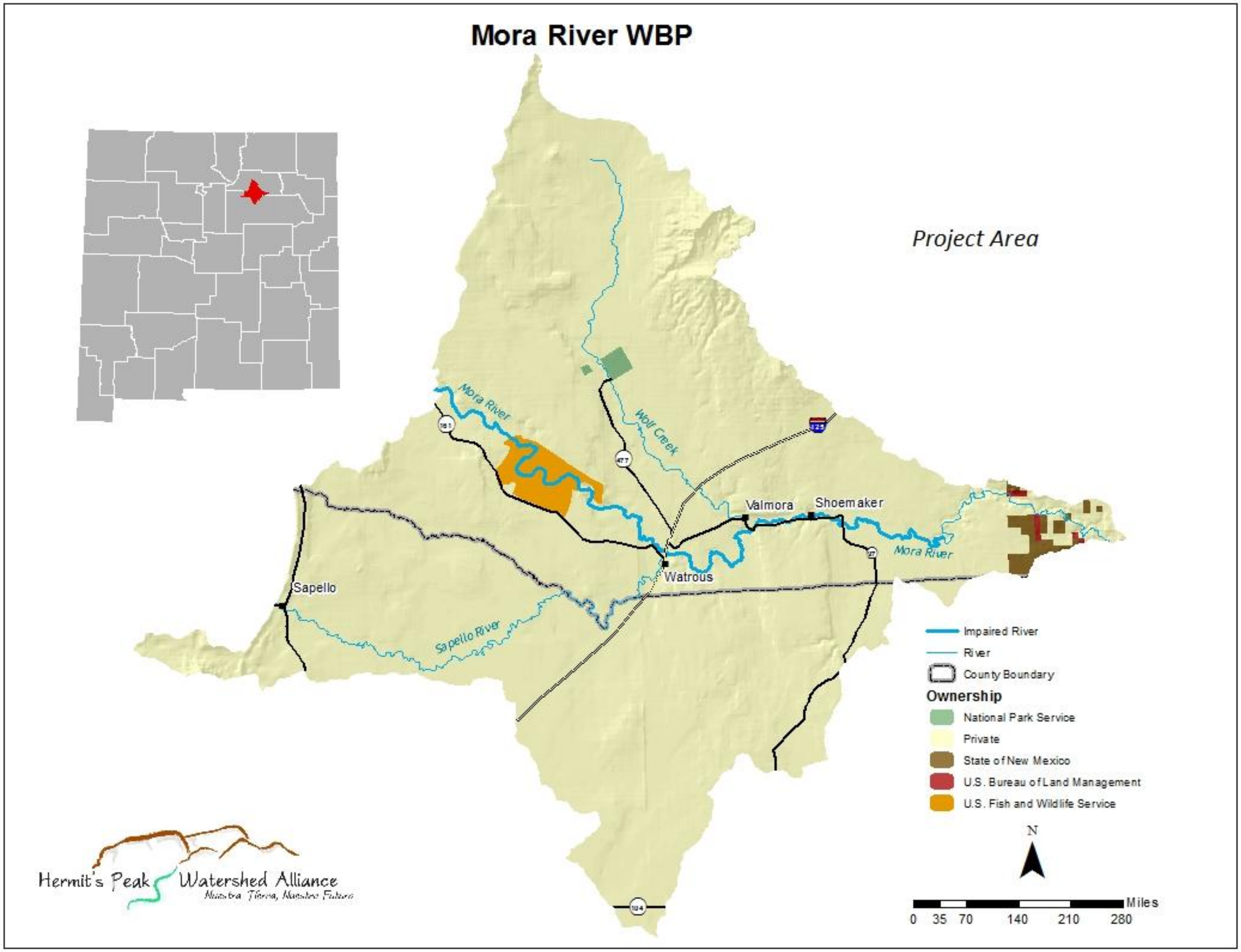
The watershed is mostly comprised of plains and rangeland with some piñon-juniper forest, canyon lands and agricultural valleys. Mostly intermittent streams and some perennial streams come from mountain sources to the north and west. Some flatter areas with small depressional wetlands or intermittent playas are scattered throughout the rangelands.

Sub-watersheds

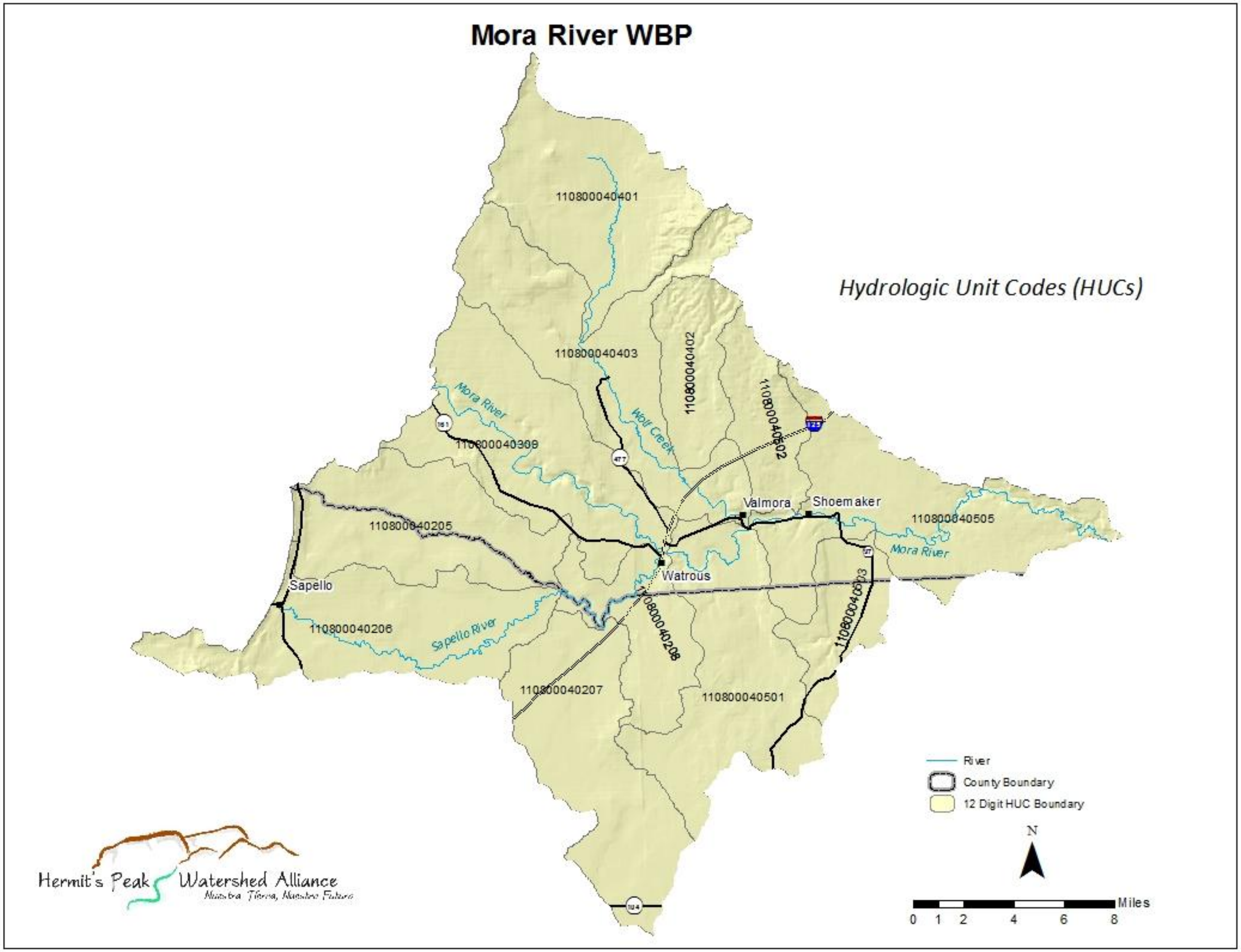
The project area is approximately 477 square miles (305,280 acres). It includes twelve 12-digit hydrologic unit codes: 110800040205, 110800040206, 110800040207, 110800040208, 110800040309, 110800040401, 110800040402, 110800040403, 110800040501, 110800040502, 110800040503 and 110800040505.

Table 1- Hydrologic Unit Codes in the Mora Watershed Project Area

HUC Name	HUC 12	HUC Size (mi^2)	Length of Impaired Mora River (mi)	Length of Tributaries (mi)
Arroyo de La Jara	110800040205	42.13		16.57
Sanguijuela Arroyo-Sapello River	110800040206	49.151		24.95
Lewis Ranch	110800040207	48.30		
Phoenix Lake-Sapello River	110800040208	23.19		11.22
Sapello River-Mora River	110800040309	53.43	19.35	
Headwaters Wolf Creek	110800040401	46.71		10.06
Arroyo Needam	110800040402	19.01		18.02
Outlet Wolf Creek	110800040403	55.40		22.95
Tiptun Creek-Mora River	110800040501	49.24	6.45	16.34
Dog Creek	110800040502	17.62		9.99
Cherry Valley Lake	110800040503	17.57		
Arroyo Tierra Blanca-Mora River	110800040505	55.27	10.8	
Total	**110080004**	**477.02**	**36.6**	**130.1**



Map 1- Project Area



Map 2- Hydrologic Unit Codes (USDA-NRCS, 2010)

Drainage System and Hydrology

The Mora Watershed is a sub-basin in the Canadian Watershed. The Mora River starts in the Rincon Mountains north of Chacon (at about 10,000 ft.) and enters the Canadian River near the tri-county border of Mora, Harding and San Miguel Counties, a distance of 116 miles. The main tributaries feeding the lower Mora River in the Upper Canadian Plateau are the Sapello River (perennial), Wolf Creek, Tipton Creek and Dog Creek (all intermittent). The project area includes 36.6 miles of the main stem of the Mora River, which is listed as nutrient impaired, as well 130.1 miles of tributaries.

The USGS gaging station on the Mora River at Golondrinas has been recording flow since 1915, with a period of no data recorded in the 1920s. The average flow over the past 91years is 31.73 cfs. The minimum average flow, recorded in 2003, was 2.31 cfs. The maximum average flow, recorded in 1941was 144.4 cfs. The average peak flow over the 91 year period is 1147 cfs. The lowest peakflow ever recorded was 15 cfs in 2003. The highest peak flow on record was 14,000 cfs in 1952 (U.S. Geological Survey, 2016).

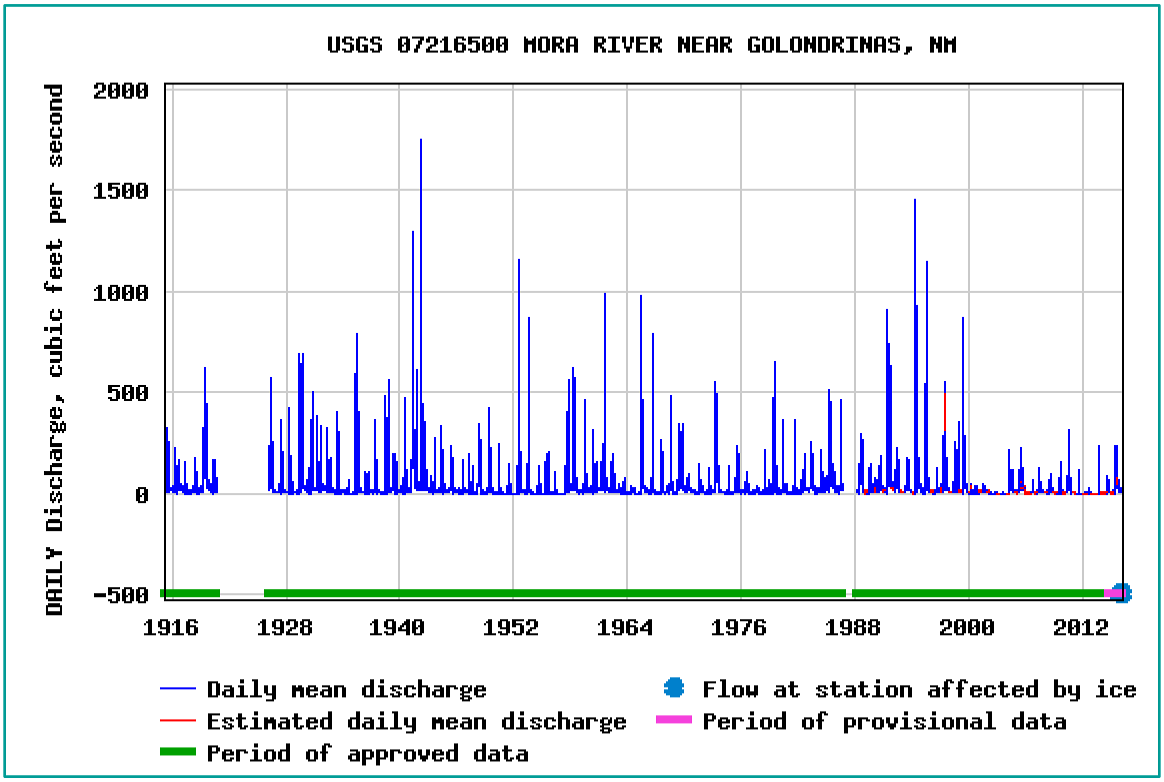


Figure 1- USGS Flow on the Mora River at Golondrinas from 1915 to 2016 (U.S. Geological Survey, 2016).

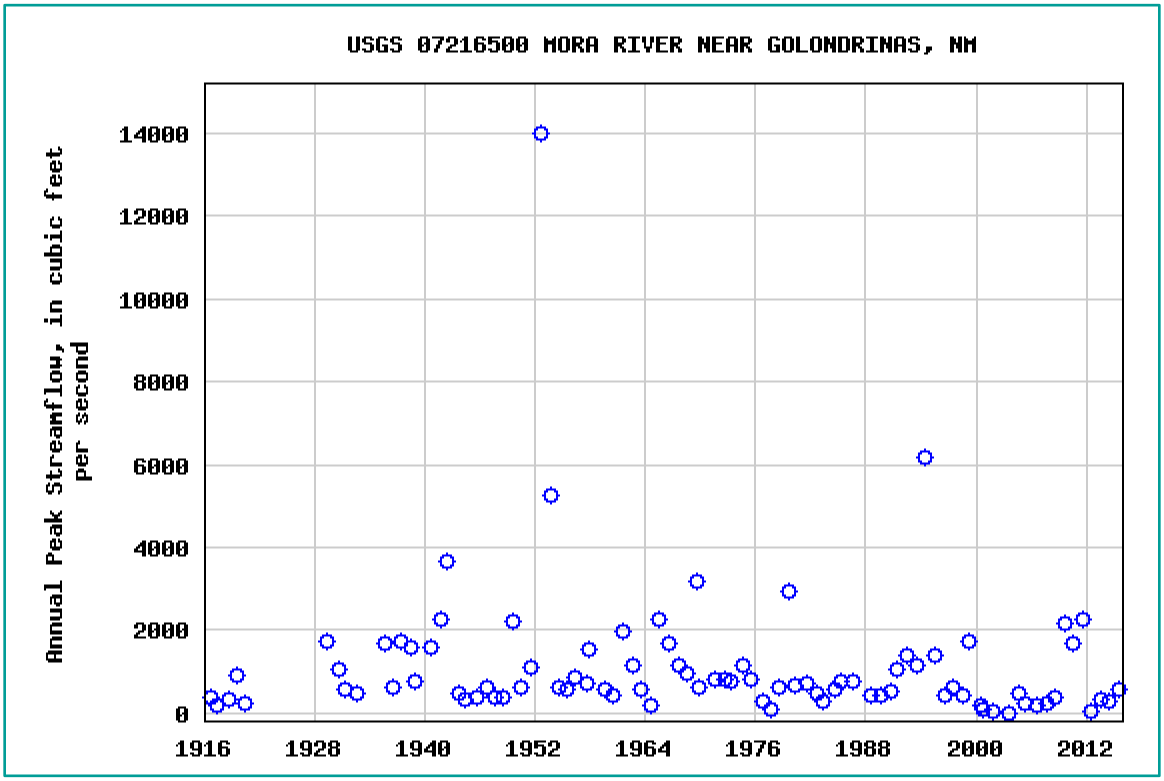
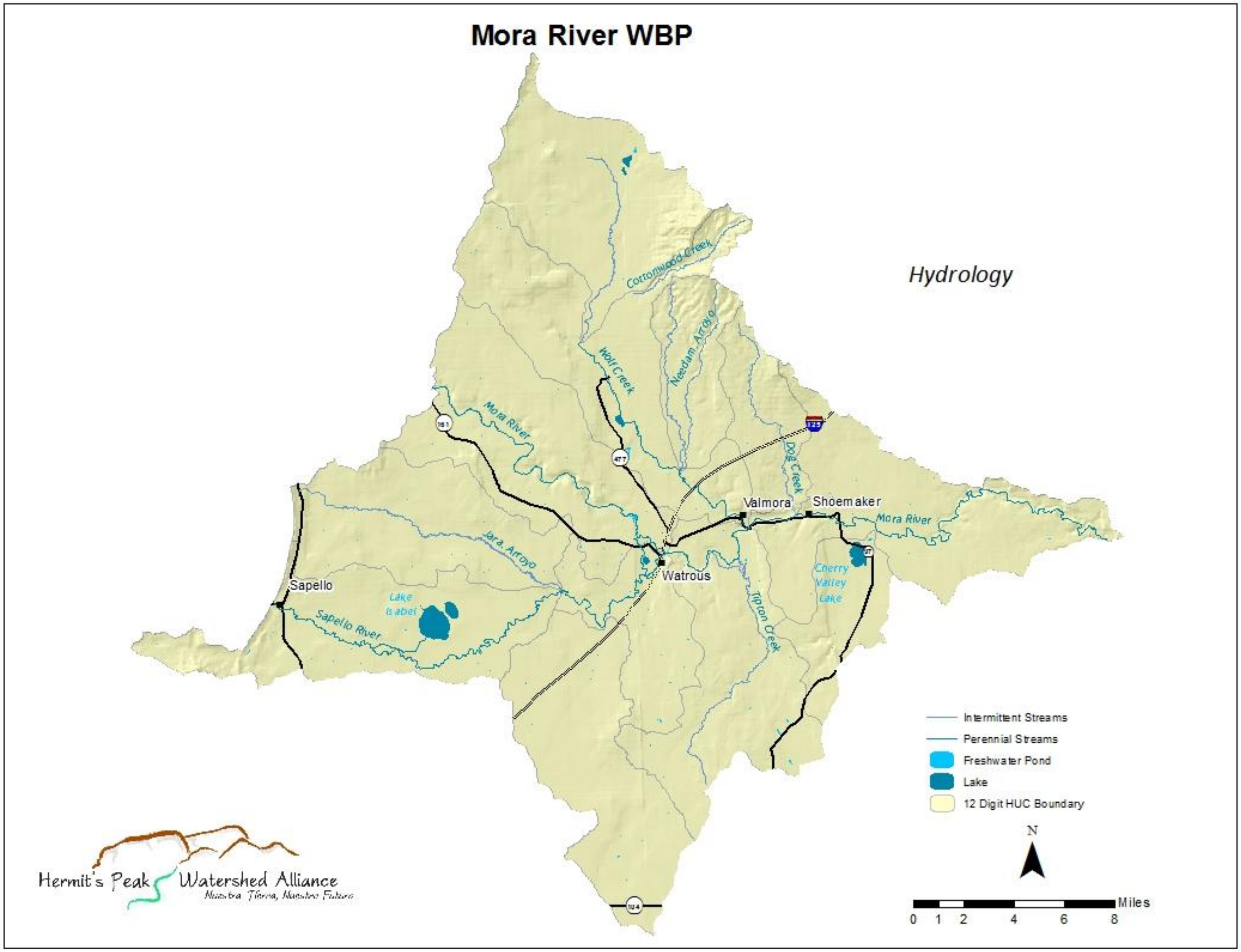


Figure 2- USGS Peak Stream Flow Measurements 1915 to 2016 (U.S. Geological Survey, 2016)



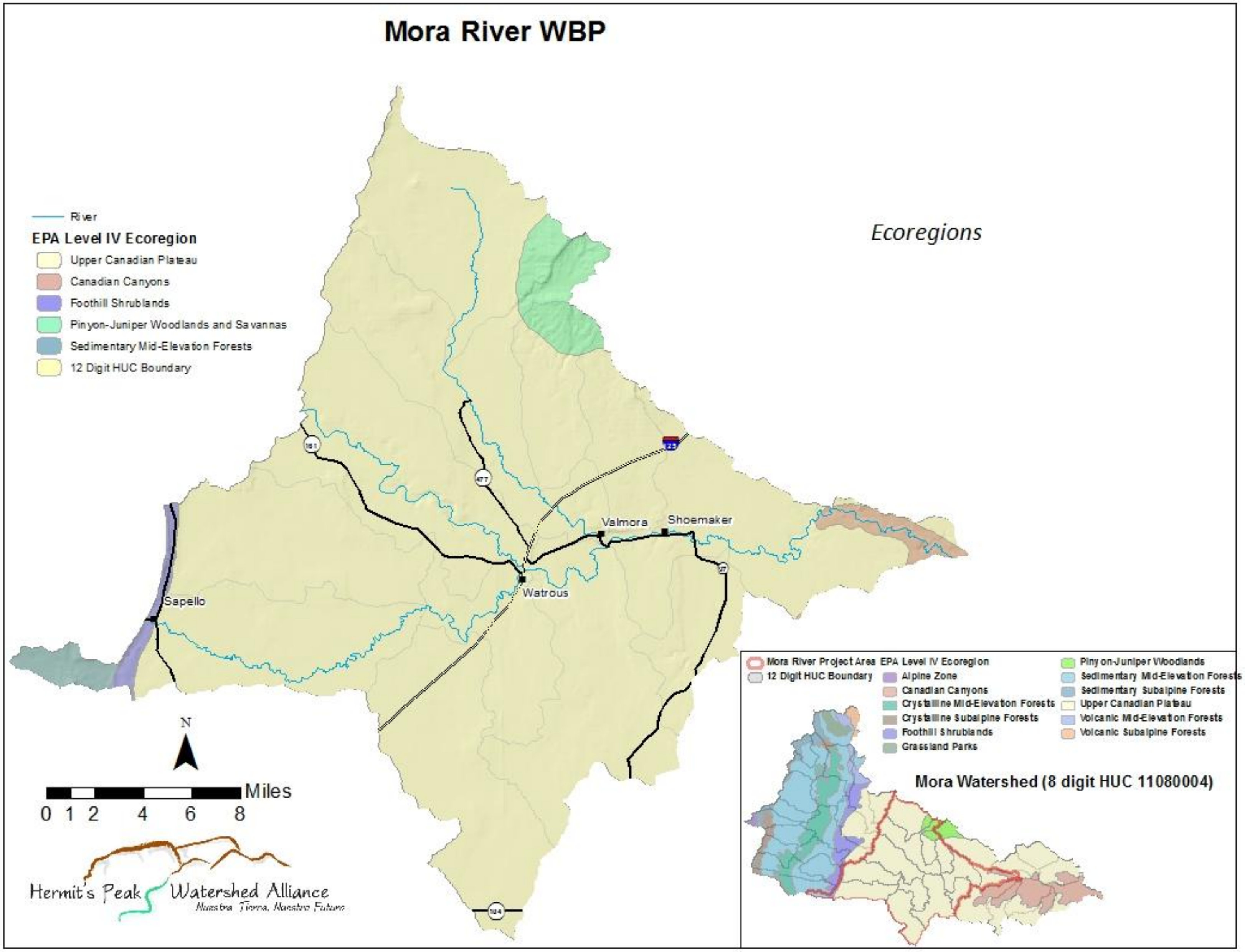
Map 3- Hydrology (USDA-NRCS, 2010)

Ecology

The lower Mora Watershed is in the Great Plains: South Central Semi-Arid Prairies: Southwestern Tablelands: Upper Canadian Plateau Ecoregion (EPA Ecoregion Levels I-IV respectively) as described by the EPA (U.S. EPA, 2016). The area is also commonly referred to as being in the Southern Shortgrass Prairie Ecosystem (The Nature Conservancy, 2004).

The Southwestern Tablelands flank the High Plains Ecoregion with red-hued canyons, mesas, badlands and dissected river breaks. Unlike most adjacent Great Plains http://www.eoearth.org/article/Ecologyecological regions, little of the Southwestern Tablelands is in cropland. Much of this region is in sub-humid grassland and semiarid rangeland. The eastern boundary represents a transition from the more extensive cropland within the High Plains to the generally more rugged and less arable land within the Southwestern Tablelands Ecoregion (U.S. EPA, 2016)).

The Upper Canadian Plateau Ecoregion IV (Ecoregion 26l) dominates the project area with small areas of piñon-juniper woodlands, Canadian Canyons, grassland parks, and foothill shrublands, ecoregions (see Map 4). It is heterogeneous relative to relief, geologic substrates and vegetation patterns. Parts of the region are influenced by proximity to mountainous regions, and there are other east to west differences within the region. The ecoregion contains mesic soils, higher elevations and areas of greater relief compared to the thermic soils and lower elevations to the south (Ecoregion 26n). Much of the topography is flat to rolling plains dissected by canyons and caprock escarpments. In addition to the relatively level plains, the ecoregion is topographically diverse and includes isolated volcanic formations (The Nature Conservancy, 2004).



Map 4- Level IV Ecoregions (U.S. EPA, 2016)

Climate

The climate in the lower Mora Watershed and the Watrous area is continental and is defined by both the Rocky Mountains to the west and the plains to the east. Precipitation over the entire area often varies from extremely dry to wet in relatively short periods, with few years near the long term average. Similarly, rapid changes in temperature occur seasonally as well as daily. This variability is partially responsible for the diversity of habitats and wildlife resources found in the area, and adaptability of many of the native plants and animals.

Winter precipitation and winter snowmelt provides the base flow for the Mora River. In most years, the streams originating in the mountains have a spring snowmelt-driven pulse of flow. Summer rains are typically brief and intense and usually occur between July and September. Approximately two-thirds of the precipitation is received during the late summer monsoons. Streams are often flooded by locally heavy summer thunderstorms. Intense summer rains have historically and continue to cause significant arroyo formation and downcutting of drainages in areas with degraded vegetation.

Mean annual precipitation ranges from 14-17 inches (U.S. EPA, 2016). According to the Western Regional Climate Center, the average annual precipitation for Valmora (the nearest COOP station) is 16.5 inches (1893--2014), and average annual snowfall is 23.6 inches (Western Regional Climate Center, 2015). The average annual accumulated precipitation at Tolby Peak SNOTEL station (elev. 10,180 ft approximately 50 miles north of the project area) is 26.8 inches which is the nearest SNOTEL station in the Canadian Watershed (NRCS, 2015).

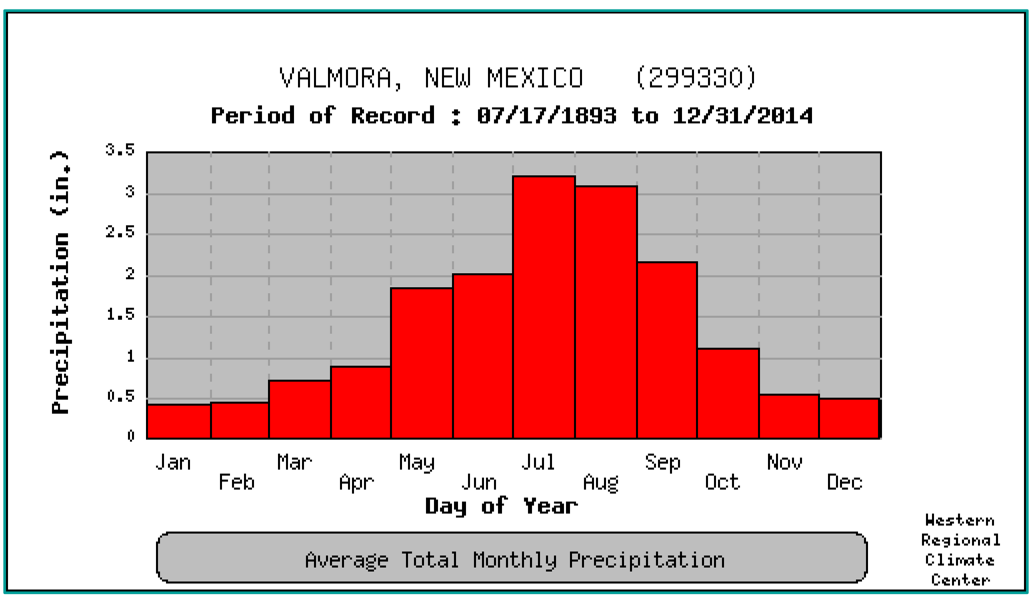


Figure 3- Average Monthly Precipitation at Valmora (Western Regional Climate Center, 2015)

Average maximum temperature for Las Vegas during June, July and August is approximately 83℉ (28.3℃), and average temperature for June, July and August at Tolby Peak is 53℉ (11.8℃). The Temperature/ Moisture Regime for the Upper Canadian Plateau is described as Mesic/Aridic Ustic, Ustic Aridic (U.S. EPA, 2016). Mean minimum/maximum temperatures in January are 14℉/48.6℉ (-10℃/9.2℃) and in July they are 52.8℉/85.1℉ (11.5℃/29.5℃). The mean annual Frost Free days range from 140-160 (U.S. EPA, 2016).

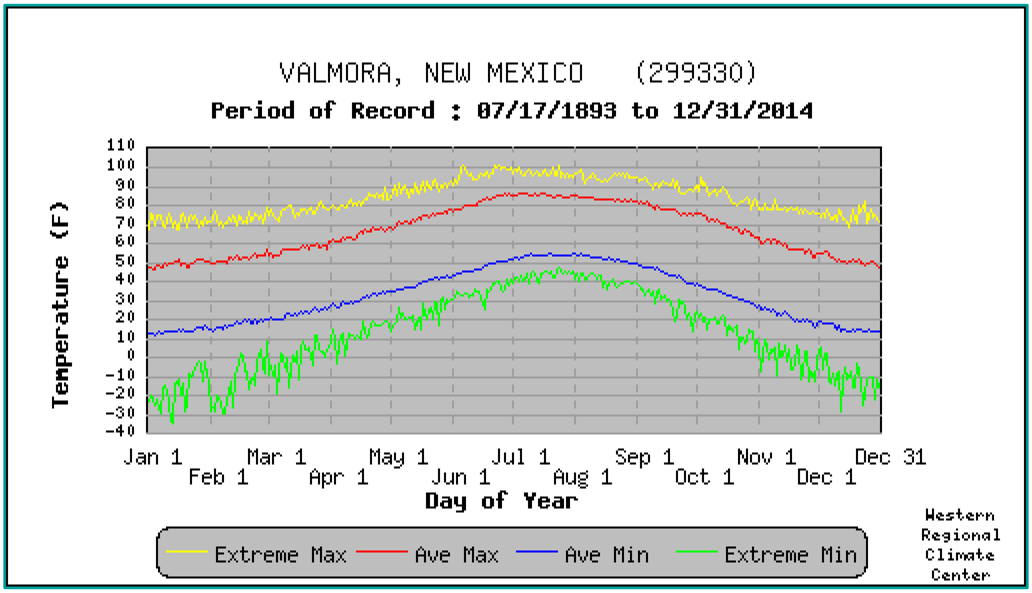


Figure 4- Average Monthly Max and Min Air Temperature (Western Regional Climate Center, 2015)

Geology and Soils

The lower Mora Watershed lies on the high plains east of the Sangre de Cristo Mountains. This is the southern end of the Rocky Mountain chain, a discontinuous series of ranges. The entire Rocky Mountain chain extends from central New Mexico to northern Canada. About 140 million years ago, during the Cretaceous, eastern New Mexico was flooded by a shallow sea (Chronic, 1987) (Smith, 2000). This sea left thick deposits of shale and sandstone (Chronic, 1987). About 80 million years ago, the Laramide Orogeny began fault-lifting Pre-Cambrian rocks upward to start the New Mexican part of the Rocky Mountain chain; the upward faulting continued into the Cenozoic Era (Smith, 2000). Along the east edge of the faulting, sedimentary layers bent upward to form the present-day hogbacks (Chronic, 1987).

Erosion from the mountains was heaviest during the Pleistocene Epoch of the Cenozoic Era because of continued uplift combined with Ice-Age precipitation (Chronic, 1987). Dakota sandstone and Pierre shale still lie on the basin east of the mountains today. The dark gray Pierre shale was deposited as mud on the floor of the shallow sea (Smith, 2000). The Dakota sandstone, however, is a beach and shore deposit, and like beach sand it is porous and permeable (Smith, 2000). Thus, the soil-covered sandstone serves as an aquifer throughout the east side of the Sangre de Cristo Mountains (Smith, 2000). Various layers of soil cover this sedimentary base, with topsoil averaging about four inches thick (Zeedyk B. a.-W., 2009). The Upper Canadian Plateau is underlain mostly by Cretaceous sandstone and shale, with some Tertiary and Quaternary volcanic rocks. It includes parts of the Raton-Clayton and Ocate volcanic fields.

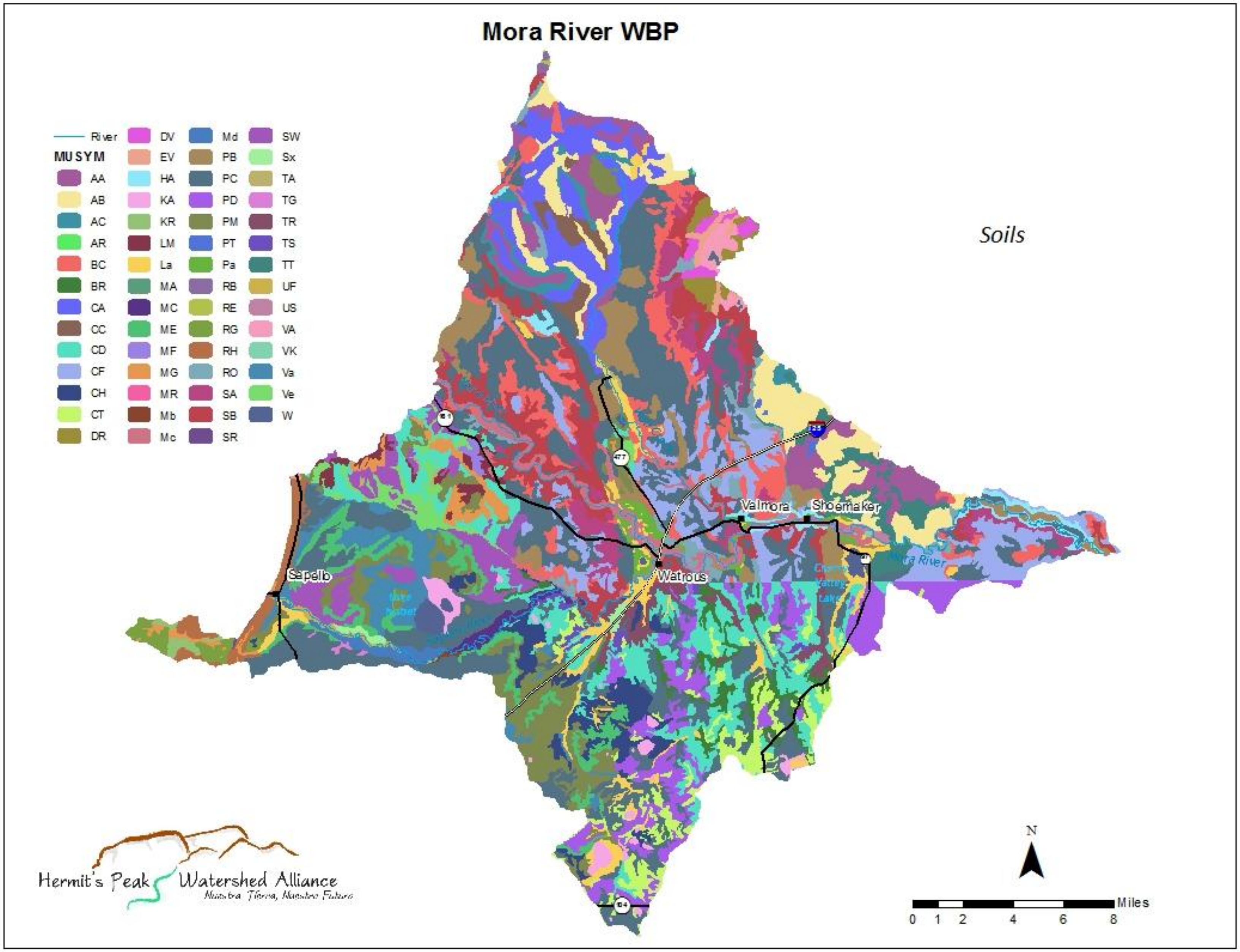
Soils are diverse, but NRCS soil data shows that dominant soil types include: PC (Patri-Carnero-Bernal association), CD (Colmor loam), CF (Crew-Tricon association), PM (Penrose-Mion-Litle association), SB (Sombordoro-Rock outcrop-Tuloso complex) and BC (Bernal-Rock outcrop-Carnero complex) (NRCS USDA, 2003). Dominant ecological site types include Loamy Upland (R070AY001N), Shallow Upland (R070AY003N) and Shallow Sandy Savanna (R070C7122N).

Table 2- Soils in the WBPMR Project Area by Dominance

MUSYM	Soil	Percent
PC	Partri-Carnero-Bernal association, undulating	18.64%
CD	Colmor loam, undulating	6.37%
CF	Crews-Tricon association, undulating	5.22%
SB	Sombordoro-Rock outcrop-Tuloso complex, very steep	5.01%
PM	Penrose-Mion-Litle association, moderately sloping	4.77%
BC	Bernal-Rock outcrop-Carnero complex, moderately sloping	4.67%
PD	Partri-Tricon association, undulating	4.22%
AB	Apache-Rock outcrop complex, moderately sloping	4.04%
CA	Capulin-Charette-Ayon association, gently sloping	3.68%
PB	Partri loam, gently sloping	3.40%
AA	Apache-Ayon complex, gently sloping	3.08%
CT	Crews-Tricon association, undulating	2.63%
SW	Swastika silt loam, gently sloping	2.54%
La	La Brier silty clay loam, 0 to 3 percent slopes	2.41%
SA	Sombordoro-Rock outcrop-Tuloso complex, moderately sloping	2.37%
ME	Mion-Litle-Rock outcrop association, very steep	2.33%
Va	Vermejo clay, 0 to 5 percent slopes MLRA 70A	2.22%
CH	Colmor silt loam, undulating	2.09%
Mc	Manzano loam, 1 to 3 percent slopes	1.60%
TT	Torreon-Thunderbird association, gently sloping	1.51%
BR	Bernal-Rock outcrop association, gently sloping	1.49%
RO	Rock outcrop-Bernal complex, moderately steep	1.40%
TR	Tuloso-Rock outcrop-Sombordoro association, steep	1.16%
Ve	Vermejo clay, 0 to 5 percent slopes MLRA 70A	1.11%
RH	Rock outcrop-Haploborolls complex, very steep	1.02%
MG	Mion-Penrose variant-Rock outcrop association, very steep	0.97%
AC	Apache-Rock outcrop-Ayon complex, moderately steep	0.93%
HA	Haplustolls-Rock outcrop complex, extremely steep	0.89%
KA	Karde-Vermejo association, gently sloping	0.82%
W	Water	0.71%
CC	Charette-Capulin association, gently undulating	0.70%
LM	Litle-Mion association, moderately sloping	0.57%
DR	Dargol-Rocio-Vamer association, hilly	0.56%
Pa	Partri loam, 1 to 3 percent slopes	0.54%
RG	Rocio-Dargol-Stout association, hilly	0.51%
US	Ustifluvents, frequently flooded	0.48%
Md	Manzano clay loam, 1 to 3 percent slopes	0.44%
MC	Manzano loam, gently sloping	0.40%
VA	Vamer-Rock outcrop-Eutroboralfs complex, hilly	0.39%
DV	Dargol-Rocio-Vamer association, very steep	0.38%

MUSYM	Soil	Percent
EV	Eutroboralfs-Rock outcrop-Vamer complex, extremely steep	0.30%
TS	Tuloso-Sombordoro-Rock outcrop complex, moderately sloping	0.29%
Sx	Swastika silty clay loam, 0 to 3 percent slopes	0.21%
UF	Ustifluvents, frequently flooded	0.20%
KR	Krakon-Rock outcrop complex, hilly	0.19%
MF	Mion-Penrose variant-Rock outcrop complex, very steep	0.16%
TA	Tinaja gravelly loam, moderately steep	0.09%
PT	Pidineen-Tricon complex undulating	0.06%
TG	Tinaja gravelly loam, hilly	0.05%
RB	Raton-Barela association, hilly	0.05%
Mb	Manzano fine sandy loam, 1 to 3 percent slopes	0.03%
SR	Stout-Rocio-Dargol association, very steep	0.02%
RE	Raton-Rock outcrop complex, very steep	0.02%
VK	Vermejo-Karde association, gently sloping	0.02%
MA	Maes-Etoe complex, hilly	0.01%

Soils in the Upper Canadian Plateau are typically very erosive and are prone to arroyo formation when vegetative cover is degraded. The soil types in the watershed with the highest erosion rates are Colmor loam which is highly erodible (K factor 0.55) and Crews-Tricorn, Capulin-Charette-Ayon and Swastika silt loam, all of which are moderately erodible (K factor 0.43) (NRCS USDA, 2003).



Map 5- Soils (NRCS USDA, 2003)

Wetlands

In this arid region, rivers, streams and other wetlands play a vital role in maintaining diverse plant and animal communities.

According to the National Wetlands Inventory there are almost 7,000 acres of wetlands in the lower Mora Watershed (U.S. Fish and Wildlife Service, 2010). The vast majority of these wetlands are classified as Palustrine (associated with no flowing water, often located on floodplains, this includes marshes and playas) or Lacustrine (associated with a lake or other fresh water). A small percent of the existing wetlands in the lower Mora Watershed are classified as Riverine (associated with flowing water).

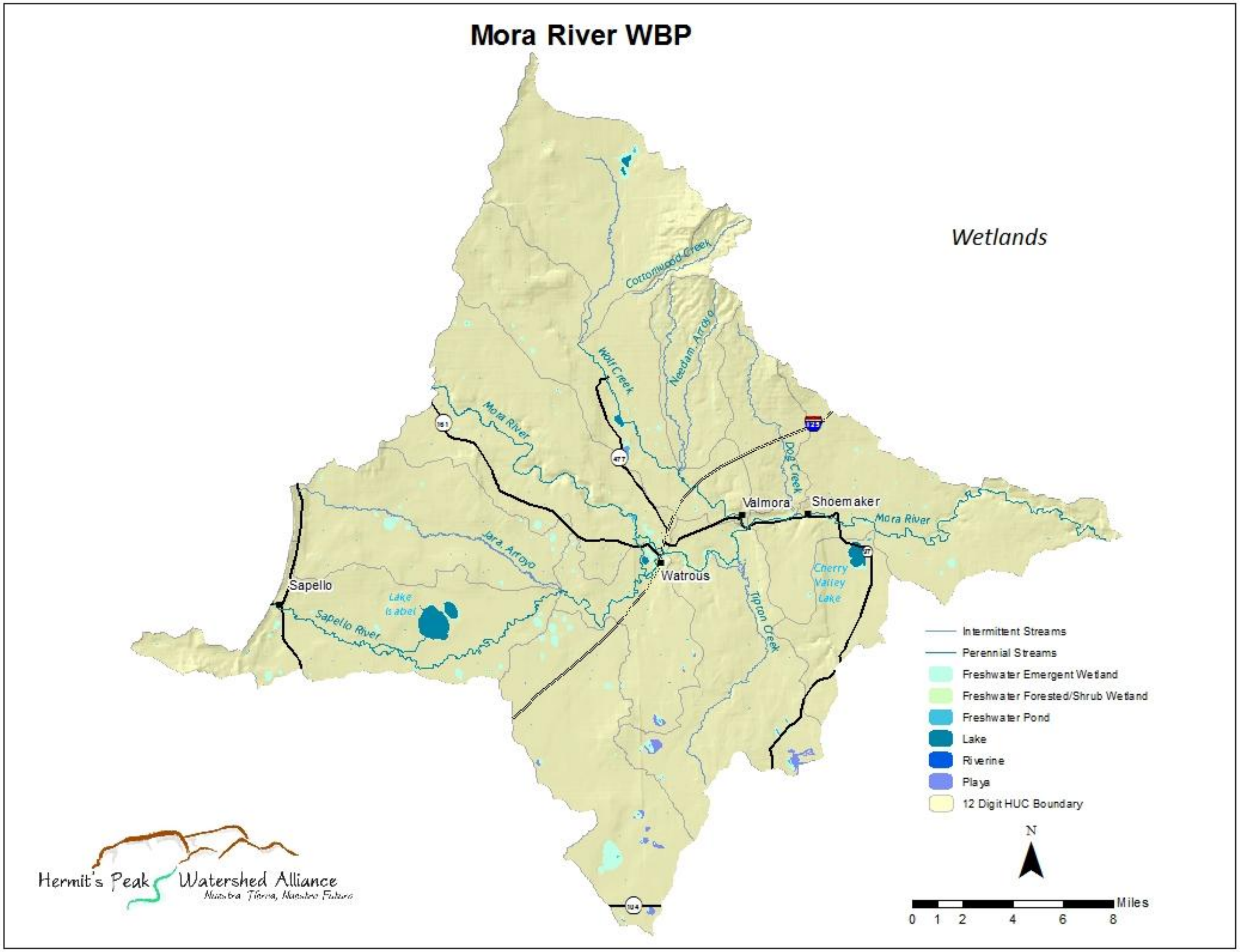
Table 3- Dominant Wetland Types in the Lower Mora Watershed

ID	Description	Acres
PEM1Ci	Palustrine Emergent Persistent Seasonally Flooded Alkaline	1610.73
PEM1Ji	Palustrine Emergent Persistent Intermittently Flooded Alkaline	1154.65
L1UBHh	Lacustrine Limnetic Unconsolidated Bottom Permanently Flooded Diked/Impounded	737.42
PEM1C	Palustrine Emergent Persistent Seasonally Flooded	594.55
L1UBH	Lacustrine Limnetic Unconsolidated Bottom Permanently Flooded	504.23
PFO1A	Palustrine Forested Broad-Leaved Deciduous Temporary Flooded	372.64
PEM1B	Palustrine Emergent Persistent Saturated	271.25
PSS1C	Palustrine Scrub Shrub Broad-Leaved Deciduous Seasonally Flooded	271.16
PEM1Bd	Palustrine Emergent Persistent Saturated Partially Drained/Ditched	160.41
PEM1Ch	Palustrine Emergent Persistent Seasonally Flooded Dike/Impounded	128.89
PUBFh	Palustrine Unconsolidated Bottom Semipermanently Flooded Diked/Impounded	95.51
L2UBG	Lacustrine Littoral Unconsolidated Bottom Intermittently Exposed	93.72
L2UBGh	Lacustrine Littoral Unconsolidated Bottom Intermittently Exposed Diked/Impounded	89.65
PFO1Ab	Palustrine Forested Broad-Leaved Deciduous Temporary Flooded Beaver	79.81
L2UBF	Lacustrine Littoral Unconsolidated Bottom Semipermanently Flooded	79.22
PSS1Cb	Palustrine Scrub Shrub Broad-Leaved Deciduous Seasonally Flooded Beaver	76.87
PEM1A	Palustrine Emergent Persistent Temporary Flooded	72.62
PEM1F	Palustrine Emergent Persistent Semipermanently Flooded	72.07

Playas are ephemeral, closed-basin wetlands that are important zones of recharge to the High Plains aquifer and critical habitat for birds and other wildlife in the otherwise semiarid, shortgrass prairie and agricultural landscape (Gurdak, 2009). These depressional basins punctuate the relatively flat portions of the Upper Canadian Plateau ecoregion and represent significant wetland habitat for migratory waterfowl, shorebirds and other species (New Mexico Department of Game and Fish, 2006). Playas are the primary source of recharge for the nearby Ogallala, contributing up to 95 percent of the overall return of water to the aquifer (Playa Lakes Joint Venture, 2016). Playa wetlands are important to aquifer recharge (Gurdak, 2009) and help capture sediments and nutrient-laden surface flows.

Playas are not as abundant in the lower Mora Watershed as in other Great Plains areas but are nonetheless key features in habitat diversity and local hydrology. See Map 6.

The Playa Lakes Joint Venture (PLJV – pljv.org) mapped approximately 43 playa wetlands totaling approximately 1,571 acres within the Mora Watershed. Playa wetlands within the area occur in native grasslands which is a condition necessary to maintain the hydrologic conditions critical for long-term natural function (Johnson, 2011). Some playa wetlands in the area appear to have been irrigated to grow crops, or excavated to make permanent or semi- permanent impoundments to provide water to livestock (US Fish and Wildlife Service, 2012).



Map 6- Wetlands and Playas (U.S. Fish and Wildlife Service, 2010) (Playa Lakes Joint Venture, 2011)

Plant Communities

The varied topography and geologic features in this ecoregion allow for a wide range of floral and faunal communities from arid grassland plant communities to ponderosa pine woodlands. Vegetation in the lower Mora Watershed is predominantly herbaceous and is dominated by the Plains-Mesa Grassland (Dick-Peddie, 1993) vegetation type with grama-buffalograss as the dominant species. Scattered throughout the area are juniper-scrub oak-grass savannas and piñon-juniper woodlands on hills and escarpment bluffs.

The development and maintenance of this system was dependent on several ecological processes, most likely driven by climate. Bison grazing and fire were also important processes that maintained the grasslands of the shortgrass prairie and suppressed encroachment of shrub and woody species (The Nature Conservancy, 2004) (U.S. EPA, 2016). Beyond the dominant grama-buffalograss plant communities, other important plant species include: western wheatgrass, bottlebrush squirreltail, threeawn, ring muhly, winterfat, fringed sage; mixed grama-little bluestem with some western wheatgrass and galleta (U.S. EPA, 2016). Other important plant communities in the New Mexico part of the Southern Shortgrass Prairie Ecoregion include juniper and piñon-juniper woodlands and sand shrublands. Changes in natural processes (e.g. fire suppression and the loss of bison herbivory) have led to shrub invasion of the prairie grassland systems (The Nature Conservancy, 2004).

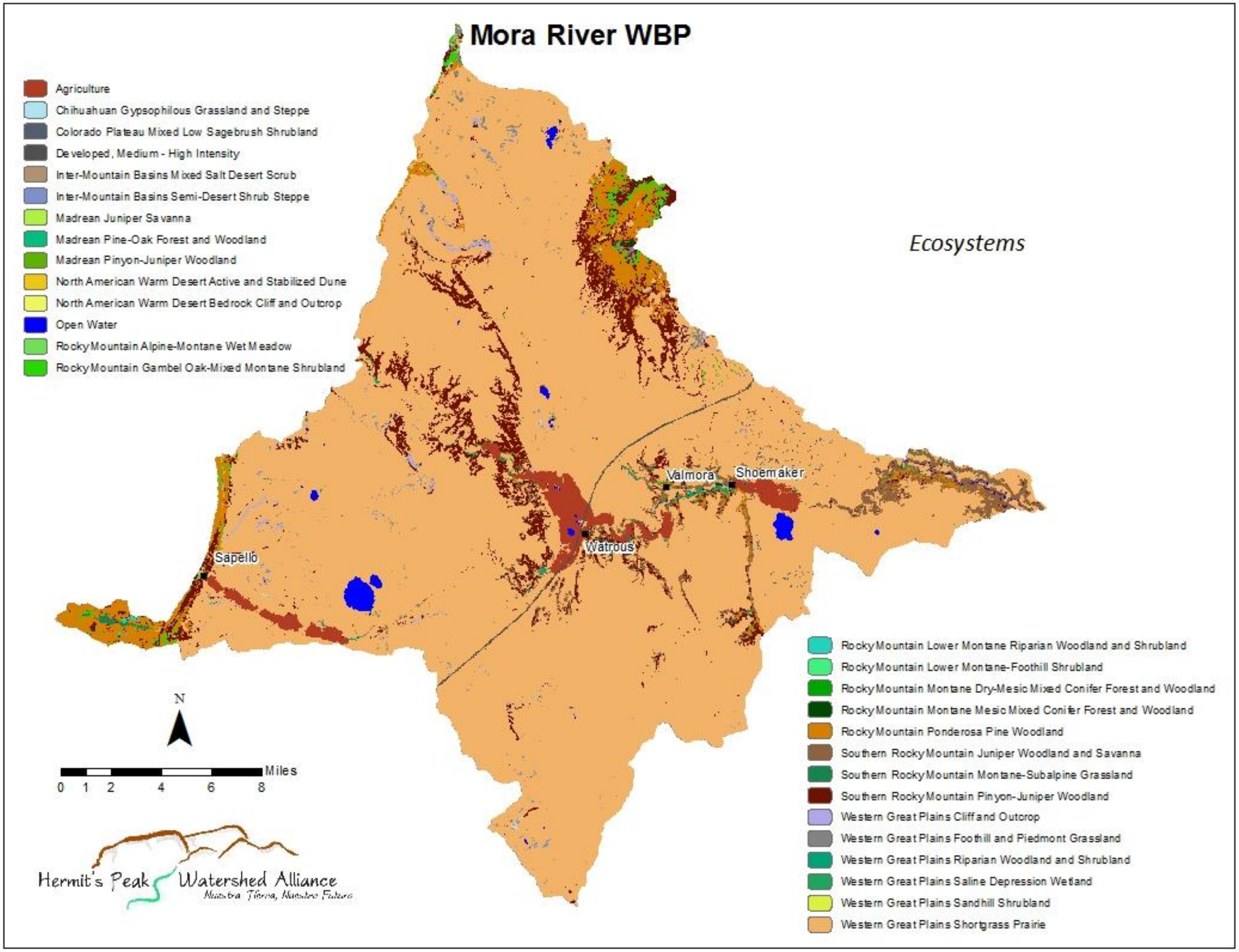
Based on WebSoilSurvey, the typical vegetation for the area is predominantly grasses, such as gramas (blue, black, sideoats, hairy), little bluestem, western wheatgrass and squirreltail. Other vegetation includes scrub (Gambel's and wavyleaf oak) and juniper (predominantly one seed juniper) (NRCS USDA, 2003).

Riparian areas in the lower Mora Watershed are typically dominated by willow (Salix spp.) and Rio Grande cottonwood (*Populus deltoides var. wislizeni*); however tamarisk (*Tamarix* spp.) and Russian olive (*Eleagnus angustifolia*) are non-native invaders (The Nature Conservancy, 2004) in some areas. A diversity of native riparian trees and shrubs occur including: boxelder (*Acer negundo*), New Mexican olive (*Forestiera neomexicana*), New Mexican locust (*Robinia neomexicana)*, little walnut (*Juglans microcarpa*), coyote willow (*Salix irrorata*), peachleaf willow (*Salix amygdaloides*), Goodding willow (*Salix gooddingii*), sandbar willow (*Salix exigua*), seepwillow (*Baccharis glutinosa*), skunkbush (*Rhus trilobata*), rabbit brush (*Chrysothamnus* spp.) and western soapberry (*Sapindus drummundi*) (Dick-Peddie, 1993).

Vegetation commonly observed along the riparian corridor during the field season, in addition to the above, included hydrophilic/aquatic plants (horsetail, reed-canary grass, sedges and rushes), Japanese brome, downy brome, mullein, buffalo gourd, coyote willow, black willow and cottonwood (Mahan, 2014). Black willow (*Salix nigra*) is not native to New Mexico but is prevalent in the area due to introduction by early settlers of near Watrous. As the largest North American willow species, it has become common in riparian and adjacent areas.

Table 4- Ecosystems in the Mora Watershed (from (USGS National Gap Analysis Program, 2004)

Description	% Cover
Western Great Plains Shortgrass Prairie	83.209%
Southern Rocky Mountain Piñon-Juniper Woodland	5.497%
Rocky Mountain Ponderosa Pine Woodland	3.741%
Southern Rocky Mountain Juniper Woodland and Savanna	2.410%
Agriculture	2.144%
Open Water	0.607%
Western Great Plains Foothill and Piedmont Grassland	0.506%
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	0.445%
Western Great Plains Cliff and Outcrop	0.294%
Western Great Plains Riparian Woodland and Shrubland	0.226%
Developed, Medium - High Intensity	0.214%
Inter-Mountain Basins Semi-Desert Shrub Steppe	0.212%
Inter-Mountain Basins Mixed Salt Desert Scrub	0.158%
Southern Rocky Mountain Montane-Subalpine Grassland	0.081%
Colorado Plateau Mixed Low Sagebrush Shrubland	0.070%
Madrean Piñon-Juniper Woodland	0.064%
Rocky Mountain Lower Montane Riparian Woodland and Shrubland	0.035%
Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland	0.022%
Chihuahuan Gypsophilous Grassland and Steppe	0.018%
Madrean Juniper Savanna	0.015%
Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland	0.008%
Rocky Mountain Lower Montane-Foothill Shrubland	0.007%
North American Warm Desert Active and Stabilized Dune	0.006%
Rocky Mountain Alpine-Montane Wet Meadow	0.004%
Western Great Plains Sandhill Shrubland	0.003%
Western Great Plains Saline Depression Wetland	0.002%
North American Warm Desert Bedrock Cliff and Outcrop	0.001%
Madrean Pine-Oak Forest and Woodland	0.001%



Map 7- Ecosystems (USGS National Gap Analysis Program, 2004)

The Plains-Mesa Grassland in eastern New Mexico has been greatly reduced because of dryland and irrigated farming though this land use is not prevalent in the lower Mora Watershed; the more typical land use is grazing. Under significant grazing pressure, the Plains-Mesa Grassland plant communities tend to succeed at the high elevation areas in the direction of juniper savanna and on the lower elevation areas toward desert grassland (Dick-Peddie, 1993).

In a survey of vascular plants of northeastern New Mexico, 5 plants found in Mora County are considered to be rare (Schiebout, 2008). They include:

- One-flowered milkvetch (*Astraualus wittmannii*)
- Pecos mariposa lily (Calochortus gunnisonii var. perpulcher)
- Larkspur (*Delphinium sapellonis*)
- New Mexico stickseed (*Hackelia hirsuta*)
- Arizona willow (*Salix arizonica*)

Numerous noxious and non-native weeds are known to occur in Mora and San Miguel Counties and are likely to occur in the lower Mora Watershed (see Table 5).

Table 5- Noxious and Invasive Non-native Plants Found in Mora and San Miguel Counties that are Likely to Occur in the Lower Mora Watershed (Schiebout, 2008) (U.S. Fish and Wildlife Service, 2015) (Ashigh, 2010) (USDA, Natural Resources Conservation Service, 2016)

Common Name	Scientific Name	Status CAW - Class A noxious weed CBW - Class B noxious weed CCW - Class C noxious weed I - Invasive
perennial pepperweed	*Lepidium draba*	CAW
Scotch thistle	*Onopordum acanthium*	CAW
Canada thistle	*Cirsium arvense*	CAW
spotted knapweed	*Centaurea stoebe*	CAW
yellow starthistle	*Centaurea solstitialis*	CAW
diffuse knapweed	*Centaurea diffusa*	CAW
purple starthistle	*Centaurea calcitrapa*	CAW
Dalmatian toadflax	*Linaria dalmatica*	CAW
oxeye daisy	*Leucanthemum vulgare*	CAW
musk thistle	*Carduus nutans*	CBW
Russian knapweed	*Acroptilon repens*	CBW
poison hemlock	*Conium maculatum*	CBW
Fuller's teasel	*Dipsacus fullonum*	CBW
cheat grass	*Bromus tectorum*	CCW
Russian olive	*Elaeagnus angustifolia*	CCW
jointed goatgrass	*Aegilops cylindrical*	CCW
bull thistle	*Cirsium vulgare*	CCW
field bindweed	*Convolvulus arvensis*	CCW
saltcedar	*Tamarix ramosissima*	CCW
Siberian elm	*Ulmus pumila*	CCW
western salsify	*Tragapogon dubuis*	I

Common Name	Scientific Name	Status CAW - Class A noxious weed CBW - Class B noxious weed CCW - Class C noxious weed I - Invasive
butter and eggs	*Linaria vulgaris*	I
western sticktight	*Lappula occidentalis*	I
goathead/puncture vine	*Tribulus terrestris*	I
Japanese brome	*Bromus japonicas*	I
common mullein	*Verbascum thapsus*	I
Russian thistle	*Salsola kali L.*	I
whitetop	*Cardaria draba*	I
spiny cocklebur	*Xanthium spinosum*	I

Wildlife Communities

Wildlife communities that occupy and interact with the land in the lower Mora Watershed benefit from and contribute to health of the land and its function as a watershed. Diverse and abundant native plant communities fuel diverse wildlife communities and vice-versa. Diversity in plant and animal communities also supports watershed resilience so that natural and human communities can withstand and rebound from disturbances and changes in their environment.

Two notable examples of wildlife species that are central to healthy watershed functions are bison and beaver. Beaver support wetland and riverine ecosystem health while bison help maintain healthy grasslands. The Southern Shortgrass Prairie Ecoregion has experienced the elimination or significant reduction of keystone species (Refuge Staff Northern New Mexico National Wildlife Refuge Complex & National Wildlife Refuge System Southwest Region Division of Planning, 2014), namely bison, prairie dogs and beaver. When key species decline, a series of indirect effects ripple across trophic levels, affecting life-forms that seem distantly removed from the keystone (Terborgh J. J., 1999) (Soule, 2005) (Terborgh J. a., 2010). The specific effects of these reductions are not well understood locally or on a broader scale.

Birds, rodents, insects and mammals are also important to watershed functions and resilience by offering seed dispersal services which help to revegetate disturbed areas. They also serve as both predator and prey, fueling the dynamic relationships that maintain plant and animal communities.

Biological assessments done at the Rio Mora National Wildlife Refuge (formerly Wind River Ranch) provide the most comprehensive surveys of wildlife in the lower Mora Watershed. These species lists form the basis of this discussion (www.windriverranch.org). See Appendix F. Wildlife and Plant Species Lists for a duplication of these lists.

Insects in the lower Mora Watershed are diverse and abundant, forming the foundation of food chains in prairie ecosystems. Seasonally, insect abundance is notable and tends to be cyclical in nature. A list of insect species found in the area of the Rio Mora National Wildlife Refuge is in Appendix F. Wildlife and Plant Species Lists.

Crustaceans and mollusks are not included in species lists for the Rio Mora Wildlife Refuge. However, information from researchers (Jesus Rivas, 2015) indicate that Conchas Crayfish

(*Orconectes deanae)* may have been a native species historically but now is extirpated or likely extinct and has been replaced by Northern Crayfish (*Orconectes virilis),* which is invasive and commonly detrimental to native fauna.

Eight species of fish (see Appendix F. Wildlife and Plant Species Lists) occur in the lower Mora River; one of those, brown trout is non-native. The green sunfish and brown trout are the only two harvested species, the remaining species are nongame. Rio Grande cutthroat trout, while it has been extirpated from the area, may have once occurred in the lower Mora River and its tributaries.

The area is rich in reptile and amphibian species relative to the higher elevation areas to the west; twenty eight species (Appendix F. Wildlife and Plant Species Lists) are known to occur. None of these species are considered Species of Concern. The bullfrog is an introduced and invasive species that occurs in permanent wetlands like rivers, lakes and ponds (Degenhardt, 1996). While we still need more information about their relationships with other species, bullfrogs certainly prey on and may negatively affect native fauna including fishes, snapping turtles, snakes, native amphibians like the Woodhouse toad, birds and mice. We also know that they prey on some non-native species such as crayfish. Crayfish may play an important role in the capacity of the bullfrog to invade new habitats (Jesus Rivas, 2015).

One hundred and eighty three species of birds have been found to occur at the Rio Mora National Wildlife Refuge at one time of the year (see Appendix F. Wildlife and Plant Species Lists). Twenty-one are considered species of concern (see Table 6). Rio Mora NWR has been named an Important Bird Area by the Audubon Society. Great Blue Heron rookeries occur in a number of locations along the Mora River.

Habitats within the Mora Watershed provide important life-cycle needs for a wide variety of neo-tropical migratory birds and many other riparian, grassland, woodland, aquatic and wetland dependent species (US Fish and Wildlife Service, 2012). Northeastern New Mexico has historically been an important migration and wintering area for waterfowl in the Central Flyway, particularly Canada geese. The rolling high plains along the eastern slope of the rugged Sangre de Cristo Mountains, scattered with numerous playa wetlands, are a haven for waterfowl and sandhill cranes during the fall and winter months. The limited aquatic habitats in this arid part of the country have always been heavily utilized by ducks and geese, and have been of some importance as production areas (US Fish and Wildlife Service, 2012).

Forty eight species of mammals (Appendix F. Wildlife and Plant Species Lists) are known to occur in the lower Mora Watershed including many large mammals like black bear, mountain lion (puma), pronghorn, elk, mule deer and white-tailed deer. A managed bison herd occurs at the Rio Mora National Wildlife Refuge and Gunnison's prairie dog, while extirpated, was reintroduced by the Wind River Ranch Foundation in 2007 (Refuge Staff Northern New Mexico National Wildlife Refuge Complex & National Wildlife Refuge System Southwest Region Division of Planning, 2014). The prairie dog has yet to become reestablished because of plague related losses. Mexican wolves also extirpated where historically a vital part of this ecosystem. Beaver occur in many reaches of the Mora River.

Species of Concern

At least 42 species listed as Threatened, Endangered, or Species of Concern by the New Mexico Department of Game and Fish may occur in the Mora Watershed (either upper or lower) (US Fish and Wildlife Service, 2012) (Table 6), but their occurrence is not necessarily substantiated with recent data.

Two wildlife species are listed with the federal government as endangered. The southwestern willow flycatcher (*Empidonax traillii extimus*) is one and has been observed during the breeding season on the Rio Mora National Wildlife Refuge where suitable willow dominated riparian habitat exists, but breeding has not been confirmed. Critical habitat for the species is designated in the upper Mora River Watershed (US Fish and Wildlife Service, 2012).

The New Mexico Meadow Jumping Mouse (*Zapus hudsonius luteus*) is also listed as Endangered, both federal and state, and has suitable wetland and riparian habitat within the lower Mora Watershed and this area falls within documented historic range. Systematic surveys have not been conducted in the area to fully document the presence or abundance of the species. The species has been documented at Coyote Creek State Park in the upper part of the Mora River Watershed (US Fish and Wildlife Service, 2012).

The Gunnison's prairie dog *(Cynomys gunnisoni*) is listed as a federal Candidate species and is considered Sensitive by the USFS and a Species of Greatest Conservation Need by NM Game and Fish. The Wind River Ranch established a colony of 300 Gunnison's prairie dogs on the ranch in 2006 and 2007. The Mora County Commission overturned a law against importing prairie dogs into Mora County so that this colony could be established. The colony is still not currently active due to plague losses but future reestablishment would be beneficial to this short-grass prairie ecosystem.

The southern redbelly dace (*Phoxinus erythrogaster)*, a nongame fish species is listed as endangered in New Mexico. The species is more common in the Ohio and Mississippi River basins but there are a few disjunct populations in the foothills of the Rocky Mountain. The only locations for this species in New Mexico are in the headwaters of the Mora River, mainly Coyote Creek, one of the larger tributaries of the Mora River, and in tributaries to Black Lake (Sublette, 1990) (New Mexico Department of Game and Fish, 2006).

The Rio Grande cutthroat trout, while extirpated in the lower Mora Watershed, does occur in the headwaters of the Mora River (Sublette, 1990) (New Mexico Department of Game and Fish, 2006). The Rio Grande cutthroat trout is recognized as Sensitive by New Mexico State and the US Forest Service (New Mexico Department of Game and Fish, 2016).

Table 6- Species of Concern that Potentially Occur within the Lower Mora River Watershed and/or on the Rio Mora National Wildlife Refuge with Updated Information from BISON-M

Common Name	Scientific Name	[1]ESA Status	[2]NM Status	[3]Other Status
Crustaceans				
Conchas Crayfish	*Orconectes deanae*		S	Possibly Extirpated/extinct
Molluscs				
Lake Fingernailclam, the Long Fingernailclam, Paper pondshell (SE)	*Musculium lacustre, Musculium transversum,* *Utterbackia imbecillis*		T	
Fish				
Arkansas River Shiner	*Notropis girardi*	T	E	
Rio Grande Chub	*Gila pandora*		S	
Rio Grande Cutthroat Trout	*Oncorhynchus clarki virginalis*	C	S	Extirpated
Suckermouth Minnow	*Phenacobius mirabilis*		T	
Southern Redbelly Dace	*Phoxinus erythrogaster*		E	
Reptiles				
Arid Land Ribbonsnake	*Thamnophis proximus*		T	
Birds				
Baird's Sparrow	*Ammodramus bairdii*	Species of Concern	T	
Bald Eagle	*Haliaeetus leucocephalus*		T	
Bell's Vireo	*Vireo bellii*		T	
Black Swift	*Cypseloides niger*		*Sensitive*	
Brown Pelican	*Pelecanus occidentalis*		E	
Burrowing Owl	*Athene cunicularia*	Species of Concern		MBFS
Cassin's sparrow	*Peucaua cassinii*			PIF-RC
Chestnut-collared longspur	*Calcarius ornatus*			PIF-RC
Ferruginous hawk	*Buteo regalis*			PIF-RC
Golden eagle	*Aguila chrysaetos*			PIF-RC
Grasshopper sparrow	*Ammodramus savannarum*			PIF-RC
Lark sparrow	*Chondestes grammacus*			PIF-RC
Least Tern	*Sternula antillarum*	E	E	
Lewis's Woodpecker	*Melanerpes lewis*			PIF-WL

Common Name	Scientific Name	[1]ESA Status	[2]NM Status	[3]Other Status
Loggerhead Shrike	*Lanius ludovicianus*		S	PIF-RC
Long-billed Curlew	*Numenius americanus*			MBFS
Mountain Plover	*Charadrius montanus*		S	MBFS
Northern Harrier	*Circus cyaneus*			PIF-RC
Peregrine Falcon	*Falco peregrinus*		T	
Pinyon Jay	*Gymnorhinus cyanocephalus*			PIF-WL
Prairie Falcon	*Falco mexicanus*			PIF-RC
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	E	E	
Swainson's Hawk	*Buteo swainsoni*			PIF-WL
Yellow-billed Cuckoo	*Coccyzus americanus occidentalis*	*T*	*S*	
Yellow Warbler	*Setophaga petechia*			PIF-RC
Mammals				
Fringed Myotis	*Myotis thysanodes*		*S*	
Pale Townsend's Big-eared Bat	*Corynorhinus townsendii*	Species of Concern	S	
Long-legged Myotis	*Myotis volans*		*S*	
Western Small-footed Myotis	*Myotis ciliolabrum*		*S*	
Yuma Myotis	*Myotis yumanensis*		*S*	
Red Fox	Vulpes vulpes		S	
Swift Fox	Vulpes velox	Species of Concern	S	
Ringtail	*Bassariscus astutus*		*S*	
Black-tailed Prairie Dog	*Cynomys ludovicianus ludovicianus*	Species of Concern	S	
Gunnison's Prairie Dog	Cynomys gunnisoni gunnisoni		S	
NM Meadow Jumping Mouse	*Zapus hudsonius luteus*	E	E	
Heather Vole	*Phenacomys intermedius*		S	
Prairie Vole	*Microtus ochrogaster*		S	

[1]ESA Status

T = Threatened
E = Endangered
C = Candidate

[2]NM Status

T = Threatened
E = Endangered
S = Sensitive

[3]other status

MBFS = USFWS Migratory Bird Focal Species

PIF = Partners in Flight high priority
RC=Regional Concern
WL= National Watchlist

Culture

The following discussion of the history, demographics, landownership, land use and current cultural context of the lower Mora Watershed sets the stage for land management and restoration recommendations that are well grounded in the local culture and are practical to implement.

History

Prior to Spanish settlement, the Mora River Valley and areas to the east were largely occupied by nomadic native tribes including the Navajo, Apache, Ute, Kiowa and Comanche, but little archeological evidence exists to tell the stories of early lives of these tribes (Zhu, 1992). While travel through the Mora Valley occurred during the Spanish exploration period (1500's to 1700's), it was not settled until early in 1800's. Settling by people of largely Spanish descent began with the Mexican Land Grant. In 1835 Albino Perez, governor of the New Mexico Territory, granted 827,621 acres of land including most of the valley to Jose Tapia and 75 others; it was called the Mora Land Grant.

By 1830 the Santa Fe Trail, an international highway between Mexico and the U.S., had been established. In the eastern Mora Valley near the current town of Watrous, the junction of the two routes of the Santa Fe Trail, the Mountain Branch and the Cimarron Cutoff, came together (Zhu, 1992). By the eve of the Mexican-American War (1846 – 1848), Americans had become commonplace in the Mora Valley and when war broke out between the United States and Mexico, the Santa Fe Trail was transformed into a military road. With the acquisition of New Mexico in 1848, the United States began to carry the entire burden of protecting traders and travelers on the Santa Fe Trail and in the Southwest. The frequent Indian raids on travelers and settlers brought 1,300 soldiers to New Mexico. In 1851, Lt. Col. Edwin V. Sumner, the commander of the Department of New Mexico, established Fort Union at the junction of the two branches of the Santa Fe Trail and within the Mora Land Grant in order to provide more effective protection for the region.

The villages of Loma Parda, Tiptonville and Watrous became settled around the same time as Fort Union was established. The communities provided the Fort, local ranchers/settlers and travelers with supplies, a connection to other places along the Santa Fe Trail and entertainment. Military protection of settlers and travelers from resident Native American tribes continued until the native people were relocated in 1874.

La Junta (later named Watrous) was established in 1848 first by Alexander Barclay then was further developed by Samuel B. Watrous. As the largest town in the area, it became the town of Watrous in 1879 when the railroad was completed, linking Watrous with Las Vegas and areas to the north (http://www.sangres.com/newmexico). During the winter months, Mr. Watrous transplanted wagon loads of black willow from the eastern U.S. to establish tree cover in the settled areas. This non-native species adapted well and spread, becoming a notable feature throughout the area.

Landownership patterns were influenced by land grant traditions (Arellano, 2014). Large holdings that were common use areas (ejidos) were juxtaposed with privately held long-lots (suertes) that offered river access, irrigated lands and upland rangelands to enable each family to support itself with farmland, residential area and rangeland. Long-lot landownership patterns are still evident in the Tiptonville and Sapello River areas of the watershed.

This landownership and development scheme was enabled by the design and construction of acequias (irrigation ditches) to carry water from the Mora River to farmland. Samuel Watrous and Alexander Barclay facilitated the creation of the lower Mora acequia system; acequias were hand dug and fully functional in the 1840's and remain so today.

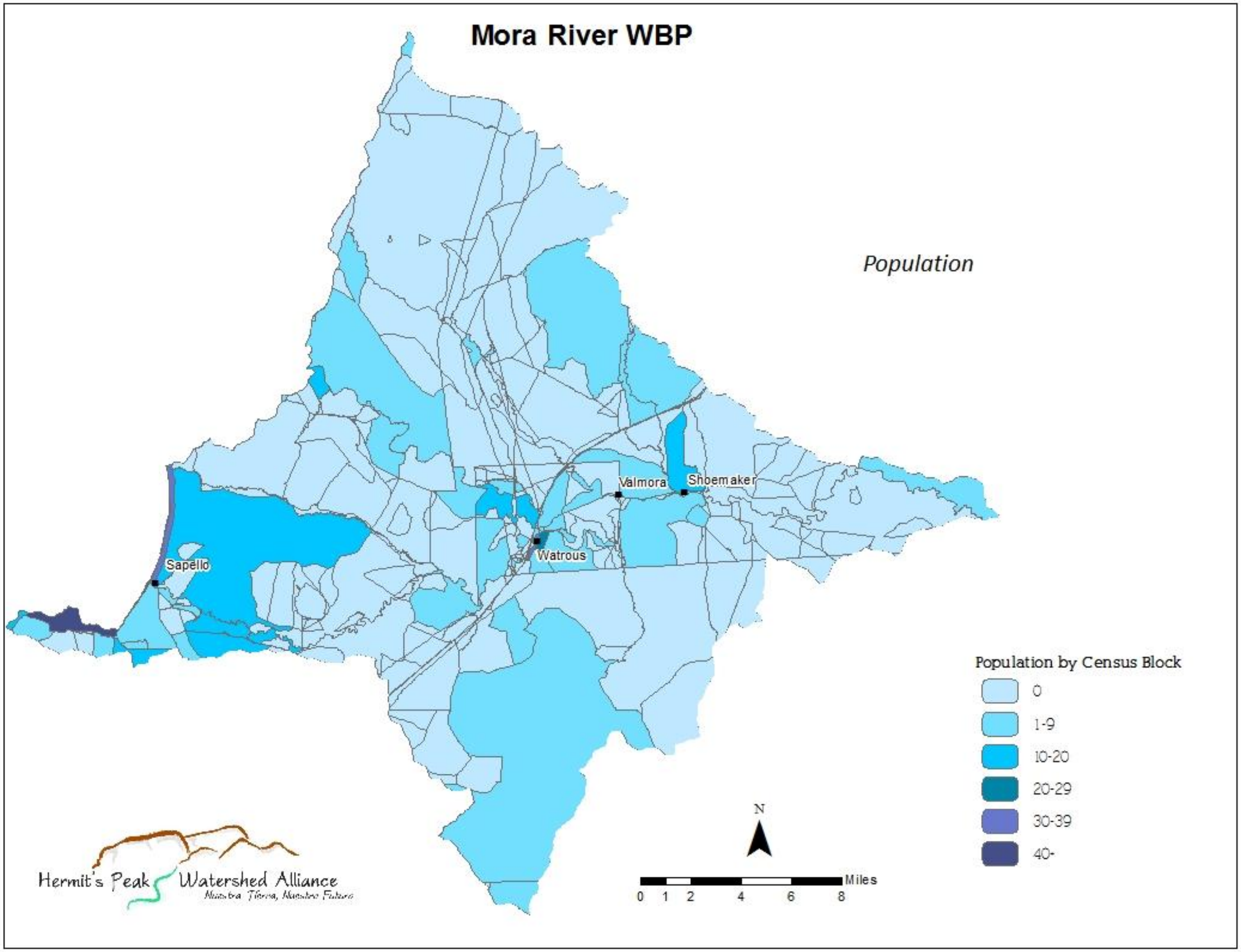
Military domination and associated support began to change when the Atchison, Topeka and Santa Fe Railroad came through in 1879 with a stop in Watrous. The railroad opened a new era in the Southwest by replacing the Santa Fe Trail as the main artery of commerce. During the 1880's Fort Union lost its military importance and commercial usefulness due to the defeat of the Native Americans and the arrival of the railroad. Fort Union, once the largest military post west of the Mississippi River, was abandoned in 1891, a year after the traditional closing of the frontier (Zhu, 1992). The Fort property and surrounding area was used as ranchland by the Union Land and Grazing Company until it became a National Monument in 1956.

As the military status declined the cattle and sheep industry bloomed in the lower Mora Valley and surrounding areas after the Civil War (1872). Large numbers of sheep and cattle grazed throughout suitable rangeland. According to Henry A. Atkinson, Surveyor General of NM (Aug. 27, 1879), "it is estimated that 500,000 cattle and 10,000,000 sheep were supported in New Mexico." The Rough Rider Museum of Las Vegas has information indicating that 20,000,000 tons of wool was shipped out of Las Vegas in 1902, undoubtedly some came from the Watrous area. While mostly cattle and horses, livestock grazing continues as the mainstay of land use to this day. It is likely that significant livestock grazing, followed the railroad and the resultant land and watershed degradation is still evident today.

Demographics

Overall, Mora County is currently very sparsely populated with 2.5 people/sq. mi. (U.S. Census Bureau, 2015) over an area of 1,934 square miles. The county seat, the town of Mora in the western portion of the county, is the largest populated place in the county with 656 residents. 135 people reside in Watrous (2010 Census). The total population of the lower Mora Watershed Based Plan project area is 591 according to the 2010 census. Approximately 32 families live in Watrous and there are 10 – 15 ranches in the surrounding area (according to the Watrous Fire Department). The remainder of the population is dispersed throughout the area in the small villages of Sapello, Tiptonville, and Shoemaker or on private ranches. The population estimate for 2014 was 4,592 for the entirety of Mora County in contrast to the 4,881 people in 2010. Mora County has experienced large population declines of 11.3 percent over the past 15 years. Population declines have been largely attributed to recent drought conditions, reducing the number of available agricultural jobs (NM Office of the State Engineer/Interstate Stream Commisssion, 2016). Livestock numbers during recent drought years have also declined, as have the area of irrigated croplands.

The population of the county is 81% Hispanic, 17.7% Caucasian and 1.3% Native American. The median household income in Mora County is $24,425 with 24.2% of the population living in poverty (U.S. Census Bureau, 2015).



Map 8- Population (U.S. Census Bureau, 2015)

Landownership

Over 97% of lands in the foothills and Great Plains portions of the watershed are privately owned (Table 7). Private ownership is a mixture of large ranches (including at least two over 75,000 acres) as well as many smaller ranches in the range of 100s to 1,000s of acres. The average parcel size in the project area is 780 acres.

While a significant portion of the current population in the lower Mora consists of year-round and long-term residents, probably the largest land base is owned and operated by absentee landowners. These large ranches are typically managed by a resident ranch manager. Residents of the area most typically obtain their income outside the area with the exception of a few ranches/farms that acquire most of their income from the land.

Public lands in the lower Mora Watershed consist of the Fort Union National Monument administered by the National Park Service (718 acres) and the Rio Mora National Wildlife Refuge (4,443 acres) administered by the US Fish and Wildlife Service, both under the U.S. Department of Interior. A small amount land in the far eastern edge is managed by the Bureau of Land Management (376 acres) and by the State of New Mexico (1,980 acres). See Map 1.

No other public lands occur in the lower Mora Watershed, but in the western parts of Mora County (upper Mora Watershed) the Carson National Forest and small portions of the Santa Fe National Forest occur. The Kiowa National Grasslands, administered by the US Forest Service, Cibola National Forest, occur to the northeast of the lower Mora.

Table 7- Land Ownership in the Mora Watershed Project Area

Ownership	Acres	%
Private	297,635	97.54%
U.S. Fish and Wildlife Service	4,443	1.46%
State of New Mexico	1,980	0.65%
National Park Service	719	0.24%
U.S. Bureau of Land Management	376	0.12%

Land Use

Within the watershed, ranching is the dominant land use, occurring in many undeveloped forest, shrub and grassland areas (Table 8). There are small areas with irrigated hay fields or crops in the Mora River and Sapello River valleys. Outdoor recreation such as hunting, fishing and hiking are popular in the area with local residents on their private lands, as well as with citizens from outside of the local area, primarily on the two USDI public lands.

Development on the land within the Project Area makes up only 0.41% of the landscape. Land in this area is primarily divided into large ranches. These ranches are set up with headquarters in one area and undeveloped (grazing) land surrounding them. For this reason, land within the Project Area is primarily grassland (80.69%), used for cattle/livestock grazing. 10.84% of the land is evergreen forest, uses for which include logging and timber management and 5.57% of the land is shrub or scrub. Other minor land uses include open water, cultivated crops, hay, gravel or rock extraction pits and wetlands (U.S. EPA, 2010).

Table 8- Land Use in the Lower Mora Watershed (U.S. EPA, 2010)

Land Use	Percent	Acres
Open Water	0.55%	1,680.90
Developed, Open Space	0.31%	954.47
Developed, Low Intensity	0.08%	254.30
Developed, Medium Intensity	0.02%	68.30
Barren Land (Rock/Sand/Clay)	0.06%	192.23
Deciduous Forest	0.01%	34.93
Evergreen Forest	10.83%	33,070.39
Shrub/Scrub	5.57%	17,010.32
Grassland/Herbaceous	80.69%	246,333.36
Pasture/Hay	0.11%	344.41
Cultivated Crops	0.50%	1,513.59
Woody Wetlands	0.30%	930.89
Emergent Herbaceous Wetlands	0.95%	2,891.90

Along the Mora and Sapello Rivers, water is diverted from the river to irrigate land for hay production and other agricultural uses. Approximately 47 acequias, or community operated irrigation ditches, occur on the Mora River and its tributaries throughout the watershed (Thompson, 2009). Acequias are part of a strong cultural heritage of cooperative land management in the local communities and throughout New Mexico (NM Office of the State Engineer/Interstate Stream Commisssion, 2016). In the Mora, where other social organizations are scant, acequia members remain connected by traditional sharing of water resources.

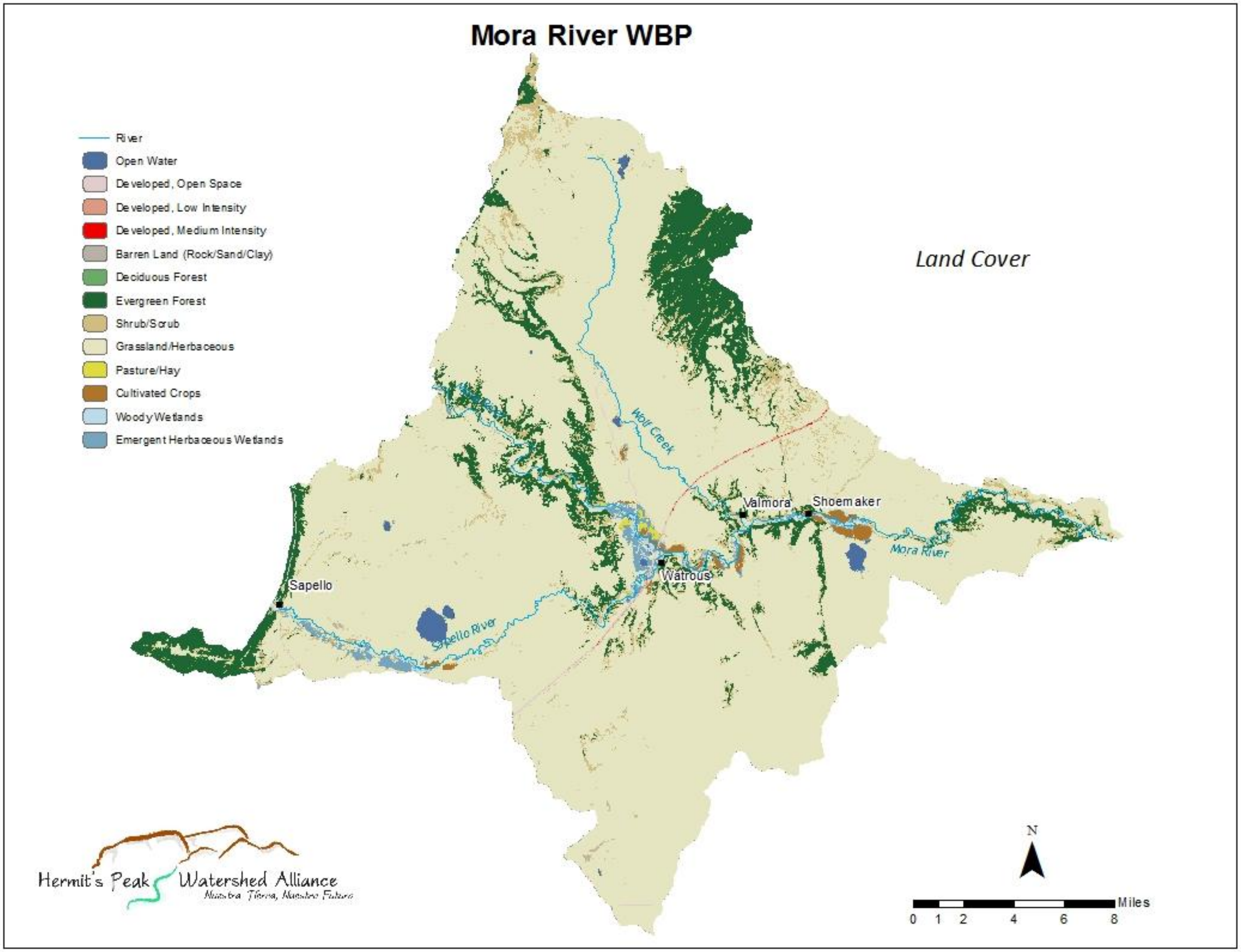
In the project area the following ditches are listed by the NM Office of the State Engineer (http://www.nmacequiacommission.state.nm.us/organizations.html) and numerous other private ditches that are not listed also occur:

Mora River:

- Sandoval Ditch
- Larrazola Ditch
- Upper Clyde Ditch
- Phoenix Ditch
- Crowley Ditch
- Tipton Ditch
- Cherry Valley Ditch

Sapello River:

- Acequia del Llano
- La Molina Ditch



Map 9- Land Cover (U.S. EPA, 2010)

SECTION 3: WATERSHED ASSESSMENT

An assessment of the current environmental and social conditions of the lower Mora Watershed forms the basis of later recommended remediation plans. The environmental investigation stems from the desire to verify the nutrient impairment (excessive Nitrogen and Phosphorus), understand the conditions that have led to it and then later guide management and restoration measures to improve degraded conditions. The social condition study aimed to better understand the reasons and history of observed degradation, learn from residents and develop measures that are well grounded in practicality.

Environmental Condition Assessment

Many factors can cause high nutrient levels in river water; those same factors also impair other watershed functions, characteristics and processes. Erosion from streambanks, upland erosion, septic systems, low flow and flow diversions and municipal discharges can all cause high nutrient levels. While this project considered all potential causes, this plan only addresses nonpoint sources (i.e. will not address or try to remediate point sources such as municipal discharges). Therefore this Environmental Condition Assessment does not address point sources of nutrient loading.

In order to be as comprehensive as possible, this assessment of the condition of the lower Mora River Watershed consists of the following studies:

1. Nutrient Assessment Level 1 and 2 including collecting river samples for nitrogen and phosphorus analysis, collecting periphyton for chlorophyll a analysis and collecting sonde data;
2. Riparian and instream condition using the NM Rapid Assessment Method (NMRAM) for Montane Riverine Wetlands, ver. 2.0;
3. Geomorphology using a Rosgen Level II assessment;
4. Macroinvertebrates survey as additional water quality indicators;
5. River Behavior and Recovery Assessment (RBRA);
6. River Visual Assessment
7. Watershed modeling – Bare ground, Hydrologic, Sediment and Nutrient.

Water Quality

Hermit's Peak Watershed Alliance collected water quality data in 2014 and 2015 to both confirm the nutrient impairment listed in the TMDL and to identify the geographic scope and severity of impairment in order to guide restoration planning. All data was collected in accordance to the approved Quality Assurance Project Plan (QAPP) (HPWA, 2014). HPWA followed the New Mexico Environment Department Standard Operating Procedure for Nutrient Survey and Sampling (NMED SWQB, 2014). Procedures were employed with no modifications. Eight sites were chosen throughout the watershed. Several of the sites were chosen to determine what the nutrient inputs of the Sapello River and Wolf Creek were to the Mora River. Results determined that 2 out of 8 sites were not supporting (i.e. were impaired) for nutrients, although all 8 sites were not supporting for Total Nitrogen (TN) and Total Phosphorus (TP) (see Table 9).

Nutrient Level 1 surveys were conducted in June of both years. Level 1 surveys consisted of collecting water samples for TN and TP analysis, collecting instantaneous sonde readings (which include pH, turbidity, dissolved oxygen, temperature and specific conductance) and observing algae, periphyton (a combination of organisms that grow on underwater surfaces including algae, bacteria, fungi, protozoa and other organisms) and anoxia presence. Level 2 surveys were conducted during the Biological Sampling Index Period (BSIP) between August 15 and November 15 in 2014 and 2015. Level 2 surveys consisted of collecting additional water samples for nutrient analysis, periphyton for chlorophyll *a* analysis and long term sonde data (72 hours at 15 minute intervals). According to the Nutrient Assessment Protocol to be considered, "Not Supporting" or impaired, at least one causal variable (Total Nitrogen, Total Phosphorus) and at least one response variable (Dissolved Oxygen, pH, Chlorophyll *a*) must exceed the allowable threshold (NMED SWQB, 2015). Table 9 contains a summary of the results of this assessment by site. Although the results of the water analysis for TP and TN at all sites well exceeded the threshold for Marginal Coldwater Aquatic streams in the Southwestern Tablelands Ecoregion, an exceeding response variable (Dissolved Oxygen) was only observed at the two sites that are farthest downstream. All other variables were within acceptable ranges.

Table 9-Summary of Nutrient Impairment Assessment from data collected in 2014 and 2015

Causal Variables					Response Variables						Assessment Conclusion
Site Upstream to downstream	Total Nitrogen		Total Phosphorus		Dissolved Oxygen		pH		Chlorophyll *a*		One causal variable and one response variable must exceed in order to be considered "Not Supporting"
Threshold	>0.38 mg/L		>0.03 mg/L		<6.0 mg/L		6.6-9.0		8.2-14.0 µg/cm^2		
	Max (mg/L)	Determination	Max (mg/L)	Determination	Min (mg/L)	Determination	Range	Determination	Max (µg/cm^2)	Determination	
MR4	2.16	Exceeded	1.206	Exceeded	7.38	In range	8.49-8.75	In range	1.2	In range	Fully Supporting
MR3b	2.4	Exceeded	0.981	Exceeded	6.57	In range	8.41-8.67	In range	4.08	In range	Fully Supporting
MR3a	2.05	Exceeded	0.843	Exceeded	6.96	In range	8.25-8.53	In range	0.487	In range	Fully Supporting
MR3	2.66	Exceeded	0.918	Exceeded	7.87	In range	8.16-8.32	In range	0.578	In range	Fully Supporting
MR2	3.58	Exceeded	0.759	Exceeded	8.06	In range	8.14-8.29	In range	0.314	In range	Fully Supporting
MR1b	2.9	Exceeded	1.28	Exceeded	7.52	In range	8.13-8.31	In range	0.337	In range	Fully Supporting
MR1a	2.68	Exceeded	1.281	Exceeded	3.35	Exceeded	7.59-7.80	In range	1.7	In range	Not Supporting
MR1	5.99	Exceeded	0.073	Exceeded	5.71	Exceeded	7.59-7.9	In range	2.2	In range	Not Supporting

NM Rapid Assessment Method

Land and stream health was evaluated by Kathryn Mahan of KI Bar Consultants at eight sites using the New Mexico Rapid Assessment Method: Montane Riverine Wetlands ver. 2.0 (NMRAM) protocol developed by NM Environment Department (see Supporting Documents for the full description of this assessment). This method uses several different metrics to assess landscape health (available nutrient buffer and context of the site within a larger landscape), biotic health (plant communities, physical structure and diversity) and abiotic health (river channel shape and function and landscape diversity) (NMED SWQB, 2014). The table below provides a summary of the results. The NMRAM summary rating system is based on a scale of 1 to 4, where 4 is considered excellent condition, 3 good, 2 fair and 1 poor. NMRAM scores varied depending upon the site, but overall site scores all fell within the "good" to "excellent" range, which is 2.5-4.0. Common low-scoring areas across the eight sites included vegetation structure (vertical and horizontal), soil surface condition and hydrologic connectivity and historic wetland size. High-scoring areas were commonly native plant presence, relative native plant community composition, buffer integrity and riparian corridor connectivity.

Table 10- NMRAM Site Summary

Site	Biotic	Abiotic	Landscape	Overall NMRAM score
MR4	3.1	3	3.2	3.1
MR3B	3.3	4	3.3	3.55
MR3A	3	3.2	2.7	2.98
MR3	2.8	3.9	2.59	3.12
MR2	3.8	2.8	2.59	3.15
MR1B	2.9	3.15	3.4	3.14
MR1A	3.5	3.8	2.9	3.43
MR1	3.1	1.9	2.9	2.63
AVERAGE	**3.19**	**3.22**	**2.95**	**3.14**

The lowest overall scoring site was MR1, which is located furthest downstream. The highest overall scoring site was MR3B, located at the Rio Mora Wildlife Refuge, near the upstream end of the project area. In general, landscape scores tended to be poorer the further downstream the site was located. Biotic and abiotic scores did not appear to have a trend based on location but rather the site-specific condition resulting from current and historic land management.

Fluvial Geomorphology

An adapted version of the Rosgen Level II method of assessing fluvial geomorphology was used at eight sites to determine stream channel conditions (see Supporting Documents for the entire report). This intensive study was performed by Kathryn Mahan of KI Bar Consultants and a field crew of NMHU interns. Rosgen Level II assessment included surveying a cross-sectional profile and sampling the streambed substrate with a pebble count. It is a recognized standard protocol for assessing geomorphic conditions. The purposes of gathering fluvial geomorphology data were: identify stream types; have baseline data for monitoring trends in geomorphic condition over time; evaluate watershed wide geomorphic condition; use the data to identify geomorphic conditions needing treatment; and to potentially determine specific locations in need of restoration. Sites for possible restoration were identified by fringe characteristics in the cross-sectional data for the stream type, in particular, entrenchment ratio, in combination with the NMRAM scores. Geomorphologic data can also be used to identify at-risk stream systems as the bimodal distribution of sediments (pebble count) is altered by erosion and deposition of fine particles. This methodology is a nationally and USFS recognized approach for studying fluvial channel dynamics and is similar to the nationally recognized Rosgen Level II (Rosgen, 1996).

Table 11- Summary of Results of Rosgen Cross Sections

Site	Bankfull Width (ft)	Max Depth (ft)	Mean Depth (ft)	W/d ratio	Wet P (ft)	Xsec area (ft^2)	Entrenchment Ratio
MR4	59.5	2.3	1.4	43	60.3	83.1	1.88
MR3B	55	5.3	3.5	16	57.9	192.1	4.66
MR3A	31.5	3	1.8	17	31	56.9	3.6
MR3	64.5	4.5	2.9	22	73.9	189.2	2.6
MR2	27.5	2	1.5	19	26.4	40.1	2.08
MR1B	28	2.1	1.5	19	29.1	41.6	3.5
MR1A	61.8	2.7	1.7	36	61.4	105.9	2.73
MR1	56	5.1	3.6	16	57.5	200.7	1.27
Average	**48**	**3.4**	**2.2**	**23.5**	**49.7**	**113.7**	**2.79**

The dominant substrate at four of the sites (MR4, MR3B, MR1A and MR1) was sand. Cobble was dominant at two sites (MR2 and MR1B). Bedrock was the dominant substrate at MR3A. Silt/clay was dominant at MR3. Sand was common where the site has been disturbed and erosion was observed, or other activities, including beaver activity which slowed water movement enough to capture sediment. Silt/clay was found at a site with a large log jam, which likely slowed water enough to allow smaller sediment to drop out of suspension. Cobble was observed on 2 sites with strong depositional features (e.g. pools and point bars) indicating the river was moving and had sufficient flow and velocity to deposit larger material and maintain movement of small particles. Bedrock was observed on a site heavily impacted by a neighboring gravel operation and disturbance from flooding and grazing.

Determination of entrenchment ratio was part of the Rosgen Level II performed at all eight sites. Entrenchment ratio is defined as the width of the flood prone area divided by the bankfull width. When entrenchment is at the low end of its range (or stream exhibits more incision), the stream is potentially at risk of losing access to the floodplain. An entrenchment ratio over 1.5 is considered "high"; a ratio between 1.2 and 1.5 is "moderate"; less than 1.2 is considered "low" (Zeedyk W. D., 2009). All sites surveyed had "high" ratios (indicating the river can access its floodplain) with the exception of MR1 which had a "moderate" ratio (indicating that it can access only portions of its floodplain during high flow events). It is worth noting that, while most of the sites were found to have high entrenchment ratios, this is due to the averaging effect of the two banks. Most sites had incision along one bank (mostly due to road and railroad impacts) with floodplain access on the other bank.

Although there is some variation, the most common Rosgen stream type of the Mora River throughout the project area is a classic C-type channel. C channels are characterized by having high entrenchment ratios, moderate to high width:depth ratios and moderate sinuosity. They tend to be made up of riffle-pool series with point bars and have well developed floodplains.

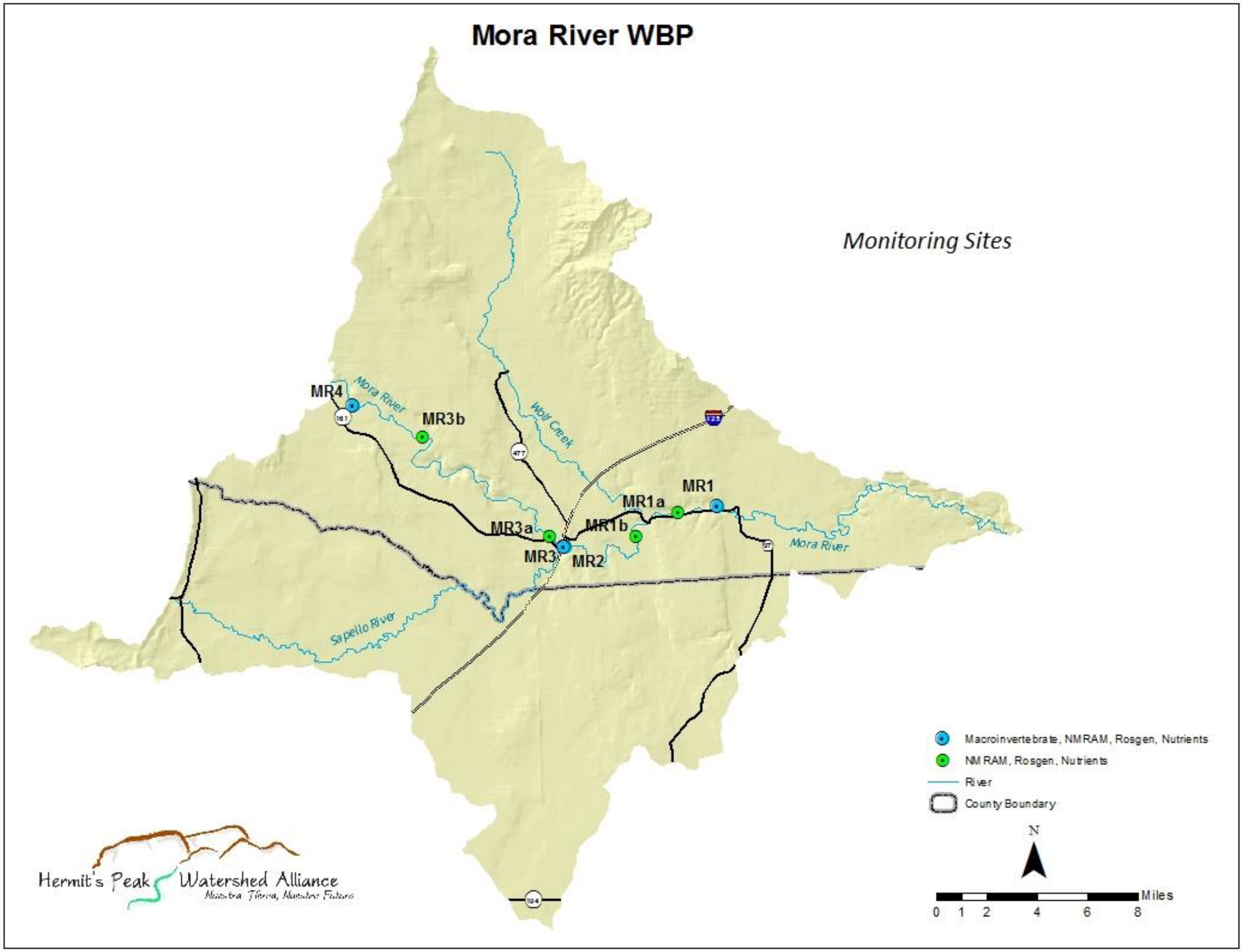
Field observations suggest that much of the river channel appears to have been manipulated in the past with the hope of farming additional land, leading to present-day entrenchment. Some sections of channel were once straightened and the entire channel was moved to the toe of the valley slope. This was a common practice when New Mexico river valleys were first settled because one large contiguous area was more conducive to tillage and pasturing than two smaller plots bisected by a live stream. Later, channels were routinely straightened and/or dredged in response to flood events. The predictable response to this type of river manipulation is for the channel to become incised (Zeedyk W. D., 2009). Stream incision has led to some floodplain sections becoming abandoned, de-watered and desiccated. These now form low terraces. In addition, conifer encroachment into the historic floodplain suggests a lowering of the water table has occurred in some areas. In other areas, development (primarily roads and railroads) restricts the stream dimension, pattern and profile.

Benthic Macroinvertebrates

The primary purpose of this portion of our study was to support or refute water quality data collected by other means by conducting a biological assessment of the benthic macroinvertebrate populations. Macroinvertebrates were sampled and collected during March and October of 2014 at four locations. Samples were preserved and later sorted and identified in the laboratory. Macroinvertebrates were identified to the family level and tallied by family. This assessment was conducted by Ernesto Sandoval a student at NMHU under the direction of Dr. Edward Martinez.

Benthic macroinvertebrates are used as water quality indicators based on their tolerance values. Certain species or taxa, such as Plecoptera (stoneflies), have a higher sensitivity to pollution and their presence is considered a good indication of a healthy stream (DeWalt, 2005). Additionally, taxa such as Ephemoptera (mayflies) and Trichoptera (caddis flies) are also sensitive to pollution and the combination of the three make up the EPT index. Other taxa, primarily Chironomidae, are highly tolerant to pollution. The EPT index is a calculation of the sum of the number of individuals in Ephemoptera, Plecoptera and Trichoptera families divided by the number of midges (Chironomidae) which are more tolerant to pollutants. The presence of higher tolerable taxa and the lack of less tolerant taxa can indicate a poorer quality stream.

The Family Biotic Index (FBI) was used to give a tolerance score to each of the sample sites using various macroinvertebrate families found in the Mora River. Based on these indices, MR4, the furthest site upstream, had a better water quality rating than the other three sites. Both MR3 and MR2 had a “fairly poor” rating in March but were “fair” in October. MR1 received a “Fairly Poor” rating in both sampling months. Based on the FBI, the data showed a decrease in water quality as we moved downstream (see Table 12), thus corroborating other water quality data collected. All four sample sites had a large decrease in overall macroinvertebrate population from March to October which is likely due to sampling time of year rather than other factors. The sampling in March was prior to runoff and the sampling in October was after the monsoon season. A scouring event during monsoons is likely to have removed macroinvertebrates from the benthic area. Taxa richness decreased from March to October at MR4, MR3 and MR2 while taxa richness increased at MR1. The total number of organisms at MR1 decreased dramatically while taxa richness increased, however the number of tolerant taxa at this site was increased as well.



Map 10- Monitoring Sites

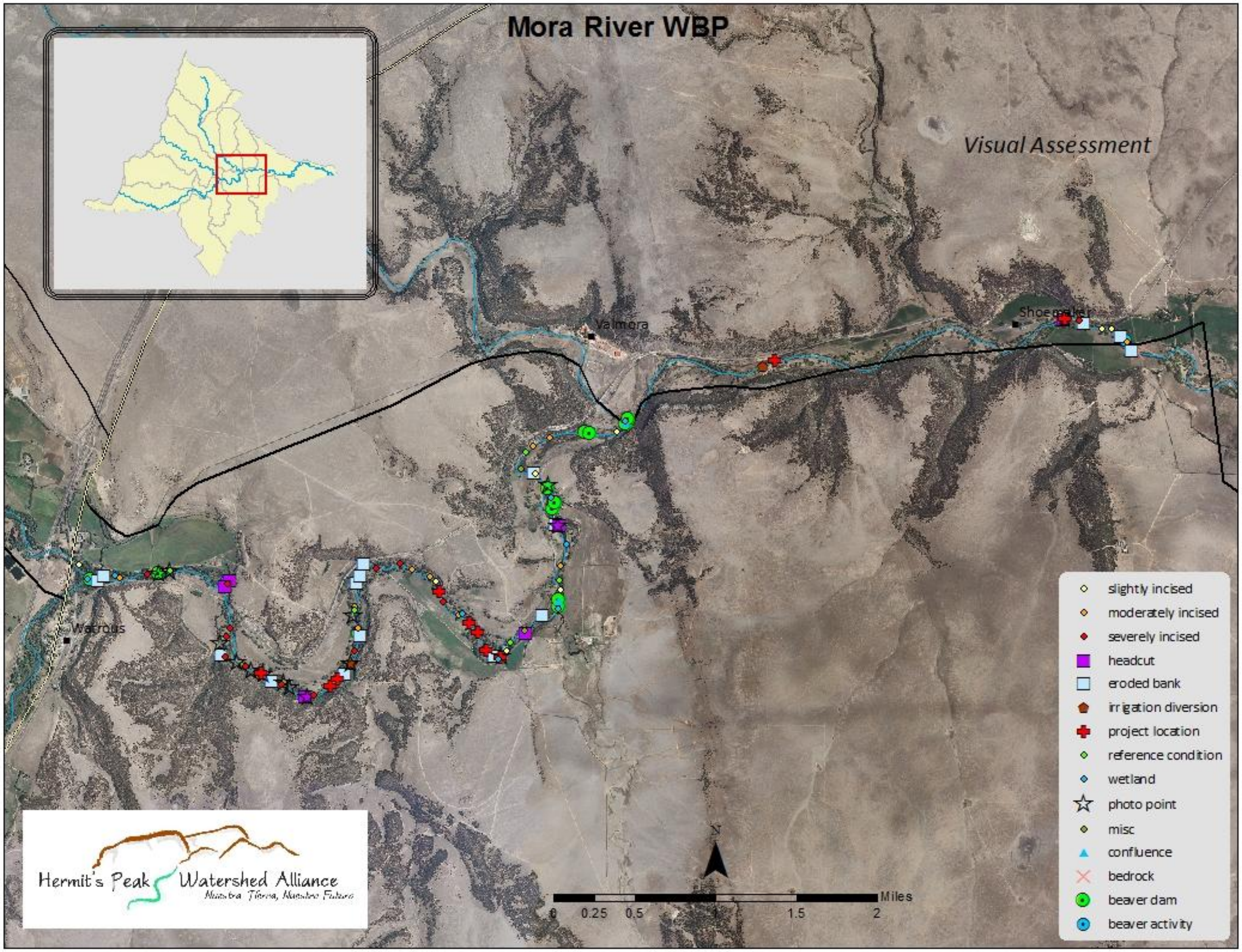
Table 12- Family Biotic Index Values (Hilsenhoff, 1988) for All Sampling Sites

Site	Family Biotic Index	
	March 2014	October 2014
MR4	5.72 (Fair)	4.91 (Good)
MR3	6.37 (Fairly Poor)	5.63 (Fair)
MR2	6.18 (Fairly Poor)	5.42(Fair)
MR1	5.89 (Fairly Poor)	6.50(Fairly Poor)

Visual Assessment

To address the need to examine on-the-ground conditions over a larger area than could be sampled with more intensive study (e.g. Rosgen, NMRAM), we conducted a stream channel Visual Assessment of the Mora River from its confluence with the Sapello River downstream to the State Road 97 bridge at Cherry Valley. This assessment was performed by Craig Sponholtz and Kathryn Mahan (both project contractors) on March 11 and July 7, 2015. Surveyors walked in or along the channel and cataloged degraded conditions and project opportunities. This segment was chosen for more in-depth examination because it was showing the greatest concern in terms of water quality and degraded conditions needing treatment. We also had access permission from all the landowners along this 10.5 mile section.

The purpose of the assessment was to identify active channel and stream habitat degradation symptoms and causes and to identify potential project locations based on river restoration need and potential, as well as site suitability. The assessment focused on geomorphic features along the river corridor that are the result of past degradation or the cause of current degradation. The GPS mapping performed during the assessment characterized the degree of channel incision throughout the assessment reach as well as the locations of headcuts, bank erosion, wetlands, signs of beaver activity and potential project locations. This assessment contributed a catalog of 53 recommended project locations to repair degraded conditions (see Map 11). Results of this assessment are contained in the Supporting Documents.

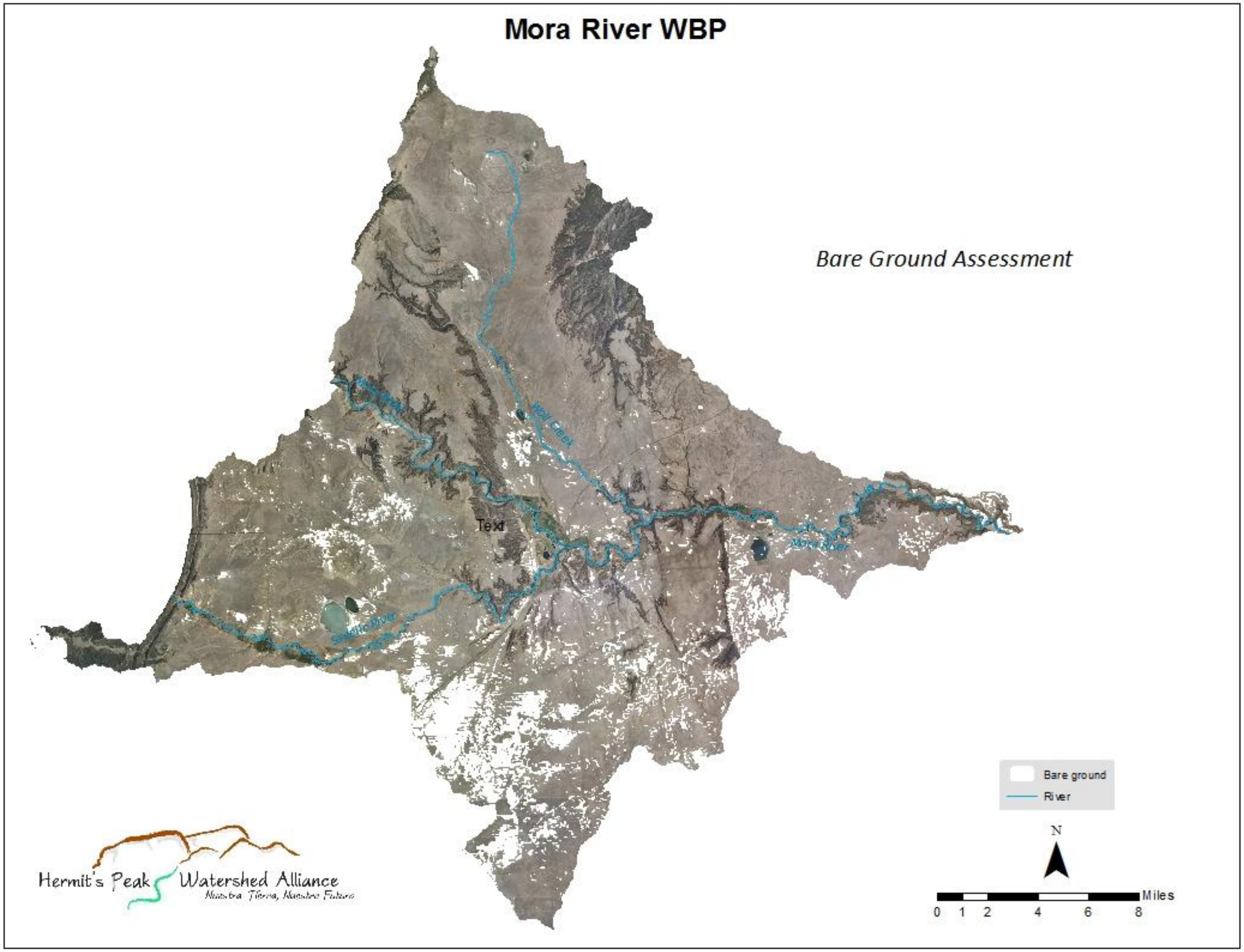


Map 11 - Visual Assessment

Bare Ground Assessment

In order to more accurately identify locations with excessive bare ground, especially those locations that are a result of desertification, overgrazing, ground disturbing activities or erosion related to roads or other causes, a remote sensing assessment was of the lower Mora Watershed was performed by Katie Withnall of HPWA. Using image based object analysis (Definiens eCognition) and Landsat 8 imagery from June 2014, bare ground in the watershed was identified based on brightness value. Threshold brightness values were based on locations of known bare ground. This assessment found that 27,000, acres or 8%, of the watershed was bare ground in 2014.

Areas with high amounts of bare ground appear to be largely related to overgrazing during drought conditions such as the significant bare ground found in the south and southwest part of the project area on property with known degraded plant cover and surface erosion issues. This map offers locations to target for further investigation of potential erosion control or plant cover enhancement projects.



Map 12- Bare Ground Assessment

Watershed Modeling

Hydrologic, sediment and nutrient modeling was conducted in order to gain a better understanding of the geographic and temporal variability of these processes on a watershed wide scale. This modeling effort also provided the vital ability to calculate nutrient loads on which load reduction calculations were based.

The US EPA's Better Assessment Science Integrating Point and NonPoint Sources (BASINS) was selected for this project for its comprehensive set of modeling tools. BASINS was developed by the EPA as a multipurpose analysis system to assist in watershed management and TMDL development. The BASINS environment makes it possible to analyze large amounts of point and nonpoint source data by combining environmental data, analytical tools and modeling programs. Several hydrologic and water quality models such as AQUATOX, SWMM, HSPF and WASP are included in the BASINS suite of methods and models (US EPA, 2015).

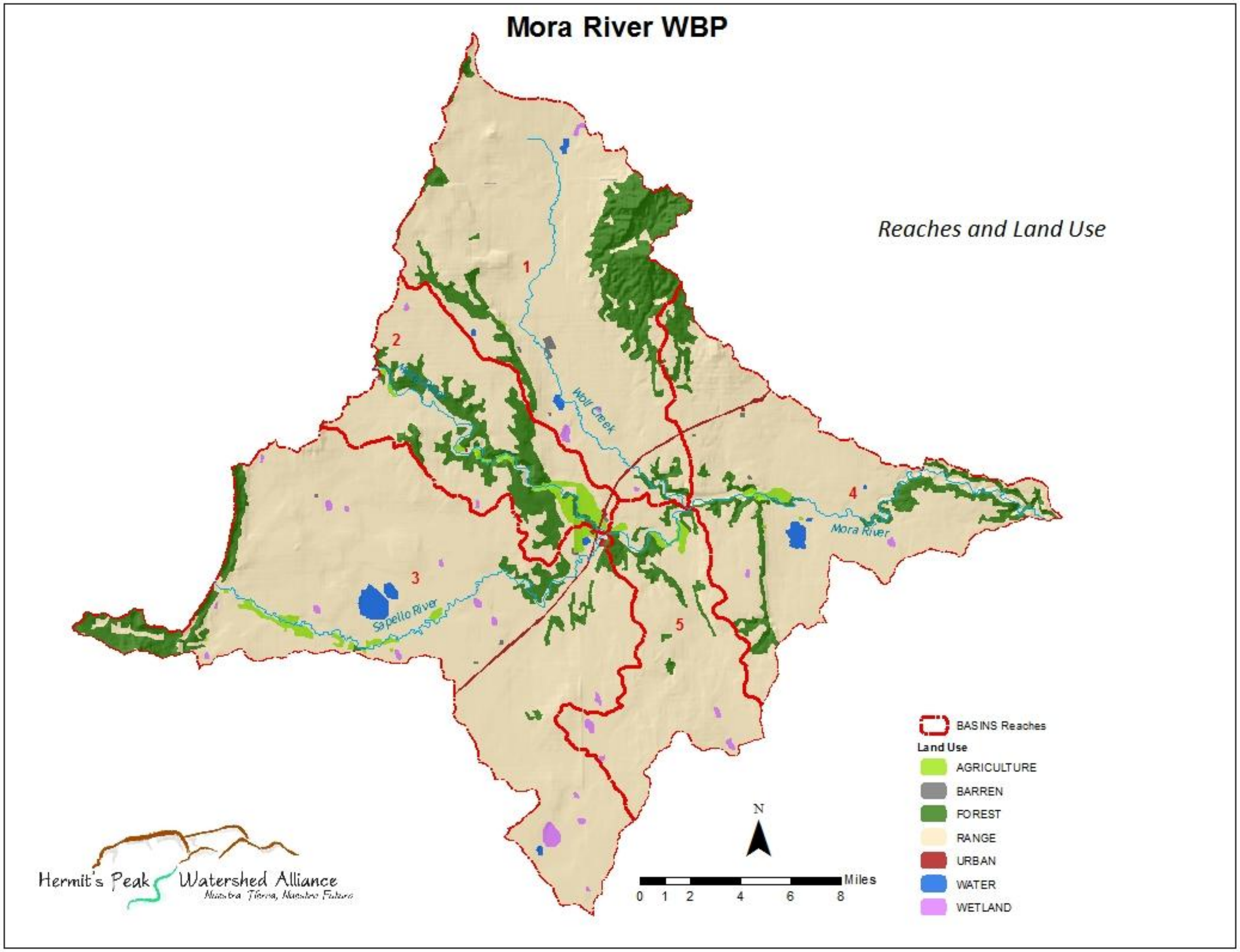
The Hydrologic Simulation Program - Fortran (HSPF) was chosen from the suite of BASINS models for use in this study. HSPF can simulate a wide range of stream and watershed conditions and it allows flexibility in scenario creation to simulate alternative conditions (Donigian, 1995). HSPF is capable of simulating many types of pollutants including pesticides, nitrogen, phosphorus, sediment, fecal coliform or other user-defined pollutants (Bicknell, B. R., Imhoff, J. C., Kittle, J. L., Donigian, A. S., and Johanson, R. C., 1993) (Bicknell, B. R., Imhoff, J. C., Kittle, J. L., Jobes, T. H., and Donigian, A. S., 2005).

The HSPF model simulates water movement through and across impervious (IMPLND) and pervious (PERLND) land to the atmosphere, ground water, or surface runoff. The behavior of water between storage zones, river and atmosphere is affected by many process related model parameters. Please see Supporting Documents for detailed results of the model and the calibration process. Table 13 shows the calibration criteria for HSPF modeling and the results of the Mora Watershed model. Modeling for the Mora River was calibrated and validated within the "very good" range for all processes. This provides a high confidence for the data calculated from this modeling effort.

For hydrologic parameter development, the model calibration time period was January 1, 1998 through December 31, 2001. The verification time period was January 1, 2002 through December 31, 2006. This time period was chosen due to lack of meteorological data necessary for simulation of total nitrogen and total phosphorus (solar radiation, wind speed, cloud cover and air temperature) after 2006 as well as lack of precipitation data after 2009.

Table 13-HSPF Calibration/Validation Targets for HSPF (Donigian, 2002)

Model	% Difference Between Simulated and Recorded Values			
	HPWA Mora WBP Model	Very Good	Good	Fair
Hydrology	-5.79	<10	10-15	15-25
Sediment	11.84	<20	20-30	30-45
Water Quality/Nutrients	6.84 (TN); 4.30 (TP)	<15	15-25	25-35



Map 13- BASINS Subwatersheds and Land Use

Map 13 shows the location of subwatersheds and land use used in the BASINS modeling. These subwatersheds were used to calculate nutrient loads (see Nutrient Load Reductions). HSPF modeling was conducted in order to calculate average Total Nitrogen and Total Phosphorus loads over a nine year period. These calculated loads have a higher confidence for average actual conditions over a longer time period than field data collected over just a year or two can provide as they include a broad range of environmental conditions (years of low, moderate and high flow, precipitation, water temperature, dissolved oxygen, etc.) over time. The model was also able to calculate pollutant loadings by land use in order to determine which land uses contribute the highest and lowest loadings. Additionally, it was able to determine what geographic reaches of the watershed contribute the highest and lowest loadings.

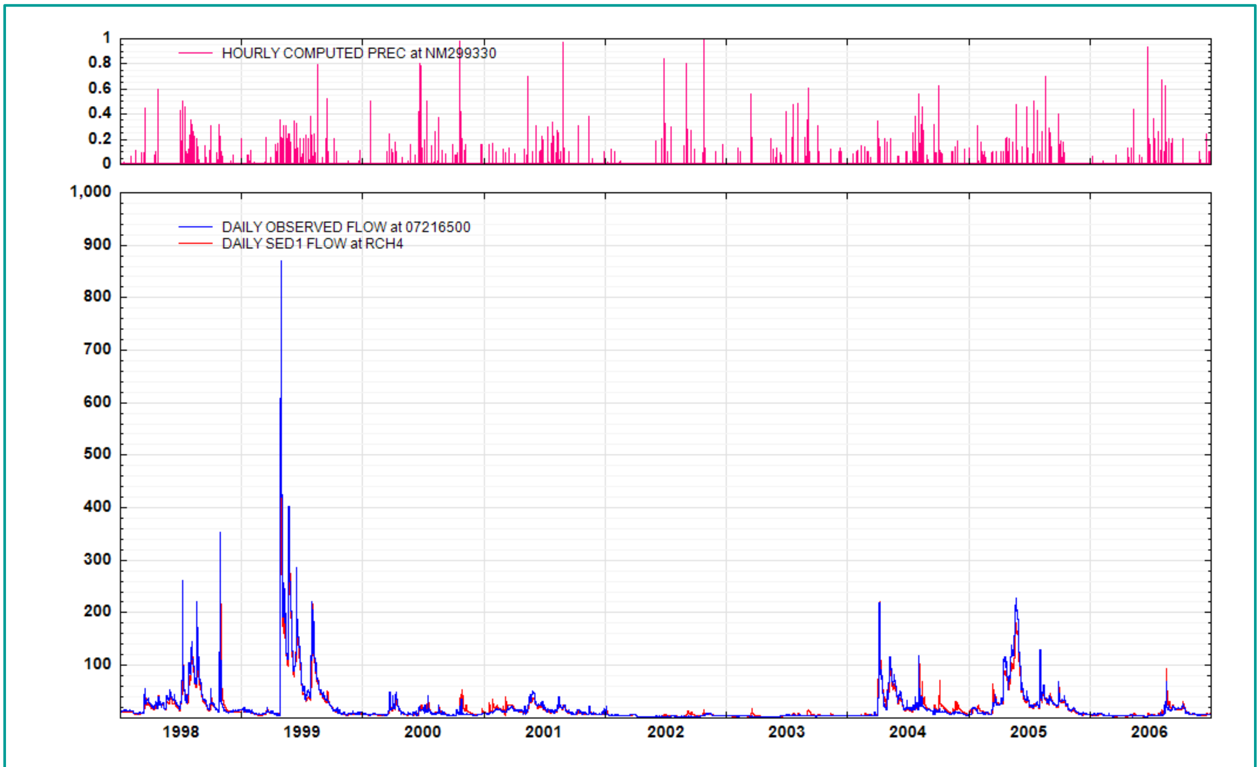


Figure 5 -Simulated (red) and Observed (blue) flows (cfs) 1998-2006. Observed flows from USGS Station 07216500 Mora River near Golondrinas, NM (U.S. Geological Survey, 2016). Precipitation (inches) for the Simulation Period on Auxiliary Axis in Pink.

Sediment loading rates were calculated for the six land uses. Agricultural and barren land had the highest unit area loading followed by range and urban areas as expected by the Environmental Protection Agency (US EPA, 2006) sediment calibration guidance. Rangeland had the highest average tons/year sediment yield because it occupies 83% of the study area; although, rangeland had a relatively low unit area load. The average annual simulated suspended sediment concentration at the watershed outlet under current conditions was 26.5 mg/L. The average simulated flow was 18 cfs, while the total average simulated annual sediment yield, including bedload and suspended sediment, was 4,024 tons/year.

Table 14 – BASINS Sediment Loading Rates and Land Use

Land Use	Avg. tons/acre/yr	Acres	Avg. tons/year	% of Total Sediment
Urban[a]	0.21	1,078	231	0.56
Agriculture	1.12	4,423	4,985	12.0
Rangeland	0.14	244,040	34,239	82.43
Forest	0.03	38,173	1,470	3.54
Wetlands	0.02	3,333	84	0.20
Barren	1.47	358	528	1.27
Total		291,405	41,537	100

[a]Urban loading values are an average of impervious and pervious rates.

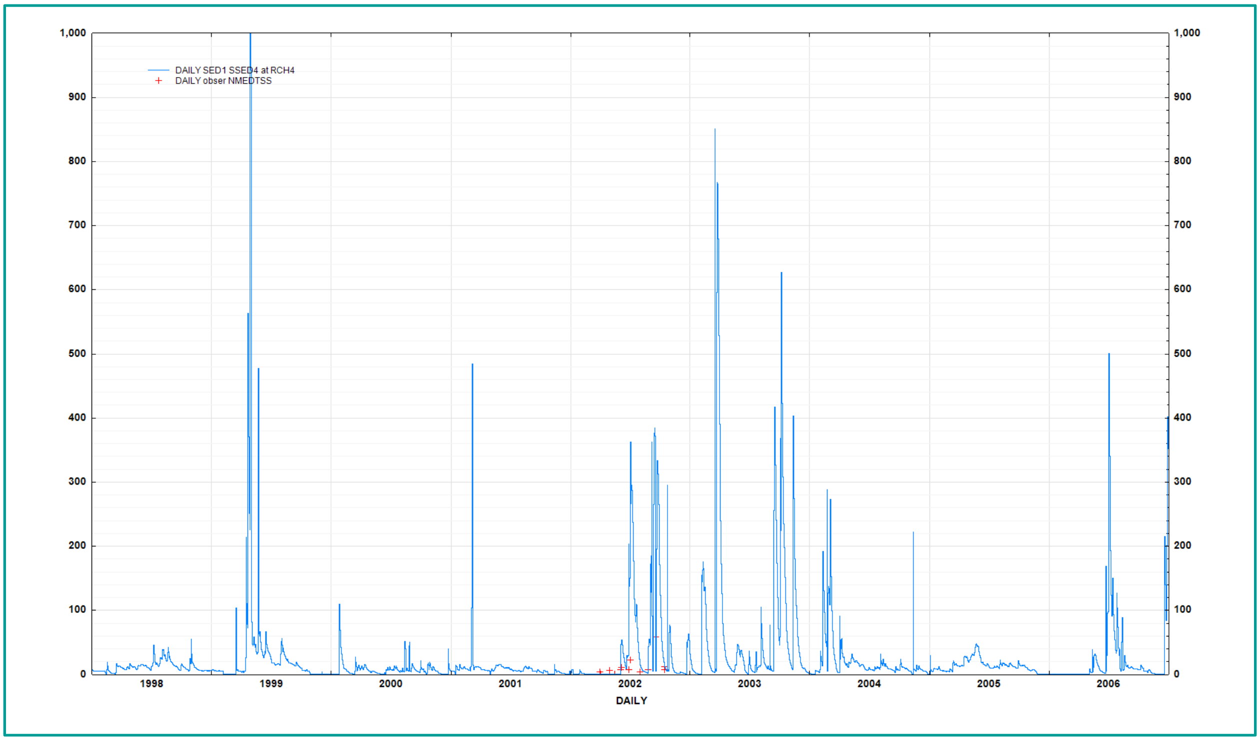


Figure 6- Simulated (red) and Observed (blue) Total Suspended Sediment (TSS) Concentrations at the Study Area Outlet

Phosphorus (TP) loading rates were calculated for the six land uses. Agricultural, urban and barren land had the highest unit area load. Rangeland had the highest average tons/year TP yield due to occupying 83% of the study area; however, rangeland had a relatively low unit area load. The average TP concentration at the watershed outlet during the simulation period was 0.05 mg/L, while the total average daily TP load was 0.194 lbs/day. Average simulated annual TP outflow at the study area outlet was 1,702 lbs.

Table 15 - Total Phosphorus Loading Rates by Land Use

Land Use	Avg. lbs/acre/yr	Acres	Avg. lbs/year	% of Total Phosphorus
Urban[a]	0.232	1,078	250	4.20
Agriculture	0.244	4,423	1,079	18.11
Rangeland	0.014	244,040	3,417	57.34
Forest	0.029	38,173	1,107	18.58
Wetlands	0.011	3,333	37	0.62
Barren	0.191	358	68	1.15
Total		291,405	5,958	100

[a]Urban loading values are an average of impervious and pervious rates.

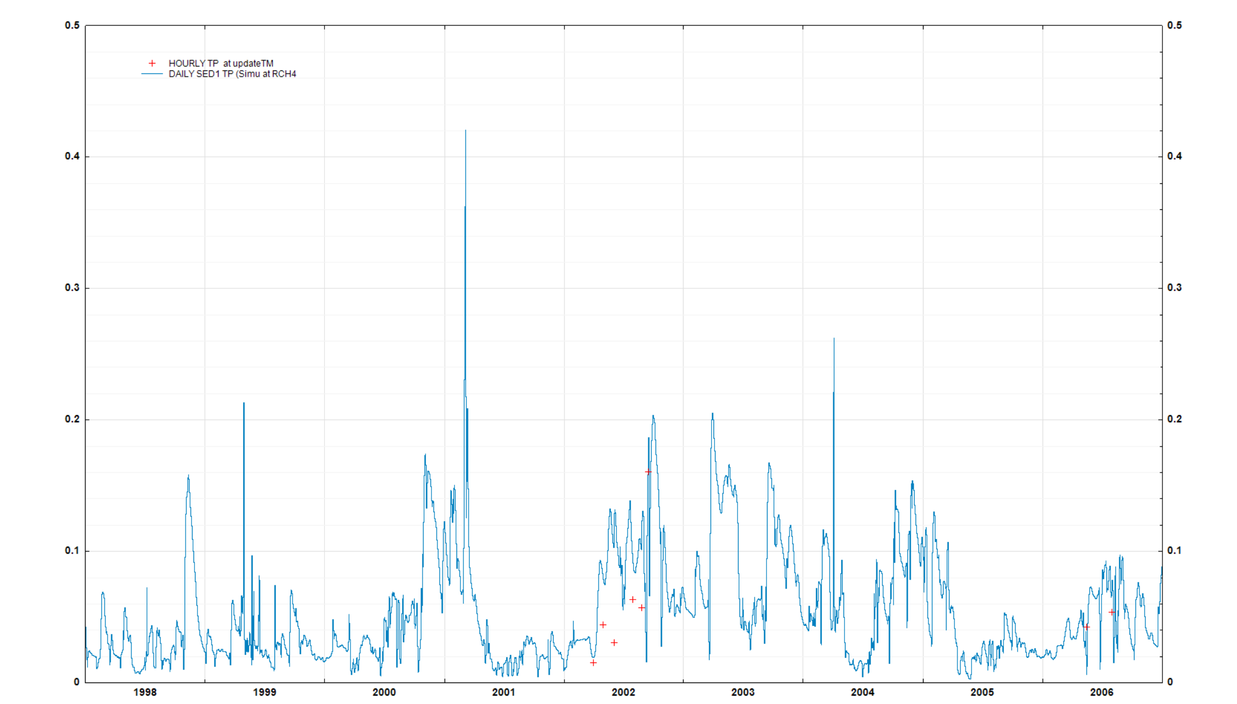


Figure 3 - Simulated (red) and Observed (blue) Total Phosphorus Concentrations (mg/L) at the Study Area Outlet

Nitrogen (TN) loading rates were calculated for the six land uses. Agricultural, urban and barren land had the highest unit area load. Rangeland had the highest average tons/year TN yield due to occupying 83% of the study area; although, rangeland had a relatively low unit area load. The average TN concentration at the watershed outlet during the simulation period was 0.20 mg/L, while the total average daily TN load was 0.725 lbs/day. Average annual outflow of TN at the study area outlet was 6,337 lbs.

Table 16- Average Annual Total Nitrogen Loading Rates by Land Use

Land Use	Avg. lbs/acre/yr	Acres	Avg. lbs/year	% of Total Nitrogen
Urban[a]	3.89	1,078	4,193	11.84
Agriculture	1.69	4,423	7,475	21.10
Rangeland	0.089	244,040	21,720	61.30
Forest	0.027	38,173	1,031	2.91
Wetlands	0.016	3,333	53	0.15
Barren	2.68	358	962	2.71
		291,405	35,434	100

[a]Urban loading values are an average of impervious and pervious rates.

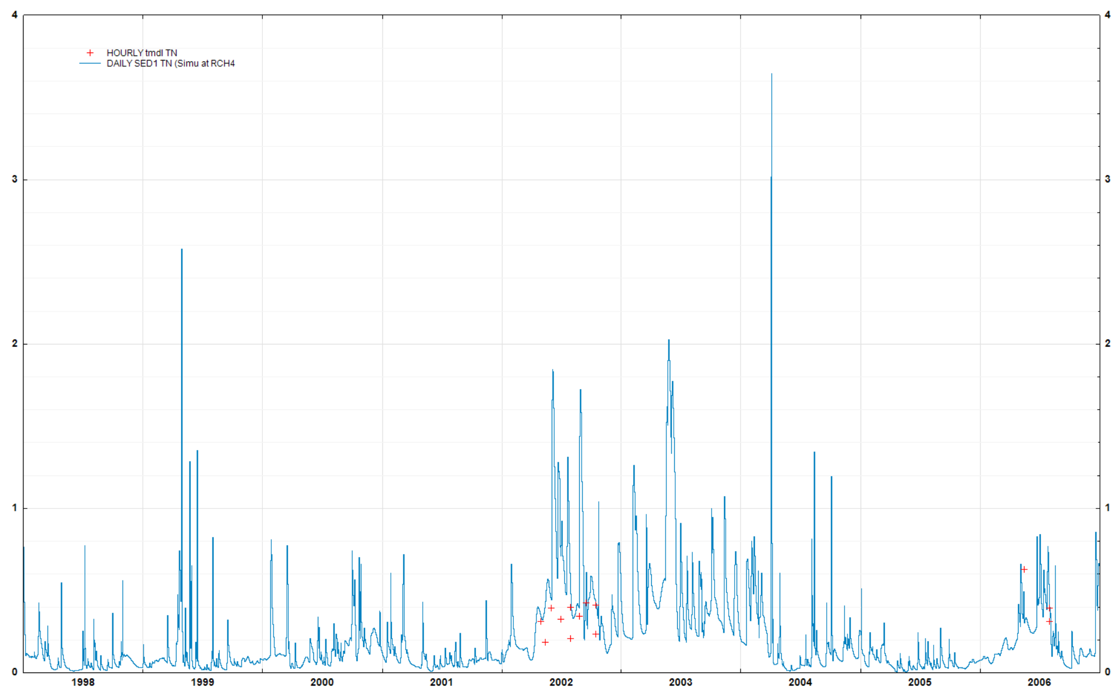


Figure 7-Simulated (red) and Observed (blue) Total Nitrogen Concentrations (mg/L) at the Study Area Outlet

The in-depth nutrient modeling in BASINS provided the capability to calculate Total Phosphorus and Total Nitrogen loading rates. Loading rates were calculated by using the geometric mean of exceedences for each constituent over the nine year period. See section Nutrient Load Reductions and Appendix B: Load Reduction Methods for the results.

Summary

Field nutrient assessments conducted in 2014 and 2015 concluded that the Mora River (USGS gage east of Shoemaker to Hwy 434) is impaired due to high TN and TP concentrations as well as low dissolved oxygen readings. A general trend was found that water quality degraded from upstream to downstream. The macroinvertebrate study conducted in 2014 also found a pattern of increasingly degraded conditions as the study sites moved downstream. The macroinvertebrate study concluded that the water quality, according to the Family Biotic Index, ranged from “Fair” to “Fairly Poor.”

The Rosgen survey found common themes among all sites including incision on one bank with floodplain access on the other (which resulted in high entrenchment ratios due to the averaging effect of the two banks), dominant substrates of sand and cobble and similar mean/max depth ratios. This survey identified locations where channel morphology needs to be improved due to evident historic alterations, incision and drying floodplains.

NMRAM scores varied but most fell within the “good” to “excellent” range. Common low-scoring areas included vegetation structure, soil surface condition and hydrologic connectivity and historic wetland size. High-scoring areas were relative native community composition, buffer integrity and riparian connectivity. This study identified locations of insufficient stream canopy, lack of diverse riparian vegetation, riparian grazing impacts and over wide streams.

The Bare Ground Assessment provided a method to assess the entire watershed based on current Landsat imagery. Eight percent of the watershed was determined to be bare ground based on June 2014 remote sensing imagery. This assessment helped to identify areas (especially uplands and inaccessible land) that are in need of erosion remediation.

Finally, the BASINS modeling calculated Total Nitrogen and Total Phosphorus loading rates over a nine year period. This data was used to calculate load reductions (see Section Nutrient Load Reductions and Appendix B: Load Reduction Methods) and provided an overview of pollutant loading over time and variable environmental conditions. In correlation with the field data, the modeling also showed a pattern of degrading water quality as the river moved downstream.

Watershed Health Issues

The collection of studies done to assess environmental conditions in the lower Mora Watershed yielded the following list of degraded watershed health conditions that require remediation and will be addressed in the Management and Restoration Measures to Support Load Reductions section. Those issues are:

Stream Channel and Floodplain

1. Straightened stream channels
2. Stream entrenchment
3. Over-wide channels
4. Streambank erosion – particularly apparent on one bank where the channel is confined by roads and train tracks
5. Lack of floodplain connectivity
6. Lack of instream diversity (pools, riffles, falls)
7. Excessive instream fine sediments
8. Excessive algae
9. Lost or degraded wetlands
10. Diversion-related impacts on channel geomorphology
11. Confinement by infrastructure (road, railroad, acequias, farm fields)
12. Irrigation diversion changes to channel function

Riparian Area

13. Lack of cottonwood and other woody vegetation reproduction
14. Lack of species diversity
15. Lack of woody species
16. Some weedy species

Uplands

17. Top soil erosion
18. Arroyo formation and related erosion
19. Excessive bare ground and limited plant productivity
20. Piñon and juniper encroachment
21. Road-caused erosion and disruption of water flow patterns

Social Conditions Assessment

Assessment of the social climate in order to develop remediation plans and priorities is equally as important as the effort of assessing the physical condition of the lower Mora Watershed. Determining the willingness of landowners to participate in watershed-sensitive management and restoration and determining what entities are willing and capable of collaborating on this work is an essential component. In addition, soliciting on-the-ground practical knowledge from landowners, land managers and organizations that have familiarity with the area to supplement field data collection and remote sensing data is imperative.

Stakeholders including public and private organizations, private landowners and relevant contractors in the lower Mora Watershed were identified and interviewed to better understand the social climate and landowner/land manager culture, perspectives, goals and constraints. This understanding was used to establish realistic approaches to changing land management and performing restoration work with a good likelihood of local support. Without willing landowners, land managers and cooperators, implementation of recommended management measures is unlikely.

Informal discussions were held with willing landowners and stakeholders, written questionnaires were circulated, and public meetings and educational events were held to solicit further input. Draft copies of the Watershed Based Plan were circulated to interested landowners and stakeholders for their review. As part of this social conditions assessment, 19 education and outreach events occurred to share information and become better acquainted with local residents.

An assessment of social conditions relevant to implementing improved land management and watershed restoration practices in the lower Mora Watershed specifically consisted of:

- Gaining familiarity with local stakeholders;
- Interviewing landowners and stakeholders;
- Conducting a mapping exercise to catalog land health issues and opportunities; and
- Holding numerous education and outreach events.

Stakeholders

Public and private organizations, landowners/land managers and land management and restoration contractors were identified as the major relevant stakeholder groups in the lower Mora Watershed.

Familiarity with these groups was established during this planning process. Below, we provide an introduction to key organizational stakeholders that serve as potential collaborators and contractors to help implement this WBPMR. To protect the confidentiality of private landowner/land manager stakeholders, they have not been included in this section but are discussed generally in the following section that presents results of landowner/land manager interviews.

Organizations

A description of relevant natural resource management public and private organizations is below.

Rio Mora National Wildlife Refuge and Conservation Area, US Fish and Wildlife Service

The USFWS acquired the 4,300 acre Wind River Ranch (5 miles west of Watrous and near the upstream end of the project area) as a donation from a private landowner in 2012 and established the Rio Mora National Wildlife Refuge (RMNWR). Related to that, a 952,000 acre Rio Mora Conservation Area was identified within the Mora River Watershed to establish partnerships and cooperatively manage lands to improve wildlife conservation efforts. The USFWS also established "the ability to acquire land through fee title purchase or work cooperatively with the owner through a conservation easement on up to 300,000 acres" within the Rio Mora Conservation Area.

The RMNWR has a mission of land restoration efforts in the lower Mora Watershed. The refuge has focused on reestablishing plant and animal communities characteristic of the short-grass prairie ecosystems, including bison, black-tailed prairie dogs, beaver and native plants. In support of this work they have restored about one mile of the Mora River, and about 20 acres of wetlands, installed over 200 erosion control structures in arroyos, rehabilitated five miles of roads and removed exotic plants and animals. RMNWR, with help from Bill Zeedyk, has completed an assessment of the refuge to catalog land restoration issues and opportunities and has developed a land management plan to guide that work.

As the Wind River Ranch Foundation, educational activities and outreach were a focus of work at the ranch prior to it becoming a refuge. There were programs for K through 12 students, university interns and graduate students and workshops for neighbors. Tribal partnerships were an important part of the restoration and education efforts. The RMNWR has continued this education and outreach work with help from Denver Zoo, New Mexico Highlands University, the Pueblo of Pojoaque tribe and the High Plains Grassland Alliance.

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Fort Union National Monument, US Department of Interior

Fort Union was established in 1851 at the junction of two branches of the Santa Fe Trail to provide protection and supplies for travelers and settlers. The Fort was abandoned in 1891 and subsequently used for livestock grazing by the Union Land and Grazing Company. It later became the Fort Union National Monument in 1954 to preserve the 720 acres of ruins of Fort Union and tell its story (Zhu, 1992). While the primary purpose of the Monument is to preserve its history, there is interest in managing the landscape for its environmental health to include healing erosion related to the historic Santa Fe Trail ruts and past rangeland use.

While natural resource management has not been the focus or the expertise of the Monument, preserving the natural environment occurred historically to some extent with more concerted efforts more recently. Fire suppression has dominated their efforts and remains a priority to protect the facilities and surrounding landscape. Only one recorded prescribed fire of five acres occurred in 1985. Weed control was a significant effort early on since cattle overgrazing degraded much of the Monument land. Since its inception, cattle were excluded from the Monument, trespassing was controlled and natural resources have been protected from use.

Erosion control has been a significant concern of the Monument especially as it has affected the ruins. Attempts to arrest gully erosion have occurred starting in 1973 with various structures and efforts. Reestablishing grass with seeding in damaged areas was found to be the most successful effort to arrest erosion. Beginning in 1985, a soil erosion control project helped care for the Santa Fe Trail ruts and addressed erosion of gullies with potential impacts to the ruins. Sandra Schackel's (1983) Historic Vegetation at Fort Union National Monument, 1851-1983 provided an in-depth evaluation of the Fort's vegetation. In the last 36 years, vegetation at the monument has been gradually restored. Today the prairie is once again growing toward a potential climax according to the 1979 Resource Management Plan and Environmental Assessment.

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USDA Natural Resources Conservation Service (NRCS)

USDA, Natural Resources Conservation Service provides farmers and ranchers with financial and technical assistance to voluntarily put conservation on the ground, not only helping the environment but agricultural operations too. Agricultural producers are eligible to receive help and funding through a number of federal programs, many of them aimed at improving watershed health, among other things. Farm Bill funded programs include Environmental Quality Incentives Program (EQIP), Conservation Stewardship Program (CSP) and the Agricultural Management Assistance Program. Landscape Conservation Initiatives are also available through the National Water Quality Initiative and Working Lands for Wildlife. NRCS also offers easement programs to eligible landowners to conserve working agricultural lands, wetlands, grasslands and forestlands. This is done through the Agricultural Conservation Easement Program and the Healthy Forests Reserve Program. The Regional Conservation Partnership Program (RCPP) is an NRCS facilitated effort to provide further support to producers by partnering with multiple funding sources and agencies.

The Cañon Bonita Ranch, near Wagon Mound, is one nearby example of an NRCS funded land restoration effort that partnered with Quivira Coalition, Kirk Gadzia, Bill Zeedyk, Craig Sponholtz and others to help the landowner accomplish more on the ground (Gadzia, 2014).

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Tierra y Montes and Mora-Wagon Mound Soil and Water Conservation Districts

The Tierra y Montes and Mora-Wagon Mound Soil and Water Conservation Districts serve the lower Mora Watershed area. Soil and Water Conservation Districts (SWCD) are independent subdivisions of state government governed by boards of supervisors, local landowners and residents elected or appointed to the board for four-year term. An SWCD is authorized by the Soil and Water Conservation District Act to conserve and develop the natural resources of the state, provide for flood control, preserve wildlife, protect the tax base and promote the health, safety and general welfare of the people of New Mexico. SWCDs coordinate assistance from all available sources — public and private, local, state and federal — in an effort to develop locally-driven solutions to natural resource concerns. The SWCDs work collaboratively with NRCS, EPA through the NMED's Surface Water Quality Bureau, US Forest Service, New Mexico State Forestry and the USFWS Partners for Fish and Wildlife Program to put federal and state dollars to work on the ground.

These two conservation districts have been in existence in this area since 1940's and have funded numerous projects to improve land management and do restoration in the lower Mora Watershed. These districts work with private landowners to do upland and instream erosion control and restoration. Projects such as riparian fencing for wetland protection and enhancement also play a big part in their work load. Forest thinning and noxious weed mapping and eradication are two other examples of work the districts do with local landowners. They also work with landowners and local schools to educate the public about these issues and concerns. Their education and outreach has taken the form of using a watershed demo trailer or doing on-the-ground "hands on" workshops and tours of previous projects.

Some specific projects in the area have been: USFWS Partners for Wildlife work on wildlife habitat enhancement on David Blagg's property on the lower Sapello River which included riparian planting of cottonwoods and willows, native grasses, re-configuring and stabilizing the river channel over several hundred feet. Riparian fencing, water storage for irrigating new plants and wetland pond re-shaping were also included in the work.

The district worked with USFWS Partners funding and Adam and Sonya Berg on their property stabilizing and enhancing some 4000' of two of their drainages in the Sapello Watershed. This included heavy equipment and manual labor to move many cubic feet of rock and boulders into dozens of structures intended to raise the channel, eliminate head cuts, induce meandering and improve riparian vegetation and soil water-holding capacity. This project area has been used for various educational activities involving adults and school children.

The Pritzlaff Ranch, located in the upper Sapello watershed is a 4,000 acre ranch that is part of the larger conservation area tied into the Rio Mora NWR located in the lower Mora Watershed. This

USFWS Partners project involved nearly a mile of instream work on two drainages. Work here involved heavy equipment and manual labor to build many one-rock dams (channel bed raising), Zuni bowls (head cut elimination) and baffles that create point bars which induce meandering. Several work sessions and tours have taken place on this site.

Another USFWS Partners project occurred on the property of Carlos Ramirez in the upper Sapello Watershed. It involved 1.2 miles of stream restoration and riparian fencing to control grazing along the stream. It consisted of re-connecting an abandoned meander to gain over 120' of stream length. Several places were created to allow over bank flooding onto abandoned meanders and floodplains to enhance vegetation type and saturate soils. Stream banks were stabilized in several locations. Cottonwoods, willows and other shrubs were planted to improve wildlife habitat. Noxious weeds were treated and continue to be treated. School children were brought out for a field day and various individuals were given tours of the site.

Tierra y Montes worked with HPWA on a day long workshop on the Humphreys property located along side the Rio Mora NWR building rock structures to eliminate a large head cut and other eroded areas and building rolling dip drain-outs on one of the property's access roads.

There are many other examples of SWCDs' involvement in their local communities.

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New Mexico Acequia Association

Acequias are community-managed and operated irrigation systems with deep roots in the history and culture in New Mexico. They are more than solely a system of irrigation but represent communal means of managing water and land for agricultural production and community support. While most acequias in the project area are managed privately rather than communally, a few retain the traditional acequia organization.

The New Mexico Acequia Association provides resources to protect water and acequias, grow healthy food for our families and communities, and honor our cultural heritage. They provide technical assistance in the form of information and guidance on acequia governance, regulation of water transfer, water banking (protecting water rights from loss from non-use), financial reporting and auditing, acequia liability, and other legal issues. They also provide information on state and federal funding for infrastructure improvement and farm and ranch funding for conservation practices, disaster relief and loans.

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High Plains Grassland Alliance

The High Plains Grassland Alliance (HPGA) was casually formed in 2012 and later formalized by receiving their 501(c)(3) status in 2014. HPGA represents over 200,000 acres of private ranchland in Northeastern New Mexico consisting of five private ranch members and two public land managers (USFWS, NPS). This community of landowners and ranch managers is dedicated to passing on a healthier, more productive landscape to future generations. They strive to achieve this goal through active land and wildlife stewardship, creative pursuit of economic viability without depletion of resources, shared learning and collaboration. Currently members are monitoring climate and weather conditions and are working with Zeigler Geologic Consulting, LLC to monitor ground water dynamics in the area. In addition, HPGA is in the process of developing a scholarship fund to support graduate level research that would inform rangeland management in the region.

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Playa Lakes Joint Venture

The Playa Lakes Joint Venture (PLJV) is a regional partnership of federal and state wildlife agencies, conservation groups and private industry dedicated to conserving bird habitat throughout the western Great Plains — including portions of Colorado, Kansas, Nebraska, New Mexico, Oklahoma and Texas. They provide science-based planning tools, decision-support tools and outreach to help habitat managers become more efficient and effective at delivering on-the-ground conservation (http://pljv.org/).

Of particular concern and focus of the PLJV is the loss of playa wetlands which occur in the lower Mora Watershed (see Map 6). Playas are the most numerous and pervasive wetland habitat in the region and therefore critical to wildlife health and survival. They are also the primary source of recharge for the Ogallala Aquifer. The biggest threat to playas is sedimentation. Sedimentation occurs on playas in cropland or rangeland when rain or irrigation runoff carries loose soils into the playa basin, gradually filling it. Sediment build up reduces the volume of water playas can hold and increases the rate of evaporation, thus limiting recharge. According to researchers, during the past two to three decades, more than half of all playas have been buried by sedimentation.

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Quivira Coalition

Founded in 1997 by two conservationists and a rancher, the Quivira Coalition is a non-profit organization based in Santa Fe, New Mexico, dedicated to building economic and ecological resilience on western working landscapes. Their mission is to build resilience by fostering ecological, economic and social health on western landscapes through education, innovation, collaboration and progressive public and private land stewardship. They do so through four broad initiatives: (1) improving land health; (2) sharing knowledge and innovation; (3) building local capacity; and (4) strengthening diverse relationships.

From 1997 to present, at least 1 million acres of rangeland, 30 linear miles of riparian drainages and 15,000 people have directly benefited from the Quivira Coalition's collaborative efforts. They have organized over 100 educational events on topics as diverse as drought management, riparian restoration, harvesting water from ranch roads, conservation easements, reading the landscape, ecological and photo monitoring, water harvesting, low-stress livestock handling, grassbanks and grassfed beef. They publish numerous newsletters, journals and books.

Quivira Coalition collaborates with the High Plains Grassland Alliance and Hermit's Peak Watershed Alliance on education and on-the ground projects. They have been a chief collaborator on restoration work done on the Cañon Bonita Ranch near Wagon Mound. Work on that project included piñon-juniper removal, brush clearing, prescribed fire, planned grazing, erosion control treatments, riparian restoration, water harvesting, dam building, ranch road repair and relocation, monitoring and mapping—all in service of restoring ecological health to the land in order to support a multitude of diverse wildlife. This project provides an excellent example for similar work that could occur in the lower Mora Watershed.

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New Mexico Land Conservancy

Founded in 2002, the New Mexico Land Conservancy (NMLC) is a statewide, non-profit land trust working with private landowners, community groups, public agencies, and other organizations to preserve New Mexico's land heritage by protecting significant natural habitat, productive agricultural lands, scenic open space, and other important land and resources. NMLC works to conserve these resources and public benefits at community, watershed, and landscape scales. To date, NMLC has worked with over 70 landowners across New Mexico to protect approximately 150,000 acres of high conservation value land, primarily focused on working farms and ranches and land located within important riparian corridors and watersheds.

Beginning with the organization's strategic planning effort in 2012, NMLC began a focused effort for conservation of working lands in northeast New Mexico by engaging landowners along the front range of the Sangre De Cristo mountains and the along the tributaries to the Canadian River, including the Rio Mora. As a result of these efforts, NMLC now holds conservation easements on approximately 33,000 acres in northeast New Mexico, including approximately 13,000 acres in the Rio Mora Watershed. NMLC continues its work with our conservation partners, farmers, ranchers, and other landowners to protect the land and water resources in this region.

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Contractors

The following contractors have been involved to varying degrees in the assessments and networking related to this WBPMR. They also have experience working in this geographic region. Because of that past experience and their particular expertise, these contractors would be appropriate for future assessment, design and implementation of the work recommended in this plan.

Craig Sponholtz, Watershed Artisans, Inc.

http://www.watershedartisans.com/

Watershed Artisans, Inc. is a design/ build land restoration contracting service based in Northern New Mexico that provides restoration, education and inspiration to clients worldwide. Craig Sponholtz, a skilled designer, builder, teacher and artist, founded the company in 2003 as Dryland Solutions and renamed it Watershed Artisans, Inc. in 2014 to better reflect his own unique approach to land restoration and the many diverse environments in which he works.

Watershed Artisans, Inc. embraces the philosophy that degraded land can best be healed with regenerative practices that are inspired by natural processes. The resulting solutions are beautiful, resilient and blend harmoniously into the surrounding landscape. Their goal is to educate and inspire landowners and land managers worldwide.

Watershed Artisans, Inc. assisted with field assessment work and project identification in this WBP project and has built numerous river restoration projects in the upper Gallinas Watershed.

Mark Reineke and Margie Tatro, Reineke Construction, LLC

http://reinekeconstruction.com/

Reineke Construction, LLC was incorporated in the state of New Mexico in July 2005 and is resident in the lower Mora Watershed. The company possesses New Mexico construction licenses GB-98, GF-98 and GS-8. The company's founders, Margie Tatro and Mark Reineke, are a husband and wife team with over 50 years of combined experience in project management and hands-on construction. Both are degreed engineers and have many years of trail and watershed restoration design and construction experience including field and classroom training. The company has been an active member of the Professional Trail Builders Association since 2006. Mark is a licensed professional engineer in the state of New Mexico and a charter member of the New Mexico Forest Industries Association.

Reineke Construction's specialty is recreational land improvements that increase general awareness of the earth's natural resources, enhance sustainable access to these resources and protect these same resources. The firm is interested in projects that involve any of the following elements: water management, riparian restoration and erosion control; trail design, construction and maintenance; trailhead facility improvements; campground construction; and wildlife habitat improvements. The firm is comfortable performing work as an independent contractor or working cooperatively with volunteers on joint projects. Reineke Construction has attended Quivira Coalition workshops and conferences, presented at a New Mexico Environmental Department Wetlands Roundtable Meeting on innovative watershed treatment construction projects, and attended forest thinning training programs put on by NM State Forestry as well as workshops conducted by the Forest Stewards Guild.

Reineke Construction facilitated a hands-on erosion control workshop conducted during this project and resides in the lower Mora Watershed. They have also worked on various USFWS Partners for Fish and Wildlife projects locally.

Bill Zeedyk, Zeedyk Ecological Consulting, LLC

http://billzeedyk.com/

Established in 2004, its purpose is to specialize in small stream and wetland restoration across the Desert Southwest. With more than 280 completed projects, Bill has developed, tested and applied a wide variety of treatments and practices on both public and private lands in the US and Mexico. Bill has worked with a variety of individuals and organizations, including other restoration practitioners, agency personnel, university classes, volunteer groups, contractors, researchers and landowners to plan, design and carry out these projects, under a wide variety of ecological situations and conditions.

Bill grew up in the Eastern USA, graduating from the University of New Hampshire in 1956. He worked with the US Forest Service for 34 years, with experience in habitat management challenges on National Forests in the Northeast, Southeast and Southwest (New Mexico and Arizona).

Bill has presented numerous seminars and on-the-ground workshops for students, while also authoring three books and a range of other publications. He is a lifelong member of the Wildlife Society, a professional organization for wildlife biologists, as well as an active supporter of Albuquerque Wildlife Federation (founded in 1914), Ducks Unlimited, American Rivers, The Nature Conservancy and other conservation organizations. Bill and his wife Mary live in the upper Sapello Watershed.

Steve Carson, Rangeland Hands

http://rangelandhands.com/

Rangeland Hands has completed more than 120 diverse projects providing restoration and renewal to damaged roads, streams, creeks and arroyos in New Mexico and Arizona. They take an innovative, holistic approach to their work by first assessing what has caused the instability and erosion to the landform. Identify the cause, and you can design a solution that absolutely works.

They consider the unique features of each landscape, evaluating how surface water flow has been interrupted by man-made roads and structures; determining the overall potential for recovery; and designing solutions based on restoring natural patterns. Steve has a reputation as an expert of road redesign and reconstruction with water harvesting and watershed health in mind.

Kirk Gadzia, Resource Management Services, LLC

http://www.rmsgadzia.com/

Resource Management Services, LLC (RMS) is a New Mexico based consulting, training and monitoring organization committed to assisting private and professional resource managers achieve sustainable results. RMS was founded by Kirk Gadzia of Bernalillo, New Mexico. Resource Management Services, LLC, focuses on Holistic Management®, which is most easily defined by simply adding W to the word holistic. This describes what the process does - helps us manage Whole situations rather than perceived parts. Managing the whole gives better results and fewer unexpected problems. Many publications today are filled with gloomy forecasts about agriculture and the environment. Yet, there are few who offer realistic solutions that strengthen both our economy and communities. To reverse this trend we must do it with the people already on the land. Holistic Management® gives human values a priority, while creating profit through proven financial planning procedures and ecosystem enhancement techniques.

RMS has helped landowners in the lower Mora Watershed improve their livestock management and taught a workshop for this project.

Kathryn Mahan, KI Bar Consulting

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KI Bar Consulting was created to offer land health assessment and monitoring in riparian and upland areas, with an emphasis on rural and wilderness settings. KI Bar Consulting generates reports placing those monitoring and assessment results within an ecological and human context, and provides additional resources, including collaboratively generated field guides, manuals and tailored maps, to assist land managers with their planning endeavors including grazing. The company also offers basic training in select monitoring techniques.

KI Bar Consulting is a child of Northern New Mexico and spends the majority of its time and energy here. Kathryn's background includes working in various capacities in developed and wildland, riparian and upland areas with groups such as the New Mexico Wilderness Alliance, the United World College Wilderness Program, the Las Vegas and Rio Mora National Wildlife Refuges, the Sapello-Rociada-San Ignacio Volunteer Fire Company, New Mexico Highlands University, the Greater Rio Grande Watershed Alliance, the New Mexico Forest and Watershed Restoration Institute and Hermit's Peak Watershed Alliance. KI Bar was the contractor responsible for ecological field assessment done for this project.

Aaron Kaufman, Southwest Urban Hydrology

http://www.southwesturbanhydrology.com/

Southwest Urban Hydrology LLC, headed by Aaron Kauffman, provides services aimed at remediating disturbances to water quality and hydrologic functions. SUH LLC designs and implements solutions that are efficient, low-cost and aesthetically attractive. A practitioner of community-based watershed resource protection, SUH LLC has engaged people of diverse backgrounds in mitigating erosion, harvesting water in their communities and in being good stewards of the land. Previous projects include wildland water quality improvement through riparian and wetland restoration around farms and ranches, active and passive water catchment systems, bio-retention design and implementation to address polluted runoff and channel and upland erosion mitigation in areas disturbed by roads, overgrazing, fire and mining. SUH LLC has experience working throughout northern New Mexico including the Mora, Gallinas and Canadian Watersheds. Aaron has a Masters Degree in Watershed Management from the University of Arizona.

David Blagg

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David is a local beaver expert who lives in the Sapello Watershed. He is a rancher, farmer, Mayordomo and full-time beaver enthusiast. His background is in both construction and conservation. He is knowledgeable about beaver biology, ecology and the design and construction of a variety of structures (including flow devices, means of protecting their trees and property) to help prevent many beaver impacts to infrastructure and offer means of peacefully coexisting with beaver. He works with governmental agencies, acequias, tribes and private landowners, providing information so that they might see the many benefits of having beaver, and the importance of protecting them and the habitats they create. David provided educational assistance for this project.

Gordon Tooley, Tooley's Trees

http://tooleystrees.com/

Tooley's Trees is a retail and wholesale nursery in Truchas, NM. Focusing on varieties that are drought tolerant and adapted to local climates and soils, they grow trees, shrubs and grafted fruits. They carry a diversity of native trees and shrubs used in restoration projects but also have many heirloom and uncommon varieties of grafted apples, apricots, plums, pears and cherries. Their trees and shrubs are grown in native soil contained in fabric bags and rootmaker pots. Stock is grown with organic methods and holistic orchard management. These practices are time consuming and labor intensive, but result in healthier plants, soils, water quality and beneficial insect populations.

They also provide the only resident Keyline design and plowing services in New Mexico. Keyline design moves us from a linear design for farms and land to a contour design that uses fences, roads and habitat corridors as a conduit to move and slow water for beneficial uses. This supports plant and soil health and aids in restoring damaged lands. In 2015, they keylined about 350 acres of farm and rangeland in Mora County and near Las Vegas, NM. Their work is based on P. A. Yeomans' pioneering work in Australia in the 1940s.

Melanie Gisler, Institute of Applied Ecology

The Institute for Applied Ecology (IAE) is a 501(c)3 nonprofit organization founded in 1999 with offices in Corvallis, Oregon and Santa Fe, New Mexico. IAE conserves native species and habitats through restoration, research and education. Using research-based restoration practices, integrated pest management and ecologically-appropriate native plant materials, we create, restore and manage habitats for native plants and wildlife. We work to improve the supply and diversity of high quality native plant materials and have extensive experience preparing restoration and conservation plans.

IAE conducts research to identify best restoration techniques and best management practices for endangered species, integrating evaluations of climate change effects on native plant communities. In addition to providing surveys and vegetation mapping for rare and invasive species, IAE propagates, reintroduces and monitors endangered plant species to move these species closer to recovery.

IAE offers opportunities to K-12 students, teachers and community members to engage in ecological education and on-the-ground stewardship. We create outdoor school programs and curriculum and provide a variety of educational workshops for adults. In the Mora area we have provided training for native seed collection, but we also offer native plant propagation and restoration workshops.

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Interviews and Mapping Exercise

With the interest of gaining perspective from those who live on and use the land in the lower Mora Watershed, we began building relationships with locals by interviewing stakeholders, landowners and land managers. These interviews were informal discussions intended to gain a more personal understanding of the social climate and cultural history of the area, including to:

- determine how people use the land including their reliance on land based incomes,
- understand general sentiments regarding land stewardship,
- assess the types of land management and restoration projects landowners feel are needed,
- determine the type of assistance landowners require to do those projects, and
- determine which landowners would be willing to work collaboratively with us or others to do future projects.

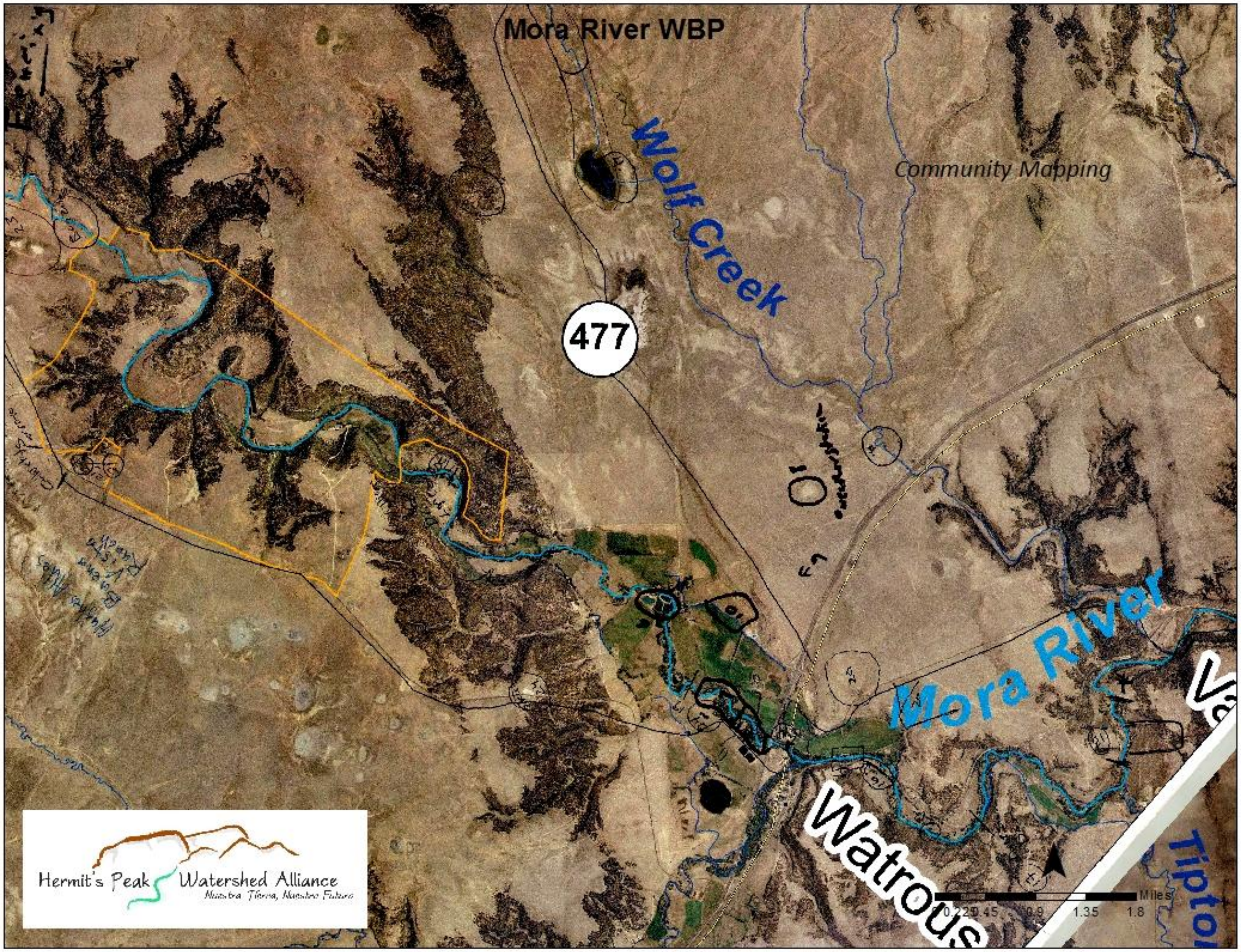
To build a list of people to interview and inform about this project, we first obtained San Miguel and Mora County landowner records from county assessors. Because these records are often incomplete or out-dated, this information only served as a guide which was later refined with information obtained from willing neighbors. We first identified landowners we knew personally and began interviewing them. We then gradually expanded that circle of people with personal introductions from neighbors or cold calls if necessary.

A description of the WBPMR effort and questionnaire was mailed to 55 people for whom we had addresses. This questionnaire was also used as the basis for interview questions. During interviews we were careful to not promise funding for any particular project and clarified that interviews were more a public opinion survey. Since potential funding for projects may be a long time in coming, we were cautious about raising hopes of doing projects in the near future.

To facilitate discussions, jog memories and observations and to develop a catalog of land health issues, we used 1:37,000 scale aerial photo maps (see Map 14). Spatial information was recorded directly on these maps to capture interviewees' observations. These maps spurred lots of discussion of observed land health concerns as well as solutions. This mapping exercise yielded information about issues that could be addressed with projects to improve watershed conditions. Specific locations of issues or opportunities identified were incorporated into our catalog of possible projects for later implementation.

During this process of "getting to know folks", we interviewed 23 landowners and stakeholders and received completed questionnaires from 2 people. Informal discussions also occurred during educational events and other public meetings. Information gleaned from all those discussions is factored into the observations discussed below.

To protect those who entrusted us with their stories, names of individuals and properties will not be referred to specifically. Their identities, observations and interests remain as internal records to be used in the future to identify landowners interested in working together on implementing management and restoration activities on-the-ground.



Map 14- Community Mapping Exercise

Characterization of Lower Mora Social Climate

As would be expected, a wide diversity of landowner types, perspectives and interests occurs in the lower Mora Watershed. How long people have resided in the area, whether they rely on the land for their livelihood and whether or not they are full-time residents substantially affects how they use and view their land. These people tend to fall into three main groups: those deeply rooted for multiple generations and full-time residents, people who are full-time residents and have resided in the area for a few decades and part-time residents with varying history in the area.

The first group of local people (both Hispanic and Anglo) has resided in the area for generations. While they are scattered to some extent, they largely reside in or near the villages of Watrous, Tiptonville and Buena Vista. Some live on small properties of a few acres or less while some have inherited large tracts of land. These deeply rooted people are connected to the land by their history and they have a long-range view of the land both past and future. A number of them still earn a large share of their income from the land - mostly ranching or farming professions. They tend to be people who have worked out their relationship with the land over time and their approach to land management was likely established by their forefathers. They may even be living with the legacy of past generations, needing to solve land health issues not of their own doing. This group is often open to land management and restoration assistance if it is backed up with funding and either preserves or reinstates conditions they accept as "the way it was when they were young."

The second group is made up of full-time landowners, mostly Anglo, who own larger ranches with a history in the area of a few decades. Few of these people maintain a living from the land exclusively but may have supplemental incomes derived from the land, again, mostly ranching or farming. Their perspective is also a long-term one; they would like to stay in the area and care deeply about their land. Often with connections elsewhere, they bring different perspectives and resources than the first group. This group is typically open to assistance or guidance in land management as they continue to discover their own land heritage.

The third group, with distinctly different viewpoints, includes part-time or absentee landowners who use their land for vacation, incidental income, hobby endeavors, or investment purposes. These people may or may not have a long-range view of the land. Lands (most often ranch lands) with part-time owners in the lower Mora Watershed are among the largest pieces of contiguous property. These landowners most often hire professional ranch managers who maintain the property and either implement some business venture of the owners' or pursue their own endeavors to defray operation costs. Land managers in this group are often protective of their owner's desires and information, hence are reluctant to discuss ranch business. They are professionals with specific objectives in mind including the need to tailor work to meet landowner desires. Gaining direct access to owners is a challenge since they are rarely in the area and when they are it is for particular vacation or management purposes. Building relationships needed to implement land management changes or restoration activities with this group takes considerable time and has a unique set of challenges. However, since these ranches are typically large, working through the challenges may be well worth the effort if projects can occur over large contiguous areas.

Independent of these private landowner groups are the Rio Mora National Wildlife Refuge and the Fort Union National Monument. These two federally managed properties are both good candidates for doing restoration work when it coincides with their agencies' objectives. As federal lands, NEPA would be required for most restoration work. However, the Rio Mora National Wildlife Refuge has already completed NEPA for much of the desirable work so would be an excellent candidate for doing future projects together. Those institutions do have a multitude of potential funding sources to accomplish work so are not as dependent on funding from future CWA 319 grants to accomplish watershed-related projects. Those funding opportunities are often not available to private landowners.

While the potential for working with landowners to alter land management practices or do restoration work spans all the groups described above, the second group appears to offer the least challenges and the greatest opportunity. Each group has individuals with particular interest in watershed restoration and those individuals have been identified in this process. Initially, working with people in the second group and those people with particular interest in watershed restoration offers the best opportunities to build demonstration projects to inform others that may have hesitation.

One particular characteristic of the social climate in the lower Mora Watershed that poses some challenges is that there does not appear to be an organized sense of community nor is there a simple, regular means of bringing people together. Residents generally do not live close to their neighbors; ranches are large and spread apart. People that live in this setting are typically self-reliant and independent people. A few organizations do however exist that bring people together in the community: the local Volunteer Fire Departments, the local 4-H club and the High Plains Grassland Alliance, but membership in these organizations is limited. An annual event, Watrous Day, held at the Fire Station in Watrous, is the one event that appears to gather locals but does not seem to be attended by many of the large ranchers; it is more of a family reunion for long-time residents. Informal ranch-specific gatherings also take place when ranchers team up to accomplish tasks like branding and doctoring livestock. For these reasons, to reach people in this area requires one-on-one meetings, the use of emails and internet as a means of communication and the building of personal relationships.

Another challenge faced was that some landowners are hesitant to begin open discussions without first knowing who it is they are talking to. While this is completely understandable, it necessitates building relationships before cooperative projects can be pursued. This is a long-term endeavor.

Project and Issue Mapping

The act of mulling over good aerial photos of the watershed and discussing the landscape at that level was an excellent tool for stimulating stories and insight with landowners. It was also a good educational tool, allowing landowners to take a broader view of land and water health. This approach is strongly recommended as a vehicle for soliciting input from stakeholders. Good quality, large scale (1:37,000) maps are needed for this effort and must be accompanied with consistent information-recording conventions to make the effort most effective.

Numerous watershed health issues and potential projects were identified by landowners and stakeholders during our mapping exercises. In an area the size of the lower Mora Watershed (477 sq. mi.), it is impossible for field assessment efforts to cover the amount of ground that can be covered by landowners that know their properties well. Issues identified by landowners will undoubtedly require field checking and further investigation to determine their suitability for restoration projects, but this mapped information provides a place to start looking. Furthermore, landowners are able to identify concerns that may not be otherwise discernible (e.g. an old, buried and leaking petroleum tank), so it is an excellent complementary effort.

Mapping with landowners identified 12 types of issues in 35 specific locations totaling approximately 3,300 acres that were felt to warrant treatment to improve watershed condition. Additionally, projects that have been identified at the Rio Mora NWR were also catalogued for inclusion in this plan. The types of issues that were identified during interviews and mapping exercises included:

- actively eroding arroyos
- areas with excessive bare ground
- eroding streambanks
- roads causing erosion
- sand, gravel, or rock pits requiring restoration
- irrigation diversion reconstructions needed
- manure dumping near the river channel
- household waste dumping near the river
- degraded pastures needing restoration
- weed infestations needing control
- straightened river channel from levee construction
- piñon/juniper encroachment

More importantly, landowners and stakeholders helped us understand the breadth of issues that need attention with qualitative background on how these degraded conditions came about.

These issues and project opportunities were added to the list of potential projects to improve watershed health and reduce water quality impairments described in the Nutrient Load Reductions and Management and Restoration Measures to Support Load Reductions sections.

Interviews and the accompanying mapping exercise provided a good indication of the types of projects that would be of interest to landowners, those that require additional education to be supported, or those that are unlikely to receive support. Below is an explanation of public interest in various types of management and restoration projects.

Erosion - Recognition by landowners that erosion issues need addressing is common. It is well understood that erosion, whether in the form of arroyo formation, top soil losses, or streambank erosion, poses watershed health problems and reduces land productivity for crops and rangeland uses. Arresting and healing erosion is widely supported and offers numerous project opportunities. Newly developed techniques that are very effective at arresting and repairing upland erosion can be taught to landowners and can be easily accomplished by most resourceful rural landowners or volunteer efforts. Hands-on workshops to build erosion control structures with new techniques offer excellent opportunities for learning and camaraderie. Awareness of stream channel entrenchment (a result of erosion), its causes and consequences for watershed health and land productivity is, however, not common. Simple explanations of its meaning and impact are easily delivered and easily understood – offering "aha moments" to many people.

Livestock Management - Because livestock management is most commonly done locally either by professional ranch managers or by individuals with a long history of experience, assistance with developing livestock management plans would only be embraced by a few landowners. However, assistance with adding tools for improving livestock distribution over space and time and reducing livestock overuse of sensitive areas would spark greater interest. Water developments, fencing and rehabilitation of plant productivity in areas with excessive bare ground or weed infestations are examples of desirable tools.

Weed Management - Weed control and management is a well supported effort with most people recognizing its impact on land productivity. But, there appears to be more emphasis on treating the symptoms rather than addressing the root causes of weed infestations. Ground disturbing activities, including plowing, are not yet fully recognized as root causes and creative alternative solutions to traditional agricultural techniques (e.g. cover cropping and no-till farming) are not widely employed to prevent the spread of weeds. The value of some apparently invasive plants (expanding non-desirable species) like pioneer native species, to assist with land health restoration is also not largely understood; it is often the view that all invasive plants are bad, when in fact some invasives are indicative of a healing landscape or can aid in restoring soil health to degraded lands. An example is coyote willow, a common native riparian shrub that quickly appears in healing riparian areas in dense thickets. This riparian species assists with anchoring streambanks and traps sediments. In previously degraded riparian areas it returns in dense monotypic stands but given the opportunity and perhaps facilitated with supplemental planting, it can succeed to more diverse and appealing riparian plant communities. Coyote willow is often seen as a weedy species (although it is native) that needs to be controlled.

Agricultural management – Two landowners expressed interest in assistance to improve farming practices; one hay farmer and one who grows produce for the local Farmer's Market. To our knowledge, only one fruit and vegetable farm exists in the area. All remaining farming is for hay production. While improved agricultural management would yield significant watershed health benefits, the opportunities may be limited. However, educational efforts to inform other farmers about practices to improve soil health, harvest water and address other challenges related to drought conditions may yield other interested parties.

Beaver – Attitudes toward beaver are generally positive. Landowners in arid areas, especially during times of drought, have seen the ability of beaver to keep water in the river channel and in adjacent wetlands significantly longer than non-beaver areas. They've observed that beaver ponds are typically the only areas with water for livestock or wildlife. Opportunities do exist to help landowners develop beaver management solutions (e.g. fencing cottonwoods, culvert protection exclosures and beaver deceivers) and landowners appear to be cooperative and interested in such help.

River and floodplain restoration – Landowners are open-minded about the idea of restoring river and floodplain conditions but are usually not familiar with the techniques and benefits. The group of landowners that embrace new ideas and appreciate working collaboratively will likely be very supportive of doing this work in the future. These projects can help to serve as demonstrations to inform other, more hesitant landowners. A number of willing landowners does exist to start an effort of river and floodplain restoration and promote the idea through educational events.

Riparian restoration – While there may be some understanding and appreciation of the value of riparian vegetation, special management of riparian areas is rare. Riparian fencing and special management of riparian areas was only observed on three properties; riparian areas are most often part of larger grazed pastures. This is likely related to both an ease of livestock management, but is also related to a lack of clear motivation or a lack of resources to accomplish the extra work of special riparian pasture management involving extra fencing and alternative water sources. This lack of motivation may circle back to a lack of understanding of the importance of riparian vegetation to land and water health.

Wetland restoration – While the value of wetlands is appreciated by most landowners, only one effort toward wetland restoration is known to have occurred on private lands. This is likely because restoring or enhancing wetland functions is a specialized and expensive task. Neither the motivation nor the knowledge or resources typically exist for private landowners, necessitating outside assistance.

In summary:

Project types that are likely to receive common support are:

- upland erosion control issues,
- livestock management tools, like water development, fencing, pasture restoration,
- beaver management,
- riparian vegetation restoration,
- wetland restoration.

Project types that will likely be supported by many, provided that additional educational work help stimulate interest, are:

- projects that repair stream entrenchment,
- weed management through preventative measures and nonchemical alternative treatments,
- improved and alternative agricultural management approaches,
- river and floodplain restoration,
- riparian vegetation restoration.

Project types that are unlikely to receive support or opportunities are limited are:

- developing livestock management plans,
- agricultural management.

Education and Outreach

In addition to identifying landowners and stakeholders in the lower Mora Watershed with public records and "word-of-mouth" information, mailing them information about the project along with a questionnaire and then interviewing many of them, 19 educational events were held to inform locals of our work and solicit their ideas and knowledge (see Table 17).

These events were part of the Land Stewardship Series (LSS) hosted by HPWA which began in 2013. This series provides a variety of educational presentations to the public about topics relevant to both land stewardship and watershed health. Landowners and managers are the target audience but others benefit as well. This series of continued, small and usually simple educational programs seems to be a very cost-effective means of providing landowner support and education, with approximately 319 participants.

LSS events are a combination of lecture presentations, on-the-ground tours and hands-on workshops. Topics have included: soil health, erosion control, weed management, managing horses on small properties, a farm tour and talk and grazing and rangeland health among many others (see Table 17).

Some topics were particularly popular, like weed management and the farm tour, while others were not well attended, such as conservation easements and a water catchment construction day.

Two specific public meetings were held for Mora-area residents to provide information about the WBP project and get to know residents. One was held collaboratively with the USFWS Rio Mora National Wildlife Refuge as part of their landowner day and one was held independently. The first entailed a hands-on workshop which HPWA conducted to build arroyo erosion control structures (Zuni Bowl and one-rock dams) on private property adjacent to refuge. The workshop was conducted concurrently with a presentation by USFWS and HPWA with information tables. Both public meetings were not well attended; the first had two landowners participate in the inside presentation portion (12 students attended the erosion control workshop portion), the second had three. This lack of attendance indicates the challenges related to bringing people together in this rural area, especially if the topic is not already familiar or individually compelling. Landowners appear to be much more interested in educational events that pertain to something they can specifically apply on their land, like weed management.

Denver Zoo, working with and at the Rio Mora National Wildlife Refuge, held over eleven educational events in conjunction with this project to provide land health education to local and distant youth; over 300 students participated in these events. Events included numerous hands-on workshops involving erosion control and weed management, general watershed health, water quality monitoring and general natural history. While they did not target landowners in the lower Mora area, they contributed to overall education of the next generation of landowners.

A further contribution to youth education that was part of this project entailed the creation and presentation of a curriculum of watershed activities for high school students. The curriculum that was developed consisted of a series of five activities including teacher instructions and background information that was provided to the West Las Vegas and Robertson High Schools in Las Vegas. Activities included:

- What is a Watershed?
- The Life In and Around a River Bosque
- Soil Texture and Permeability and How it Relates to Watershed Health
- River Discharge and Use
- Water Quality Testing

No schools exist in the villages of the lower Mora Watershed and most resident students attend schools in Las Vegas, hence its presentation to Las Vegas schools. Contact HPWA to obtain a copy of this curriculum (hpwa@hermitspeakwatersheds.org).

Table 17- Educational Events Held During the Project Period as Part of the HPWA Land Stewardship Series

Date	Topic	Presenters	# of Attendees
2014			
Feb. 19	Working on Roads and their Land Relationship	Bill Zeedyk	18
March 22	Riparian Planting work day in the Gallinas Watershed	HPWA	17
April 23	Leaving a Land Legacy: Conservation Easements	Charlie O'Leary, Santa Fe Conservation Trust and Beth Mills, NM Land Conservancy	6
June 6, 7	Managing Horses on Small Properties - a two day workshop	Cooperatively organized with Quivira Coalition	12
June 28	Water Catchment for Livestock work day	Kathryn Mahan and Ikhzaan Saleem, KI Bar Consulting	1
July 30	Weed Doctors: Identification and Treatment of Weeds	Lydia Ulibarri, Tierra Y Montes Soil and Water Conservation District and Mollie Walton, Quivira Coalition	30
Sept. 9	Watrous 4-H: Caring for you Watershed	HPWA	20
October 18	Landowner Workshop at Rio Mora National Wildlife Refuge and adjacent private land: Hands on Erosion Control at Larry Humphreys and Anne Farrell property and presentation of Mora Watershed Based Planning effort	USFWS, Tierra y Montes Soil and Water Conservation District	2 landowners 12 United World College students
October 29	Grazing and Grassland Health	Kirk Gadzia, collaboration with Denver Zoo	25
Nov. 15	Beaver: Watershed Engineers	David Blagg	18
2015			
March 14	Get Ready for Gardening Season – a farm tour of UWC Agroecology Research Center	Ben Gillock, UWC	42
March 28	La Milpa Community Garden – gardening techniques	Collaboration with USFWS and Friends of the Las Vegas Wildlife Refuge	27
June 20	Fly fishing Clinic	Aaron Juarros, Zia Fly (Taos, NM)	10
July 30	Understanding and Managing Weeds	Mollie Walton, Quivira Coalition and Craig Conley, NMHU	45
August 4	Rotary Club presentation on HPWA activities	HPWA	14
August 29	People's Faire	HPWA - booth	hundreds
Oct 17	Erosion Control Work Day	Mark Reineke, Reineke Construction, King Ranch	12

Date	Topic	Presenters	# of Attendees
Nov 7	WBP Open House	HPWA, Watrous	3
Nov. 5	Soil Health and Carbon Sequestration	Craig Conley	25

Throughout educational events and interviews, discussions with landowners and managers indicated numerous voids in watershed health understanding. Providing educational opportunities in a variety of forms would help fill those gaps. Needed educational topics that would likely be well received are:

- How watersheds work
- How improved watershed health can improve drought resilience
- Addressing climate change, carbon and nitrogen sequestration and land productivity
- Benefits and approaches to riparian vegetation restoration, instream and floodplain restoration and wetland restoration and enhancement
- Simple erosion control techniques taught as hands-on workshops
- Prevention of weed invasion and restoration of weed infested areas with techniques that also restore pasture productivity
- Alternative techniques to traditional ground disturbing agricultural techniques (plowing) like no-till farming and cover-cropping
- Techniques for improving soil health including intensive grazing, cover/pasture cropping, key-line plow and others
- Encouraging and managing beaver with structures to protect culverts, acequias and other infrastructure

Small, locally located and hands-on events on the property of private landowners are likely to be the most successful. Also, short (2 hour) single topic presentations during the non-growing season also show good potential for appealing to busy ranching people.

Landowners and managers in this area are very independent, hard-working people who don't often have the time to participate in events. To have successful events, considerable time must be invested in building relationships so there is familiarity with the topics and people, otherwise attendance is poor or uncertain.

Finding alternative means of delivering information that can be digested at home on individual schedules may be most effective. Since most people in the lower Mora Watershed are connected on the web, written information in the form of fact sheets, distributed digitally might be more effective. A digital library of educational videos was mentioned as an excellent medium for distributing information to rural people that work the land and are located away from gathering places.

SECTION 4: IMPLEMENTATION PLAN

This section integrates information gained during this project's work to describe and assess the lower Mora Watershed (see Watershed Description and Watershed Assessment sections) and outlines the plan for improving water quality and overall watershed health. It follows the guidelines provided by the Nine Key Elements of a Watershed Based Plan (described in Appendix A) and is organized by those elements (see below). The planning elements in this section illuminate the: type and degree of water quality impairment as it relates to the Mora River's designated uses and water quality standards; factors that contribute to that impairment; extent of pollutant reductions needed to bring water quality to tolerable levels; on-the-ground management and restoration measures required to reduce pollutant loads; financial and technical needs to implement those measures; a strategy for implementation; and finally a means for tracking success toward stated goals.

While reducing water quality impairments is the driving force behind this plan, management and restoration measures were assembled that simultaneously improve overall watershed condition since the two are intimately connected. So, implementing this plan has far reaching benefits to many other aspects of land and water health and productivity.

This planning section is organized into the following nine subsections that are essential parts of a Watershed Based Plan including an introductory section to clarify the TMDL. They are:

- **Clarification of the TMDL for this Plan:** This WPB is fundamentally based on the goal of achieving the state determined standard for water quality that is guided by the Total Maximum Daily Load (TMDL). However, the TMDL for the lower Mora Watershed was revised during this project. An explanation of this revision and how it relates to the TMDL basis used in this plan is presented in this subsection.
- **Causes and Sources of Impairment:** Discusses threats to water quality and the general health of the lower Mora Watershed, along with specific causes of nutrient impairments, sources of nutrient pollution, and data sources for this information.
- **Nutrient Load Reductions**: Presents the specific amounts of nutrient load reductions required in order to remove impairments from the Mora River and identifies priority reaches that should be treated based on those load reductions.
- **Management and Restoration Measures to Support Load Reductions**: Describes the actual management and restoration activities needed to achieve water quality improvements along with the expected nutrient load reductions for each activity.
- **Financial and Technical Assistance Needed**: Offers expected financial and technical resources required to implement the necessary management and restoration activities and provides potential funding sources and project partners.
- **Education and Outreach**: Discusses ongoing and future efforts to educate and provide information to local residents, agencies and other stakeholders and involve them in activities to protect and restore the lower Mora Watershed.
- **Implementation Strategy and Schedule**: Describes the schedule for implementing management and restore measures across the watershed.
- **Measurable Milestones of Implementation**: Presents specific indicators to show progress on implementing management and restoration measures.

- **Criteria for Evaluating Load Reduction Achievements**: Describes criteria that will be used to determine whether nutrient load reductions are being achieved over time and whether progress is being made toward attaining water quality standards.
- **Monitoring Program**: Describes monitoring required to determine the effectiveness of implementing the management and restoration measures.

Clarification of the TMDL for this Plan

HPWA was contracted to develop this WBP in January 2014. In late July of 2015, NMED-SWQB revised the 2007 TMDL for this reach. This changed the TMDL from:

WLA[1] (lbs/day) + LA[2] (lbs/day) + MOS[3] (10%) = TMDL (lbs/day)

Equation 1- 2007 Nutrient TMDL (NMED SWQB., 2007)

Total Phosphorus	0.135 +	0.004 +	0.015 =	0.154
Total Nitrogen	1.705 +	0.046 +	0.195 =	1.946

to:

WLA (lbs/day) + LA (lbs/day) + MOS (10%) = TMDL (lbs/day)

Equation 2- 2015 Nutrient TMDL for Summer (NMED SWQB, 2015)

Summer (May to September)

Total Phosphorus	1.16 +	1.31 +	0.27 =	2.75
Total Nitrogen	9.41 +	21.9 +	3.48 =	34.80

Equation 3- 2015 Nutrient TMDL for Winter (NMED SWQB, 2015)

Winter (October to April)

Total Phosphorus	0.38 +	0.34 +	0.08 =	0.79
Total Nitrogen	3.18 +	5.84 +	1.00 =	10.03

This substantial change was derived primarily from determining a different critical flow and, to a lesser extent, reducing measured load results by using an arithmetic mean rather than a geometric mean of exceedences of TN and TP concentrations from water quality surveys. The TMDL does not explain a rationale for the different mean calculation. Regarding critical flow, the 2007 TMDL used the low flow (0.87 cfs) because of the negative effect decreasing flows have on nutrient concentrations and algal growth. However, the revised 2015 TMDL used the median flow, which was substantially greater (17 cfs in the summer and 4.9 cfs in the winter).

The revised TMDL explains:

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[1] Waste Load Allocation (point sources)

[2] Load Allocation (nonpoint sources)

[3] Margin of Safety

[2] Load Allocation (nonpoint sources)

[3] Margin of Safety

[4] Recommendations adapted from A Landowner's Guide to Wildlife Friendly Fences: How to Build a Fence

> "The summer and winter median flows were calculated using gage data from 2004-2014. This period was selected because it represents the most recent hydrologic conditions but also is representative of long term precipitation based on tree ring data from AD 1000 – 2000 (Gutzler 2007). In addition, the median gaged flow from the period of record (considered to be 1998 to present because the Mora Fish Hatchery came online in 1998) was calculated to be 5.3 cfs and the last decade median flow value was 4.9 cfs. Thus, using the full period of record may overpredict current flow conditions in the Mora River. Summer (May to September) and winter (October to April) median flows, based on daily flows from the USGS gage at La Cueva and corrected for diversions, are listed in Table 1.4." (NMED SWQB, 2015)

In New Mexico, using the median flow appears to be unique to this revised TMDL. The conceptual effect of this new TMDL is to render the Mora River bigger than it is. In particular, the new load allocations increased by a couple orders of magnitude; however, the watershed remains the same size. In contrast, other nutrient TMDLs (apparently based on low flows rather than median flows) list the following load allocations:

Equation 4- Nutrient TMDLs for various rivers throughout New Mexico

Oak Creek (tributary to the Dry Cimarron River), 2009 (NMED SWQB, 2009):

	WLA (lbs/day) +	LA (lbs/day) +	MOS (10%) =	TMDL (lbs/day)
Total Phosphorus	0 +	0.062 +	0.016 =	0.078
Total Nitrogen	0 +	0.779 +	0.195 =	0.974

Canadian River (Cimarron River to Colorado Border), 2011 (NMED SWQB, 2011):

	WLA (lbs/day) +	LA (lbs/day) +	MOS (10%) =	TMDL (lbs/day)
Total Phosphorus	0 +	0.098 +	0.017 =	0.115
Total Nitrogen	0 +	1.47 +	0.260 =	1.73

Pajarito Creek (Canadian River to Headwaters), 2011 (NMED SWQB, 2011):

	WLA (lbs/day) +	LA (lbs/day) +	MOS (10%) =	TMDL (lbs/day)
Total Phosphorus	0.230 +	0.028 +	0.005 =	0.263
Total Nitrogen	3.45 +	0.416 +	0.074 =	3.94

Uña De Gato Creek (Chicorica Creek to Highway 64), 2011 (NMED SWQB, 2011):

	WLA (lbs/day) +	LA (lbs/day) +	MOS (10%) =	TMDL (lbs/day)
Total Phosphorus	0 +	0.041 +	0.007 =	0.048
Total Nitrogen	0 +	0.606 +	0.107 =	0.713

The first step to address non-point source load reduction planning is to determine the load reduction required. This is the measured load minus the target load, and it is expressed as a negative number (a "reduction"). The measured load derives from the concentration of the pollutant and the flow on the day is was collected. However, under the revised TMDL, the target load is much larger. As a result, the non-point source load reduction required is likewise much larger.

In fact, for this reach of the Mora River, HPWA does not believe that the load allocation in the revised TMDL is attainable. HPWA modeling conducted in 2015 identified loading rates for TN and TP based on land use. In order to meet load reductions based on the updated TMDL it would require restoration work on approximately 112,000 acres of land in the watershed. That translates to 38% of the entire watershed which is clearly unattainable. Not only would this work cost more than $350 million to accomplish but the practicality, logistics and time required to complete this work make it nearly impossible. Finally, TN and TP loading rates and BMP efficiencies are calculated on a yearly basis. There is no clear means to separate these efficiencies and loading rates by season to calculate load reductions for the updated TMDL.

Field samples collected during the 2014 and 2015 seasons show that 66% of TN and TP samples that exceeded nutrient standards were collected during flows below the median identified in the updated TMDL (17cfs). Additionally, modeling completed by HPWA show that the original critical low flow is much more representative of effects on nutrient concentrations than the updated TMDL. Modeling results show that at flows of 0.87 cfs and below 100% of TP concentrations exceed nutrient standards and 87% of TN concentrations exceed standards. On the other hand, at flows of 17 cfs and below, only 21% of TN concentrations and 61% of TP concentrations exceed standards.

Finally, the updated TMDL arguably has a WLA which is too high but HPWA is not equipped to recommend ways to alleviate discharge from the Mora WWTP and National Fish Hatchery. However, an engineered and aggressively managed riparian zone could be managed to attenuate nutrients below their outfalls.

HPWA identifies this apparent problem with the revised TMDL as a data gap. The observed pollutant concentrations and the permitted point sources seem to lead to excessive nutrient concentrations that cannot be ameliorated with non-point source controls. HPWA doesn't know whether this can be resolved through greater control over the point sources.

As a result of the above listed problematic issues with the revised TMDL, this Mora WBP is using the original 2007 TMDL as a basis for calculating loads and load reductions. With the original TMDL this WBP contemplates reasonable load reductions. This planning could achieve the load allocation in the previous TMDL, but (as explained above) not the revised TMDL. All further references to load reductions in this plan will refer to the original 2007 TMDL.

Causes and Sources of Impairment

The New Mexico Standards for Interstate and Intrastate Surface Waters designates use of water in the Mora River (USGS gage east of Shoemaker to HWY 434) as irrigation, livestock watering, marginal coldwater fishery, primary contact (swimming or other direct human contact with water), warmwater fishery and wildlife habitat.

According to the 2004-2006 State of New Mexico CWA §303(d)/§305(b) Integrated Report Appendix B 2004 Surface Water Assessment, the Mora River from the USGS gage east of Shoemaker to Hwy 434 does not support its designated standard for marginal coldwater aquatic life (NMED SWQB, 2004). This impairment was confirmed in the most recent 2014-2016 State of New Mexico CWA §303(d)/§305(b) Integrated List & Report Appendix A List of Assessed Surface Waters (NMED SWQB, 2014).

Probable causes of impairment are identified in the Total Maximum Daily Load (TMDL) as: nutrient/eutrophication, biological indicators and dissolved oxygen. The TMDL for nutrients approved by the EPA in 2007 states that the Mora River (USGS gage east of Shoemaker to Hwy 434) exceeded nutrient targets, specifically nitrogen and phosphorus, in multiple field tests conducted in

2002 by NMED SWQB (NMED SWQB., 2007). According to Procedures for Assessing Water Quality Standards Attainment For the State of New Mexico CWA §303(d)/§305(b) Integrated Report Assessment Protocol, Appendix D nutrient targets for transitional streams with marginal coldwater uses in the EPA Level III Ecoregion Southwestern Tablelands should not exceed 0.38 mg/L of nitrogen and 0.03 mg/L of phosphorus (NMED SWQB, 2015). However the TMDL lists the Mora River (USGS gage east of Shoemaker to Hwy 434) as having geometric mean of exceedence of 0.515 mg/L of nitrogen and 0.064 mg/L of phosphorus.

The TMDL for plant nutrients is:

Equation 5- TMDL for Total Phosphorus (NMED SWQB., 2007)

$$Total\ Phosphorus: WLA\ (0.135)\ +\ LA\ (0.004)\ +\ MOS\ (0.015)\ =\ 0.154\ lbs/day$$

Equation 6 - TMDL for Total Nitrogen (NMED SWQB., 2007)

$$Total\ Nitrogen: WLA\ (1.705)\ +\ LA\ (0.046)\ +\ MOS\ (0.195)\ =\ 1.946\ lbs/day$$

The TMDL recommends a total load reduction of 34% for nitrogen and 58% for phosphorus. The pollutant source summary for the Mora River (USGS gage east of Shoemaker to Hwy 434) identifies 54% of the total phosphorus and 62% of the total nitrogen as point source (from municipal and industrial source discharge). The Mora Mutual Domestic Water and Sewerage Works Association (NM0024996) and the Mora National Fish Hatchery and Technology Center (NM0030031) have the only two individual National Pollutant Discharge Elimination System (NPDES) permits in the assessment unit. While the point source pollution was taken into account while calculating loading rates and load reductions, this plan primarily addresses nonpoint sources of pollution as per the purpose of 319(h) Watershed Based Plans.

Probable sources of impairment are identified in the 2007 TMDL as: flow alterations from water diversions, municipal point source discharges and on-site treatment systems (septic systems and similar decentralized systems). The updated 2015 TMDL also adds the following probable sources: recreation pollution sources, silviculture harvesting, wildlife other than waterfowl, habitat modification, drought-related impacts, natural sources, and rangeland grazing. During the lower Mora Watershed WBP assessment, in addition to the previous mentioned sources HPWA also identified loss of riparian habitat, loss of wetlands, mass wasting and streambank modifications/destabilization as other probable sources of nutrient impairment. See Table 18 below for identified probable sources and the corresponding acreages of restoration needed to address that source. The sources and acreages listed in the following table were identified through field assessment, GIS and remote sensing, land owner interviews, and expert consultants as the main source of impairment for land determined to benefit from management and restoration measures. These acreages correspond with all MRM projects listed in Table 20 and Table 21.

Table 18- Probable sources of nutrient impairment in the Mora Watershed

Probable Source	Acres
Stream Channel Incision	356
Streambank modifications/destabilization	74
Mass Wasting	1,830
Gravel or Dirt Roads	971
Irrigated Crop Production	689
Drought Related Impacts	1,262

Probable Source	Acres
Rangeland Grazing	1,785
Exotic Species	191
Loss of Riparian Habitat	1,877
Loss of Wetlands	1,023

Nutrient Load Reductions

This section determines the specific amounts of nutrient load reductions required to remove impairments from the lower Mora River and identifies priority reaches that should be treated based on areas needing the greatest load reductions. These required nutrient load reductions are later used to determine the extent of projects needed to achieve these reductions and to form the basis of monitoring to track success. Table 19 identifies, prioritizes and lists the calculated nutrient load reduction required for specific stream segments identified as contributing to the nutrient impairment on the Mora River to get from current conditions to target loads within water quality standards. Map 15 shows the geographic locations of these priority stream segments. See Appendix B: Load Reduction Methods for Measured Load and Load Reduction calculation methods.

Data for stream withdrawals has not been available in the past. While the NM Office of the State Engineer has installed gages on some irrigation ditches in the Canadian Watershed, none are currently installed on the Mora River. According to the Updated TMDL (2015), field measurements taken at diversions by NMED in 2014 showed that diversions are not consistent, gaged, and cannot be directly correlated back to flows in the Mora River. The Updated TMDL averaged diversions of 4 cfs from April to October and 2 cfs from November to March. While these numbers are a starting point for understanding nutrient loading related to withdrawal more information is needed to effectively calculate this relationship. However, withdrawal data may be available in the future. Because the withdrawal data is not available, we are not able to calculate the loadings related to withdrawal. As flow decreases, the stream cannot effectively dilute its constituents, which causes the concentration of plant nutrients to increase. The 4Q3 low flow was identified in the TMDL as 0.87 cfs. Low flow was chosen as the critical flow because of the negative effect decreasing flows have on nutrient concentrations and algal growth. While the critical flow has been identified and incorporated into load and load reduction calculations (see Appendix B: Load Reduction Methods), as there are no irrigation gages to provide information on stream withdrawal, the effect of irrigation on critical flow cannot be currently calculated.

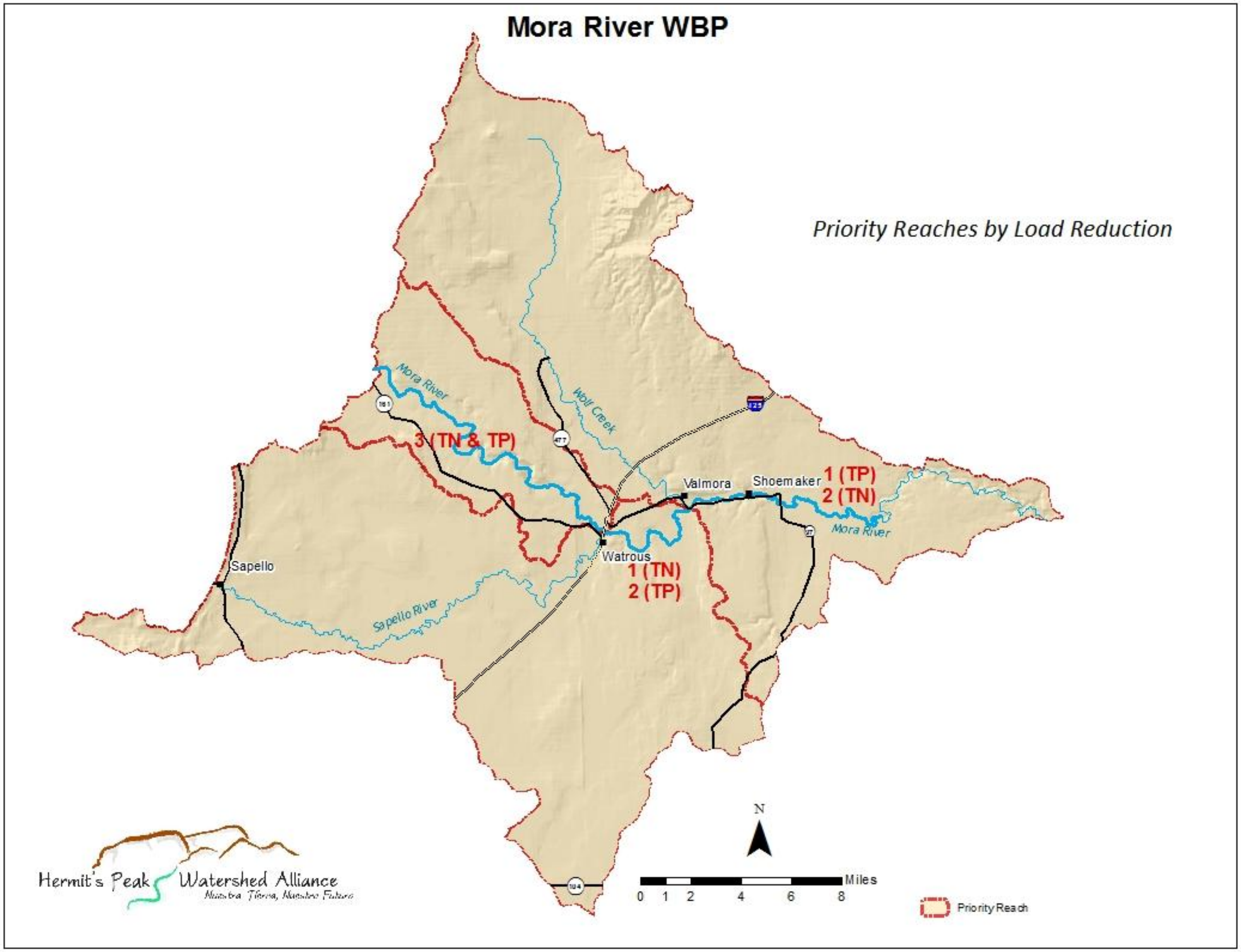
Total Phosphorus and Total Nitrogen load was calculated on three reaches of the lower Mora River; Reach 2: the section of river from the upstream end of the project area (near Golondrinas, NM) to the confluence with the Sapello River, Reach 5: the section from the confluence of the Sapello to the confluence with Wolf Creek and Reach 4: the section of river from the confluence of Wolf Creek to the downstream end of the project area. These loads were calculated in BASINS using the geometric mean of exceedences of daily TN and TP concentrations for the 9 year modeling period.

The following segments in Table 19 are prioritized based on total load reduction in lbs/day from the highest reduction to the lowest. While these priorities are based on load reductions, it must be recognized that during project implementation, other factors may come into play in determining the order in which projects will occur. These priorities will drive implementation order but factors such as cost, landowner willingness (only generally assessed thus far) and project feasibility will practically need to be considered. Loads for the Sapello River, a significant tributary to the Mora River and Wolf Creek, an intermittent tributary to the Mora River, were not calculated individually as neither river has a USGS gage and nutrient samples were not collected there. As a result of this data gap, BASINS could not model those streams individually; hence those subwatersheds have been included in the priority listing with the reaches that they directly drain into. Collecting data on these key tributaries will be added during subsequent funding requests and phases of work. Because of their significance, restoration and improved land management work will be pursued along with the above priority reaches. Map 15 shows the location of the priority reaches in the watershed.

Table 19- Prioritized Nutrient Load Reductions required (lbs/day)

Priority	Reach ID	BASINS TN Load (lbs/day)	TN Load Reduction Required (lbs/day)	BASINS TP Load (lbs/day)	TP Load Reduction Required (lbs/day)
1 (TP) & 2 (TN)	Reach 4 (Mora below confluence with Wolf Creek including Wolf Creek subwatershed)	3.175	1.424	0.348	0.209
1 (TN) & 2 (TP)	Reach 5 (Mora below confluence with Sapello, above Wolf Creek including Sapello subwatershed)	3.211	1.460	0.307	0.168
3 (TN & TP)	Reach 2 (above confluence of Sapello)	2.919	1.168	0.271	0.132

The Spreadsheet Tool for Estimating Pollutant Loads (STEPL) was used to calculate load reductions. After loading rates were determined by land use type in BASINS, STEPL was used to calculate load reductions expected for each Management and Restoration Measure (MRM) and land use type. Please see the following section for detailed load reductions by MRM.



Map 15- Priority Reaches

Management and Restoration Measures to Support Load Reductions

Management and Restoration Measures (MRMs) that are planned to reduce nutrient impairments and improve overall condition of the lower Mora Watershed are presented in this section. These measures are based on conclusions drawn from our Environmental Condition Assessment, Social Conditions Assessment, Literature Review, experiences gained from stakeholders and HPWA work in other watersheds. The first part of this section explains the types of MRMs that are planned followed by tables that provide MRM implementation priorities and expected load reductions when those MRMs are implemented.

The desired future condition of the lower Mora Watershed that drives these Management and Restoration Measures was qualitatively described in the section - A Vision for the Lower Mora Watershed (see page 9). More specifically they address the degraded watershed health conditions listed in the summary at the end of Environmental Condition Assessment section – page 58.

Education and Outreach efforts (see page 138), as well as the pursuit of Conservation Programs, Policies, Planning and Regulatory Measures (see page 114) are needed in concert with these on-the-ground MRMs to reduce water quality impairments and rebuild a resilient, sustainable and healthy watershed to thrive into the future.

Watershed-friendly land management coupled with restoration of degraded conditions can yield improved water quality and sustainable land health. In the lower Mora Watershed, land use and management revolves around livestock and agricultural production. Sound management of livestock and farming must first be in place to reap the benefits of restoration activities; so, management and restoration come hand-in-hand.

The planned Management and Restoration Measures (MRMs) that are presented in this section are designed to reinstate watershed functions, characteristics and processes that are necessary to reduce the nutrient impairment to meet state standards for water quality. Beyond that, MRMs strive to support the full suite of watershed functions in order to restore and sustain an ecologically functional watershed within the current capacity of the area. The watershed functions, characteristics and processes that these MRMs hope to achieve were described in the Introduction of this plan (see sections Goals and Objectives and Planning Approach and a Guide to this Document).

These MRMs constitute a comprehensive list of all measures that are locally appropriate and could be applied in many locations throughout the watershed. To examine every potential project location is not possible; instead we have later in this section presented priorities for treatment and also a geographically phased approach for working across the lower Mora landscape. These general MRMs hope to provide guidance to both public and private landowners to improve watershed conditions and also guide funding agencies when making decisions about projects that appropriately address water quality and watershed health.

In this plan we use the term Management and Restoration Measures (MRMs) to describe on-the-ground treatments, sound management and planning or regulatory tools that should be used to improve watershed conditions. The term MRMs is considered to be synonymous with the term Best Management Practices (BMPs) that is commonly used elsewhere.

Decisions about whether to consider an activity as Management or Restoration are somewhat arbitrary as many activities are both and are intertwined. Below is the list of recommended MRMs presented here and whether they are considered Management or Restoration.

Management Measures

Livestock Management with Planned Grazing Systems

- Riparian and watershed sensitive grazing plans
- Riparian fencing and special riparian pasture management
- Pasture fencing
- Water development
- Pasture rest
- Pasture enhancement
- Discourage livestock use of sensitive areas – (e.g. hemi-fences, drift fences, salting)
- Livestock herding
- Convert grazed areas to hunting access areas

Agricultural Management

- No-till or reduced till farming systems
- Conservation, pasture, or cover crop systems
- Contour farming
- Terracing cropland
- Filter strips
- Soil enhancement
- Alternatives to fertilizers, herbicides and pesticides
- Diversify and rotate crops
- Reconstruct irrigation diversions
- Evaluate and modify acequias

Infrastructure Management and Improvement (e.g. roads, railroad, residential)

- Vegetated buffers and filter strips
- Remove infrastructure in riparian areas and floodplains
- Road improvements
- Bio-retention basins/water harvesting
- Decommission unused/ineffective dirt tanks
- Septic and animal waste treatment

Support and Manage Beaver

Critical Area Protection – e.g. wetlands

Noxious and Invasive Weed Management

Restoration Measures

Restore Upland Vegetation

- Restore plant cover and soil health
- Restore appropriate piñon-juniper densities and distribution

Arrest and Reverse Upland Erosion

- Arrest and heal areas damaged by soil surface erosion
- Arrest and heal arroyos (gullies)
- Restore sand, gravel, stone mining pits

Restore Riparian and Floodplain Vegetation

- Plant diverse woody vegetation
- Improve ground cover with herbaceous plants
- Reduce conifer encroachment in riparian areas
- Control establishment of non-native species

Reconnect Streams to Floodplains

- Provide floodwater overflow areas
- Arrest and reverse channel incision
- Increase channel roughness
- Remove or relocate infrastructure that unnecessarily confines stream flow

Restore streambank and channel characteristics

- Arrest and heal areas damaged by streambank erosion
- Arrest and reverse channel incision
- Reduce stream width
- Increase channel sinuosity
- Enhance instream obstacles and diversity for aquatic organisms

Wetland Restoration and Enhancement

- Recreate wetlands
- Restore existing wetland function

Management Measures

Sound land management must first be in place in order to restore the health and functionality of the lower Mora Watershed. Restoration measures alone are inadequate without first addressing the management issues that are often the source of problems that require restoration. Sound management must then continue after restoration efforts to reap long-term benefits. Considering watershed functions and characteristics that are integral to humans' use of the landscape must be incorporated in all of our land management activities. Modifying how we use the land and how that use affects water first requires a basic understanding of watersheds. Watershed-friendly land management techniques are still evolving so will require that land managers have an understanding of the working of a watershed to adapt and help advance those techniques.

Livestock Management with Planned Grazing Systems

The development and implementation of planned grazing systems that maintain the integrity and function of vegetation and soils in riparian areas and in uplands is paramount in the lower Mora Watershed. Livestock grazing without these considerations or large numbers of livestock grazed with free, unmanaged access to rangelands has had historical impacts and is continually contributing to elevated nutrient levels in streams and degraded watershed conditions. Assisting landowners and ranch managers with developing and implementing Riparian and Watershed Sensitive Grazing Plans is a high priority in this watershed.

Although many ranching operations in the area are run by professional ranch managers with different goals than watershed health, providing those managers technical and physical assistance with watershed-friendly approaches will help find the common ground between land productivity and watershed health. Ranch managers can benefit from educational materials and also financial assistance to implement improved practices. Although not as common, ranching efforts without full-time, professional ranch managers can benefit from help to develop and later implement Riparian and Watershed Sensitive Grazing Plans that are customized to meet landowner needs and objectives.

83% of the lower Mora Watershed is considered rangeland; we have estimated that 3,500 cows, 160 horses, 60 bison and likely other livestock are supported in the area. That is a density of 7.8 domestic animals per square mile; a density that is approximately 33% below maximum ecologically sound stocking rates for present drought conditions in this area according to standard AUM calculations using the NRCS Web Soil Survey (NRCS USDA, 2003) tool. Our estimated livestock numbers are most likely low since they are based on landowner interviews and represent numbers at a time that many landowners have reduced herd sizes because of multiple drought years. So the estimated current stocking rate in the area leaves some margin for our underestimates. Also, livestock are typically not evenly distributed, favoring wet, more productive sites, so a current stocking rate that is below what is ecologically sound appears reasonable.

Riparian and Watershed Sensitive Grazing Plans and a variety of tools to implement them should be made available to improve grazing management in ways that meet particular circumstances and landowner needs.

- **Riparian and Watershed Sensitive Grazing Plans** – Many approaches to grazing management exist and can be used to protect healthy watershed characteristics but they must be applied uniquely to each situation. Riparian and Watershed Sensitive Grazing Plans should be developed and later implemented to direct stocking rates, duration, seasonal timing and distribution in order to improve or maintain diverse and abundant plant cover (especially in riparian areas), soil health and prevent or repair erosion. Customized grazing plans should be developed by professionals with expertise in watershed-friendly grazing management in arid regions and with a multitude of tools in their toolbox. Suitable grazing plans may be developed by ranch managers but assistance with implementation may be needed. Assistance to landowners by livestock management professionals with expertise in watershed functions, characteristics, processes and remediation measures should be provided. Commonly used tools to potentially incorporate in Riparian and Watershed Sensitive Grazing Plans include directing: livestock types, stocking rates, timing, duration, distribution (with herding, salt and supplements), water development, fencing and periods of rest (Alberta Riparian Habitat Management Society, 2016).

- **Riparian Fencing and Special Riparian Pasture Management**– Because livestock concentrate in moist, cool and vegetatively productive riparian areas, fencing them or otherwise controlling that disproportionate use is perhaps the most important practice to improve watershed health. While permanent fencing is expensive to install and maintain and can impede wildlife travel, it provides the most assured means of managing livestock. Alternatives to fencing (e.g. herding, temporary fencing), however may be practical and should be seriously explored.

  Riparian areas, perhaps more than any other watershed feature, offer significant ecological services to sequester, store and regulate nutrient delivery to streams and protect streambanks from erosion so they should be prioritized for protection. They are also particularly vulnerable to soil and vegetation damage which have direct impacts on water quality and watershed health. Historic and continual degradation of riparian areas throughout the lower Mora Watershed was observed in many areas. Construction and maintenance of wildlife-friendly fencing of riparian areas will help to regulate livestock use in a manner that is specific to the sensitive nature and critical importance of riparian areas.

  Since riparian pastures occur on more productive soils, are naturally irrigated, sustain a wide variety forbs and grasses and are relatively more productive during drought cycles, they warrant careful and intense management; they should not be managed as inclusions within larger upland pastures. Wetland and riparian pastures can produce up to ten or more times the per acre yield more reliably than adjacent uplands so also offer an economic resource to livestock managers if specially managed. The ecological and economic value of well managed riparian areas merits specific evaluation and long-term management that allows periodic grazing at suitable times and intensities. The use of tools like: appropriate fencing, , periods of rest, alternative water and shade development , and other considerations will not only protect soil, water and environmental values, but increase profitability.

  Riparian areas should be fenced a minimum of 50' away from either side of the streambank. However, 150' on either side is a preferable width that allows better filtration of nutrients. Riparian fences should enclose the entire wetted area and the extent of riparian vegetation. Ideally fencing will also provide a buffer outside of the identifiable riparian area for further protection. See Appendix E. Wildlife-Friendly Riparian, and Cross-River Fencing Guidelines for more information. Riparian pastures can then be specially managed to repair riparian conditions and minimize future damage.

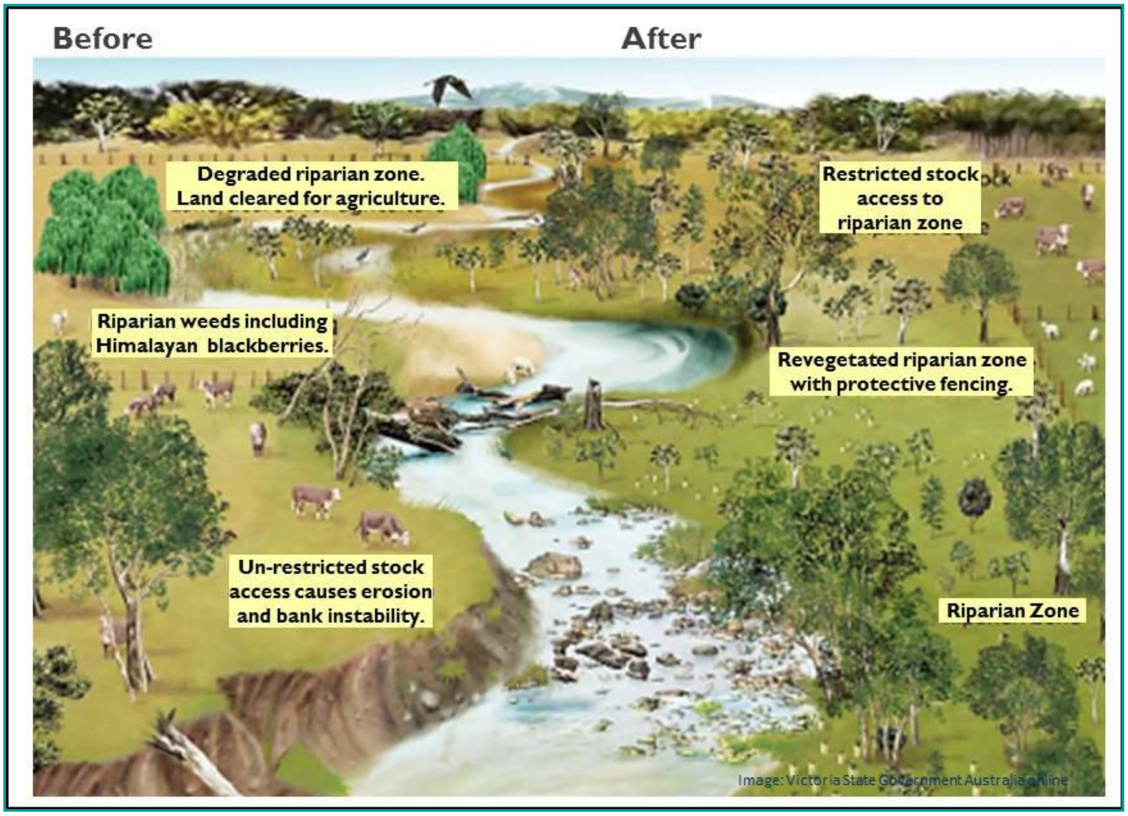


Figure 8- Watershed Conditions Before and After Installing Riparian Fencing and Specially Managing Riparian Areas (Victoria State Government, online image)

- Pasture Fencing – Dividing ranches with permanent or temporary fencing offers another important tool for implementing grazing management systems that protect or rehabilitate soil and plant health. Installing permanent fencing may be the best option to reduce man-power in the long run but it also reduces flexibility afforded by temporary fencing to manage changing conditions. Permanent fencing should be wildlife-friendly to help maintain wildlife populations that are inherent in healthy watersheds but also offer diverse options for land uses – i.e. hunting access. See Appendix E. Wildlife-Friendly Riparian, and Cross-River Fencing Guidelines or consult the following source for fencing guidelines: http://www.wildlife.state.nm.us/download/conservation/habitat-handbook/project-guidelines/Livestock-Wildlife-Fence-Guidelines.pdf

- Water Development – Water development outside riparian areas is an important tool to discourage livestock concentration near streams and encourage more even distribution across upland pastures. Some limited access to streams (i.e. water gaps) can be appropriate if it is well placed and fortified to anchor stream bed and banks. Water development may involve constructing water catchment and storage systems or well development with storage tanks and drinkers. Water development should also be wildlife-friendly to encourage well distributed wildlife populations.

- Pasture Rest – Resources to enable needed rest and rehabilitation of degraded pastures is an essential tool that should be provided. Various alternatives to pursue include: the establishment and use grass banks or leased pastures, payments to defer grazing, or use of fodder growing systems (such as that in use at the Piojo Ranch) that offer cost-effective, high-quality feed grown on site as a supplemental feeding program while pastures are rested.

- Pasture Enhancement – In order to attract livestock to upland pastures away from riparian areas, improve forage productivity and quality by: piñon-juniper thinning and prescribed fire, supplemental pasture seeding, weed treatment, or soil enhancement strategies. While those techniques will improve utilization of upland pastures, they must be done in combination with riparian fencing or other means to discourage grazing in riparian areas. Potential productivity of riparian pastures is commonly 10 times greater than even improved upland pastures. Therefore, upland pasture enhancement alone will not improve riparian conditions.

- Discourage Livestock Use of Sensitive Areas – Apply a variety of techniques to discourage livestock use of degraded, erosive or sensitive riparian areas, wetlands or uplands. Covering damaged soil with brush or limbs, partial or drift fencing, salting, constructed trails, shade development or water development are examples of means of discouraging livestock use of vulnerable areas and to redirect livestock travel away from these locations.

- Livestock Herding – In locations where pasture fencing is cost-prohibitive or not desirable, livestock herding can be a viable option. It not only employs a cowboy (helping to maintain a western way of life) but also offers high-quality care of livestock to reduce disease, injury and predation. Cowboys develop a keen sense of both land and herd health and can adaptively manage both to match specific and dynamic local conditions.

- Convert Grazed Areas to hunting or wildlife viewing areas for a fee to supplement income. Deer, elk, antelope, bear and cougar are all present and locally abundant in the lower Mora Watershed and offer alternative means of income with hunting access fees. Bird watching has become a popular recreational pursuit; riparian areas, wetlands, playas and uplands in the lower Mora offer unique birding opportunities. Ungrazed areas could be managed to improve wildlife habitat with piñon-juniper restoration, diversifying riparian vegetation with planting and wetland restoration; all activities that simultaneously improve watershed health. Fencing or improved access may also be needed.

Agricultural Management

Agriculture and watershed health can be compatible and complementary if potential farming impacts to water quality and watershed health are understood and techniques are modified to eliminate impacts. Regenerative or sustainable farming practices can, in the long-run, not only eliminate watershed impacts but also have great potential to:

- reduce water use,
- encourage water infiltration, storage and filtration in soils reducing irrigation needs,
- improve soil health and productivity,
- enrich crop nutritional value for human, livestock or wildlife consumption,
- mitigate and reverse climate change,
- reduce the dependence on artificial fertilizers, pesticides and petroleum products, and
- improve farm profits and longevity.

Sustainable farming techniques are often a combination of reviving traditional methods and embracing newer techniques by migrating away from ecologically detrimental industrial farming practices. A diversity of regenerative or sustainable farming practices should occur in a way that meets landowner objectives and simultaneously supports watershed health and water quality.

An estimated 4,423 acres of farmland occur in the project area consisting of about 58 farms. The most common crop grown is hay; only one farm is known of that grows fruits and vegetables for humans. Fertile farmland adjacent to the Mora and Sapello Rivers could offer new opportunities to convert hay fields to locally appropriate food for direct human consumption.

Farming techniques that should be considered to improve water quality and overall watershed health are described below.

- **No-till or Reduced Till Farming Systems** – Maintaining year round plant cover on farm fields protects soil from erosion, maintains the environment to keep soil organisms healthy, improves water infiltration and water storage in soils and reduces the movement of excessive nutrients and sediments into water courses. Regular plowing jeopardizes critical soil organisms by exposing them extreme temperatures and dehydration. Bare soils are prone to wind and water erosion which carries nutrients and sediments to water courses and loses fertile top soil. Plant and maintain perennial, deep rooted vegetation (particularly native grasses) at all times to best protect the soil and soil organisms. By planting a second, harvestable crop (e.g. oats, wheat, vegetables, herbs) within perennial vegetation, plant cover can be maintained without jeopardizing harvests or soil health. Alternatively, keeping soil covered with a cover crop between tilling and planting cycles is a second-best approach.

- **Conservation, pasture, or cover crop systems** – Employ alternative crop rotation measures to maintain plant cover at all times; bare soil is the most significant concern for watershed and soil health. Use cropping systems that maintain perennial cover with native grasses or another cover crop that can be used seasonally as forage or hay and intermixed during the growing season with a second crop, such as corn or wheat that has a different growth period from the perennial vegetation. Alternatively, plant cover crops to rehabilitate soils (e.g. replace lost nitrogen with legumes), replace soil organic matter and maintain plant cover between other crops.

- **Contour Farming** – Contour farming includes tillage, planting and other farming operations performed with the rows on or along the contour of the field slope. It helps to reduce sheet and rill erosion and the resulting transport of sediments and other waterborne contaminants. By plowing and planting along contours, water flow is slowed and more evenly distributed and topsoil movement down slope is significantly reduced. The keyline plow (aka Yeoman's Plow) is commonly used to apply contour farming accompanied by careful field design. Contour farming can also assist with rebuilding topsoil faster than natural means. See Tooley's Trees in the Contractors section on page 67.

- **Terracing Cropland** – Building and maintaining constructed benches in sloped fields offers a traditional method of slowing surface water flow, improving water infiltration and storage, preventing erosion and gully formation, trapping sediments and increasing cropland productivity. Terracing can be used in small localized settings or across larger areas. While terraces can be labor and mechanically expensive to construct and maintain, they offer a means of environmentally using sloped areas without degrading water quality and watershed health.

- **Filter Strips** – Strips of permanent perennial vegetation, particularly grasses and woody vegetation, located within and around farm fields are very effective at trapping sediments, nutrients and other pollutants and keeping them out of water courses (see– Supporting Documents: Literature Review). They should especially be located between farmed fields and water courses, drainages or wetlands. Filter strips can also improve cropland conditions by acting as windbreaks, providing shade and as hedgerows to improve wildlife habitat. Filter strips support beneficial insects and insect-eating birds that pollinate crops and prey on pest insects, reducing the need for pesticides. Filter strips can consist of perennial vegetation with crop value like fruit-producing trees or shrubs.

- **Soil Enhancement** – By enhancing the structure and nutrient composition of farm field soils, their capacity to grow beneficial crops (especially perennial vegetation) and infiltrate water so it can be stored and cleaned underground, is significantly improved. Replacing micronutrients and organic matter that may have been depleted with successive farming can be done with means other than the addition of synthetic fertilizers. Keyline plowing techniques along with cover crops and addition of organic micronutrients should be pursued to rebuild conditions that support soil microorganisms and processes.

- **Alternatives to Fertilizers, Herbicides and Pesticides** – By using restorative farming practices like soil enhancements with natural micronutrients (e.g. rock dust, sea water derived nutrients) and compost, contour plowing, no-till systems and filter strips, the need for fertilizers, herbicides and pesticides can be significantly reduced. Maintaining healthy soils with organic material and abundant and diverse soil organisms and year-round plant cover are the healthiest practices for farmland and watersheds.

- **Diversify and Rotate Crops** – Cropland monocultures have significantly simplified above and below ground organisms and processes over time and have created the conditions that require excessive use of synthetic fertilizers, herbicides and pesticides. Designing farms with inherent diversity in crop types (both woody and herbaceous) can restore diversity to ecological systems and human resources. Adopting a dynamic system of crop rotations will further reduce pest problems and nutrient loss conditions.

- **Reconstruct Irrigation Diversions** – Irrigation diversions in the lower Mora Watershed, as elsewhere, were often not constructed with holistic river processes and functions in mind. Irrigation diversions have changed stream geomorphology both above and below the diversion, sometimes causing channels to braid or widen, trapping excessive sediments upstream in overly wide and shallow areas, or sometimes constricting flow causing entrenchment and straightening of natural channels. While many diversions are significant structures and may not be good candidates for reconstruction, each diversion should be evaluated to determine if its modification is practical and beneficial for the natural geomorphology and function of the stream channel.

- **Evaluate and Modify Acequias** – Historically designed and built acequias may need evaluation to determine if their location and construction hinders natural drainage patterns. Abandoned, irrigation ditches are ubiquitous throughout the Mora River Basin, drastically alter natural drainage patterns, cause or contribute to accelerated erosion and are generally unnoticed or ignored. A deliberate effort to identify, map and treat abandoned and neglected ditches would be highly beneficial, save water, soil and money.

To maintain water infiltration afforded by active acequias across the landscape, they should not be constructed with concrete, nor reduced to pipes. Water losses from earthen acequias benefit the wide distribution of ground water where sediment and nutrient laden water can be filtered and later returned to recharge rivers, wetlands or aquifers.

Some acequia locations have captured the majority of river flow during high flow events meaning they have the potential to move natural drainages to straightened and entrenched channels that do not perform well to slow and infiltrate streambank water. Irrigation ditches with high banks and those constructed parallel to natural drainages can constrict the ability of streams to flow onto their floodplain and maintain a natural meander pattern. Those constricted natural channels become straightened and entrenched, reducing their ability to prevent erosion and filter nutrients and sediments. Historical acequias that have been abandoned yet still constrain or alter natural stream channels should be appropriately decommissioned with techniques like Plug and Spread (Zeedyk, 2015).

Infrastructure Management and Improvement

Although the lower Mora Watershed is a rural setting without the impervious surfaces and the extensive infrastructure of urban areas, roads, railroads, homes, farms and ranches do occur and affect watershed functions. A train track follows closely to the lower Mora River along its downstream end; while this will likely not change, recognizing the way it constrains the river and its floodplain may provide opportunities for river restoration structures to offset these impacts. Unimproved, low-standard ranch roads permeate the area potentially interrupting drainage patterns and increasing bare ground and actively eroding surfaces. While the density of homes and their associated septic systems is small (an estimated 0.3 homes/sq. mi.), those homes that do occur a short distance from drainages or wetlands pose some possibility of nutrient inputs to water.

There are many management measures that can help to reduce or negate impacts of infrastructures on water quality and watershed health. Developing filter strips and redesigning and repairing dirt roads offer the most promising results. Filter strips between infrastructure and drainages offer the greatest service to sequester and treat sediment and nutrient laden water before it reaches water courses. Roads, especially low-use dirt roads, can significantly degrade watershed health and water quality, however, cost-effective means of reducing their impacts by improving their location and utility exist that also reduce road maintenance costs and improve more efficient water use.

- Vegetated Buffers and Filter Strips – Natural vegetation (grasses, forbs, trees and/or shrubs) between developed areas and water bodies provide a self-sustaining and effective means of filtering sediments, nutrients and pollutants, keeping them out of our water supply. These filter strips also protect streambanks from erosion, provide temperature regulation and fuel instream ecosystems. Vegetated, undeveloped, buffers or filter strips should ideally be composed of deep rooted, perennial vegetation. Native, perennial grasses should cover the ground with a diversity of forbs and woody plants. Native species, like willows and cottonwoods, require the least maintenance and simultaneously provide aesthetically pleasing wildlife habitat. Buffers or filter strips should be a minimum of 50′ wide but wider strips have greater filtration capacity and offer a more resilient buffer. They should occur along all ephemeral, intermittent, or perennial drainages and wetlands. By avoiding developments in riparian areas, flood damage to infrastructure will also be prevented.

- Road Improvements – Roads interrupt natural patterns of water flow and distribution across the landscape and in doing so can cause: desiccation of local areas, a loss of productive plant growing surfaces, and significant erosion (of the roadbed and gully formation elsewhere) that becomes a major source of sediments and nutrients into water courses. Well constructed and maintained low standard rural roads, including ranch roads, county roads and even abandoned roads offer opportunities to harvest water to improve productivity of adjacent lands, prevent erosion and by making the road invisible to water eliminate their impact on natural drainage patterns. This saves scarce maintenance funds and earns money in terms of increased forage production, water storage and other benefits. Because the efforts to redesign and improve major paved roads are significant and engineering is extensive they are not addressed here. Unimproved, low-standard, ranch roads are instead the focus; they have caused considerable damage and simultaneously offer the most practical opportunities. Sixteen miles of roads were identified as needing improvements to reduce associated erosion, however, many other miles of roads were not examined and likely need work. The following activities are important steps in remediating road impacts; this information generally came from Zeedyk (2006).

    - **Road assessment and planning** - Assess road use, road conditions and plan remediation. Assessment should identify: roads that should be closed, drainage issues (either where roads interrupt natural drainages or drainage onto or off the road causes watershed impacts), erosion-related issues, road/wetland crossing issues and road placement issues related to sensitive aquatic areas.
    - **Close and rehabilitate abandoned and unnecessary roads** – Active closure rather than abandonment is important. To close roads involves first blocking use by vehicles and livestock, installing drainage structures or reestablishing natural drainage patters (e.g. remove berms, waterbars), revegetating the roadbed and protecting sensitive areas. Explore the use of new techniques like Plug and Spread structures to close abandoned roads to prevent further degradation and effectively distribute water across the landscape (Zeedyk B. , 2015).
    - **Resolve road drainage problems** - Address drainage issues related to bar ditches, culverts and bridges. Improve road drainage with outsloping, berm removal, cross drains (like rolling dips), blading, insloping, crowning, water bars and grade reversals. Road relocation may be necessary. Resolving road drainage offers good opportunities to harvest water to revegetate adjacent areas.
    - **Repair related erosion** - Repair gullies related to past road impacts. See information on Arrest and Reverse Upland Erosion (page 107).
    - **Low-water road crossings** - Improve water course road crossings to correct placement, anchor surfaces, use the appropriate crossing structure (low water crossing, bridge, culverts) and couple the crossing with structures to narrow stream width and reduce associated streambank and channel erosion.
    - **Protect aquatic areas** – Streams, wetlands, springs, cienegas and wet meadows need special consideration in road placement and construction; roads that pass too close or bisect these sensitive areas may need to be relocated.

- Remove Infrastructure in Riparian Areas and Floodplains – Buildings, roads, corrals and other developments should ideally be placed well out of the floodplain and riparian area of ephemeral drainages, intermittent and perennial streams and wetlands. The existence of these infrastructures in those areas limits restoration options and reduces their functionality. Infrastructure in floodplains or even temporarily saturated soils is vulnerable to water damage which encourages landowners to build flood control and drainage structures that interfere with aquatic and floodplain functions. Removing and relocating this infrastructure would be preferable if possible.

- Bio-retention Basins/Water Harvesting – Constructing water retention basins can offer a means of collecting, storing, filtering and detoxifying either storm runoff or waste water from domestic or agricultural uses. Bio-retention basins also provide the service of water catchment for use in landscaping, farming or livestock watering. While traditionally constructed dirt tanks offer some of these services, there are also some important distinctions. Bio-retention basins are designed specifically to remove sediments, excessive nutrients and other contaminants from water and also assist with ground water recharge in deference to dirt tanks that are primarily designed for livestock watering. The basins can be designed to additionally harvest water for domestic and agricultural uses. Basins to collect and treat contaminated water can be coupled with phytoremediation (use of specially selected plants that are capable of detoxifying contaminants) techniques to improve the effectiveness of these water collection structures to prevent nutrients and other contaminants from reaching water courses. Careful placement and design of bio-retention and water harvesting structures is necessary and may require assistance from experts.

- Decommission Unused/Ineffective Dirt Tanks – Dirt tanks constructed for livestock watering, farming or other water storage needs expose water to excessive evaporation and remove it from underground storage (where it cannot evaporate and can be used to grow vegetation). While the value and use of many dirt tanks still warrant their occurrence, some have become dysfunctional. Dirt tanks that no longer hold water for livestock or human use, are no longer needed, or are causing secondary erosion issues should be decommissioned and the area restored. Plug and Spread techniques, filling with dirt and revegetation, or conversion to functional wetlands or bio-retention basins should be pursued on dysfunctional dirt tanks.

- Septic and Animal Waste Treatment – Interviews with locals indicate the existence of septic leakage into water courses, particularly in the Sapello River and Tiptonville areas. Those systems need to be identified, evaluated and reconstructed. While there are no stock yards or high concentrations of livestock, some disposal of animal waste was noted near water courses. Removing large amounts of animal waste near drainage courses and disposing of it well away from water courses will help prevent nutrients from reaching water courses. Building bio-retention basins offers a technique of treating concentrated septic or animal wastes.

    - **Improve Existing Septic Systems** – For the estimated 148 households and an approximate 2-5% septic system failure rate, we estimate that about five systems would need redesign and reconstruction. Each system needs individual evaluation, redesign and reconstruction to ensure its functionality in each specific situation.

    - **Construct Bio-retention Basins** – Bio-retention basins or natural wetlands should be constructed in strategic locations to collect and treat waste water from human and livestock sources. Retention basins and wetlands should employ native wetland plants to assist biological degradation of sediments, nutrients, harmful microbes and other pollutants. Investigate plants that have particular ability to break down specific known pollutants.

Support and Manage Beaver

Beaver are the most beneficial and cost-effective means of improving river, wetland and riparian conditions; they offer the simplest way to reduce water quality impairments with a natural, self-sustaining method. Beaver constructed wetlands have multiple benefits to watershed health. They:

- Capture and breakdown nutrients and pollutants;
- Capture and store sediments and debris;
- Slow and store water during flood events and slowly release it during drought to maintain more consistent stream flows and to support wetland ecosystems;
- Maintain vibrant riparian areas;
- Improve fish and wildlife habitat;

Benefits to landowners include that they:

- Reduce flood damage by storing water;
- Provide water supply well into drought periods and are known to turn intermittent drainages to streams with year-round flow;
- Produce lush, moist and beautiful areas to enjoy;
- Raise water tables;
- Increase sub-irrigation to adjacent areas to improve pasture productivity without irrigation.

A number of real and perceived conflicts exist between man and beaver that have resulted in the past and current elimination of this watershed workhorse. Some of the conflicts include:

- Flooding of pastures, roads or other infrastructure;
- Clogging culverts or irrigation ditches;
- Cutting down woody vegetation especially fruit trees and large cottonwoods or ornamentals;
- Erroneously perceived that they “steal all the water”;
- Erroneously perceived conflict with fish populations.

Beaver populations exist in various locations throughout the lower Mora Watershed and those locations are among the healthiest. Management measures needed to attract beaver and enable coexistence include:

- Plant and support willow and cottonwood in riparian areas (beaver food source);
- Fence some large or planted cottonwoods or other valuable trees to protect them from beaver harvesting;
- Construct infrastructure protection structures like beaver deceivers, culvert cages (consult experts for assistance);
- Construct flow control devices to regulate wetland levels that jeopardize infrastructure;
- Educate landowners on the importance of beaver and means of coexistence.

Providing the resources and support to landowners so they can support and manage beaver – so beavers can do their job to maintain watersheds – is a wise, effective and inexpensive effort.

Critical Area Protection

Wetlands, including playas, offer one of the most significant watershed features for reducing nutrient impairments and improving overall watershed health so deserve special protection. The number of intact wetlands and playas in the lower Mora Watershed are limited by natural climatic, geologic and geomorphology but also by past land uses. According to the National Wetlands Inventory 7,000 acres of wetlands cover 2% of the land in the lower Mora planning area. Because of this limited extent and significant watershed value, protection should be pursued for all such wetlands.

Obtaining protection status and managing these wetlands as protected areas can be an important tool in ensuring their future viability. Landowner acquisition of Conservation Easements offers the most practical means of protecting these special areas. Transferring land ownership to either public or private entities with land protection as their principal mission offers another possibility. Obtaining a Conservation Easement on large land parcels with wetlands increases the value of the easement and increases benefits to the landowner. In areas where wetlands can be created, enhanced or protected, another possibility is to enroll those wetlands in a Wetlands Mitigation Bank (see Conservation Programs, Planning, Policies and Regulatory Measures, page 114) as a means of offsetting the costs of restoration, protection, creation or lost revenues if those areas were developed or used for other purposes.

The following entities can assist with such endeavors:

- New Mexico Land Conservancy - http://nmlandconservancy.org/
- Santa Fe Conservation Trust - http://www.sfct.org/
- U.S. Fish and Wildlife Service – Rio Mora National Wildlife Refuge

In cases where protection is not desirable or practical, site-specific management measures to protect these special areas should be developed and prioritized.

Noxious and Invasive Plant Management

Although ground cover by weedy species is better than no plant cover at all (from a soil and watershed health perspective), noxious and invasive weeds are typically not as effective as native, perennial vegetation at sequestering sediments and nutrients and preventing erosion. Furthermore, annual, non-native plants can suppress the vitality of native plant communities and reduce overall plant diversity. Many weed species are not desirable for livestock or agriculture and can be detrimental to both. It is also the legal responsibility of the landowner to control listed Noxious Weeds. The New Mexico Department of Agriculture has the authority to select plant species to be listed as noxious weeds under the Noxious Weed Management Act (76-7D-1 to 76- 7D-6 NMSA 1978). A weed control agent with Tierra y Montes or Mora-Wagon Mound Soil and Water Conservation Districts can help with noxious weed identification and treatment.

Not all perceived weedy species are detrimental to human land uses or watershed health. Some invading plants are natural pioneers and come into disturbed areas, preparing the site for future succession to other more desirable plant communities. This succession may occur naturally without intervention and may be an important part of reestablishing soil conditions needed by more desirable vegetation.

Curly-cup gumweed is such an example of a native pioneer plant found commonly in the lower Mora Watershed, especially after drought or disturbance. It is easily outcompeted with perennial grasses and forbs once they become established and healthy. Coyote willow, a common native riparian shrub, quickly appears in dense thickets in degraded riparian areas as they begin to heal. This riparian species assists with anchoring streambanks and traps sediments. Coyote willow is often seen as a weedy species (although it is native) that needs to be controlled in spite of its beneficial values.

A complete inventory of noxious or invasive plants did not occur during this project; however, since identification of exotic plants is part of the NMRAM assessment completed on 8 study sites, we do have a preliminary list of non-native plants that occur in addition to information from the Rio Mora NWR and other plant studies (Schiebout, 2008), (U.S. Fish and Wildlife Service, 2015), (Ashigh, 2010). See the previous section Plant Communities (page 27) for a description of noxious and invasive weeds found in the lower Mora Watershed. A more extensive survey is recommended to fill this data gap.

Noxious and Invasive Weed Treatments should include:

- **Prevention** - Focus on improving conditions that support year-round cover of desirable plants and reduce land disturbances that provide good growing conditions for weeds.

- **Early Detection and Treatment** – Continual monitoring for new noxious or invasive weeds should occur to enable treatment before an infestation becomes widespread. Early treatment can be often be done by simple mechanical or hand removal and reestablishment of more desirable species.

- **Non-chemical Treatment Where Possible** - Treat weed infestations by biological and mechanical means when possible. Reestablish native or desirable plants in the treated area as quickly as possible to prevent future infestations.

- **Chemical Treatments - Treat Noxious Weeds Early and Aggressively** – Use chemical treatments if needed to eradicate listed noxious weeds if biological or mechanical means are ineffective or impractical. Carefully follow recommendations to use appropriate herbicides and keep chemicals from water drainages. Seek assistance from chemical treatment experts including the weed control agents with Tierra y Montes or Mora-Wagon Mound Soil and Water Conservation District.

Restoration Measures

Even when management is corrected, many degraded watershed conditions either cannot heal themselves over time or will heal so slowly that benefits will not be realized in the foreseeable future. Active restoration of vital but degraded watershed characteristics and processes must occur to reach optimally functional watersheds that produce clean and abundant water.

This section offers the suite of restoration activities that are needed to rebuild watershed functionality and reduce nutrient impairments to acceptable levels. When land management measures are in place, restoration activities can proceed without their effectiveness being negated by inappropriate management. If landowners and managers are not committed to maintaining the restored features, restoration should be pursued cautiously or focused on work that is naturally maintained and has little likelihood of causing conflicts with land uses.

Ideally, restoration activities start in the uplands, higher in watersheds, where they can address the source of degradation experienced in low lands. However, the practical matter of on-the-ground implementation often necessitates a combined and sometimes less than ideal approach.

Restoration Measures that were deemed important to implement in order to address the wide range of watershed health concerns in both uplands and lowlands include:

- Restore Upland Vegetation
- Arrest and Reverse Upland Erosion
- Restore Riparian and Floodplain Vegetation
- Reconnect Streams to their Floodplains
- Restore Streambank and Channel Characteristics
- Wetland Restoration and Enhancement

Restoration techniques are relatively new so are continually being developed and evolving. This plan has not attempted to describe or recommend specific techniques since their application is site specific and requires expert design. Bill Zeedyk has been at the forefront of developing these techniques and has authored numerous documents (many listed in References section) describing them; his publications offer an excellent place to start planning restoration projects.

Restore Upland Vegetation

Well vegetated ground with a healthy, living soil ecosystem is perhaps the most important watershed feature while bare ground is the most significant issue. Diverse and abundant plant cover enables water infiltration and supports below-ground soil ecosystems that provide the services of water storage and filtration. Vibrant plant cover also maintains above-ground processes that more evenly distribute water across the landscape fueling more plant production which in turn supports the diversity of above-ground ecosystems.

Restoring and maintaining ground cover with abundant and diverse plant communities is a key strategy to protecting watershed functions. Beyond implementing watershed-friendly land management (presented in the previous section), restoration of degraded upland plant communities in the lower Mora Watershed involves the following activities:

- Restore Plant Cover and Soil Health – Upland plant cover and soil health is best enhanced with careful livestock and agricultural management; those activities, if applied correctly, can be restorative in nature. But, in locations where degradation is significant, restoration (not directly related to livestock and agriculture) of diverse, largely native plant cover and vibrant soil communities may be needed. Restoring soil health and plant cover go hand-in-hand. Areas with considerable bare ground or serious annual weed infestations are candidates for more thoughtful restoration.

  Soil restoration activities may entail breaking up hardened soil surfaces with equipment such as the keyline plow, raking, tilling or imprinting with animal hooves. Then adding organic matter to top soil with compost, manure, or mulch may be needed to reestablish vibrant plant communities. Planting cover crops in concert with keyline plowing may be appropriate. In some situations, where continual surface water flow prevent the accumulation of top soil, structures like straw bales, logs or straw wattles can help collect top soil and stop erosion. Rest from grazing, coupled with follow-up intensive managed grazing methods, may also help to improve water permeability and organic material incorporation. Salt or other soil nutrient imbalances or soil texture issues may also needed to be addressed if soil testing has determined those issues exist. Addition of clay, sand, lime or other elements to correct imbalances may be needed. Application of trace minerals and nutrients may be called for, as might the inoculation of soils with fungi spores (mycelium).

Both after and as part of treating soil problems, seeding with an appropriate assemblage of native seed may be required if it is unlikely that a seed bank of desirable species exists in the soil. Undesirable, weed or pioneer seeds typically persist for decades so, without supplemental seeding with native plants, reestablishment of diverse, native communities may be difficult.

Restoring healthy soils and reestablishing diverse plant communities can be a challenging and expensive endeavor and often requires consultation with plant restoration specialists. Soil chemical analysis and survey of existing and potential plant communities is likely needed on a site specific basis for restoration activities to be effective. Without employing experts and doing existing condition studies, this type of restoration will likely have mixed results.

Because of the high cost of these activities, focused restoration on high priority areas or treating islands that can naturally reseed adjacent areas is likely needed (Martin, 2016).

- **Restore Appropriate Piñon-Juniper Densities and Distribution** – Piñon-juniper plant communities currently cover about 8% of the lower Mora Watershed. They consist of piñon-juniper woodlands with a sparse grass understory on steep slopes and mesas and as juniper savannas with abundant grass understory where topography is gentler and in valley bottoms. Piñon-juniper encroachment has occurred in areas that were historically grass (short-grass steppe) dominated as a result of altered fire regimes and overgrazing.

  In areas where piñon-juniper encroachment has occurred into previously grass dominated areas, or where piñon-juniper densities currently exceed former low density conditions in juniper savannas, bare ground (below the dense woody canopy) is common. Top soil erosion and gully formation is prevalent and hydrological processes and many other ecological conditions are impacted. In order to reestablish grass understory and arrest and repair erosion, active restoration of juniper savannas and formerly grass dominated plant communities is needed to reduce sediment delivery to water courses.

  Various activities can help restore appropriate piñon-juniper densities and abundant understory grass cover. They include: thinning by a variety of means coupled with some means of slash treatment, prescribed fire, intensive livestock grazing and arresting active gully erosion. Replanting herbaceous vegetation is costly and marginally successful in these large arid landscapes so is not usually suggested; instead, natural reestablishment of grassland communities is anticipated after thinning, prescribed fire restorative activities. Piñon-juniper thinning, prescribed fire or intensively managed grazing should occur under the guidance of experts with particular experience in piñon-juniper communities in order to prevent unintended consequences and improve successes.

Arrest and Reverse Upland Erosion

Eight percent of the lower Mora Watershed is bare ground. While some of that is naturally occurring, the majority of it is the result of land management that has degraded plant cover. Bare ground and other ground disturbances result in various types of erosion like the loss of surface soils and the formation of gullies (arroyos). Both types of erosion have significant impacts on watershed health and water quality.

Prevalent upland erosion consists of excessive loss of topsoil from wind and water in areas lacking adequate plant cover. This kind of erosion can lead to other forms of erosion like the formation of arroyos. The loss of vital topsoil reduces water infiltration, soil water storage and the capacity of the soil to filter nutrients and pollutants. Compacted soils without a living topsoil component quickly shed precipitation as surface flow causing further soil erosion. Treating topsoil erosion is largely a matter of restoring plant cover (which was dealt with in the previous section), but many other techniques exist to arrest loss of top soil and facilitate reformation of healthy soils.

Arroyos are the other prevalent type of erosion evident across the lower Mora landscape. Arroyos have formed by historic and continued land uses related to roads, trails, unrepaired ground disturbances and a lack of plant cover. Preventing, arresting and healing arroyos that were created in the past or those currently forming is a priority.

Arroyos not only replace productive plant growing surfaces with bare ground but they substantially change water flow patterns across the landscape. Arroyos concentrate surface flows and prevent them from infiltrating and dispersing rain and snow across larger areas. Arroyos are downcut drainages that dewater surface soils and rapidly carry water that was once stored in topsoils out of local areas and concentrate it elsewhere. This lowers water tables and reduces water stored in soils available for plant growth. Furthermore, arroyos are often actively eroding, either downcutting or growing longer with headcuts or lateral migration. This continual erosion delivers excessive sediments and nutrients to water courses during storm events. Arroyos tend to lack in structures (rocks, vegetation, logs, or meanders) that help slow water flow and arrest and heal bare surfaces. Without active restoration, arroyos tend to worsen or not heal over time.

- Arrest and Heal Soil Surface Erosion – Beyond efforts to restore plant cover and soil health (discussed above), arrest and repair surface erosion by slowing, spreading and soaking surface water flows. Some of the following structures can be used:

    - media luna (a sheet flow spreader)
    - rock or log lines on the contour
    - log flow splitter
    - plug and spread
    - worm ditch
    - burrito dam
    - straw wattles
    - swales and berms
    - micro-catchments
    - topsoil mulch with dead plant material (e.g. straw, wood) or living mulch like cover crops or erosion cloths

- rolling dips (for roads or trails) or diversion drains, to spread out concentrated flow

Many of these structures can be built by landowners or volunteers with some training or supervision by experts. See (Zeedyk B. a.-W., 2009) (Zeedyk W. D., 2009), (Zeedyk B. , 2015) for more information).

- **Arrest and Heal Arroyos (Gullies)** – Arrest gully formation and growth, raise the bed level of gullies to reverse their existence, and then facilitate redistributing gully water flow across the landscape. Techniques to do this gully restoration have become more common place, effective and practical, producing considerable gains for watershed health, water quality and land productivity. Many old and new techniques form a diverse toolbox to apply in appropriate circumstances. Assistance from experienced practitioners of arroyo restoration is helpful. Principal goals and techniques are:

    - Arrest arroyo headcuts and lateral migration with Zuni bowls, rock or log rundowns, worm ditches (bypass channel), log and fabric step falls, or straw bale falls;
    - Raise the bed level of arroyos or reduce channel slope with grade control structures that slow water flow and accumulate sediment with: one-rock dams, log mats, wicker-weirs, brush dams, strawbale dams;
    - Widen channel;
    - Increase channel roughness to slow water flow with induced meandering with one-rock dams, brush dams;
    - Retain moisture to improve plant growth with most above structures; and
    - Redirect gully flow with plug and spread techniques or worm ditches.

- **Restore Sand, Gravel and Rock Mining Pits** – Approximately 12 gravel pits representing 633 acres occur in the lower Mora Watershed, most of which are abandoned. Some of the abandoned pits are being reclaimed while others have no such plans. Half of these pits occur some distance away from water drainages (greater than one mile) but 6 gravel pits are close enough to warrant priority treatment. Arresting and healing erosion that has resulted from access roads or the mining pit itself and revegetation with appropriate native plants is recommended first for the priority sites near water courses and to a lesser degree to other gravel pits. Assistance from reclamation experts may be needed if the affected land is seriously degraded or large in scope.

Restore Riparian and Floodplain Vegetation

Diverse and abundant vegetation in riparian areas (aka bosque) and floodplains offers significant watershed services. As the last filtering system before surface and ground water enters water courses, herbaceous and woody plants capture, infiltrate and sequester sediments, nutrients and toxins, slowly releasing them to rivers and streams at tolerable levels. Abundant riparian vegetation assimilates nitrogen during metabolic processes thus helps to sequester excess nitrogen from fertilizers and manure. Riparian and floodplain vegetation with dense root masses prevents erosion, sedimentation and stream entrenchment by providing structural support for soils in this wet and vulnerable environment. Beyond the filtering and erosion control functions, riparian and floodplain vegetation help attenuate floods by providing surface roughness and facilitating water infiltration where water can be stored and slowly released to help maintain stream flow during dry periods. Riparian and floodplain vegetation also helps to moderate temperature extremes and retain a moist, cool microclimate. This cool, rich and diverse ecosystem also supports a high diversity and abundance of fish and wildlife.

Riparian and floodplain vegetation throughout the lower Mora Watershed has been degraded by historic and current residential, farming and ranching land uses; both the extent and vigor has been compromised in many areas. Regeneration of woody vegetation (willows and cottonwoods) has not kept up with its losses. In some locations, where grazing pressure has lessened and plant communities have begun to recover, dense, pioneer, coyote willow thickets have dominated, simplifying the potentially diverse and rich area. Agricultural fields, transportation infrastructure and irrigation structures have impinged on floodplain areas, constraining river channels and reducing the extent of floodplain and riparian vegetation.

Restoration measures to rebuild functional riparian and floodplain vegetation must include restoration of drainage channels and their hydrologic connectivity to their floodplains (see Restoration Measures below). Also, restoring riparian and floodplain vegetation necessitates that Management Measures are in place (see above Livestock, Agricultural and Infrastructure Management). Riparian and floodplain areas offer the best location in watersheds to provide a buffer (filter strip) of natural vegetation and intact soils to maintain water quality and quantity.

Simultaneous to restoring hydrologic connectivity and improving management, the following actions to restore riparian and floodplain vegetation are needed:

- **Plant Diverse Woody Vegetation** – Assist the restoration of diverse woody vegetation with supplemental planting in areas where riparian management and hydrologic restoration have occurred. Emphasize tall woody species like Rio Grande and Narrowleaf Cottonwood (*Populus deltoides and angustifolia*), Boxelder (*Acer negundo*), Goodding's Willow (*Salix gooddingii*), Peachleaf Willow (*Salix amygdaloides*), New Mexican Olive (*Forestiera neomexicana*), Arizona Walnut (*Juglans major*) and New Mexican Locust (*Robinia neomexicana*). Examples of diverse shrubs to plant include: Skunkbush (*Rhus trilobata*), Rabbit brush (*Chrysothamnus spp.*), Sandbar Willow (*Salix exigua*), Seep Willow (*Baccharis salicifolia),* Western Soapberry (*Sapindus saponaria),* False-Indigo Bush (*Amorpha fruticosa*), Buffaloberry (*Shepherdia argentea)* and Chokecherry (*Prunus virginiana*). Woody vegetation could include fruit trees to increase the economic and cultural restoration of these fertile and naturally irrigated areas. These diverse species will not only offer riparian areas resilience during extreme weather conditions but also offer resources and refugia for riparian-dependent fish and wildlife. If priorities must be established, focus planting woody vegetation in the most significantly degraded areas.

- **Improve Ground Cover with Herbaceous Plants** – In areas with extremely degraded and bare ground, plant sedges, rushes and other riparian grasses to stabilize soils and diversify cover. Mulch fabric or other types of mulch may be required to assist herbaceous vegetation reestablishment. Where non-native weeds dominate, use biological and mechanical means of encouraging the reestablishment of native species. Assistance from wetland plant or restoration specialists may be required to select appropriate species and planting approaches.

- **Reduce Conifer Encroachment in Riparian Areas** – In riparian areas that have dried out as a consequence of entrenchment, encroachment by upland conifers (usually piñon or juniper) has occurred. By reestablishing hydrologic connectivity in riparian and floodplain areas, conifer encroachment will be naturally controlled to a large extent. Some removal of conifer in riparian areas will support reestablishment of deciduous woody vegetation once hydrology has been restored. Bushy junipers can be a resource used for restoration projects; they provide woody material to use in construction of brush dams to heal arroyos and woody structures for streambanks and channels.

- **Control Establishment of Non-Native Species** – Because Russian Olive and Salt Cedar are not yet established in the area at a serious level, early eradication is simpler and can prevent more costly and challenging control efforts later. Mechanical means of removing these two species at the few locations where they occur can be effective and inexpensive. See section Noxious and Invasive Plant Management.

Reconnect Streams to their Floodplain

Streams (ephemeral, intermittent, or perennial) that can easily spill onto a wide and vegetated floodplain can release energy and deposit sediments during flood events. Floodwaters can then infiltrate where soils and vegetation work to clean and store flood water before it is returned at some future time to the stream course. Floodwater stored in floodplains extends the benefits of floods into periods of drought by slowly releasing water and improving the consistency of river base flows. In contrast, streams without easy access to their floodplain because of entrenchment or artificial confinement, accelerate flow, erosion and the accumulation of sediments during high flow events. Straightened and entrenched channels with easily eroded streambanks that lack roughness (e.g. logs, backwater, turns, falls) are often disconnected from their floodplains, meaning that it takes large flood events for flood waters to elevate to reach floodplains. High stream flows carried by these channels tend to cause further erosive damage to the channel and streambanks and further mobilize sediments and stored nutrients reducing water quality.

The Mora River and its tributaries are not adequately connected to their floodplains in numerous locations because of past streambank erosion, loss of riparian vegetation, stream entrenchment and confinement by roads, train tracks and acequias. Six miles of the river channel was identified as needing restoration of floodplain connectivity; this is likely an underestimate.

Restoration of appropriate stream geomorphology, in-channel obstacles and riparian vegetation can help reconnect streams to their floodplains or enable the development of a new floodplain. This can be accomplished with the following restoration activities:

- **Provide Floodwater Overflow Areas** – At appropriate locations, excavate flood water relief areas to former floodplains or install rock or log structures that raise water levels enough to enable overbank flooding.

- **Relocate River Channel** – River channel locations naturally change over time but occasionally they move in response to flood events or are artificially moved when infrastructures are added. Sometimes changes in the channel location result in the disconnection of a channel from its floodplain because of straightening, confinement or entrenchment. A common example of this is during a flood event, a stream channel may move to an adjacent irrigation ditch which is inherently straight and entrenched. The new stream course is now disconnected from its active floodplain. The confinement of a river channel with road construction is another common example. To restore floodplain connectivity it is possible to relocate the stream back to its abandoned channel or move it away from damaging infrastructure. While this can be expensive and challenging, it may be the only solution in some circumstances.

- **Remove or Relocate Infrastructure that Unnecessarily Confines Stream Flow** - Roads, train tracks and acequias confine the Mora River and its tributaries, disconnecting the channel from its floodplain in many areas. In areas with only minor confinement, usually by irrigation ditches or unimproved ranch roads, explore the possibility of relocating the infrastructure to eliminate confinement and enable flooding. Most other infrastructures (major roads and train tracks) that confine the Mora River and smaller streams will be difficult and cost-prohibitive to remove or relocate.

- **Arrest and Reverse Channel Incision** with grade control structures that also provide instream channel roughness (e.g. one rock dams, cross-vanes and J-hooks that create falls and pools) and streambank erosion control structures (baffles, vanes) and riparian vegetation.

- **Increase Channel Roughness** - Restore channel structures that slow water flow and encourage its flooding onto the floodplain. Such structures include: instream woody debris, falls and pools constructed with logs and boulders, induced meanders and streambank riparian vegetation.

These types of restoration activities require the expertise of river and floodplain restoration specialists and should not be attempted without that consultation. Specific evaluation, design and implementation of restoration activities is complex and if done without expertise can be more harmful than restorative.

Restore Streambank and Channel Characteristics

Streambank and channel characteristics of ephemeral, intermittent and perennial drainages affect the production, accumulation, chemical breakdown and transportation of sediments, so affect water quality especially related to nutrients. The ability of water courses to balance the dynamic processes of degradation and aggradation depends on their physical and geomorphic characteristics (channel shape). Geomorphic characteristics that are appropriate for each drainage type enables a channel to moderate delivery of new sediments and balance sediment storage and transportation. Streams continually adjust their channel shape and their position in the valley to manage the sediment inputs and these natural adjustments do not always create the best channel conditions (e.g. stream entrenchment) if a channel is overloaded with sediments and lacks the structure to manage them.

Physical and chemical interactions also occur in the hyporheic zone (the region beneath and alongside a streambed) that affects the assimilation of nitrogen through biotic and abiotic mechanisms (Gomez-Velez, 2015). Streambank and channel conditions affect the circulation of water through the hyporheic zone hence nitrogen regulation.

The balance of sediment handling has been upset in the lower Mora River and its tributaries both from excessive sediment inputs and the inability of over-widened channels to move those sediments through the system, hence their accumulation. This imbalance has contributed to excessive nutrients in stream water.

Degraded channel characteristics documented in the lower Mora Watershed include: streambank erosion, channel headcuts, channel incision (aka entrenchment), over-wide channels, sediment laden streambeds, straightened channels and a lack of instream structures like woody debris, falls, pools, and riffles.

Techniques to restore suitable streambank and instream characteristics that help channels manage sediments and best function to regulate nutrient loads have recently become more sophisticated, widely used and effective. The goals and applicable restorative techniques are explained below.

- Arrest and Reverse Streambank Erosion – Use locally appropriate techniques that mimic and restore naturally occurring stream features to arrest and repair streambank erosion. Employ the site specific appropriate techniques to stop streambank erosion where it exceeds acceptable levels. This can be done with installation of baffles, vanes, willow fascines, woody debris and rock bank protection structures or other techniques to deflect stream energy away from eroding banks.

- Arrest and Reverse Channel Incision - Use locally appropriate techniques that mimic and restore naturally occurring stream features to arrest and repair channel headcuts and incision. Structures that help with this include: cross vanes, J-hooks, Zuni-bowls, run downs, or adding streambank woody vegetation with root systems that anchor the channel bottom.

- Reduce Stream Width – In areas where channels are over-wide and excessively shallow (hence accumulating sediments), reduce stream width with cross vanes, baffles, J-hooks and structures that arrest streambank erosion that are causing over-widening.

- Increase Channel Sinuosity – Employ induced meandering techniques (Zeedyk W. D., 2009) to reinstate natural sinuosity appropriate to the stream type. Channel sinuosity improves stream connection to its floodplain and slows water flow to facilitate infiltration into floodplain soils.

- Enhance Instream Obstacles and Diversity – Instream structural diversity like deep pools and falls, large cobble riffles, large woody debris, side channels and backwater offer critical habitats for aquatic organisms, slow water flow and encourage overbank flooding. Many of these obstacles have been lost overtime with straightened, entrenched or over-widened channels. Restoring these features to stream channels with structures like cross-vanes, J-hooks, woody debris jams, willow baffles and many others. Strategic addition of these structures can also accomplish stream channel, streambank and floodplain restoration needs.

As with restoration work to reconnect streams with their floodplains, restoring streambank and channel conditions requires assistance from river restoration specialists.

Wetland Restoration and Enhancement

Wetlands and their associated riparian habitats have vital ecological, economic, aesthetic and cultural value. They serve many essential ecosystem functions including water purification and storage, erosion control, sediment storage, pollution control, nutrient cycling, carbon storage and critical habitat for many different plants and animals. They are one of the most effective watershed features at capturing, sequestering and breaking down sediments and nutrients. Their overall importance is vastly disproportionate to their limited occurrence in this arid region. They collect water during flood events (reducing flood damage), store that water and then slowly release it during dry periods. Much of the stored water in wetlands is underground where it is protected from evaporation; this subsurface storage reservoir is particularly important in dry periods and can help recharge river and wetland surface water. During drought, well vegetated wetlands often provide the only available water for livestock and wildlife since even river courses like the Mora River stop flowing. The biological breakdown of nutrients and other pollutants that occurs in wetlands is significant. Carbon sequestration in wetlands is higher than in most other environments. Especially in our arid environment, wetlands provide extremely productive habitat to support fish, wildlife and invertebrates.

Wetland types found in the lower Mora Watershed include palustrine, lacustrine, riverine and playas. Other than the Mora River and its tributaries, the National Wetlands Inventory has only listed 1,778 wetlands in this large area. There are an estimated 1,500 acres of playas and 5,500 acres of other wetland types, representing 2% of the lower Mora Watershed landscape. Since wetlands are so rare across the lower Mora landscape and their functions are so vital, they are all critical.

In spite of their value, wetlands have and continue to be lost nationally and locally. In the lower Mora Watershed, wetlands have been historically drained for agricultural and domestic land uses. They have become degraded from livestock overgrazing. They have become dewatered when river channels become straightened, entrenched and disconnected from their floodplains. And, as an unintentional consequence, they have been lost when the Mora River and its tributaries have been confined by infrastructure like roads and train tracks.

Recreating lost wetlands and restoring full functionality to degraded wetlands would yield considerable gains in reducing excessive nutrients in water courses and would improve overall watershed health. Beyond protecting all existing wetlands (discussed in the section on Critical Area Protection, page 103) and Supporting and Managing Beaver (see page 102), recreating and restoring wetlands should receive a high priority for action in all suitable locations.

- **Recreate Wetlands** – Recreating wetlands associated with river courses may be the most practical means of recreating wetlands that have been historically lost. This type of restoration can often occur simultaneously with reconnecting rivers to their floodplains (see page 110) and restoring streambank and channel characteristics (see page 111). Arresting and healing gullies also offers another such opportunity to create small wetlands and wet meadows (see page 107). Thoughtful decommissioning of dysfunctional dirt tanks (see page 99) may also be another opportune location for recreating viable wetlands since some of the dirt work has already been done.

  Locations appropriate for recreating wetlands must consider adequate hydrology and potential conflicts with existing or likely future land uses. Since the lower Mora Watershed is largely undeveloped, many good locations still exist for wetland re-creation and numerous landowners are supportive. Experts are usually required to effectively recreate wetlands.

- **Restore Existing Wetland Function** – Beyond remedying the cause of wetland degradation, wetland restoration is focused on restoring hydrologic connectivity, intact soils and appropriate vegetative cover. Water flow into and through wetlands at least for a part of the year is needed to maintain wetland functions. Wetlands damaged by excessive hoof action (soil that is bare, pedestalled, pitted, hummocked or compacted) may need rewetting and replanting with sod or plugs. Abundant native wetland vegetation should be replanted to cover or naturally recolonize all riparian wetland areas. Planting native vegetation that is specific to the wetland type is needed. Assistance from wetland restoration specialists is likely required for this restoration.

- **Playa Specific Measures** - Playas (shallow, seasonal wetlands with no outlets that occur in arid environments) are valuable for aquifer recharge, capturing and storing sediments and as unique wildlife habitat. 43 playas are known to occur in the lower Mora Watershed. Playas are excellent candidates for protection from land uses that convert them to other types or dewater and degrade them. Recommended playa restoration and management measures include (see Playa Lakes Joint Venture for more information – www.pljv.org):
    - Create a 100' native grass buffer around all perimeters. This buffer should be fenced if the area is grazed. The buffer area can have carefully managed high-intensity, short-duration grazing.
    - Fill in artificially dug pits inside playas that were dug to collect extra water for livestock. These pits reduce recharge and natural hydrologic function.
    - Restore native vegetation around the perimeter of playas that has been used to grow farm crops.
    - Stem sediment flow into playas from nearby arroyos with vegetation or rock filter structures.
    - Reduce or eliminate infrastructure within a minimum of 100' of playa perimeters to protect their function and wildlife use.

Conservation Programs, Planning, Policies and Regulatory Measures

Many programs, planning efforts, policies and regulations exist that facilitate implementing the Management and Restoration Measures described above. They should be pursued to increase the incentives, financial support and long-term strength of recommended and planned MRMs. These tools are not associated with load reductions but are an integral part of accomplishing those MRMs. Here is a brief summary of those existing tools and new tools that need to be developed:

Programs

- **EXISTING - Conservation Easements** – Ecologically valuable, undeveloped and working lands (rangeland and agricultural lands) can be protected from future developments by placing them in a Conservation Easement. Land trust organizations facilitate and oversee the development and maintenance of Conservation Easements with private landowners. The New Mexico Land Conservancy and the Santa Fe Conservation Trust both work in the lower Mora Watershed and can help. Pursue Conservation Easements with interested landowners to provide the incentives to protect and maintain natural areas. Land parcels with wetlands, including playas, rivers, streams and their riparian areas are most important to secure with Conservation Easements.

- **EXISTING - Wetland Mitigation Banking** – A wetland mitigation bank is a site where wetlands are restored, created, enhanced, or preserved, expressly for the purpose of providing compensatory mitigation in advance of unavoidable impacts to wetlands or other aquatic resources. Mitigation wetlands can be offered to governmental agencies (e.g. NM Department of Transportation) or private individuals that are required by law to mitigate lost wetlands with improved wetlands elsewhere. Wetlands provided as mitigation must be protected by a Conservation Easement or other approved protection measure. Wetland mitigation is governed by the Clean Water Act, Section 404 Compensatory Mitigation Requirements administered by the U.S. Army Corps of Engineers. To facilitate this process, it is recommended that a list of wetlands in the lower Mora Watershed that are potentially suitable to offer for mitigation purposes be developed.

- EXISTING - **Funding Incentives** – Funding to support improved land management or restoration is available through a number of programs to enable this work by private landowners, nonprofits or other entities. Funds available to landowners and other conservation-minded organizations that might be pursued include (also see the Implementation Strategy and Schedule section on page 141):

    - NMED Clean Water Act section 319 On-the-Ground Improvement Projects;
    - Natural Resource Conservation Service including Wildlife Habitat Incentives Program, Environmental Quality Incentives Program and Wetlands Reserve Enhancement Program (available to private landowners);
    - Soil and Water Conservation District funding (Tierra y Montes and Mora-Wagon Mound SCWD)(available to private landowners);
    - US Fish and Wildlife Service Partners for Fish & Wildlife Program (available to private landowners);
    - New Mexico Water Trust Board support for Restoration and Management of Watersheds and Flood Prevention Projects;
    - North American Wetlands Conservation Act (small and large grants) administered by the US Fish and Wildlife Service.

Planning

- EXISTING - **Regional Water Plan** - The Mora-San Miguel-Guadalupe Regional Water Plan (Daniel B. Stephens & Associates, 2005) is currently undergoing an update (slated for completion at the end of 2016). A Watershed Subcommittee (Hermit's Peak Watershed Alliance is the committee chair) is providing feedback to the update process that would broaden watershed management, restoration and protection activities beyond what was covered in the 2005 plan. Updates related to watershed health will hopefully include the full suite of watershed improvement activities that are needed to improve water quality and overall watershed health in the lower Mora Watershed and adjoining watersheds in the three-county region. Among other things, the Regional Water Plans provide guidance to the NM Water Trust Board in funding effective water projects for this region.

- EXISTING - **County Planning** – While both San Miguel and Mora County have existing comprehensive land use plans, they do not adequately address the full suite of policies and strategies needed to improve and sustain healthy watersheds in the lower Mora Watershed. In updates to those plans, it is recommended that the management and restoration measures included in this WBP be incorporated in their water and natural resources sections. See San Miguel County Comprehensive Plan (2004) – http://www.smcounty.net/_WebDocs/_Planning&ZoningDocs/Comprehensive%20Plan%202003-14.pdf, and Mora County Comprehensive Land Use Plan (2009). Floodplain management and planning activities aimed at reducing flood damages would benefit by incorporating stream and floodplain restoration activities included in this WBP.

- **NEW - Establish Riparian Buffers Recommendations** – No locally recognized riparian buffers are included in county or municipal regulations, policies or plans, nor are there accepted Best Management Practices to guide riparian activities in these buffers. Develop recommended riparian buffer widths and allowable and recommended management practices in riparian areas to serve as guidelines for planning documents, local regulations, or private and public land management plans.

- **NEW – Watershed-Friendly Road Assessments and Modification Planning** – Collaboration with State and County Road Departments is needed to assess road systems and plan needed modifications to accommodate watershed functions, processes and characteristics. Assessment and improvements that are needed include providing adequate vegetated buffers between streams and roads, determining water course and road drainage conflicts and locating erosion caused by road locations and construction.

Policies and Regulations

Work with various government entities and elected officials to improve upon regulations and policies as they pertain to protection and restoration of water courses, riparian areas and wetlands. Pertinent regulatory and management guidelines include:

- EXISTING - **Mora and San Miguel County Floodplain Ordinances** – Pursue floodplain ordinance improvements that ensure floodplain building rules adequately protect floodplains from development, Include riparian area buffer requirements to all new developments, andrecognize stream and floodplain restoration described in this WBP as a means of naturally attenuating floods and managing floodplains for their inherent purpose.

- EXISTING - San Miguel and Mora County road construction and maintenance standards and practices - include road specifications and maintenance standards with adequately sized culverts, drainage, road crossings or bridges that do not affect riparian vegetation, streambanks, or wetlands. Include vegetated stream buffers and drainage that is directed through areas with vegetated filter zones.
- EXISTING - San Miguel County regulations (SMC-07-13-99-ORD-3 Sand and Gravel Mining Ordinance) adopted in 1999 govern sand and gravel mining operations and reclamation for operations that exceed 0.5 acres in any five continuous years. No comparable ordinances exist in Mora County. At the state level, NM Energy, Minerals and Natural Resources Department, Mining and Minerals Division, regulate mining in NM under the New Mexico Mining Act, however, sand, gravel, stone and aggregate mining is exempt from state regulations and no permit is required.

Management and Restoration Measure Priorities and Associated Load Reductions

During the course of this project, a list of potentially effective, practical and available (willing landowners) Management and Restoration projects has been assembled that are ready for implementation providing the availability of funding. This list forms the basis of anticipated load reductions detailed in this section. To protect landowner privacy and not prematurely obligate landowners to projects before funding is secured, this list is kept internally but can be made available to specific organizations interested in securing funding for implementation. In order to prioritize and monitor watershed treatments to improve water quality, this section presents anticipated reductions in nitrogen and phosphorus as a result of implementing MRMs contained in that internal list.

A comprehensive list of MRMs that can reduce nitrogen and phosphorus loads is provided in Appendix C. Management and Restoration Measure Efficiencies. There, they are ranked with Management and Restoration Measure Efficiency estimates (Estimated Load Reduction percentages). Those rankings form the basis of anticipated Actual Load Reductions listed in Table 20- MRMs to Achieve Total Nitrogen Load Reductions on Priority Reaches and Table 21- MRMs to Achieve Total Phosphorus Load Reductions on Priority Reaches.

Based on literature review and professional judgment, the Management and Restoration Measures that were expected to result in the highest efficiencies of reducing nutrient loads (efficiencies of 70% and greater) in decreasing order of efficiency are: developing and implementing Riparian and Watershed Sensitive Grazing Plans and tools, especially riparian fencing; wetland recreation and restoration; riparian vegetation restoration; creating natural vegetation buffer strips between agriculture fields and infrastructure and water courses; reconnecting drainages to their floodplains, arresting and healing streambank erosion; and supporting and managing beaver.

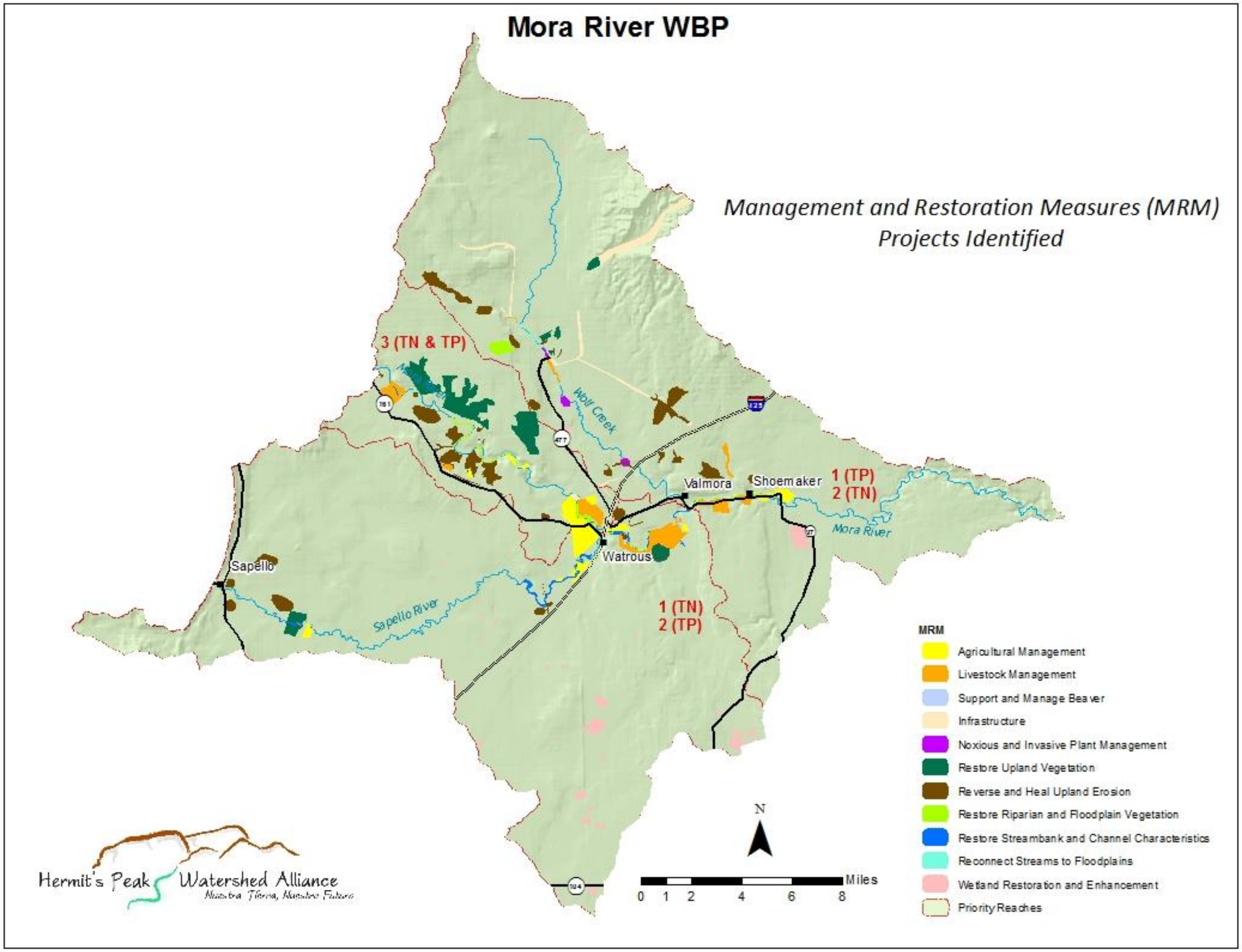
Each priority reach was evaluated using hydrologic and nutrient modeling, field assessments, consultant input and information gleaned from landowner interviews to determine the most effective and most applicable MRMs needed for each reach. Priority reaches were identified by determining which reaches have the highest nutrient loadings and require the most load reductions to meet the TMDL target load (see Table 19).

The projects identified in Table 20 and Table 21 will drive work that occurs during implementation of this plan and projects will be pursued in that order of priority. However, in order to begin engaging a number of landowners early on, projects may be spread out over numerous stream segments to some extent. Table 20 and 21 list all identified projects by scientific priority reach, or the section of river which requires the most nutrient remediation. The tables also list the MRMs identified to address nutrient impairment, the efficiency of the MRMs to remediate TN and TP, and the total load reduction that would result from implementation of the MRMs.

Through field monitoring, landowner and agency interviews, restoration consultant expertise and remote sensing imaging, more than 22,000 acres of management and restoration measure projects were identified (see Map 16). By selecting projects with the highest MRM efficiencies the greatest feasibility and those with willing landowners, those projects were narrowed down to approximately 10,000 acres of specific MRM projects. The following tables include more MRM projects than are necessary to reduce the TN and TP load of the Mora River (see Load Reduction Required and Total Load Reduction columns) in order to allow flexibility while implementing this plan, to account for variables such as future landowner willingness, land management changes and funding.

While the identified projects listed in Table 20 and 21 are grouped by scientific or technical priority, other factors such as landowner willingness, practicality and cost will affect the order in which these projects are implemented. For privacy purposes, HPWA will not disclose the names of willing landowners, however, the majority of the projects listed below have landowners who are eager to implement management and restoration measures on their property. While at the time of this plan's publication HPWA has identified the following projects to be practical, to have willing landowners and to be cost effective, however, many factors such as land changing ownership can affect the implementation of projects in the future. As the projects listed in Table 20 and 21 will be completed over 16 years (see section Implementation Strategy and Schedule), landowner willingness, cost and practicality will need to be reevaluated as each phase of implementation commences.

Table 22 contains a list of the cost-benefit priority of all MRM projects. Each MRM and associated land use type is listed along with the load reduction per acre for TN and TP as well as the cost per acre for implementing the MRM. The two final columns show the priority of the MRM in reference to the cost benefit ratio. This table is meant to help prioritize which projects to implement of those listed in Tables 20 and 21.



Map 16- Identified MRM Projects

Table 20- MRMs to Achieve Total Nitrogen Load Reductions on Priority Reaches

Priority	Reach ID	BASINS TN Load (lbs/day)	TN Load Reduction Required (lbs/day)	MRM	Land Use	MRM Efficiency	TN Load Reduction (lbs/acre/day)	Acres	TN Load Reduction (lbs/day)
1	Reach 5 (Mora below confluence with Sapello, above Wolf Creek)	**3.211**	**1.46**	Agricultural management	AGRICULTURE	0.75	3.47E-03	121.1	**4.21E-01**
				Arrest and heal arroyos (gullies)	AGRICULTURE	0.5	2.32E-03	135	**3.13E-01**
				Arrest and heal streambank erosion	AGRICULTURE	0.7	3.24E-03	11.5	**3.74E-02**
				Arrest and reverse channel incision	AGRICULTURE	0.4	1.85E-03	36.1	**6.69E-02**
				Enhance instream obstacles and diversity for aquatic organisms	AGRICULTURE	0.25	1.16E-03	7.9	**9.16E-03**
				Increase channel sinuosity	AGRICULTURE	0.25	1.16E-03	3.7	**4.32E-03**
				Restore riparian and floodplain vegetation	AGRICULTURE	0.8	3.70E-03	42.5	**1.57E-01**
				Restore sand, gravel, stone mining pits	AGRICULTURE	0.1	4.63E-04	21.3	**9.85E-03**
				Riparian and watershed sensitive grazing plans	AGRICULTURE	0.8	3.70E-03	106	**3.93E-01**
				Arrest and heal streambank erosion	AGRICULTURE	0.7	3.24E-03	53	**1.72E-01**
				Restore plant cover and soil health	AGRICULTURE	0.5	2.32E-03	339.1	**7.85E-01**
				Support and manage beaver	AGRICULTURE	0.7	3.24E-03	19.9	**6.44E-02**
				Arrest and heal arroyos (gullies)	FOREST	0.5	3.70E-05	2.7	**1.00E-04**
				Arrest and heal streambank erosion	FOREST	0.7	5.18E-05	2.7	**1.39E-04**
				Arrest and reverse channel incision	FOREST	0.4	2.96E-05	51.3	**1.52E-03**
				Increase channel sinuosity	FOREST	0.25	1.85E-05	6.6	**1.21E-04**
				Restore appropriate piñon-juniper densities and distribution	FOREST	0.25	1.85E-05	216.2	**4.00E-03**
				Restore plant cover and soil health	FOREST	0.5	3.70E-05	3.2	**1.18E-04**
				Restore riparian and floodplain vegetation	FOREST	0.8	5.92E-05	2.6	**1.52E-04**
				Riparian and watershed sensitive grazing plans	FOREST	0.8	5.92E-05	108.9	**6.45E-03**
				Support and manage beaver	FOREST	0.7	5.18E-05	1.8	**9.20E-05**

Priority	Reach ID	BASINS TN Load (lbs/day)	TN Load Reduction Required (lbs/day)	MRM	Land Use	MRM Efficiency	TN Load Reduction (lbs/acre/ day)	Acres	TN Load Reduction (lbs/day)
				Arrest and heal arroyos (gullies)	RANGE	0.5	1.22E-04	157.8	**1.92E-02**
				Arrest and heal streambank erosion	RANGE	0.7	1.71E-04	4.4	**7.59E-04**
				Arrest and reverse channel incision	RANGE	0.4	9.75E-05	69.7	**6.80E-03**
				Enhance instream obstacles and diversity for aquatic organisms	RANGE	0.25	6.10E-05	2.9	**1.79E-04**
				Increase channel sinuosity	RANGE	0.25	6.10E-05	40.9	**2.49E-03**
				Restore riparian and floodplain vegetation	RANGE	0.8	1.95E-04	40.1	**7.83E-03**
				Restore sand, gravel, stone mining pits	RANGE	0.1	2.44E-05	32.8	**8.00E-04**
				Water development	RANGE	0.25	6.10E-05	16.4	**1.00E-03**
				Playa restoration	RANGE	0.1	2.44E-05	493.4	**1.20E-02**
				Wetland restoration and enhancement	RANGE	0.8	1.95E-04	19.5	**3.81E-03**
				Agricultural management	RANGE	0.75	1.83E-04	171	**3.13E-02**
				Arrest and heal soil surface erosion	RANGE	0.4	9.75E-05	84	**8.20E-03**
				Reconstruct irrigation diversions	RANGE	0.2	4.88E-05	0.6	**2.75E-05**
				Wetland restoration and enhancement	URBAN	**0.8**	8.53E-03	4	**3.38E-02**
				Management and Restoration Measures Total					**2.57E+00**
2	Reach 4 (Mora below confluence with Wolf Creek)	**3.175**	**1.424**	Agricultural management	AGRICULTURE	0.75	3.47E-03	270.8	**9.40E-01**
				Arrest and heal arroyos (gullies)	AGRICULTURE	0.5	2.32E-03	0.1	**1.59E-04**
				Arrest and heal streambank erosion	AGRICULTURE	0.7	3.24E-03	0.4	**1.32E-03**
				Arrest and reverse channel incision	AGRICULTURE	0.4	1.85E-03	4.5	**8.40E-03**
				Restore riparian and floodplain vegetation	AGRICULTURE	0.8	3.70E-03	21	**7.79E-02**
				Restore streambank and channel	AGRICULTURE	0.4	1.85E-03	0.3	**5.78E-04**

Priority	Reach ID	BASINS TN Load (lbs/day)	TN Load Reduction Required (lbs/day)	MRM	Land Use	MRM Efficiency	TN Load Reduction (lbs/acre/day)	Acres	TN Load Reduction (lbs/day)
				characteristics					
				Riparian and watershed sensitive grazing plans	AGRICULTURE	0.8	3.70E-03	78.8	**2.92E-01**
				Support and manage beaver	AGRICULTURE	0.7	3.24E-03	27	**8.77E-02**
				Wetland restoration and enhancement	AGRICULTURE	0.8	3.70E-03	0.4	**1.59E-03**
				Restore sand, gravel, stone mining pits	BARREN	0.1	7.34E-04	58.6	**4.31E-02**
				Arrest and heal soil surface erosion	BARREN	0.4	2.94E-03	60.3	**1.77E-01**
				Restore plant cover and soil health	BARREN	0.5	3.67E-03	26.3	**9.66E-02**
				Arrest and heal arroyos (gullies)	FOREST	0.5	3.70E-05	106	**3.92E-03**
				Arrest and heal soil surface erosion	FOREST	0.4	2.96E-05	128.9	**3.81E-03**
				Decommission unused/ineffective dirt tanks	FOREST	0.1	7.40E-06	151.8	**1.12E-03**
				Restore appropriate piñon-juniper densities and distribution	FOREST	0.25	1.85E-05	174.6	**3.23E-03**
				Road improvements	FOREST	0.5	3.70E-05	197.5	**7.31E-03**
				Arrest and heal soil surface erosion	RANGE	0.4	9.75E-05	868	**8.47E-02**
				Decommission unused/ineffective dirt tanks	RANGE	0.1	2.44E-05	18.5	**4.51E-04**
				Reconstruct irrigation diversions	RANGE	0.2	4.88E-05	5.9	**2.86E-04**
				Restore riparian and floodplain vegetation	RANGE	0.8	1.95E-04	86.3	**1.68E-02**
				Riparian and watershed sensitive grazing plans	RANGE	0.8	1.95E-04	418.8	**8.17E-02**
				Riparian fencing	RANGE	0.8	1.95E-04	120.2	**2.35E-02**
				Playa restoration	RANGE	0.1	2.44E-05	432	**1.05E-02**
				Wetland restoration and enhancement	RANGE	0.8	1.95E-04	7.1	**1.38E-03**
				Arrest and heal arroyos (gullies)	RANGE	0.5	1.22E-04	80.7	**9.84E-03**

Priority	Reach ID	BASINS TN Load (lbs/day)	TN Load Reduction Required (lbs/day)	MRM	Land Use	MRM Efficiency	TN Load Reduction (lbs/acre/ day)	Acres	TN Load Reduction (lbs/day)
				Noxious and invasive plant management	RANGE	0.25	6.10E-05	170.5	**1.04E-02**
				Reconnect streams to floodplains	RANGE	0.75	1.83E-04	70.1	**1.28E-02**
				Reduce conifer encroachment in riparian areas	RANGE	0.1	2.44E-05	260.4	**6.35E-03**
				Restore plant cover and soil health	RANGE	0.5	1.22E-04	61.6	**7.51E-03**
				Restore sand, gravel, stone mining pits	RANGE	0.1	2.44E-05	50.3	**1.23E-03**
				Road improvements	RANGE	0.5	1.22E-04	715.9	**8.73E-02**
				Management and Restoration Measures Total					**2.10E+00**
3	Reach 2 (above confluence of Sapello)	**2.919**	**1.168**	Agricultural management	AGRICULTURE	0.75	3.47E-03	86	**2.99E-01**
				Reconnect streams to floodplains	AGRICULTURE	0.75	3.47E-03	26.9	**9.33E-02**
				Restore riparian and floodplain vegetation	AGRICULTURE	0.8	3.70E-03	55.3	**2.05E-01**
				Riparian and watershed sensitive grazing plans	AGRICULTURE	0.8	3.70E-03	96	**3.56E-01**
				Restore sand, gravel, stone mining pits	BARREN	0.1	7.34E-04	10.3	**7.58E-03**
				Arrest and heal arroyos (gullies)	FOREST	0.5	3.70E-05	437	**1.62E-02**
				Arrest and heal soil surface erosion	FOREST	0.4	2.96E-05	120.6	**3.57E-03**
				Arrest and heal streambank erosion	FOREST	0.7	5.18E-05	1.8	**9.09E-05**
				Restore appropriate piñon-juniper densities and distribution	FOREST	0.25	1.85E-05	423	**7.82E-03**
				Restore riparian and floodplain vegetation	FOREST	0.8	5.92E-05	112.4	**6.65E-03**
				Riparian and watershed sensitive grazing plans	FOREST	0.8	5.92E-05	374.9	**2.22E-02**
				Road improvements	FOREST	0.5	3.70E-05	45.9	**1.70E-03**
				Wetland restoration and	FOREST	0.8	5.92E-05	1.5	**8.93E-05**

Priority	Reach ID	BASINS TN Load (lbs/day)	TN Load Reduction Required (lbs/day)	MRM	Land Use	MRM Efficiency	TN Load Reduction (lbs/acre/day)	Acres	TN Load Reduction (lbs/day)
				enhancement					
				Agricultural management	RANGE	0.75	1.83E-04	39.9	**7.30E-03**
				Arrest and heal arroyos (gullies)	RANGE	0.5	1.22E-04	277.8	**3.39E-02**
				Arrest and heal streambank erosion	RANGE	0.7	1.71E-04	0.5	**8.30E-05**
				Arrest and reverse channel incision	RANGE	0.4	9.75E-05	1.5	**1.47E-04**
				Enhance instream obstacles and diversity for aquatic organisms	RANGE	0.25	6.10E-05	17	**1.03E-03**
				Noxious and Invasive Plant Management	RANGE	0.25	6.10E-05	20	**1.22E-03**
				Reconnect streams to floodplains	RANGE	0.75	1.83E-04	16.4	**3.00E-03**
				Reconstruct irrigation diversions	RANGE	0.2	4.88E-05	26.1	**1.27E-03**
				Restore riparian and floodplain vegetation	RANGE	0.8	1.95E-04	12.4	**2.42E-03**
				Restore sand, gravel, stone mining pits	RANGE	0.1	2.44E-05	412.7	**1.01E-02**
				Riparian and watershed sensitive grazing plans	RANGE	0.8	1.95E-04	475.1	**9.27E-02**
				Road improvements	RANGE	0.5	1.22E-04	11.6	**1.41E-03**
				Support and manage beaver	RANGE	0.7	1.71E-04	7.3	**1.24E-03**
				Wetland restoration and enhancement	RANGE	0.8	1.95E-04	8.7	**1.70E-03**
				Restore sand, gravel, stone mining pits	URBAN	0.1	1.07E-03	47.1	**5.02E-02**
				Management and Restoration Measures Total					**1.23E+00**

Table 21- MRMs to Achieve Total Phosphorus Load Reductions on Priority Reaches

Priority	Reach ID	BASINS TP Load (lbs/day)	TP Load Reduction Required (lbs/day)	MRM	Land Use	MRM Efficiency	TP Load Reduction (lbs/acre/day)	Acres	TP Load Reduction (lbs/day)
1	Reach 4 (Mora River below confluence with Wolf Creek)	**0.348**	**0.209**	Agricultural management	AGRICULTURE	0.75	5.014E-04	270.8	**1.357E-01**
				Arrest and heal arroyos (gullies)	AGRICULTURE	0.50	3.342E-04	0.1	**2.298E-05**
				Arrest and heal streambank erosion	AGRICULTURE	0.70	4.679E-04	0.4	**1.906E-04**
				Arrest and reverse channel incision	AGRICULTURE	0.40	2.674E-04	4.5	**1.213E-03**
				Restore riparian and floodplain vegetation	AGRICULTURE	0.80	5.348E-04	21.0	**1.125E-02**
				Restore streambank and channel characteristics	AGRICULTURE	0.40	2.674E-04	0.3	**8.348E-05**
				Riparian and watershed sensitive grazing plans	AGRICULTURE	0.80	5.348E-04	78.8	**4.215E-02**
				Support and manage beaver	AGRICULTURE	0.70	4.679E-04	27.0	**1.266E-02**
				Wetland restoration and enhancement	AGRICULTURE	0.80	5.348E-04	0.4	**2.290E-04**
				Restore sand, gravel, stone mining pits	BARREN	0.10	5.233E-05	58.6	**3.069E-03**
				Arrest and heal soil surface erosion	BARREN	0.40	2.093E-04	60.3	**1.262E-02**
				Restore plant cover and soil health	BARREN	0.50	2.616E-04	26.3	**6.881E-03**
				Arrest and heal arroyos (gullies)	FOREST	0.50	3.973E-05	106.0	**4.213E-03**
				Arrest and heal soil surface erosion	FOREST	0.40	3.178E-05	128.9	**4.097E-03**
				Decommission unused/ineffective dirt tanks	FOREST	0.10	7.945E-06	151.8	**1.206E-03**
				Restore appropriate piñon-juniper densities and distribution	FOREST	0.25	1.986E-05	174.6	**3.469E-03**
				Road improvements	FOREST	0.50	3.973E-05	197.5	**7.846E-03**
				Arrest and heal soil surface erosion	RANGE	0.40	1.534E-05	868.0	**1.332E-02**
				Decommission unused/ineffective dirt tanks	RANGE	0.10	3.836E-06	18.5	**7.091E-05**
				Reconstruct irrigation diversions	RANGE	0.20	7.671E-06	5.9	**4.500E-05**
				Restore riparian and floodplain	RANGE	0.80	3.068E-05	86.3	**2.647E-03**

Priority	Reach ID	BASINS TP Load (lbs/day)	TP Load Reduction Required (lbs/day)	MRM	Land Use	MRM Efficiency	TP Load Reduction (lbs/acre/day)	Acres	TP Load Reduction (lbs/day)
				vegetation					
				Riparian and watershed sensitive grazing plans	RANGE	0.80	3.068E-05	418.8	**1.285E-02**
				Riparian fencing	RANGE	0.80	3.068E-05	120.2	**3.688E-03**
				Playa restoration	RANGE	0.10	3.836E-06	432.0	**1.657E-03**
				Wetland restoration and enhancement	RANGE	0.80	3.068E-05	7.1	**2.169E-04**
				Arrest and heal arroyos (gullies)	RANGE	0.50	1.918E-05	80.7	**1.548E-03**
				Noxious and invasive plant management	RANGE	0.25	9.589E-06	170.5	**1.635E-03**
				Reconnect streams to floodplains	RANGE	0.75	2.877E-05	70.1	**2.016E-03**
				Reduce conifer encroachment in riparian areas	RANGE	0.10	3.836E-06	260.4	**9.989E-04**
				Restore plant cover and soil health	RANGE	0.50	1.918E-05	61.6	**1.182E-03**
				Restore sand, gravel, stone mining pits	RANGE	0.10	3.836E-06	50.3	**1.931E-04**
				Road improvements	RANGE	0.50	1.918E-05	715.9	**1.373E-02**
				Management and Restoration Measures Total					**3.027E-01**
2	Reach 5 (Mora below confluence with Sapello, above Wolf Creek)	**0.307**	**0.168**	Agricultural management	AGRICULTURE	0.75	5.014E-04	121.1	**6.072E-02**
				Arrest and heal arroyos (gullies)	AGRICULTURE	0.50	3.342E-04	135.0	**4.512E-02**
				Arrest and heal streambank erosion	AGRICULTURE	0.70	4.679E-04	11.5	**5.393E-03**
				Arrest and reverse channel incision	AGRICULTURE	0.40	2.674E-04	36.1	**9.661E-03**
				Enhance instream obstacles and diversity for aquatic organisms	AGRICULTURE	0.25	1.671E-04	7.9	**1.323E-03**
				Increase channel sinuosity	AGRICULTURE	0.25	1.671E-04	3.7	**6.237E-04**
				Restore riparian and floodplain vegetation	AGRICULTURE	0.80	5.348E-04	42.5	**2.273E-02**

Priority	Reach ID	BASINS TP Load (lbs/day)	TP Load Reduction Required (lbs/day)	MRM	Land Use	MRM Efficiency	TP Load Reduction (lbs/acre/ day)	Acres	TP Load Reduction (lbs/day)
				Restore sand, gravel, stone mining pits	AGRICULTURE	0.10	6.685E-05	21.3	**1.423E-03**
				Riparian and watershed sensitive grazing plans	AGRICULTURE	0.80	5.348E-04	106.0	**5.669E-02**
				Arrest and heal streambank erosion	AGRICULTURE	0.70	4.679E-04	53.0	**2.480E-02**
				Restore plant cover and soil health	AGRICULTURE	0.50	3.342E-04	339.1	**1.134E-01**
				Support and manage beaver	AGRICULTURE	0.70	4.679E-04	19.9	**9.293E-03**
				Arrest and heal arroyos (gullies)	FOREST	0.50	3.973E-05	2.7	**1.078E-04**
				Arrest and heal streambank erosion	FOREST	0.70	5.562E-05	2.7	**1.495E-04**
				Arrest and reverse channel incision	FOREST	0.40	3.178E-05	51.3	**1.629E-03**
				Increase channel sinuosity	FOREST	0.25	1.986E-05	6.6	**1.302E-04**
				Restore appropriate piñon-juniper densities and distribution	FOREST	0.25	1.986E-05	216.2	**4.294E-03**
				Restore plant cover and soil health	FOREST	0.50	3.973E-05	3.2	**1.272E-04**
				Restore riparian and floodplain vegetation	FOREST	0.80	6.356E-05	2.6	**1.632E-04**
				Riparian and watershed sensitive grazing plans	FOREST	0.80	6.356E-05	108.9	**6.922E-03**
				Support and manage beaver	FOREST	0.70	5.562E-05	1.8	**9.878E-05**
				Arrest and heal arroyos (gullies)	RANGE	0.50	1.918E-05	157.8	**3.026E-03**
				Arrest and heal streambank erosion	RANGE	0.70	2.685E-05	4.4	**1.193E-04**
				Arrest and reverse channel incision	RANGE	0.40	1.534E-05	69.7	**1.069E-03**
				Enhance instream obstacles and diversity for aquatic organisms	RANGE	0.25	9.589E-06	2.9	**2.818E-05**
				Increase channel sinuosity	RANGE	0.25	9.589E-06	40.9	**3.918E-04**
				Restore riparian and floodplain vegetation	RANGE	0.80	3.068E-05	40.1	**1.232E-03**
				Restore sand, gravel, stone mining pits	RANGE	0.10	3.836E-06	32.8	**1.259E-04**
				Water development	RANGE	0.25	9.589E-06	16.4	**1.576E-04**

Priority	Reach ID	BASINS TP Load (lbs/day)	TP Load Reduction Required (lbs/day)	MRM	Land Use	MRM Efficiency	TP Load Reduction (lbs/acre/ day)	Acres	TP Load Reduction (lbs/day)
				Playa restoration	RANGE	0.10	3.836E-06	493.4	**1.893E-03**
				Wetland restoration and enhancement	RANGE	0.80	3.068E-05	19.5	**5.996E-04**
				Agricultural management	RANGE	0.75	2.877E-05	171.0	**4.920E-03**
				Arrest and heal soil surface erosion	RANGE	0.40	1.534E-05	84.0	**1.289E-03**
				Reconstruct irrigation diversions	RANGE	0.20	7.671E-06	0.6	**4.320E-06**
				Wetland restoration and enhancement	URBAN	**0.80**	5.085E-04	4.0	**2.018E-03**
				Management and Restoration Measures Total					**3.816E-01**
3	Reach 2 (above confluence of Sapello)	**0.271**	**0.132**	Agricultural management	AGRICULTURE	0.75	5.014E-04	86.0	**4.312E-02**
				Reconnect streams to floodplains	AGRICULTURE	0.75	5.014E-04	26.9	**1.347E-02**
				Restore Riparian and Floodplain vegetation	AGRICULTURE	0.80	5.348E-04	55.3	**2.959E-02**
				Riparian and watershed sensitive grazing plans	AGRICULTURE	0.80	5.348E-04	96.0	**5.134E-02**
				Restore sand, gravel, stone mining pits	BARREN	0.10	5.233E-05	10.3	**5.402E-04**
				Arrest and heal arroyos (gullies)	FOREST	0.50	3.973E-05	437.0	**1.736E-02**
				Arrest and heal soil surface erosion	FOREST	0.40	3.178E-05	120.6	**3.834E-03**
				Arrest and heal streambank erosion	FOREST	0.70	5.562E-05	1.8	**9.762E-05**
				Restore appropriate piñon-juniper densities and distribution	FOREST	0.25	1.986E-05	423.0	**8.402E-03**
				Restore riparian and floodplain vegetation	FOREST	0.80	6.356E-05	112.4	**7.142E-03**
				Riparian and watershed sensitive grazing plans	FOREST	0.80	6.356E-05	374.9	**2.383E-02**
				Road improvements	FOREST	0.50	3.973E-05	45.9	**1.823E-03**

Priority	Reach ID	BASINS TP Load (lbs/day)	TP Load Reduction Required (lbs/day)	MRM	Land Use	MRM Efficiency	TP Load Reduction (lbs/acre/ day)	Acres	TP Load Reduction (lbs/day)
				Wetland restoration and enhancement	FOREST	0.80	6.356E-05	1.5	**9.586E-05**
				Agricultural management	RANGE	0.75	2.877E-05	39.9	**1.149E-03**
				Arrest and heal arroyos (gullies)	RANGE	0.50	1.918E-05	277.8	**5.328E-03**
				Arrest and heal streambank erosion	RANGE	0.70	2.685E-05	0.5	**1.306E-05**
				Arrest and reverse channel incision	RANGE	0.40	1.534E-05	1.5	**2.312E-05**
				Enhance instream obstacles and diversity for aquatic organisms	RANGE	0.25	9.589E-06	17.0	**1.626E-04**
				Noxious and invasive plant management	RANGE	0.25	9.589E-06	20.0	**1.918E-04**
				Reconnect streams to floodplains	RANGE	0.75	2.877E-05	16.4	**4.725E-04**
				Reconstruct irrigation diversions	RANGE	0.20	7.671E-06	26.1	**2.001E-04**
				Restore riparian and floodplain vegetation	RANGE	0.80	3.068E-05	12.4	**3.803E-04**
				Restore sand, gravel, stone mining pits	RANGE	0.10	3.836E-06	412.7	**1.583E-03**
				Riparian and watershed sensitive grazing plans	RANGE	0.80	3.068E-05	475.1	**1.458E-02**
				Road improvements	RANGE	0.50	1.918E-05	11.6	**2.224E-04**
				Support and manage beaver	RANGE	0.70	2.685E-05	7.3	**1.952E-04**
				Wetland restoration and enhancement	RANGE	0.80	3.068E-05	8.7	**2.679E-04**
				Restore sand, gravel, stone mining pits	URBAN	0.10	6.356E-05	47.1	**2.996E-03**
				Management and Restoration Measures Total					**2.284E-01**

Table 22- Cost-benefit analysis of MRM Projects.

MRM	Land Use	TN Load Reduction (lbs/acre/day)	TP Load Reduction (lbs/acre/day)	Cost per acre	Cost Benefit Priority TN	Cost Benefit Priority TP
Support and manage beaver	AGRICULTURE	3.24E-03	4.68E-04	179	1	1
Road improvements	RANGE	1.22E-04	1.92E-05	33	2	3
Restore plant cover and soil health	BARREN	3.67E-03	2.62E-04	1000	3	7
Arrest and heal soil surface erosion	BARREN	2.94E-03	2.09E-04	1000	4	9
Restore plant cover and soil health	AGRICULTURE	2.32E-03	3.34E-04	1000	5	4
Restore riparian and floodplain vegetation	AGRICULTURE	3.70E-03	5.35E-04	2000	6	6
Riparian and watershed sensitive grazing plans	AGRICULTURE	3.70E-03	5.35E-04	2500	7	8
Agricultural management	AGRICULTURE	3.47E-03	5.01E-04	2500	8	10
Arrest and heal arroyos (gullies)	AGRICULTURE	2.32E-03	3.34E-04	2000	9	11
Road improvements	FOREST	3.70E-05	3.97E-05	33	10	2
Support and manage beaver	RANGE	1.71E-04	2.69E-05	179	11	12
Restore sand, gravel, stone mining pits	URBAN	1.07E-03	6.36E-05	2000	12	18
Wetland restoration and enhancement	AGRICULTURE	3.70E-03	5.35E-04	10000	13	13
Restore sand, gravel, stone mining pits	BARREN	7.34E-04	5.23E-05	2000	14	19
Reconnect streams to floodplains	AGRICULTURE	3.47E-03	5.01E-04	9735	15	14
Support and manage beaver	FOREST	5.18E-05	5.56E-05	179	16	5
Restore sand, gravel, stone mining pits	AGRICULTURE	4.63E-04	6.69E-05	2000	17	17
Noxious and invasive plant management	RANGE	6.10E-05	9.59E-06	500	18	24
Reduce conifer encroachment in riparian areas	RANGE	2.44E-05	3.84E-06	200	19	23
Restore plant cover and soil health	RANGE	1.22E-04	1.92E-05	1000	19	23
Restore riparian and floodplain vegetation	RANGE	1.95E-04	3.07E-05	2000	20	25
Arrest and heal soil surface erosion	RANGE	9.75E-05	1.53E-05	1000	21	25
Riparian fencing	RANGE	1.95E-04	3.07E-05	2323	22	26
Arrest and heal streambank erosion	AGRICULTURE	3.24E-03	4.68E-04	39432	23	29
Decommission unused/ineffective dirt tanks	RANGE	2.44E-05	3.84E-06	309	24	27
Riparian and watershed sensitive grazing plans	RANGE	1.95E-04	3.07E-05	2500	25	28
Agricultural management	RANGE	1.83E-04	2.88E-05	2500	26	30

MRM	Land Use	TN Load Reduction (lbs/acre/day)	TP Load Reduction (lbs/acre/day)	Cost per acre	Cost Benefit Priority TN	Cost Benefit Priority TP
Arrest and heal arroyos (gullies)	RANGE	1.22E-04	1.92E-05	2000	27	31
Arrest and reverse channel incision	AGRICULTURE	1.85E-03	2.67E-04	39432	28	32
Restore streambank and channel characteristics	AGRICULTURE	1.85E-03	2.67E-04	39432	28	32
Restore appropriate piñon-juniper densities and distribution	FOREST	1.85E-05	1.99E-05	400	29	15
Restore plant cover and soil health	FOREST	3.70E-05	3.97E-05	1000	30	16
Arrest and heal soil surface erosion	FOREST	2.96E-05	3.18E-05	1000	31	18
Restore riparian and floodplain vegetation	FOREST	5.92E-05	6.36E-05	2000	31	18
Enhance instream obstacles and diversity for aquatic organisms	AGRICULTURE	1.16E-03	1.67E-04	39432	31	34
Increase channel sinuosity	AGRICULTURE	1.16E-03	1.67E-04	39432	31	34
Decommission unused/ineffective dirt tanks	FOREST	7.40E-06	7.95E-06	309	32	20
Riparian and watershed sensitive grazing plans	FOREST	5.92E-05	6.36E-05	2500	33	21
Wetland restoration and enhancement	RANGE	1.95E-04	3.07E-05	10000	34	35
Reconnect streams to floodplains	RANGE	1.83E-04	2.88E-05	9735	35	36
Arrest and heal arroyos (gullies)	FOREST	3.70E-05	3.97E-05	2000	36	22
Restore sand, gravel, stone mining pits	RANGE	2.44E-05	3.84E-06	2000	37	37
Wetland restoration and enhancement	FOREST	5.92E-05	6.36E-05	10000	38	33
Reconstruct irrigation diversions	RANGE	4.88E-05	7.67E-06	9091	39	39
Playa restoration	RANGE	2.44E-05	3.84E-06	5000	40	41
Arrest and heal streambank erosion	RANGE	1.71E-04	2.69E-05	39432	41	42
Arrest and reverse channel incision	RANGE	9.75E-05	1.53E-05	39432	42	44
Enhance instream obstacles and diversity for aquatic organisms	RANGE	6.10E-05	9.59E-06	39432	43	45
Increase channel sinuosity	RANGE	6.10E-05	9.59E-06	39432	43	45
Arrest and heal streambank erosion	FOREST	5.18E-05	5.56E-05	39432	44	38
Arrest and reverse channel incision	FOREST	2.96E-05	3.18E-05	39432	45	40
Increase channel sinuosity	FOREST	1.85E-05	1.99E-05	39432	46	43

Financial Benefits to Landowners

Beyond improving water quality and overall watershed health which benefit entire communities, most of the MRMs recommended in this plan improve long-term productivity and resilience of the land. These improvements are also anticipated to yield economic or other intrinsic benefits to landowners although enumerating them has not been attempted in this project. Economic benefits to landowners are expected to be:

- Increased forage production through soil health and plant cover improvements;
- Increased acreage of productive land by restoring unproductive eroded areas;
- A more consistent income through periods of drought or other natural disturbances;
- A potentially more diverse income source (from recreational sources like hunting, fishing, bird-watching, or new agricultural products) which builds resilience.

Intrinsic benefits to private landowners are expected to be:

- Improved aesthetic quality;
- A sense of contributing to overall land and water health;
- Increased land stewardship knowledge, personal investment and satisfaction;
- Contributing a healthy land base to future generations.

Additionally, motivation for landowners to implement recommended MRMs may be the availability of outside funds for assistance. The Funding Sources section details a variety of sources of financial support available to private landowners either directly or through cooperating with organizations like HPWA. Some of these funds have landowner matching requirements while others do not.

Financial and Technical Assistance Needed

Funding Needs

In order to implement the recommended Management and Restoration Measures that are needed to reduce lower Mora River nutrient loads to acceptable levels, it is estimated that $33,372,826 over a 16 year period will be required (see Table 23). This budget necessitates continuous funding of $2,085,502 per year which is ambitious to say the least.

Cost estimates are based on our experience and that of our collaborators. They are applicable across the entire lower Mora Watershed (Table 23). Budgeted costs include an estimated 10% above the actual on-the-ground implementation to support project management, monitoring and education and outreach, as well as some efforts needed to protect the investment of project funds (e.g. Conservation Easements). It is anticipated that these estimates are likely to change over time so should be periodically updated. Financial requirements are generalized for estimating purposes to the best of our ability and the basis of those estimates is included in the below table. Estimates can be used for general planning purposes but will need review for the purposes of specific project planning.

This budget covers the projects identified the Load Reduction tables (Table 20, Table 21). Those tables list slightly more projects than are necessary to meet load reductions required by the TMDL. That slight overage is intentional and offers greater flexibility in selecting projects while also accounting for unanticipated project complications.

This significant estimated budget is a goal that will require funds to be supplied by many sources over a number of years. Potential sources of funding to meet these needs are described in the Funding Sources section on page 146.

Table 23. Financial requirements for on-the-ground implementation of the projects needed to reduce nutrient impairments listed in Table 20 and 21. Cost estimates include on-the-ground work plus 10% project administration to include management, monitoring and education and outreach.

Task	Number of years/ projects/acres/miles	Cost ($) Per year/ project/acre/mile	Total Cost ($)
Management Measures			
1. Livestock Management with Planned Grazing Systems			
Develop and implement Riparian and Watershed Sensitive Grazing Plans - assessment and planning ($50/ac.) , fencing ($4/ft. = $21,120/mile), hemi-fences, drift fences, salting ($1000/ac.), water development ($5,000/project), herding ($6/ac./yr.), pasture rest, pasture enhancements ($500/ac.), piñon -juniper restoration ($400/ac.) - **(units: acres)**	1,668	2,750	4,587,000
Riparian fencing ($4/ft x 5280 ft = $21,120 per mile) **(units: miles)**	13	23,232	302,016
2. Agricultural Management			
Assessment and planning, implementation of appropriate strategies like: No-till or reduced till farming systems, Conservation, pasture, or cover crop systems, Contour farming, terracing cropland, filter strips, soil enhancement, alternatives to fertilizers, herbicides and pesticides, diversify crops and crop rotation, evaluate and modify acequias **(units: acres)**	689	2,750	1,894,750

Task	Number of years/ projects/acres/miles	Cost ($) Per year/ project/acre/mile	Total Cost ($)
Reconstruct irrigation diversions **(units: projects)**	3	110,000	330,000
3. Infrastructure Management and Improvement (e.g. roads, railroad, residential)			
Vegetated buffers and filter strips **(units: acres)**	1,871	1,100	2,058,100
Remove infrastructure in riparian areas and floodplains **(units: projects)**	4	22,000	88,000
Road improvements **(units: miles)**	16	2,200	35,200
Bio-retention basins/water harvesting **(units: projects)**	5	5,500	27,500
Decommission unused/ineffective dirt tanks **(units: acres)**	7	8,250	57,750
Improve Septic Systems and Animal Waste Treatment **(units: projects)**	5	27,500	137,500
4. Restore and Manage Beaver			
Install infrastructure protection structures, flow devices, beaver deceivers **(units: projects)**	5	2,200	11,000
5. Critical Area Protection			
Establish Conservation Easements or other protection measures **(units: projects)** – costs are incorporated in the 6.5% markup of all on-the-ground projects			
6. Noxious and Invasive Weed Management			
Assess and treat noxious or invasive weed infestations **(units: acres)**	191	550	105,050

Task	Number of years/ projects/acres/miles	Cost ($) Per year/ project/acre/mile	Total Cost ($)
Restoration Measures			
7. Restore Upland Vegetation			
Restore plant cover and soil health (units: acres)	430	1,100	473,000
Restore appropriate piñon-juniper densities and distribution with thinning and prescribed fire **(units: acres)**	814	440	358,160
8. Arrest and Reverse Upland Erosion			
Arrest and heal soil surface erosion **(units: acres)**	1,262	1,262	1,388,200
Arrest and heal arroyos **(units: acres)**	1,197	2,200	2,633,400
Restore sand, gravel, stone mining pits **(units: acres)**	633	2,200	1,392,600
9. Restore Riparian and Floodplain Vegetation			
Plant diverse woody vegetation, Improve ground cover with herbaceous plants **(units: acres)**	373	2,200	820,600
Reduce conifer encroachment in riparian areas **(units: acres)**	260	220	52,000
10. Reconnect Streams to Floodplains			
Reestablish floodplain connectivity with: floodwater overflow areas, Arrest and reverse channel incision, Increase channel roughness, Remove or relocate infrastructure that unnecessarily confines stream flow **(units: miles)**	6	220,000	1,320,000

Task	Number of years/ projects/acres/miles	Cost ($) Per year/ project/acre/mile	Total Cost ($)
11. Restore streambank and channel characteristics			
Perennial Channels - Arrest and reverse streambank erosion and channel incision, reduce stream width, increase channel sinuosity and enhance instream obstacles and diversity for aquatic organisms **(units: miles)**	25	550,000	13,750,000
Intermittent/ephemeral Channels - Arrest and reverse streambank erosion and channel incision, reduce stream width, increase channel sinuosity and enhance instream obstacles and diversity for aquatic organisms **(units: miles)**	3	58,575	175,725
12. Wetland Restoration and Enhancement			
Recreate and restore wetlands **(units: acres)**	41	11,000	451,000
playa restoration and management (e.g. fencing) **(units: acres)**	200	5,500	1,100,000
TOTAL			**$33,372,826**

Technical Assistance

Technical Assistance that is needed to implement this plan is described below in Table 24. Professional stakeholder organizations and consultants that can be a source of assistance are described in the Stakeholder and Contractors sections on pages 60 and 67.

Table 24 - Technical Assistance needed for Implementation

Task	Type of Assistance	Source of Assistance
Overall Management and Coordination of Watershed Level projects	Apply for funding, contract with funding agencies, seek willing landowners, oversee project implementation, conduct project monitoring and carry out education and outreach.	Watershed groups, e.g. Hermit's Peak Watershed Alliance, Tierra y Montes Soil and Water Conservation District, large land management agencies or landowners, e.g. US Fish and

Task	Type of Assistance	Source of Assistance
		Wildlife Service, Ft. Union National Monument, Ft. Union Ranch.
Livestock Management Measures	Project planning, training, oversight and implementation	Quivira Coalition, High Plains Grassland Alliance, Resource Management Services, KI Bar Consulting
Agricultural Management Measures	Project planning, training, oversight and implementation	USDA NRCS
Infrastructure Management Measures	Project planning, training, oversight and implementation	Zeedyk Ecological Consulting, LLC, Rangeland Hands, Reineke Construction, Southwest Urban Hydrology
Support and Manage Beaver	Consultation and construction related to reducing beaver/human conflicts	David Blagg, Tierra y Montes SWCD
Critical Area Protection	Conservation Easements, transfer to public lands	NM Land Conservancy, Santa Fe Conservation Trust, Trust for Public Lands
Noxious and Invasive Weed Management	Identification and treatment of weed problems.	Tierra y Montes SWCD, Quivira Coalition
All Restoration Measures	Project planning, training, oversight and implementation	Hermit's Peak Watershed Alliance, Tierra y Montes SWCD, Watershed Artisans, Rangeland Hands, Zeedyk Ecological Consulting, LLC, Reineke Construction, NMED
Education and Outreach	Specialist Instructors for landowner workshops	Quivira Coalition, Tierra y Montes SWCD, Michael Bain, Resource Management Services, Rangeland Hands, Watershed Artisans, Zeedyk Ecological Consulting, LLC
Conservation Planning and Regulation	NEPA Requirements, Wetlands Mitigation Banking	US Army Corps of Engineers, EPA, NMED, NMOSE
Restoration Project Permits	404, 401 permits, Wetland Mitigation Banking	US Army Corps of Engineers, NMED
Restoration Project Permits	County permitting	Mora and San Miguel County – Planning and Zoning Departments
Road Related Projects	Road related guidelines	Mora and San Miguel County Road Department
Project Monitoring	Monitoring assistance	HPWA, HPGA, NMHU, various consultants

Education and Outreach

For planned Management Measures to be effective, the fundamental social reasons that have lead to impaired conditions must be addressed through education and outreach. The importance of maintaining high water quality that meets state standards must be clearly understood by all stakeholders. Furthermore, the relationship between water quality and land management must also be better understood. Finally, the tools need to be in place to provide land managers with resources to make and maintain improvements to their land management.

A strong education and outreach effort is also a critical foundation upon which to put EPA's Healthy Watershed Initiative (HWI) into place in the future. HWI recognizes "that our waters and aquatic ecosystems are dynamic systems that are interconnected in the landscape." A key part of that interconnected system is the people that live in and affect our watersheds. For local residents to contribute to restoration and management improvements and support Conservation Programs, Planning and Regulatory Measures, their understanding and commitment to the holistic care of the lower Mora Watershed is essential.

To the best of our understanding, we believe the fundamental social issues related to past watershed degradation are:

Ecological Knowledge – There is an incomplete understanding of the ecological functions of rivers, riparian areas and watersheds and the consequences of a lack of function, particularly related to meeting water quality standards and land productivity. In fact, some serious misconceptions are commonly held that have resulted in degraded conditions. For example, there is a common belief that streams and their riparian areas need to be "cleaned up" to be healthy; by this, most people often mean removing the willows, other woody vegetation and dead wood from stream channels and riparian areas. Riparian vegetation, especially dense willow stands, is "unsightly" and hinders access to a desirable "park-like" river environment. Another commonly held misunderstanding is that riparian vegetation "steals all the water" leaving little for human use. There is a general lack of understanding of the role riparian vegetation plays in preventing evaporation through a cooler microclimate and helping to store water in soils.

Values – While a deep love of the land and desire to keep it healthy is apparent in our area, maintaining the health of the land is often seen as a "nice thing to do" after other needs are met, rather than an integral part of our own long-term livelihoods. Building an understanding of the diverse ecological services, particularly high water quality and abundant water quantity, provided by a healthy watershed is needed. Fostering community support for watershed management and restoration will help drive a reprioritization of the importance of land stewardship in our watersheds.

Economics – Our economically depressed area in the past and present has resulted in our use of the land in excess of its ability to regenerate. Financial resources to adequately care for the land with a long-term vision that balances human and ecological needs are often lacking.

Without addressing these fundamental social conditions and misconceptions, elevating the importance of watershed stewardship to our community and providing community and financial support, restoration efforts described in this plan will be challenging to sell while landowners and managers deal with the pressures to increase water yield, reduce risks of catastrophic wildfire, develop recreational pursuits and "eke" out a living in our sparse and fragile landscape.

While there is a need for basic educational materials, actively engaging the community in restoration and monitoring efforts is the most likely means of deepening an understanding of watershed health and empowering people to take action to improve and maintain it.

Strategy

In this rural, widely dispersed, ranching and farming community, an education and outreach strategy that recognizes the independent and hardworking nature of landowners and land managers and provides educational opportunities that can be digested individually is likely to be most effective. Simultaneously, creating a forum to bring those independent people together periodically to enable the exchange of ideas, knowledge and support would provide an important balance. This can be done with frequent, small and personal educational events that are held close to home.

The following programs comprise an Educational and Outreach Strategy that would facilitate implementing the Management and Restoration Measures contained in this plan. While they are listed in order of priority, they would most likely occur in a more fluid order.

- **Landowner Toolbox** - Develop and/or assemble web-based informational fact sheets and videos about various land and water management principles and techniques. This information could be assembled into a Landowner Toolbox that should be a dynamic system that encourages user feedback and contribution.

  Finding an organization that is capable of securing financial support to develop, maintain and promote this Toolbox is needed.

  Beginning topics to address in this collection of information are:

    - Alternative agricultural methods that keep soils intact and build soil health (e.g. no-till, pasture cropping, cover cropping, key-line field layout and plow);
    - Simple means of arresting and healing erosion;
    - Construction and maintenance of low-standard rural roads;
    - Weed prevention and treatment;
    - Grazing management systems to rebuild soil and plant health;
    - Water development and catchment systems for farming and ranching;
    - Restoring wetlands;
    - Restoring riparian vegetation;
    - Cost/benefit analysis tools for various projects;
    - Techniques for managing beaver.

- **Land Stewardship Series** - Conduct regular educational events and hands-on demonstrations that present topics of local relevance. While educational events should offer access to expert knowledge that may not be available locally, they should also encourage the sharing of local knowledge that does exist among landowners and managers. Short lecture style presentations, longer hands-on workshops and tours are formats that appear to work well in this area. Offering hands-on workshops can help foster a community of neighbors working together on tasks that require many hands, similar to the shared ranch work of branding and doctoring livestock.

Examples of suitable types of on-the-ground management or restoration that lend themselves well to nonprofessional, hands-on, volunteer workshops are:

- Fencing;
- Planting woody or herbaceous vegetation;
- Constructing erosion control structures;
- Building water catchment systems;
- Building beaver management structures.

Lecture style presentations that are needed include:

- How watersheds work;
- How improved watershed health can improve drought resilience;
- How healthy land can help address climate change, carbon and nitrogen sequestration and land productivity;
- Benefits and approaches to riparian vegetation restoration, instream and floodplain restoration and wetland restoration and enhancement;
- Rural road construction and maintenance;
- Prevention of weed invasion and restoration of weed infested areas with techniques that also restore land productivity;
- Alternative techniques to traditional ground disturbing agricultural techniques (plowing) like no-till farming and cover-cropping;
- Techniques for improving soil health including intensive grazing, cover/pasture cropping, key-line plow and others;
- Encouraging and managing beaver with structures to protect culverts, acequias and other infrastructure.

HPWA developed the Land Stewardship Series in 2013 and has held 17 events held in San Miguel and Mora Counties with over 300 people participating. They have been very successful at broadening the understanding of watershed stewardship and have expanded the number of people who are exposed to this information.

- **Foster Champions** – Providing a demonstration of watershed stewardship techniques that also work to support landowners that make a living on the land can be the most effective educational tool. Select and foster an Agricultural and a Ranching Champion that is willing and able to implement some of the measures recommended in this plan and showcase watershed-friendly land management and restoration. Financial and technical resources should be made readily available to these Champions. Selecting Champions should consider the likelihood of demonstrating economic viability and watershed health with their activities.

- **Connect Land Stewards** – Develop and implement a means of connecting the lower Mora community of landowners and managers to keep stakeholders informed about new funding and technical support opportunities. This likely web-based connection, must also have some means of building social networks to enable continued sharing of ideas. The means might also involve a semi-annual newsletter.

Implementation Strategy and Schedule

Approach and Schedule

To address water quality priorities, the practicality of willing stakeholders, and the number of effective project opportunities, the following phased approach was developed to implement planned Management and Restoration Measures (see Table 25). While these phases will provide focus areas, it is recognized that opportunities to work together with collaborators (e.g. the US Fish and Wildlife Service) outside of these focus areas to seize excellent opportunities and leverage other funding sources may occur.

The expected time frame for implementing this WBP is a total of 16 years, from 2017 to 2032. Treating the total area of 477 square miles with 95 individual projects (see Map 16- Identified MRM Projects) that cover over 10,000 acres and more is a long-term endeavor. This time frame is based on continuous and adequate funding which is unlikely, therefore it is anticipated that this time frame will be extended.

Focus areas for implementation of planned projects, and other unidentified projects, would occur in the following two phases and multiple two year sub-phases. Two-year sub-phases are planned, since based on our experience, a two-year project maintains greater momentum than those extended to last three or more years. The first year of a two-year project is designed for refining project designs, obtaining landowner agreements, obtaining necessary permits and developing contracts with specialists. That first year would also be accompanied by numerous education and outreach events to ensure good public support. The second year would be devoted to conducting the projects and doing follow-up public tours.

Phase 1 – 2017-2026

Watrous to Cherry Valley including the sub-watersheds of Sapello River and Wolf Creek – This phase was identified in order to address the two highest priority reaches for TN and TP loads (see Table 20 and Table 21). This area of the watershed also was identified as a high priority for remediation in field monitoring assessments. Phase 1 is made up of 5 sub-phases of 2 years each. This phase includes Priority Reach 1 and 2 and the main tributaries which drain into these reaches, the Sapello River, Wolf Creek and Dog Creek.

Phase 1a - (2017-2018) *Mora Main stem from Watrous to Cherry Valley* - A concentrated effort to identify viable projects began in this area during this project. A watershed restoration specialist conducted a walk-thru of this area because water quality data was deemed the worst and numerous willing landowners were identified. Watershed Artisans catalogued all river and riparian area issues and opportunities and identified many potential restoration projects that would provide a starting point for implementation of this Watershed Based Plan (see Supporting Documents for this report).

Phase 1b - (2019-2020) *Mora Main stem from Watrous to Cherry Valley* – This phase is a continuation of Phase 1a.

Phase 1c - (2021-2022) *Wolf Creek and Dog Creek* - Implementation of this phase was chosen to occur second for two reasons: 1) implementation is simplified because the area has two main landowners (Ft. Union Ranch and Ft. Union National Monument), both of which are willing partners; 2) these intermittent streams offer numerous opportunities to improve flows and reduce storm event erosion and sedimentation.

Phase 1d - (2023-2024) *Lower Sapello R.* – Because of the large size of the lower Mora Watershed, the lower Sapello R. was not the focus of data collection efforts. This area is also distinctly different than the Mora R. in terms of the types of landowners, population density and river conditions. Because of this, we recommend addressing the Sapello River as a separate planning unit. Follow-up funding requests to develop a separate Sapello Watershed Based Plan are planned by HPWA. However, if independent funding requests are not successful, on-the-ground treatment will begin in this area during this Phase.

Phase 1e - (2025-2026) - *Remaining projects* - Projects in the Phase 1 area that were not completed in the prior four phases or follow-up maintenance work to previously completed projects will be accomplished in this phase.

Phase 2 –2027-2032

Golondrinas to Watrous – This phase was identified in order to address the third priority reach of TN and TP loading on the Mora River (see Table 20 and Table 21). While numerous project opportunities have been identified for this area, focusing on the Rio Mora NWR, it was identified as a lower priority area to treat with EPA 319 funding since it has a lower nutrient load reduction priority and as USFWS funding will be available to do some of this implementation. This phase is made up of 3 sub-phases of 2 years each.

Phase 2a - (2027-2028) *Rio Mora National Wildlife Refuge*

Phase 2b - (2029-2030) *Private Lands*

Phase 2c - (2031-2032) *Private Lands*

Map 17 shows the location of the phases and the priority reaches which the management and restoration projects will address.

Table 25- Implementation Schedule. Units (projects, acres or miles) are in superscript.

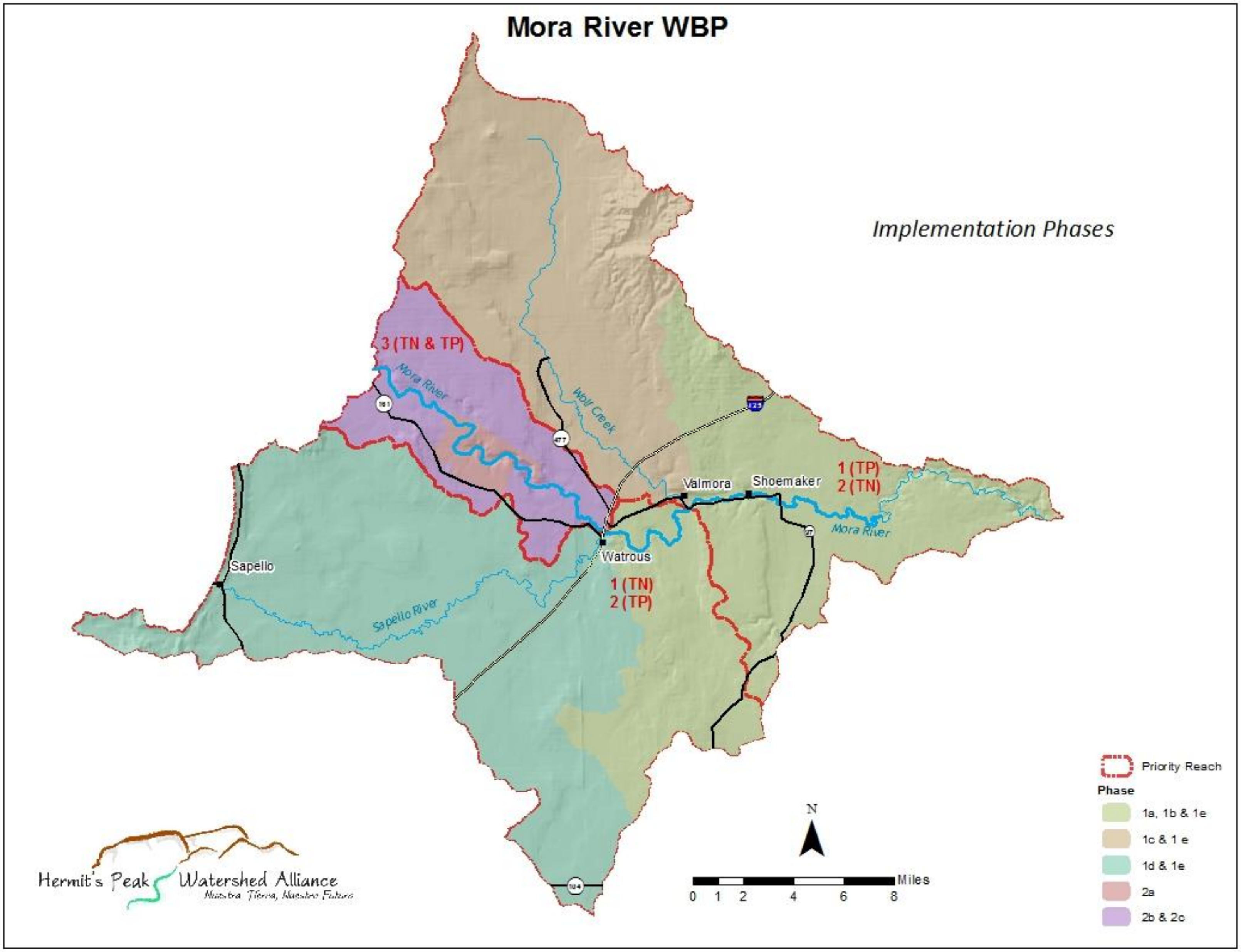
Management Measure	Total # of acres/ projects^{2}, miles^{3}	Phase 1a (# of acres/ projects^{2}, miles^{3})	Phase 1b (# of acres/ projects^{2}, miles^{3})	Phase 1c (# of acres/ projects^{2}, miles^{3})	Phase 1d (# of acres/ projects^{2}, miles^{3})	Phase 1e (# of acres/ projects^{2}, miles^{3})	Phase 2a (# of acres/ projects^{2}, miles^{3})	Phase 2b (# of acres/ projects^{2}, miles^{3})	Phase 2c (# of acres/ projects^{2}, miles^{3})
MRMS									
Livestock Management									
Riparian and watershed sensitive grazing plans	1669	142	142	142	142	142	319	319	319
Water development	1^{2}			1^{2}					
Riparian fencing	13^{3}	4.3^{3}	4.3^{3}	4.3^{3}					
Agricultural Management									
Agricultural Management	689	113	113	113	113	113	42	42	42
Reconstruct irrigation diversions	3^{2}	1^{2}	1^{2}	1^{2}					
Infrastructure Management									
Road improvements	16^{3}	2.4^{3}	2.4^{3}	2.4^{3}	2.4^{3}	2.4^{3}	0.6^{3}	0.6^{3}	0.6^{3}
Decommission unused/ineffective dirt tanks	7^{2}	1^{2}	1^{2}	4^{2}		1^{2}			
Support and Manage Beaver	5^{2}	1^{2}	1^{2}	1^{2}	1^{2}		1^{2}		
Noxious and Invasive Plant Management	191	34	34	34	34	34	7	7	7
Restore Upland Vegetation									
Restore plant cover and soil health	430	86	86	86	86	86			
Restore appropriate piñon-juniper densities and distribution	814	78	78	78	78	78	141	141	141
Arrest and Reverse Upland Erosion									
Arrest and heal arroyos (gullies)	1197	96	96	96	96	96	238	238	238
Arrest and heal soil surface erosion	1262	228	228	228	228	228	40	40	40
Restore sand, gravel, stone mining pits	633	33	33	33	33	33	157	157	157
Restore Riparian and Floodplain Vegetation									

Management Measure	Total # of acres/ projects[2,] miles[3]	Phase 1a (# of acres/ projects[2,] miles[3])	Phase 1b (# of acres/ projects[2,] miles[3])	Phase 1c (# of acres/ projects[2,] miles[3])	Phase 1d (# of acres/ projects[2,] miles[3])	Phase 1e (# of acres/ projects[2,] miles[3])	Phase 2a (# of acres/ projects[2,] miles[3])	Phase 2b (# of acres/ projects[2,] miles[3])	Phase 2c (# of acres/ projects[2,] miles[3])
Restore Riparian and Floodplain Vegetation	373	39	39	39	39	39	60	60	60
Reduce conifer encroachment in riparian areas	260	52	52	52	52	52			
Reconnect Streams to Floodplains	6[3]			3[3]			2[3]	1[3]	
Restore Stream and Channel Characteristics									
Arrest and heal streambank erosion; Arrest and reverse channel incision; Enhance instream obstacles and diversity for aquatic organisms; Increase channel sinuosity;	28[3]	3.6[3]	3.6[3]	3.6[3]	3.6[3]	3.6[3]	3.3[3]	3.3[3]	3.3[3]
Wetland Restoration and Enhancement									
Wetland Restoration and Enhancement	41	6	6	6	6	6	3	3	3
Playa Restoration	925	185	185	185	185	185			
Education and Outreach									
Landowner Toolbox (one effort with yearly progress)		x	x	x	x	x	x	x	x
Land Stewardship Series (six events per year)		x	x	x	x	x	x	x	x
Select and Foster Two Champions		x	x	x	x	x	x	x	x
Connect Landowners		x	x	x	x	x	x	x	x
One-on-one visits landowner visits									

[2] units: projects

[3] units: miles

x: Project Activity will occur during this phase



Map 17- Implementation Phases

Funding Sources

Table 26 provides known funding sources that could help implement this WBP. Some are available directly to private landowners and some only to non-profit, for-profit and governmental entities. The following section (Partners) offers some potential partners for collaboration on grant proposals listed below.

One notable option for funding would be the Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP) as many landowners in the lower Mora Watershed would be considered agricultural producers according to NRCS definitions so are eligible to receive financial support from these federal programs through NRCS.

Table 26- Possible funding sources for Implementation

Funding Organization	Funding Program	Eligible Entities	Types of Applicable Projects and Notes
NM Environment Department	Clean Water Act 319 On-the-Ground Improvements	citizen watershed groups, non-profit organizations, for-profit organizations, individuals and federal, state and local agencies (including those of Indian Nations, Pueblos and Tribes)	Projects identified in applicable Watershed Based Plans.
NM Environment Department	Watershed Based Plans	citizen watershed groups, non-profit organizations, for-profit organizations, individuals and federal, state and local agencies (including those of Indian Nations, Pueblos and Tribes)	New or updates to existing Watershed Based Plans
NM Environment Department	River Stewardship Program	towns, cities, counties, soil and water conservation districts, irrigation districts, for-profit and not-for-profit organizations, and Indian Nations, Pueblos and Tribes	For the restoration of rivers and streams statewide, including clearing vegetation, lowering river bank lines, replanting native species vegetation and installing erosion control measures. Types of priority projects vary but water quality improvements related to past fires or urban water quality have been past priorities.
USFWS	Partners for Fish & Wildlife	Private Landowners	Technical and financial assistance to private landowners with a desire

Funding Organization	Funding Program	Eligible Entities	Types of Applicable Projects and Notes
			to improve fish and wildlife habitat on their property.
USFWS	North American Wetlands Conservation Act (NAWCA) Standard grants	Public-Private Partnerships	Matching grants to increase bird populations and wetland habitat.
USFWS	North American Wetlands Conservation Act (NAWCA) Small grants	Organizations and partnerships	Matching grants to carry out wetland conservation projects that involve long-term protection, restoration, enhancement of wetland habitat for the benefit of wetlands associated migratory birds. Grants cannot exceed $75,000.
USDA, NRCS	Environmental Quality Incentives Program, Wildlife Habitat Incentives Program, Agricultural Management Assistance, Conservation Reserve Program, Water Bank Program, Regional Conservation Partnership Program	Private agricultural producers	Farm Bill funded programs for a variety of agricultural related improvements that also benefit watersheds.
Tierra y Montes and Mora-Wagon Mound SWCD		Private Landowners	
NM Finance Authority, Water Trust Board	Water Project Fund	1. state agencies; 2. intercommunity water or natural gas supply associations 3. recognized Indian nations, tribes or pueblos, and 4. political subdivisions a) municipalities; b) counties; c) land grant-mercedes; d) regional or local	Water conservation or recycling, treatment or water reuse projects; Flood prevention projects; Endangered species act (ESA) collaborative projects; Water storage,

Funding Organization	Funding Program	Eligible Entities	Types of Applicable Projects and Notes
		public water utility authorities created by statute; e) irrigation districts; f) conservancy districts; g) special districts; h) acequias; i) soil and water conservation districts; j) water and sanitation districts; and k) associations organized and existing pursuant to the Sanitary Projects Act	conveyance or delivery projects; Watershed restoration and management projects.
NM Game & Fish	Habitat Stamp Program	Habitat Stamp funds available for federal lands managed by BLM or USFS	Wildlife habitat improvement projects.
NM Game & Fish	Share with Wildlife	Non-profit, for-profit, other organizations and individuals	Research, public education, habitat protection and wildlife rehabilitation.
Private conservation organizations: Ducks Unlimited, National Fish and Wildlife Foundation, Turkey Federation, Quivira Coalition, etc.	Various	Non-profit, for-profit, other organizations, various requirements	

Partners

Table 27- Project Partners for Implementation

Organization	Interest	Specific Opportunities
Fort Union National Monument	Land restoration at the Monument	Erosion control, weed management, native plant improvements
Hermit's Peak Watershed Alliance, 501(c)(3) nonprofit	Improved management and restoration in Gallinas, Sapello, Tecolote, lower Mora Watersheds	Watershed Based Plans, On-the-Ground Implementation, Education programs, secure funding and implement this WBP
High Plains Grassland Alliance, 501(c)(3) nonprofit	Land and wildlife stewardship and economic viability of working lands	Weather and ground water monitoring, scholarship fund
NM Acequia Association	Acequia infrastructure and agricultural projects	Reconstruct irrigation diversions, agricultural management
NM Game & Fish	Wildlife habitat improvement projects	Riparian fencing, piñon-juniper thinning, general projects
Playa Lakes Joint Venture	Playa restoration and protection	Wildlife habitat improvement

Organization	Interest	Specific Opportunities
		projects focus on wetlands, playas and bird habitat
Quivira Coalition, 501(c)(3) nonprofit	Land and water restoration and management on public and private lands	Erosion control, weed management, range management and education programs
USDA, NRCS	Agricultural related management	Fencing, water development, piñon-juniper thinning, irrigation improvements
USFWS Rio Mora National Wildlife Refuge	Landowner education programs, Conservation Easements, habitat restoration	Work on Refuge lands or in the Rio Mora Conservation Area
Tierra y Montes and Mora-Wagon Mound SWCD	Landowner education, restoration projects	Erosion control, weed management, fencing, vegetation management

Measurable Milestones of Implementation

The following are quantitative and qualitative measurable milestones that will be used to gauge progress on implementing planned activities. Measures include the effectiveness of MRMs in meeting nutrient goals as well as the ability of this effort to carry out the planned projects. Qualitative assessments will help to explain the reasons for meeting or not meeting targeted goals. While this planning effort has been very helpful in identifying local needs, attitudes and interests and developing strategies that are most likely to work, the planned activities have not been thoroughly tested to determine their effectiveness and feasibility. For that reason the following measurable milestones will be used to make adjustments in implementation efforts, focusing on efforts that work well to accomplish desired goals and eliminating those that do not. This continual adaptive management is expected to occur for on-the-ground projects, education and outreach programs and in pursuing conservation, planning and regulatory measures.

Quantitative Measurable Milestones

- Assessment of Standards Attainment – Project-specific and watershed-wide monitoring will be regularly done (see Monitoring Program section) to determine progress toward meeting load reduction targets. Those data will be analyzed at the end of each project phase (2018, 2020, 2022, 2024, 2026, 2028, 2030 and 2032) in order to assess progress toward Standards Attainment.
- Number of Acres/Stream Miles or Number of Projects Completed – The number of acres or stream miles or the number of on-the-ground projects completed in each project category (e.g. grazing management plans, stream channel enhancements) will be compared with target numbers. Actual nutrient load decreases (measured in field) will also be compared to targets. This evaluation will occur at the end of each project phase (2018, 2020, 2022, 2024, 2026, 2028, 2030 and 2032). See Table 25 for targets.
- Number of Conservation Programs/Planning/ Regulatory Efforts – The number of facilitated pursuits of Conservation Programs and progress on planning and regulatory input will be

tracked and evaluated relative to targets at the end of each project phase (2018, 2020, 2022, 2024, 2026, 2028, 2030 and 2032). See Table 25 for project targets.

- Number of Education Efforts – At the end of each phase (2018, 2020, 2022, 2024, 2026, 2028, 2030 and 2032), the number of education efforts undertaken and/or accomplished (including: landowner consultations, educational materials, workshops, training, presentations) will be compared to targets (see Table 25).

Modifications to targets and necessary adaptive management will be based on qualitative assessments of effectiveness and will occur as needed.

Qualitative Measureable Milestones

- General Effectiveness – To accompany the quantitative tracking, a narrative evaluation of project successes will occur. This evaluation will occur at the completion of each sub-phase and will be incorporated into final reports to granting agencies. It should include: effective techniques for obtaining landowner agreements to do projects, descriptions of effective management and restoration efforts in terms of correcting degraded conditions, practicality of implementing the various planned activities and evaluations from landowners or other participants in our programs. General Effectiveness milestones include:
  - Landowners are willing to embark on improved management and restoration projects on their lands.
  - Projects selected are appropriate for the landowner and location and are technically and financially feasible.
  - Projects can be maintained by landowners in the future.

- General Conflicts/Issues – A narrative evaluation of conflicts and issues that have arisen that prevent progress on specific efforts, including descriptions of adaptive management measures undertaken or planned, should be included.

In the event that the WBP is fully implemented and the TMDL total phosphorus and total nitrogen loads still exceed water quality standards, HPWA may need to reevaluate the TMDL. If measureable milestones are not being attained, HPWA will reevaluate flow and geomorphology, and finally may need to reevaluate use attainability standards.

Criteria for Evaluating Load Reduction Achievements

NMED/EPA standards for desirable nutrient conditions will be used as a basis for evaluating load reductions. Total Nitrogen should not exceed 0.38 mg/L and Total Phosphorus should not exceed 0.03 mg/L in the Mora River. If this plan has been implemented and the Mora River (USGS gage east of Shoemaker to HWY 434) is found to meet its water quality standards for nutrients, then the plan will have accomplished its goals. Assessment of standards attainment is expected to take place in 2018 (before significant implementation), in 2026 (after significant implementation) and finally, in 2032 (after all implementation is complete). Additionally, assessment of standards attainment will occur at the end of every sub-phase, or every 2 years between 2017 and 2032. The assessment of Standards Attainment are some of the measureable milestones listed in the above section.

If in 2032 this plan has been implemented in full and the Mora River does not meet its water quality standards for nutrients and effectiveness monitoring data show less improvement in water quality than expected given the level of effort of implementation, or if there is no significant improvement in water quality, then this plan will be modified using expert guidance and new management measures yet to be determined. Conversely, if the Mora River is found to meet nutrient standards in 2032 or prior to 2032, this plan will be modified to focus on protecting water quality. However, unless this plan is revised under one of the circumstances above, this plan will be considered valid for the reach of the lower Mora River (AU NM-2305.A_00). This statement applies as long as a recognized nutrient impairment and nutrient TMDL are in effect.

Monitoring Program

A monitoring program will be instated to evaluate the effectiveness of the implementation efforts based on the criteria outlined in the above section (see Criteria for Evaluating Load Reduction Achievements). Nutrient assessment monitoring will occur every year during summer months throughout the sixteen years covered in this plan, contingent upon funding. Sampling locations will include the 8 baseline sites and additional sites as necessary. Effectiveness monitoring of each project site will include Rosgen Level II Geomorphology and NMRAM at each project site before treatment. After treatment geomorphology and NMRAM monitoring will occur at each project site in the final year of each sub-phase. At the end of each Phase, a BASINS nutrient modeling assessment will occur; if/when data are available.

At the end of each sub-phase (in 2018, 2020, 2022, 2024, 2026, 2028, 2030, 2032), an assessment of the monitoring data will occur in order to determine whether progress is being made in reducing load. The monitoring will be completed under a new approved Quality Assurance Project Plan (QAPP) which will be written and submitted to EPA at the beginning of Phase I of implementation. Reporting of monitoring progress and methodology will be conducted through standard NMED quarterly reports.

The above targeted monitoring will be completed in order to assess standards attainment, however, other monitoring efforts will also take place to look at the general watershed condition and identify any other areas (besides stream nutrients) that may be of concern. Monitoring will be used as an educational tool, when possible.

Table 28- Monitoring Schedule

On-the-Ground Phase	Sub-phase	Year	Monitoring Effort	Sampling Sites
1	1a	2017	Write, submit and get approval for monitoring QAPP	
			Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Pre-MRM geomorphology	Sites at location of instream projects
			Pre-MRM NMRAM	All project sites
		2018	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Post-MRM geomorphology	Sites at location of instream projects
			Post-MRM NMRAM	All project sites

On-the-Ground Phase	Sub-phase	Year	Monitoring Effort	Sampling Sites
			Sub-phase 1a Assessment of Standards Attainment	Review of all monitoring data
	1b	2019	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Pre-MRM geomorphology	Sites at location of instream projects
			Pre-MRM NMRAM	All project sites
		2020	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Post-MRM geomorphology	Sites at location of instream projects
			Post-MRM NMRAM	All project sites
			Sub-phase 1b Assessment of Standards Attainment	Review of all monitoring data
	1c	2021	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Pre-MRM geomorphology	Sites at location of instream projects
			Pre-MRM NMRAM	All project sites
		2022	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Post-MRM geomorphology	Sites at location of instream projects
			Post-MRM NMRAM	All project sites
			Sub-phase 1c Assessment of Standards Attainment	Review of all monitoring data
	1d	2023	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Pre-MRM geomorphology	Sites at location of instream projects
			Pre-MRM NMRAM	All project sites
		2024	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Post-MRM geomorphology	Sites at location of instream projects
			Post-MRM NMRAM	All project sites
			Sub-phase 1d Assessment of Standards Attainment	Review of all monitoring data
	1e	2025	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Pre-MRM geomorphology	Sites at location of instream projects
			Pre-MRM NMRAM	All project sites

On-the-Ground Phase	Sub-phase	Year	Monitoring Effort	Sampling Sites
		2026	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Post-MRM geomorphology	Sites at location of instream projects
			Post-MRM NMRAM	All project sites
			BASINS nutrient assessment	Watershed wide
			Phase 1 Assessment of Standards Attainment	Review of all monitoring data sub-phases 1a-1e
2	2a	2027	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Pre-MRM geomorphology	Sites at location of instream projects
			Pre-MRM NMRAM	All project sites
		2028	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Post-MRM geomorphology	Sites at location of instream projects
			Post-MRM NMRAM	All project sites
			Sub-phase 2a Assessment of Standards Attainment	Review of all monitoring data
	2b	2029	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Pre-MRM geomorphology	Sites at location of instream projects
			Pre-MRM NMRAM	All project sites
		2030	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Post-MRM geomorphology	Sites at location of instream projects
			Post-MRM NMRAM	All project sites
			Sub-phase 2b Assessment of Standards Attainment	Review of all monitoring data
	2c	2031	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Pre-MRM geomorphology	Sites at location of instream projects
			Pre-MRM NMRAM	All project sites
		2032	Nutrient Assessment	8 baseline sites, may add new sites if necessary
			Post-MRM geomorphology	Sites at location of instream projects
			Post-MRM NMRAM	All project sites

On-the-Ground Phase	Sub-phase	Year	Monitoring Effort	Sampling Sites
			BASINS nutrient assessment	Watershed wide
			Phase 2 Assessment of Standards Attainment	Review of all monitoring data sub-phases 2a-2c

Bibliography

Alberta Riparian Habitat Management Society. (2016). *Cows and Fish*. Retrieved 2016, from cowsandfish.org: www.cowsandfish.org

Arellano, J. (2014). *Enduring Acequias.* Albuquerque: University of New Mexico Press.

Ashigh, J. W. (2010). *Troublesome Weeds of New Mexico.* Las Cruces: NM State University, College of Agricultural, Consumer and Evironmental Sciences.

Bernhardt, E. S. (2011). River restoration: the fuzzy logic of repairing reaches to reverse catchment scale degradation. *Ecological Applications* , 1926-1931.

Bicknell, B. R., Imhoff, J. C., Kittle, J. L., Donigian, A. S., and Johanson, R. C. (1993). *Hydrological simulation program-FORTRAN user's manual for release 10* (Vols. Rep. No. EPA/600/R-93/174). Athens, GA: Environmental Research Laboratory Office of Research and Development, U.S. Environmental Protection Agency.

Bicknell, B. R., Imhoff, J. C., Kittle, J. L., Jobes, T. H., and Donigian, A. S. (2005). *Hydrological simulation program-Fortran (HSPF) version 12.2 user's manual.* Mountain View, CA: Aqua Terra Consultants.

Brierley, G. a. (2005). *Geomorphology and river management: applications of the river styles framework.* Blackwell Publishing.

Brierley, G. a. (2008). *River Futures: An Integrative Scientific Approach to River Repair.* Island Press.

Brinson, M. M. (1993). *A Hydrogeomorphic Classification for Wetlands.* US Army Corps of Engineers.

Brinson, M. R. (1995). *A Guidebook for Application of Hydrogeomorphic Assessments of Riverine Wetlands.* Vicksburg, MS: U.S. Army Corps of Engineers, Waterways Experimental Station.

Chronic, H. (1987). *Roadside geology of New Mexico.* Missoula, Montana: Mountain Press Publishing.

County, M. (2010). *Mora County Comprehensive Land Use Plan.* Mora County Board of Commissioners.

Cowardin, L. M. (1979). *Classification of wetlands and deepwater habitats of the United States.* Northern Prairie Wildlife Research Center Online. Washington, D.C.: U.S. Department of the Interior, Fish and Wildlife Service.

Daniel B. Stephens & Associates. (2005). *Mora- San Miguel- Guadalupe Regional Water Plan.* Tierra Y Montes SWCD and the Mora San Miguel Guadalupe Regional Water Planning Steering Committee.

Degenhardt, W. C. (1996). *The amphibians and reptiles of New Mexico.* Albuquerque: University of New Mexico Press.

DeWalt, R. ,. (2005). Just how imperiled are aquatic insects? A case study of stoneflies (Plecoptera) in Illinois. *Annals of the Entomological Society of America* , 941 - 950.

Dick-Peddie, W. (1993). *New Mexico Vegetation: Past, Present, and Future.* Albuquerque: University of New Mexico Press.

Donigian, A. S. (1995). Hydrological simulation program-Fortran HSPF. In e. V. P. Singh, *Computer models of watershed hydrology.* Highlands Ranch, Co.: Water Resources Publications.

Donigian, A. S. (2002). Watershed model calibration and validation—the HSPF experience. *Specialty Conf. Proc.: Water Environment Foundation, National TMDL Science and Policy 2002.* Phoenix.

Follstad Shah, J. J. (2007). River and Riparian Restoration in the Southwest: Results of the National River Restoration Science Synthesis Project. *Restoration Ecology* , 550-562.

Ford, P. L. (1994). Ecology of fire in shortgrass prairie of the southern Great Plains. In D. M. Finch, *Ecosystem disturbance and wildlife conservation in western grasslands - A symposium proceedings.* (pp. 20-39). Albuquerque, NM: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Fry, J. X. (2011). Completion of the 2006 National Land Cover Database for the Conterminous United States. *PE&RS* , 858-864.

Fryirs, K. a. (2013). *Geomorphic Analysis of River Systems: An approach to Reading the Landscape.* Wiley-Blackwell.

Gadzia, T. R. (2014, September). Restoring Cañon Bonita Ranch in the Light of New Normals. *Resilience* (40).

Gomez-Velez, J. J. (2015, October 26). Denitrification in the Mississippi River network controlled by flow through river bedforms. *Nature Geoscience* , pp. 941-945.

Gurdak, J. a. (2009). Recharge Rates and Chemistry Beneath Playas of the High Plains Aquifer—A Literature Review and Synthesis. *US Geological Survey Circular* , 39.

Hilsenhoff, W. (1988). Rapid field assessment of organic pollution with family level biotic index. *Journal of the North American Benthological Society* , 65-68.

HPWA. (2014). *Project Quality Assurance Project Plan Water Quality Monitoring to Determine Pollutant Loading Sources for the Watershed Based Plan for the Mora River - Upper Canadian Plateau.* Las Vegas, NM: Hermit's Peak Watershed Alliance.

Jaremko-Wright, W. (2015). *One-seed Juniper Dispersal Ecology and Population Growth at a Rangeland Site in Northeastern New Mexico.* College of Arts and Sciences. New Mexico Highlands University.

Jesus Rivas, P. (2015). NMHU Dept of Biology. (L. Knutson, Interviewer)

Johnson, W. M. (2011). Factors influencing the occurrence of inundated playa wetlands during winter on the Texas high plains. *Wetlands , 31*, 1287-1296.

Kuenzler, E. J. (1989). Value of forested wetlands as filters for sediments and nutrients. In c. D. D. Hook and R. Lea, *Proceedings of the symposium: forested wetlands of the southern United States* (General Technical Report SE-SO ed., pp. 85-96). Asheville, NC: U.S.

Mahan, K. (2014). *Mora Data Report.* Las Vegas, NM: Hermit's Peak Watershed Alliance.

Martin, T. W. (2016). Intact Ecosystems Provide Best Defense Against Climate Change. *Nature Climate Change , 6*, 122-124.

Mieklejohn, K. (2013). *Ranching for Resilience: A Guiding Assessment of Opportunities for Meeting Economic and Ecological Change on the Fort Union Ranch.* Sonoran Institute – Northern Rockies Office.

Muldavin, E. C. (2004). *A Vegetation Survey and Map of Fort Union National Monument of New Mexico.* NM Natural Heritage Program, University of New Mexico.

New Mexico Department of Game and Fish. (2006). *Comprehensive Wildlife Conservation.* Santa Fe, New Mexico: New Mexico Department of Game and Fish.

New Mexico Department of Game and Fish. (2016). *Biota Information System of New Mexico (BISON-M)*. Retrieved 2016, from BISON-M: www.bison-m.org

NM Office of the State Engineer/Interstate Stream Commisssion. (2016). *DRAFT Mora-San Miguel-Guadalupe Regional Water Plan.* NMOSE.

NM State Forestry, U. F. (2008). *New Mexico Forest Practices Guidelines.*

NMED SWQB. (2004). 2004-2006 State of New Mexico CWA §303(d)/§305(b) Integrated Report Appendix B 2004 Surface Water Assessment. Santa Fe, NM. Retrieved from https://www.env.nm.gov/wqcc/303d-305b/2004/AppendixB/Part01.pdf

NMED SWQB. (2014). 2014-2016 State of New Mexico Clean Water Act §303(d) /§305(b) List of Assessed Waters. Santa Fe, NM. Retrieved from https://www.env.nm.gov/swqb/303d-305b/2014-206/index.html

NMED SWQB. (2014). NMRAM: New Mexico Rapid Assessment Method. Santa Fe, NM. Retrieved from https://www.env.nm.gov/swqb/Wetlands/NMRAM/

NMED SWQB. (2015). Procedures for Assessign Water Quality Standards Attainment for the State of New Mexico CWA §303(d) /§305(b) Integrated Report: Assessment Protocol. Santa Fe, NM. Retrieved from https://www.env.nm.gov/swqb/protocols/documents/2016_FINAL_AP_062215.pdf

NMED SWQB. (2014). Standard Operating Procedures for Nutrient Survey and Sampling. Santa Fe, NM. Retrieved from https://www.env.nm.gov/swqb/SOP/10.0SOP-NutrientSampling2014.pdf

NMED SWQB. (2015). *UPDATE USEPA Approved Total Maximum Daily Load (TMDL) for the Mora River (USGS Gage East of SHowmaker to Hwy 434).* Santa Fe, NM: NMED.

NMED SWQB. (2009). *US EPA- Approved Total Maximum Daily Load (TMDL) For the Dry Cimarron River Watershed.* Santa Fe, NM: NMED.

NMED SWQB. (2011). *US EPA- Approved Total Maximum Daily Load (TMDL) for the Mainstem of the Canadian River (from Texas to Colorado) and Select Tributaries.* Santa Fe, NM: NMED.

NMED SWQB. (2007). USEPA-Approved Total Maximum Daily Load (TMDL) for the Canadian River Watershed – Part 1 (Mora River to the Colorado Border). . Santa Fe, NM. Retrieved 2015, from https://www.env.nm.gov/swqb/documents/swqbdocs/MAS/TMDLs/Canadian/Pt1/CanadianTMDL-Pt1.pdf.

NRCS. (2015). Tolby Creek SNOTEL. Retrieved from http://wcc.sc.egov.usda.gov/nwcc/site?sitenum=934&state=nm

NRCS USDA. (2003). Soil Survey Geographic (SSURGO) Database San Miguel and Mora County NM. Retrieved from http://sdmdataaccess.nrcs.usda.gov

Playa Lakes Joint Venture. (2008). *Area implementation plan for the shortgrass prairie bird conservation region of New Mexico.* Lafayette, Colorado: Playa Lakes Joint Venture.

Playa Lakes Joint Venture. (2011). Maps of Probable Playas. Retrieved from http://pljv.org/for-habitat-partners/maps-and-data/maps-of-probable-playas/

Playa Lakes Joint Venture. (2016). *Playas & the Ogallala Aquifer.* Playa Lakes Joint Venture.

Refuge Staff Northern New Mexico National Wildlife Refuge Complex & National Wildlife Refuge System Southwest Region Division of Planning. (2014). *Draft Environmental Assessment Rio Mora National Wildlife Refuge 5- Year Action Plan.* Watrous, NM: Rio Mora NWR.

Rosgen, D. (1996). *Applied River Morphology.* Pagosa Springs, CO: Wildland Hydrology.

San Miguel County. (2004). *San Miguel County Comprehensive Plan 2004 – 2014.* Las Vegas, NM: San Miguel County.

Schackel, S. (1983). *Historic Vegetation at Fort Union National Monument: 1851-1983.* Santa Fe.

Schiebout, M. H. (2008). A Floristic Survey of Vascular Plants over parts of Northeastern New Mexico. *Journal of Botanical Research Institute of Texas* , 1407-0447.

Smith, R. a. (2000). *Windows into the Earth.* New York, New York: Oxford University Press.

Soule, M. J. (2005). Strongly interacting species: Conservation policy, management, and ethics. *BioScience* , 168-176.

Sublette, J. E. (1990). *The Fishes of New Mexico.* Albuquerque, New Mexico: University of New Mexico Press.

Swanson, S. W. (2015). Practical Grazing Management to Maintain or Restore Riparian Functions and Values on Rangelands. *Journal of Rangeland Applications , 2*, 1-28.

Tamara Gadzia, M. R. (2014). Restoring Cañon Bonita Ranch in the Light of New Normals. *Resilience* (40).

Terborgh, J. a. (2010). *Trophic cascades: Predators, prey, and the changing dynamics of nature.* Washington D.C.: Island Press.

Terborgh, J. J. (1999). Role of top carnivores in regulating terrestrial ecosystems. In M. S. Terborgh, *Continental conservation: Scientific foundations of regional reserve networks* (pp. 39-64). Island Press: Washington D.C.

The Nature Conservancy. (2004). *A Biodiversity and Conservation Assessment of the Southern Shortgrass Prairie Ecoregion.* Southern Shortgrass Prairie Ecoregional Planning Team. San Antonio, TX: The Nature Conservancy.

The Nature Conservancy. (2007). *A Biodiversity and Conservation Assessment of the Southern Shortgrass Prairie Ecoregion.* Southern Shortgrass Prairie Ecoregional Planning Team. San Antonio, TX: The Nature Conservancy.

Thompson, B. a. (2009). *Water Resources Assessment of the Mora River.* Water Resources Program University of New Mexico.

U.S. Census Bureau. (2015). QuickFacts Mora County, NM. Retrieved from http://www.census.gov/quickfacts/table/PST045215/35033

U.S. Environmental Protection Agency. (1999). *Protocol for Developing TMDLs.* Washington D.C.: U.S. EPA.

U.S. EPA. (2016). *EPA Ecoregions of New Mexico*. Retrieved February 11, 2016, from Environmental Protection Agency: http://www.epa.gov/wed/pages/ecoregions/level_iii_iv.htm

U.S. EPA. (2010). *Multi-Resolution Land Characteristics Consortium: 2001 National Land Cover Data (NLCD)*. Retrieved 2016, from Environmental Protection Agency: http://www.epa.gov/mrlc/nlcd-2001.html

U.S. Fish and Wildlife Service. (2010). National Wetlands Inventory. Washington, D.C.: U.S. Department of the Interior, Fish and Wildlife Service. Retrieved from http://www.fws.gov/wetlands/

U.S. Fish and Wildlife Service. (2015). *Working with Inasives at Rio Mora NWR: Removal and Restoration. Internal Report.* U.S. Fish and Wildlife Service.

U.S. Geological Survey. (2016). National Water Information System data Mora River near Golondrinas (USGS Water Data for the Nation). Retrieved December 2015, from http://waterdata.usgs.gov/nm/nwis/uv?site_no=07216500

US Environmental Protection Agency. (2008). *Handbook for Developing Watershed Plans to Restore and Protect Our Waters (EPA 841-B-08-002.* Washington, D.C.: US EPA Office of Water; Nonpoint Source Control Branch.

US EPA. (2015). BASINS 4.1 (Better Assessment Science Integrating point & Non-point Sources) Modeling Framework. North Carolina: National Exposure Research Laboratory, RTP.

US EPA. (2006). *Sediment parameter and calibration guidance for HSPF.* Washington, D.C.: Office of Water.

US Fish and Wildlife Service. (2012). *Rio Mora National Wildlife Refuge and Conservation Area: Land Protection Plan.*

USDA, Natural Resources Conservation Service. (2016). Plants Database. Retrieved from http://plants.usda.gov/

USDA-NRCS. (2010). National Hydrologic Data for Mora County NM.

USGS National Gap Analysis Program. (2004). Provisional Digital Land Cover Map for the Southwestern United States.

Western Regional Climate Center. (2015). Valmora New Mexico Climate Summary. Retrieved from http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nm9330

Zeedyk, B. a.-W. (2009). *An introduction to erosion control.* Santa Fe, New Mexico: Earth Works Institute and Quivira Coalition.

Zeedyk, B. (2014). *Characterization and Restoration of Slope Wetlands in New Mexico: A Guide for Understanding Slope Wetlands, Causes of Degradation and Treatment Options.* Santa Fe, NM: Quivira Coalition.

Zeedyk, B. (2015). *The Plug and Spread Treatment: Achieving Erosion Control, Soil Health and Biological Diversity.* Sapello, NM: Zeedyk Ecological Consulting, LLC.

Zeedyk, B. (2006). *Water Harvesting from Low-Standard Rural Roads.* Santa Fe, New Mexico: Quivira Coalition.

Zeedyk, W. D. (2009). *Let the Water do the Work: Induced Meandering, an Evolving Method for Restoring Incised Stream Channels.* Santa Fe, NM: Quivira Coalition.

Zhu, L. (1992). *Fort Union National Monument: An Administrative History.* Santa Fe, NM: National Park Service, Division of History, Southwest Cultural Resources Center.

Appendix A. Nine Key Elements of a Watershed Based Plan

Handbook for Developing Watershed Plans to Restore and Protect Our Waters, (US Environmental Protection Agency, 2008).

a. *Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed (e.g., X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).*

b. *An estimate of the load reductions expected from management measures*

c. *A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in paragraph 2, and a description of the critical areas in which those measures will be needed to implement this plan.*

d. *Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.*

e. *An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented*

f. *Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.*

g. *A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented*

h. *A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.*

i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item h immediately above.

Appendix B: Load Reduction Methods

The TMDL for nutrient impairment is calculated as:

Equation 7- Nutrient TMDL

$$TP\text{: } \boldsymbol{WLA}\,(.\mathbf{135}) + \boldsymbol{LA}\,(.\mathbf{004}) + \boldsymbol{MOS}\,(.\mathbf{015}) = .\mathbf{154}\ \boldsymbol{lbs/day}\ (\boldsymbol{SWQB}, \mathbf{2007}).$$

$$TN\text{: } \boldsymbol{WLA}\,(\mathbf{1.705}) + \boldsymbol{LA}\,(.\mathbf{046}) + \boldsymbol{MOS}\,(.\mathbf{195}) = \mathbf{1.946}\ \boldsymbol{lbs/day}\ (\boldsymbol{SWQB}, \mathbf{2007}).$$

The target load for nutrients is calculated with the following formula:

Equation 8- Target Load

$$\boldsymbol{LA} + \boldsymbol{WLA} = \boldsymbol{Target\ Load}$$

Target loads for TP and TN are therefore:

Equation 9- Calculation of Target Load

$$TP\text{: } \boldsymbol{WLA}\,(.\mathbf{135}) + \boldsymbol{LA}\,(.\mathbf{004}) = .\mathbf{139}\ \boldsymbol{lbs/day}$$

$$TN\text{: } \boldsymbol{WLA}\,(\mathbf{1.705}) + \boldsymbol{LA}\,(.\mathbf{046}) = \mathbf{1.751}\ \boldsymbol{lbs/day}$$

The following formula is used to calculate actual reduction in Total Phosphorus and Total Nitrogen necessary to meet surface WQS for plant nutrients:

Equation 10- Load Reduction

$$\boldsymbol{Measured\ Load} - \boldsymbol{Target\ Load} = \boldsymbol{Load\ Reduction\ Required}$$

The Mora River (USGS gage east of Shoemaker to HWY 434) TMDL calculates the total daily maximum load based on 4Q3 critical flow (calculated with DFLOW), and the nutrient target concentration (based on EPA ecoregion). The existence of plant nutrients in a river can fluctuate as a function of flow. As flow decreases, the stream cannot effectively dilute its constituents, which causes the concentration of plant nutrients to increase. Thus, the TMDL is calculated for each assessment unit at a specific flow. The critical condition can be thought of as the "worst case" scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence. The critical flow condition for these TMDLs occurs when the ratio of effluent to stream flow is the greatest and was obtained using a 4Q3 regression model. The 4Q3 is the minimum average four consecutive day flow that occurs with a frequency of at least once every 3 years. Low flow was chosen as the critical flow because of the negative effect decreasing, or low, flows have on nutrient concentrations and algal growth.

The TMDL calculated estimated annual measured loads of TP and TN by calculating the geometric mean of exceedences for all TP and TN samples collected in 2002 and 2006.

For this WBP measured loads were calculated using BASINS. TN and TP loads were calculated after calibrating and validating the model by the following formula used in the TMDL:

Equation 11- Measured Load

$$\textbf{Flowa x Geometric Mean Concentration } (mg/L)b \textbf{ x Conversion Factorc} = \textbf{Measured Load } (lbs/day)$$

[a]Combined Flow= 4Q3 low-flow (0.562 MGD) + WWTP design capacity (0.052 MGD)

[b]Geometric mean of TP and TN exceedences (1/1/1998 to 12/31/2006)

[c] 8.34 Used to convert mg/L to lbs/day see TMDL Appendix A (NMED SWQB., 2007)

The simulated geometric mean concentrations for the Mora River reaches are in the following table. All simulated BASINS loads are based on the full time period Jan 1, 1998 to December 31, 2006. TMDL loads are based on samples taken in the summer of 2002 and 2006.

Table 29- Measured Load calculation results from BASINS and TMDL

Parameter	Simulated Geometric Mean Conc. Reach 2	Simulated Geometric Mean Conc. Reach 5	Simulated Geometric Mean Conc. Reach 4	TMDL Geometric Mean Conc.
Total Phosphorus	0.053	0.060	0.068	0.064 mg/L
Total Nitrogen	0.570	0.627	0.620	0.515 mg/L

Appendix C. Management and Restoration Measure Efficiencies

Table 30- MRM Efficiencies estimated by HPWA staff with literature and STEPL values

Management Measures	MRM Efficiency (Estimated Load Reduction %)
1. Livestock Management with Planned Grazing Systems	80
a. Riparian and watershed sensitive grazing plans	80
b. Riparian fencing	80
c. Pasture fencing	50
d. Water development	25
e. Pasture rest	30
f. Pasture enhancement	30
g. Discourage livestock use – (e.g. hemi-fences, drift fences, salting)	10
h. Livestock herding	25
i. Convert grazed areas to hunting access areas	25
2. Agricultural Management	
a. No-till or reduced till farming systems	50
b. Conservation, pasture, or cover crop systems	50
c. Contour farming	50
d. Terracing cropland	25
e. Filter strips	75
f. Soil enhancement	25
g. Alternatives to fertilizers, herbicides and pesticides	50
i. Reconstruct irrigation diversions	20
j. Evaluate and modify acequias	20
3. Infrastructure Management and Improvement (e.g. roads, railroad, residential)	
a. Vegetated buffers and filter strips	75
b. Remove infrastructure in riparian areas and floodplains	10
c. Road improvements	50
d. Bio-retention basins/water harvesting	50
e. Decommission unused/ineffective dirt tanks	10
f. Septic and Animal Waste Treatment	70
4. Support and Manage Beaver	70
5. Critical Area Protection – e.g. wetlands, playas	N/A

6. Noxious and Invasive Plant Management	25
Restoration Measures	
1. Restore Upland Vegetation	
a. Restore plant cover and soil health	50
b. Restore appropriate piñon-juniper densities and distribution	25
2. Arrest and Reverse Upland Erosion	
a. Arrest and heal soil surface erosion	40
b. Arrest and heal arroyos (gullies)	50
c. Restore sand, gravel, stone mining pits	10
3. Restore Riparian and Floodplain Vegetation	
a. Plant diverse woody vegetation	80
b. Improve ground cover with herbaceous plants	50
c. Reduce conifer encroachment in riparian areas	10
4. Reconnect Streams to Floodplains	75
a. Provide floodwater overflow areas	50
b. Arrest and reverse channel incision	40
c. Increase channel roughness	25
d. Remove or relocate infrastructure that unnecessarily confines stream flow	10
5. Restore streambank and channel characteristics	
a. Arrest and heal streambank erosion	70
b. Arrest and reverse channel incision	40
c. Reduce stream width	25
d. Increase channel sinuosity	25
e. Enhance instream obstacles and diversity for aquatic organisms	25
6. Wetland Restoration and Enhancement	
a. Recreate wetlands	80
b. Restore existing wetland function	80

Appendix D. Summary of Literature Review

See Supplemental Documents for the full literature review.

In order to help develop sound MRMs to address the lower Mora Watershed nutrient impairment, we conducted a review of current literature. Its specific goal was to search recent scientific and applied science literature to determine current thinking on the most effective remediation or restoration measures to reduce nutrient loading in streams. This review was neither exhaustive nor comprehensive since funds were limited but did provide a pulse on current knowledge.

KI Bar consulting was hired to conduct this literature review. JSTOR and EBSCO Host Research Libraries were queried resulting in a review of 36 applicable articles. A summary of this literature search and complete bibliography is in Supporting Documents. Below is a synopsis.

Common findings/themes

- Few studies exist with scientific evidence of effectiveness of various nutrient reduction techniques – usually anecdotes and public opinion motivate assessment/perception of effectiveness.
- Few studies exist documenting cost-effectiveness of Nitrogen (N) reduction solutions.
- Many currently purported Phosphorus (P) reduction techniques have no evidence of actually reducing P.
- Generally, data on nutrient concentrations has not been collected over a long enough period to draw accurate conclusions and be statistically significant.
- For all of the above, what amount of monitoring does exist has high levels of uncertainty.
- Ephemeral and intermittent streams are important to overall watershed health but are not always considered in watershed plans.
- Contaminant/nutrient transport pathways are unique to each watershed, meaning watershed-specific management plans are essential for effective management.

Specific Findings

Correlations, modeling techniques, and restoration practices with accuracy/effectiveness supported by at least preliminary research are below.

General

- Restoration of channels to floodplains and wetlands has shown promise, whereas stream restoration efforts than do not reconnect channels to floodplains have limited to no documented effectiveness.
- Instream restoration is effective only when it has features designed for all flow conditions.

- Instream restoration increases mesic & decreases xeric vegetation habitat (raises water table available to vegetation).

- Deep-planting of riparian vegetation can be effective in establishing it, especially in arid and semi-arid regions.

- Upland erosion control and current agricultural N-management practices are insufficient for effective N and P reduction; additional suggestions include wetland construction, buffer strips, and streambank stabilization.

- Streamflow reduction with high sediment levels has more negative impacts on invertebrate fauna than streamflow reduction from a stream with low sediment levels.

- The optimal hydraulic retention time of septic tank effluent within a constructed wetland to maximize N & P reduction was 2 days.

- No clear relationship seems to exist between plant nutrient content & nutrients in water & sediment.

- Forest, pasture, and cropland streams have different N & P levels, as well as gain and loss mechanisms (e.g. harvested crop, tree production, subsurface flux, etc).

- More monitoring is necessary for restoration projects and should be planned for when allocating funding.

- Long-term monitoring is important for accurate nutrient cycling data evaluations & conclusions.

Nitrogen-specific conclusions

- Land use and cover impacts N levels and cycles, specifically that fertilizer use and livestock production are linked to higher N concentrations.

- Canopy cover and stream temperatures can explain the majority of the variation in nitrate uptake across various streams in the same area.

- There is a general trend of decreasing denitrification as one follows a river/watershed downstream.

- Fire is not an effective N mitigation tool in semi-arid environments.

- Natural-strip (buffer) implementation, straw management show potential for use in N reduction.

- Two-stage ditch construction (creation of floodplains along irrigation ditches) can increase NO3 load reduction during storm events.

- Seepwillow (*Baccharis salicifolia)* is an important riparian shrub for denitrification in the Sonoran Desert in Arizona (although, as with most riparian vegetation, it is not clear whether the plant assists with denitrification through uptake, or if it stimulates microbial activity in the surrounding environment).

Phosphorus-specific conclusions

- Land use and cover impacts P levels and cycles, particularly when riparian areas are converted to urban or agricultural areas.
- In studies of 40 P-management techniques, the largest reductions in P came from buffer zones & constructed wetlands; buffer zones were among the most cost-effective mitigation methods.
- High P levels in sediment were correlated to better vegetation recolonization rates.
- An average P retention amount per unit area for natural and constructed wetlands in Illinois was predicted with a Vollenwieder-type model and field-checked to be about 0.5 – 3 g $P*m^{-2}\ yr^{-1}$.

Watershed restoration work designed to improve water quality and restore other degraded conditions both in drainage channels and uplands has been done around the country with considerable work in the Southwest (Follstad, et. al. 2007). While project monitoring and reporting has had some limitations, indications are that restoration and improved management of watersheds produces positive outcomes related to water quality and improved watershed functions.

With support from the literature the following nutrient remediation Management and Restoration Measures will be recommended later in this section as well as others not specifically addressed in this literature review.

Literature supported Management and Restoration Measures:

- Reconnect drainage channels to their floodplains
- Protect, restore or enhance wetlands
- Produce or restore buffers strips of natural riparian vegetation along drainages and between nutrient sources and drainages
- Stabilize streambanks
- Manage livestock to reduce N concentrations
- Limit fertilizer use and use two-stage ditch construction (creation of floodplains along irrigation ditches) to increase NO3 load reduction during storm events
- Ephemeral and intermittent streams as well as perennial streams must be included in restoration work
- Plan pre and post monitoring for all restoration projects

Appendix E. Wildlife-Friendly Riparian, and Cross-River Fencing Guidelines

This document provides guidelines for building fences in riparian and upland areas which are flood-resistant good for the watershed and wildlife friendly.

Wildlife-friendly construction guidelines: [4]

Did you know that one ungulate per year dies for each 2.5 miles of fence from entanglement, especially when the fence is woven wire topped with barbed?

Did you know that one ungulate per year dies for each 1.2 miles of fence from being separated/blocked, especially with woven wire fencing?

To make fences safe and wildlife-friendly, construct or modify them according to the following guidelines:

1. The top of the fence should be smooth wire or rail, and the bottom should be smooth wire
2. The bottom rail or wire of the fence should *16-18 or more inches* from the ground
3. The distance between the top two wires should be *at least* 12 inches
4. The total fence height should be *40 inches or less*, and certainly no more than 42 inches
    a. The steeper the slope of the land, whether a hill or a deep ditch, the more difficult it is for wildlife to jump, so the lower the total height of the fence should be.
5. The vertical posts (e.g. t-posts) should be 16.5 feet apart
6. Either avoid vertical stays, use plastic/composite stays that don't bend, or maintain wire stays in good condition (check frequently)
7. Consider including gates, drop-drowns or crossings where wildlife trails are clearly visible on the land
8. Remove old fences that are no longer needed – wildlife are safest where there are no fences at all

When to build: [5]

1. It is recommended that fence construction take place in the early summer to allow for replanting & rehabilitation of land before winter

Riparian (along-stream) fencing guidelines: [6]

Fencing along the riparian area or stream is a great step towards improving habitat, forage production, and water quality in the area! However, the distance you fence from the stream makes a big difference. The following recommendations can help to be sure you are moving toward your management goals.

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[4] Recommendations adapted from A Landowner's Guide to Wildlife Friendly Fences: How to Build a Fence with Wildlife in Mind, Second Edition by Christine Page of Ravenworks Ecology for the Montana Fish, Wildlife and Parks Service, 2012

[5] Recommendations adapted from Water Note WN19: Flood proofing fencing for waterways, Government of Western Australia Department of Water, Water and Rivers Commission, 2000

[6] Recommendations adapted from Fencing Riparian Zones by the New South Wales Department of Primary Industries, Fishing and Aquaculture

1. If the goal is to protect riparian vegetation (e.g. willows, cottonwoods, sedges, herbaceous plants), you need to fence a *minimum of 50 feet* from each bank of the stream or drainage
2. If the goal is protection of fish habitat, you need to fence a *minimum of 60 feet* from each bank
3. If the goal is to create a nutrient buffer (e.g. to improve water quality), these buffers are most effective when fenced *over 160 feet* from each bank
4. If the goal is protection of wildlife habitat, you need to fence *90 to 150 feet* from each bank
5. If the goal is to avoid fence damages from flooding, the fence should be placed beyond the 100 year floodplain
6. All fences should follow the above wildlife-friendly fencing guidelines.

Cross-river fencing guidelines[7]:

It is better if a fence does not have to cross a river, but sometimes this is unavoidable. Most of us saw the damage done in the September 2013 floods and know how powerful a river can be. In order to have a "flood-proof" fence across a river, keep in mind the following guidelines:

1. Design your fence so it crosses the river as few times as possible
2. Build your fence at a natural high point in the land
3. Do not build across a river bend or meander (choose a straight section)
4. Choose a point where the water is flowing more slowly (a low-velocity point)
5. Do not build your fence above a confluence where it would have to cross the river twice.
6. Make your fence as short as possible to control your livestock (taller fences are less stable in floods)
7. Build posts at 45-degree angles to the flow of water to increase resistance
8. Use smooth wire, and the fewest number of wires necessary (holds debris less); keep wires tight
9. Consider using hinged gates or cables for crossing materials as these are less likely to catch debris and tear down during a flood.
10. Consider using sacrificial or drop-down or break-away fencing (e.g. star pickets, low-tensile electric fence, etc) which is inexpensive and comes apart easily during a flood, or consider building a fence which can be manually dropped in times of flood

[7] Recommendations adapted from Water Note WN19: Flood proofing fencing for waterways, Government of Western Australia Department of Water, Water and Rivers Commission, 2000

Appendix F. Wildlife and Plant Species Lists

Source: www.windriverranch.org

Birds

Canada Goose	Broad-tailed	American Robin
Wood Duck	Hummingbird	Gray Catbird
Gadwall	Rufous Hummingbird	Northern Mockingbird
Mallard	Belted Kingfisher	Sage Thrasher
American Wigeon	Common Poorwill	Brown Thrasher
Northern Shoveler	Lewis' Woodpecker	American pipit
Northern Pintail	Red-headed Woodpecker	European Starling
Green-winged Teal	Red-naped Sapsucker	House wren
Blue-winged Teal	Williamson's Sapsucker	Cedar Waxwing
Cinnamon Teal	Ladder-backed	Dipper
Canvasback	Woodpecker	Orange-crowned Warbler
Redhead	Downy Woodpecker	Yellow Warbler
Ring-necked Duck	Hairy Woodpecker	Virginia's Warbler
Bufflehead	Northern Flicker	Yellow-rumped Warbler
Common Goldeneye	Western Wood-Pewee	Cerulean warbler
Common Merganser	Willow Flycatcher	Grace's Warbler
Ruddy Duck	Eastern Phoebe	Common Yellowthroat
Wild Turkey	Black Phoebe	Wilson's Warbler
Double-crested cormorant	Say's Phoebe	Yellow-breasted Chat
Great Blue Heron	Ash-throated Flycatcher	Townsend's Warbler
Black-crowned Night-	Olive-sided Flycatcher	Kentucky Warbler
Heron	Gray Flycatcher	Hepatic Tanager
Green Heron	Dusky flycatcher	Western Tanager
Sora Rail	Vermillion flycatcher	Green-tailed Towhee
White-faced ibis	Cassin's Kingbird	Spotted Towhee
Turkey Vulture	Western Kingbird	Canyon Towhee
Osprey	Eastern Kingbird	Rufous-crowned Sparrow
Northern Harrier	Loggerhead Shrike	Chipping Sparrow
Sharp-shinned Hawk	Northern Shrike	Vesper Sparrow
Cooper's Hawk	Plumbeous Vireo	Brewer's Sparrow
Goshawk	Warbling Vireo	Clay-colored Sparrow
Swainson's Hawk	Cassin's Vireo	Lark Sparrow
Red-tailed Hawk	Red-eyed Vireo	Song Sparrow
Ferruginous Hawk	Clark's Nutcracker	Lincoln's Sparrow
Bald Eagle	Steller's Jay	Lark Bunting
Golden Eagle	Western Scrub-Jay	White-crowned Sparrow
American Kestrel	Pinyon Jay	White-throated Sparrow
Merlin	Black-billed Magpie	Dark-eyed Junco
Prairie Falcon	American Crow	Black-headed Grosbeak
Peregrine Falcon	Common Raven	Blue Grosbeak
American Coot	Horned Lark	Rose-breasted Grosbeak

Sandhill Crane Killdeer Spotted Sandpiper Solitary Sandpiper Semipalmated sandpiper Long-billed Curlew California Gull Common Tern Rock Pigeon Eurasian Collared Dove Mourning Dove White-winged dove Barn Owl Great Horned Owl Long-eared Owl Western Screech-Owl Saw-whet Owl Greater Roadrunner Common Nighthawk White-throated Swift Black-chinned Hummingbird	Violet-green Swallow Rough-winged Swallow Bank Swallow Cliff Swallow Barn Swallow Black-capped Chickadee Mountain Chickadee Juniper Titmouse Bushtit Red-breasted Nuthatch White-breasted Nuthatch Pygmy Nuthatch Rock Wren Canyon Wren Bewick's Wren Ruby-crowned Kinglet Golden-crowned Kinglet Blue-gray Gnatcatcher Western Bluebird Mountain Bluebird Townsend's Solitaire Hermit Thrush	Lazuli Bunting Red-winged Blackbird Western Meadowlark Eastern Meadowlark European Starling Yellow-headed Blackbird Brewer's Blackbird Common Grackle Great-tailed Grackle Brown-headed Cowbird Bullock's Oriole House Finch Cassin's Finch Pine Siskin American Goldfinch Lesser Goldfinch RedCrossbill Evening Grosbeak House Sparrow

Insects

Order/Sub-Order/Family	Scientific Name (Common Name)
ORDER DERMAPTERA	
FORFICULIDAE	*Forficula auricuria* (European earwig)
ORDER ODONATA	
DRAGONFLIES (Suborder Anisoptera) ***AESCHNIDAE***	*Rhionaeschna multicolor* (Blue-eyed darner) *Anax junius* (Green darner)
GOMPHIDAE	*Progomphyus obscurus* (Common sandragon)
LIBELLULIDAE	*Libellula pulchella* (12-spot skimmer) *Erythemis collocota* (Western pondhawk) *Orthemis ferruginea* (Roseate skimmer) *Libellula forensis* (Western widow) *Tramea lacerata* (Black saddlebags) *Libellula saturata* (Flame skimmer) *Erythrodiplax funerea* (Black-winged dragonlet) *Paltothemis lineatis* (Red-rock skimmer)
DAMSELFLIES (Suborder Zygoptera) ***COENAGRIONIDA*** **Pond damsels** ***CALOPTERYGIDAE***	*Hetaerina americana* (American ruby-spot) *Hetaerina vulnerata* (Canyon ruby-spot)
LESTIDAE	*Archilestes grandis* (Great spreadwing)
ORDER MANTODEA	
MANTIDAE	*Litaneutria obscura* (Obscure ground mantid)
ORDER PHASMATODEA	

HETERONEMIDIIDAE	*Diapheromera femorata* (Northern walking stick)
ORDER ORTHOPTERA	
***ROMALEIDAE* (Lubbers)**	*Brachystola magna*
ACRIDIDAE (Grasshoppers)	*Dissosteira carolina* (Carolina Locust) *Arphia pseudonietana* (Red-winged Grasshopper) *Encoptolophus coastalis* (Dusky Grasshopper) *Encoptolophus subgracilis* *Trachyrhachys aspera* (Scudder Finned Grasshopper) *Trimerotropis pallidipennis* (Pallid-winged Grasshopper) *Trimerotroipis melanoptera* (Black-winged Grasshopper) *Trimerotropis modesta* *Trimerotropis spp.* *Syrbula montezuma* (Slant-faced Grasshopper) *Phlibostroma quadrimaculatum* (Four-spotted Grasshopper) *Ageneotettix deorum* (White Whiskers Grasshopper) *Opeia obscura* (Obscure Grasshopper) Eritettix simplex (Velvet-striped Grasshopper) *Amphitornus coloradus* (Striped Slant-faced Grasshopper) *Hypochlora alba* (Cudweed Grasshopper) FIRST RECORD FOR NM *Hesperotettix viridis* (Snakeweed Grasshopper) *Dactylotum bicolor* (Pictured Grasshopper) *Melanoplus bivittatus* (Two-striped Grasshopper) *Melanoplus lakinus* (Lakin Grasshopper) *Melanoplus* spp. 1 (Slender, short-winged on Sage) *Melanoplus* spp. 2 (Robust, striped pronotum) *Melanoplus* spp. 3 (Very robust, red or blue hind tibiae) *Melanoplus* spp. 4 (Rather ordinary, slender, fully winged)
RHAPHIDOPHRIDAE	*Ceuthophilus pallidus* (Pallid camel cricket)
GRYLLIDAE	*Oecanthus niveus* (Narrow-winged tree cricket) *Oecanthus fultoni* (Snowy tree cricket) *Oecanthus* spp. (Tree cricket) *Grillus* spp. (Field cricket)
TETTIGONIIDAE	Katydid
ORDER HEMIPTERA	
REDUVIIDAE	*Apiomerus* spp. (Assassin bug) *Apiomeris* spp. (Bee assassin) *Sinea* spp.
LARGIDAE	*Oncopeltis fasciatus* (Large milkweed bug) *Lygaes kalhii* (Small milkweed bug) *Largus succintus* (Largus bug) *Largus* spp. (Largus bug) unknown Lygaridae
PENTATOMIDAE	*Murgantid histrionica* (Harlequin bug) *Chlorochroa sayi* (Say's stink bug) *Cosmopepia conspicillapis* (Two-spotted stink bug)
MEMBRACIDAE	*Ceresa* spp. *unknown Membracidae*
MIRIDAE	unknown Miridae
ALYDIDAE	*Megalotomus quinquespirosus* (Broad-headed bug) *Alydus* spp.
CICADELLIDAE	unknown Cicadellidae
DICTYOPHARIDAE	*Scolops pungens* (Planthopper)

RHOPALIDAE	*Boisea rubrolineata* (Western boxelder bug) *Boisea trivittata* (Eastern boxelder bug)
COREIDAE	*Leptoglossus occidentalis* (Western conifer seed bug)
CICADIDAE	*Tibicen dorsata* (Cicada) *Diceroprocta apache* (Desert cicada)
ORDER COLEOPTERA	
CARABIDAE	*Amara* spp. *Pasimachus* spp. unknown Carabidae
CICINDELLIDAE	*Cicindela* spp. *Cicindela punctulata* (Backroad tiger beetle) *Cicindela obsoleta* (Grassland tiger beetle)
	SCARABAEIDAE *Macrodactylus uniformis* (Western rose chafer) *Cotinus mutabilis* (Southwestern fig beetle) *Polyphylla decimlineatus* (Ten-lined June beetle) *Popillia japonica* (Japanese beetle) *Phyllophaga* spp. (June beetle) *Copris* spp. unknown Scarabaeidae *DYNASTIDAE* *Xyloryctes jamaicensis* (Rhinoceros beetle) *CUCCIMELLIDAE* *Hippodomia convergens* (Convergent lady beetle) *COCCINELLIDAE* unknown Coccinellidae *LAMPYRIDAE* *Ellychnia flavicollis* (Firefly) *CHRYSOMELIDAE* *Charidotella* spp. (Tortoise beetle) *Chrysochus cobaltimus* (Cobalt milkweed beetle) *Diabrotica undecimpuntata* (Spotted cucumber beetle) *Diabrotica virvifera* (Western corn rootworm) *BUPRESTIDAE* *Acmaeodera* spp. (Metallic wood borer) *LYCIDAE* *Calopteron discrepens* (Banded net-winged beetle) *Plateros* spp. unknown Lycidae *MORDELLIDAE* *Mordellistena* spp. (Tumbling flower beetle) unknown Mordellidae *MELYRIDAE* *Collops quadrimaculatus* (Soft-winged flower beetle) *Collops bipunctatus* (Two-spotted melyrid) *CANTHARIDAE* *Chauliograthius* spp. CERAMBICIDAE *Batyle ignicolis* *Monochanus clamator* (Spotted pine sawer) *Tetraopes femoratus* (Milkweed beetle) *Derobrachus geminatus* (Palo verde beetle)

	MELOIDAE *Nemognatha* spp. (Orange blister beetle) *Epicauta fabricii* (Ash-gray blister beetle) unknown Meloidae *TENEBRIDAE* *Eleodes tricostata* (Desert stink beetle) *Eloides obsoletus* (Obsolete darkling beetle) *Embaphium* spp. *Stenomorpha* spp. unknown Tenebridae *CURCULIONIDAE* *Compsus auricephalus* (Golden-headed weevil) *STAPHYLINIDAE* *Creophinus maxillosus* (Rove beetle) *SILPHIDAE* *Thanatophilus truncatus* (Carrion beetle) *Nicrophoris marginatus* Burying beetle) *Oiceoptoma* spp. unknown Silphidae
	ORDER NEUROPTERA *MYRMELEONTIDAE* *Brachynemurus* spp. (Antlion) *Myrmeleon* spp. (Antlion) *CHRYSOPIDAE* *Chrysopa* spp. (Green lacewing)
	ORDER LEPIDOPTERA MOTHS *ZYGANIDAE* *Harrisim americana* (Grapeleaf skeletinizer) *SESIIDAE* unknown Sessiidae unknown Sessiidae *PTEROPHORIDAE* Plume moth *CRAMBIDAE* *Crambus* spp. (Snoutmouth moth) *GEOMETRIDAE* *Biston betularia* (Peppered moth) unknown geometer moth *SATURNIDAE* *Antheraea polyphemus* (Polyphemus moth) *Automeris zephyria* (Zepher moth) *Hemileuca oliviae* (Range caterpillar moth) *Colorado pandora* (Pandora moth) *SPHINGIDAE* *Panonias excaccatus* (Blinded sphinx) *Manducada sexta* (Tomato hookworm moth) *Sphinx chersis* (Ash sphinx) *Hyles lineata* (White-lined sphinx) *NOCTUIDAE* *Catacala aholibah* (Aholibah underwing)

	Euxor aunliaris (Cutworm moth) Unknow nocutid unknown noctuid *ARCTIIDAE* *Gnophaela vermiculata* (Police car moth) *Isa isabella* (Wooley bear moth) unknown arctiidae *ERBIDAE* tiger moth *PRODOXIDAE* yucca moth BUTTEFLIES *NYMPHALIDAE* *Phyciodes picta* (Painted crescent) *Euptoieta claudia* (Western fritillary) *SATYRIDAE* *Cercionis oetis* (Small wood nymph) *Limenitis weidermeyerii* (Weidermeyer's admiral) *Vanessa cardui* (Painted lady) *Danaus gilippus* (Queen) *Nymphalis antiopa* (Mourning cloak) *PAPILLIONIDAE* *Papilio polyxenes* (Black swallowtail) *Papilio multicaudata* (Two-tailed tiger swallowtail) *Anthocharis sara* (Sara orangetip) *PIERIDAE* *Zerene cesonia* (Southern dogface) *Coleus eurytheme* (Orange sulphur) *Abaeis nicippi* (Sleepy sulphur) *Puntia occidentalis* (Western white) *Pierus rapae* (Cabbage white) *RIONINIDAE* *LYCAENIDAE* *Echinagus isola* (Reakert's blue) *Glaucopsyche lygdamus* (Silvery blue) *HESPERIIDAE* *Pyrgus* spp. (Checkered skipper) *Erynnis* spp. (Cloudy-winged skipper) *Pyrgus communis* (Common checkerspot) *Thymelicus lincola* (European skipper) *Pyprhopyge* spp. (Firetip skipper)
	ORDER DIPTERA *TABANIDAE* *Tabanus* spp. (Horsefly) *Tabanus lineata* (Striped horsefly) *Chrysops* spp. (Deer fly) *ASILIDAE* *Efferia* spp. (Robber fly) *Efferia albibarbus* (Robber fly) *Archilestris magnificus* (Robber fly) *Megaphorus* spp. (Robber fly) unknown Asilidae

	BOMBYLIIDAE *Systoechus vulgaris* (Bee fly) *Bombylius* spp. *Geron* spp. *DOLICHOPODIDAE* *Condylustylus* spp. (Long-legged fly) *SYPHIDAE* *Siphidae* (Hover fly) *SARCOPHAGIDAE* *Sarcophaga* spp. *TACHINIDAE* *Paradejiania rutilioides* (Spiry tacim fly) *Tachinomyia* spp. *Exoprosopa* spp. unknown Tachinidae *CALLIPHORIDAE* *Lucilia* spp. (Green-bottle fly) *PRYOMYZIDAE* unknown Pryomyzidae
	ORDER HYMENOPTERA *CIMBICIDAE* *Cimbex americana* (Elm sawfly) *SIRICIDAE* *Tremax columba* (Horntail) *ICHNEUMONIDAE* *Gnamtopelta obsidianator* *subfamily Ophioninae* unknown Ichneumonidae *SCOLIIDAE* *Campsomeris pilipes* Yellow scarab hunter *FORMICIDAE* unknown Formicidae *VESPIDAE* *Vespula pennsylvanica* Western yellowjacket *Polistes aurifer* paper wasp *Polistes* spp. *Polistes* spp. *POMPILIDAE* unknown Pompilidae *SPHECIDAE* *Hoplisoides punctifrons* *Chalybion californicum* Blue mud-dauber *Spex ichneumoreus* Great golden digger *Sceliphron caementarium* *Amnophilia* spp. *Amnophilia* spp. unknown Sphecidae unknown Sphecidae *HALYCTIDAE* *Agapostemon* spp. Sweat bee *Agapostemon* spp. Sweat bee *APIDAE*

	Apis mellifera European honey bee *Bombus* spp. Bumblebee *BOMBILIDAE* unknown Bombilidae *SYRIFIDAE* *Eristalis* spp. Hover fly *MEGACHILIDAE* *Megachile* spp. *BRACORIDAE* unknown Brachoridae *MUTILLIDAE* *Dasymutilla* spp. Velvet ant unknown Mutillidae *CRABRONIDAE* *Bembix* spp. Sand wasp unknown Crabronidae *MEGACHILIDAE* *Megachile* spp.

Animals		
Common Name	*Scientific Name*	*Notes (Bison-M)**
Crustacean		
Northern Crayfish	*Orconectes virilis*	Non-native (Jesus Rivas pers. com.); Taxa may be detrimental to ecosystem where non-native
Fish		
Creek chub	*Semotilus atromaculatus*	Native, sensitive to sedimentation, prefer stream pools, nongame
Long-nosed dace	*Rhinichthys cataractae*	Native, nongame
Central stoneroller	*Campostoma anomalum*	Native, nongame
Rio Grande chub	*Gila pandora*	Native to Rio Grande & Pecos watersheds, may have been introduced in Canadian, nongame
White sucker	*Catostomus commersoni*	Native, nongame
Brown trout	*Salmo trutta*	Non-native, Introduced, harvested
Fathead Minnow	*Pimephales promelas*	Native, nongame
Green sunfish	*Lepomis cyanellus*	Native, harvested
Rio Grande cutthroat trout	*Oncorhynchus clarki virginalis*	Extirpated from lower reaches of the Mora River
Amphibians		

Tiger Salamander	*Amystoma tigrinum*	
Woodhouse toad	*Bufo woodhousi*	
Red-spotted toad	*Bufo punctatus*	
New Mexico spadefoot toad	*Spea multiplicata*	
Plains spadefoot	*Spea bombifrons*	
Bullfrog	*Rana catesbeiana*	Non-native - Introduced
Northern leopard frog	*Rana pipiens*	
Reptiles		
Snapping turtle	*Chelydra serpentina*	May be non-native locally
Collared lizard	*Crotaphytus collaris*	
Short-horned lizard	*Phrynosoma douglassi*	
Prairie lizard	*Sceloperus undulatus*	
Lesser earless lizard	*Holbrookia maculata*	
Plateau striped whiptail	*Cnemidophorus velox*	
Six-lined racerunner	*Cnemidophorus sexlineatus*	
Many-lined skink	*Eumeces multivirgatus*	
Great Plains skink	*Eumeces obsoletus*	
Racer	*Coluber constrictor*	
Ringneck snake	*Diadophis punctatus*	
Corn snake	*Elaphae guttata*	
Western hog-nose snake	*Heterodon nasicus*	
Smooth green snake	*Liochlorophis vernalis*	
Bullsnake	*Pituophis melanoleucus*	
Common kingsnake	*Lampropeltis getula*	
Milk snake	*Lampropeltis triangulum*	
Blackneck garter snake	*Thamnophis cyrtopsis*	
Western terrestrail garter snake	*Thamnphis elegans*	
Lined snake	*Tropidoclonion lineatum*	
Western rattlesnake	*Crotalus viridus*	
Mammals		
Desert cottontail	*Silvilagus audubonii*	
Black-tailed jackrabbit	*Lepus californicus*	
Gunnison's prairie dog	*Cynomys gunnisoni*	
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	
Rock squirrel	*Spermophilus variegatu*	
Colorado chipmunk	*Tamias quadrivittatus*	
Least chipmunk	*Tamias minimus*	
North American porcupine	*Erethizon dorsatum*	
Northern raccoon	*Procyon lotor*	
Long-tailed weasel	*Mustela frenata*	

Striped skunk	*Mephitus mephitus*	
Western spotted skunk	*Spilogale gracialis*	
Common hog-nosed skunk	*Conepatus leuconotus*	
American badger	*Taxidea taxus*	
Common muskrat	*Ondatra zibethicus*	
American beaver	*Castor canadensis*	
Coyote	*Canis latrans*	
Gray fox	*Urocyon cinereoargenteus*	
Swift fox	*Vulpes velox*	
Puma	*Puma concolor*	
Bobcat	*Lynx rufus*	
American black bear	*Ursus americanus*	
White-tailed deer	*Odocoileus virginianus*	
Mule deer	*Odocoileus hemionus*	
Elk	*Cervus elaphus*	
Bison	*Bison bison*	
Pronghorn	*Antilocapra americana*	
Botta's pocket gopher	*Thomonys bottae*	
Ord Kangeroo rat	*Dipodomys ordii*	
Hispid pocket mouse	*Chaetodipus hispidus*	
Plains pocket mouse	*Perognathus flavescens*	
Silkly pocket mouse	*Perognathus flavus*	
Western harvest mouse	*Reithrodontomys megalotis*	
Plains harvest mouse	*Reithrodontomys montanus*	
North American deer mouse	*Peromyscus maniculatus*	
White-footed mouse	*Peromyscus leucopis*	
Piñon deer mouse	*Peromyscus truei*	
Brush mouse	*Peromyscus boylei*	
Northern rock mouse	*Peromyscus nasutus*	
Northern grasshopper mouse	*Onychomys leucogaster*	
White-throated woodrat	*Neotoma albigula*	
Mexican woodrat	*Neotoma mexicana*	
Prairie vole	*Microtis ochrogaster*	
Long-tailed vole	*Microtis longicaudus*	
Desert shrew	*Notiosorex crawfordi*	
Little brown Myotis	*Myotis lucifugus*	
Hoary bat	*Lasiurus cinereus*	

Plants
Grasses
POACEAE

Bouteloua gracialis (Blue grama)
Boutalous curtipendula (Sideoats grama)
Boutaloua hirsuto (Hairy grama)
Buchloa dactyloides (Buffalo grass)
Munroa squarrosa (False buffalo grass)
Pascopyrum smithii (Western wheatgrass)
Panicum obtusumi (Vine mesquite)
Panicum virgatum (Switchgrass)
Panicum halli (Hall's panicum)
Panicum capillae (Witchgrass)
Pleurapis jamesii (James galleta)
Mulenbergia torreyana (Ring muhly)
Muhlenbergia wrightii (Spike muhly)
Muhlenbergia rigens (Deer muhly)
Muhlenbergia cuspidate (Plains muhly)
Muhlenbergia montanus mountain muhly
Muhlenbergia repens (Creeping muhly)
Muhlenbergia richardsonii (Mat muhly)
Blepharoneuron tricholepsis (Pine dropseed)
Sporobolus crypandrus (Sand dropseed)
Sporobolus airoides (Alkalai sacaton)
Schizachyrium scoparium (Little bluestem)
Bothriochloa saccharoides (Silver bluestem)
Bothriochloa barbinodis (Cane bluestem)
Andropogon gerardii (Big bluestem)
Lycurus phleoides (Wolftail)
Piptochaetium fimbriatum (Piñon ricegrass)
Hesperostipa comata (Needle and thread grass)
Heterstipa neomexicana (New Mexico feathergrass)
Elymus canadensis (Canada wildrye)
Elymus elymoides (Squirreltail)
Elymus junceus (Russian wildrye)
Aristada spp. (Three awn)
Poa fendleri (Mutton bluegrass)
Agrostis alba (Redtop)
Koelaria macrantha (Junegrass)
Oryziopsis hymenopides (Indian ricegrass)
Sorghastrum nuttans (Indian grass)
Eragrostis intermedia (Plains lovegrass)
Festuca ovina (Sheep fescue)
Stipa robusta (Sleepygrass)
Schedennardus panicululatus (Tumblegrass)
Vulpia microstachys (Six weeks grass)
Phragmites australis (Common reed)
Carex spp. (Sedge)
Juncus spp. (Rush)

Supporting Documents

#1 Watershed Condition Assessment of the Lower Mora River, KI Bar Consulting

www.hermitspeakwatersheds.org/WBPMR/supporting/condition.pdf

#2 Benthic Macroinvertebrate Bioassessment of the Lower Mora River, Ernesto Sandoval

www.hermitspeakwatersheds.org/ WBPMR /supporting/macroinvertebrate.pdf

#3 Literature Review, KI Bar Consulting

www.hermitspeakwatersheds.org/ WBPMR /supporting/literature.pdf

#4 Walk Through Assessment of the Lower Mora River, Watershed Artisans, Inc.

www.hermitspeakwatersheds.org/ WBPMR /supporting/assessment.pdf

#5 Hydrologic Analysis of Management and Restoration Measures for Nutrient Control in the Lower Mora River, Hermit's Peak Watershed Alliance

www.hermitspeakwatersheds.org/ WBPMR /supporting/basins.pdf