Rio Puerco Watershed-Based Plan

Final Version, submitted to EPA Region 6

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11/09/2017

A Plan to Determine the Best Management Practices to Improve Water Quality on the Rio Puerco

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A PLAN TO DETERMINE THE BEST MANAGEMENT PRACTICES TO IMPROVE WATERSHED HEALTH ON THE RIO PUERCO

INTRODUCTION

The Federal Clean Water Action Plan (CWAP) of 1998 was developed to help meet the goals of the Clean Water Act through the application of state-led cooperative efforts to identify and prioritize watersheds with water quality concerns. Consequently, the New Mexico Unified Watershed Assessment (1998) was conducted by a statewide task force in response to the actions mandated in the Clean Water Action Plan. New Mexico's Unified Watershed Assessment identified 21 out of New Mexico's 83 watersheds as "in need of restoration."

This Watershed-Based Plan (WBP) is a mandatory document for the Rio Puerco Management Committee's intended applications for watershed restoration and nonpoint source pollution control project funding under Clean Water Act Section 319(h). In addition, as a living watershed planning document, it may appropriately be attached to applications for other avenues of funding, and can be expanded and updated and submitted in compliance with the Committee's obligation to report biannually to the Secretary of the Interior, who presents the report to Congress.

This WBP contains the following components:

- A description of the Rìo Puerco Watershed and water bodies of concern within the Rìo Puerco Watershed (see page 5).
- The specific water quality problems to be addressed, the sources of pollution and the relative contribution of sources (see pages 16 & 26).
- A blueprint of the actions to be taken and desired water quality, natural resources, socioeconomic and other goals and outcomes; i.e., implementation of pollution control and natural resource restoration measures (see page 44).

- Funding needs to support the implementation and maintenance of restoration measures (see page 55).
- The public outreach structure and method(s) that will be used to engage and maintain public and governmental involvement including local, state, federal, and tribal governments (see page 57).
- A schedule for implementation of needed restoration measures and identification of appropriate lead agencies or cooperators to oversee implementation, maintenance, monitoring and evaluation (see page 59).
- Monitoring and evaluation activities based on water quality and other goals and outcomes needed to refine the problems or assess progress toward achieving these goals (see page 64).

This plan is meant to identify water quality issues for the Rio Puerco, Arroyo Chico, and San Jose watersheds (HUCs 13020204, 13020205 and 13020207 respectively), recommend best management practices (BMPs) that may address these issues, and predict the effectiveness of said BMPs. These three 8-digit HUCS contribute much of the sediment to the Rio Grande, and there is community-wide interest in preventing erosion and potential post-fire flooding. Though the seven Assessment Units that are listed as NPS priority streams are the focus of this plan, problems identified in their watersheds are typically widespread across the remainder of the planning area, as much of the planning area has similar land uses and appropriate management measures. For implementation purposes it should be assumed that these seven Assessment Units are the priority areas for restoration. The Assessment Unit (AU) is used as the primary identifier for priority areas, as NMED has evaluated these areas to have similar geomorphology, stream type, and probable causes of impairment.

This plan intends to address all nine of EPA's required planning elements for the impairments of nutrient and sediment loading throughout the following AUs, yet the argument will be made that addressing these impairments will also reduce turbidity and temperature loading as well. Modeling and BMP load reductions, however, will only be completed for the impairments of nutrients and sediment.

Impaired Stream Segments

Under the New Mexico 2016-2018 303(d) Integrated List of Impaired Waters the following stream segments within the area covered by this plan are impaired and not meeting some or all of their designated uses.

AU Name	AU ID #	HUC 8	HUC 12(s)	Drainage Area (acres)	TMDL for:	Stream Length
Rio Puerco (Perennial part N bnd Cuba to headwaters)	NM-2107.A_44	Rio Puerco Watershed 13020204	1) Arroyo San Jose- Rio Puerco 130202040106	1) 33,554 - Sandoval Co.	**Sediment**	22.51 km
Rio Puerco (Arroyo Chijuilla to N bnd Cuba)	NM-2107.A_40	Rio Puerco Watershed 13020204	1) Arroyo San Jose- Rio Puerco 130202040106 2) Outlet Arroyo San Jose 130202040102	1) 33,554 – Sandoval Co. 2) 19,811 – Sandoval Co.	**Nutrients, Sediment,** Ammonia	13.62 km
Nacimiento Creek (Perennial part Hwy 126 to San Gregorio Rvr)	NM-2107.A_42	Rio Puerco Watershed 13020204	1) Arroyo San Jose- Rio Puerco 130202040106	1) 33,554 – Sandoval Co.	Uranium, Turbidity	10.9 km
Bluewater Creek (Bluewater Rvr to headwaters)	NM-2107.A_01	Rio San Jose Watershed 13020207	1) Bluewater Lake- Bluewater Creek 130202070206 2) Ojo Redondo- Bluewater Creek 130202070204 3) Agua Medio- Bluewater Creek 130202070207	1) 20,034 – Cibola Co. 2) 16,893 – Cibola Co. 3) 23,848 – Cibola Co.	**Nutrients,** Temperature	27.1 km
Bluewater Creek (non-tribal Rio San Jose to Bluewater Rvr)	NM-2107.A_00	Rio San Jose Watershed 13020207	1) Reynold Draw- Bluewater Creek 130202070207 2) Outlet Cottonwood Creek 130202070204 3) Sawyer Creek 130202070203 4) Headwaters Cottonwood Creek 130202070202	1) 13,876 – McKinley & Cibola Co. 2) 24,077 – McKinley & Cibola Co. 3) 14,430 – McKinley & Cibola Co. 4) 35, 654 – McKinley & Cibola Co.	**Nutrients,** Temperature	13.35 km
Rio Moquino (Laguna Pueblo to Seboyetita Creek)	NM-2107.A_10	Rio San Jose Watershed 13020207	1) Rio Paquate 130202070704 2) Seboyetita Creek 130202070701 3) Seboyeta Creek 130202070702	1) 10,663 – Cibola Co. 2) 12,674 – Cibola Co. 3) 26,684 – McKinley & Cibola Co.	**Nutrients,** Temperature	3.22 km

Table 1. Priority Assessment Units and watersheds for the Rio Puerco Watershed-Based Plan. The impairment of focus for each AU under this plan are in bold.

Rìo Puerco Management Committee

The Rìo Puerco Management Committee (RPMC), based in Albuquerque, New Mexico, is a collaborative watershed organization established by direction of the Congress of the United States, under the *Omnibus Parks and Public Lands Management Act of 1996,* Section 401, *Rio Puerco Watershed,* Pub. L. No. 104-333, 110 Stat. 4093 (Nov. 12, 1996). The RPMC was formed in February 1997, building on an initiative begun by the Rìo Puerco Watershed Committee, a locally led stakeholders group based in Cuba, New Mexico. Passage of the Rìo Puerco Watershed Act formalized the RPMC to carry out a broad-based, collaborative effort to restore and manage the watershed. RPMC membership includes state, federal, and tribal agencies, soil and water conservation districts, representatives of county government, residents from the rural communities within the watershed, environmental and conservation groups, and the public-at-large.

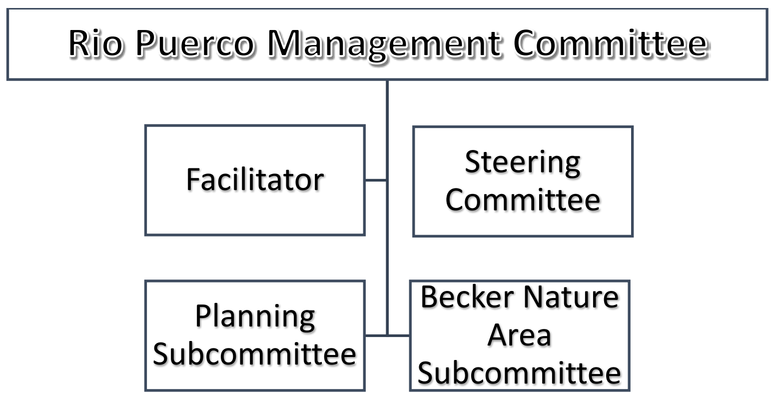


Table 2: RPMC Organizational Chart

The mixed land status of the watershed, including large tracts of Federal, Tribal, State, and private lands, contributes to the complexity of the situation, and makes it necessary to enlist the support and cooperation of numerous diverse interests in organizing and implementing projects. The forum provided by the RPMC is an effective approach to the multi-jurisdictional situation.

In passing this legislation, the Congress was demonstrating its commitment and support for the collaborative approach to improving the impaired watershed's condition. This WBP for the Rìo Puerco Watershed will summarize the recognized conditions and identify necessary efforts and mechanisms whereby watershed restoration and improvement activities will be pursued by the broad-based membership of the RPMC. The Bureau of Land Management (BLM) has assumed a vital leadership role in the development and support of the RPMC.

Historical Context and Summary of Previous Work

Through their work in the watershed, various State and Federal agencies, Tribal governments, local communities, private landowners, and environmental interest groups have made numerous attempts to upgrade ground cover and vegetation conditions, protect habitat, improve water quality and quantity, establish valid land management practices, and arrest the erosion processes. Many of these past efforts may fairly be characterized as largely non-collaborative and were short-lived. The Rio Puerco Watershed Act formalized the creation of the RPMC to conduct a coordinated effort to restore and maintain the watershed by organizing the different interests, consolidating available data, and developing sound approaches to watershed restoration by focusing on a reduction of erosion, achieving an increase in native vegetation, and improving riparian habitat.

In 2001, the RPMC developed an initial Watershed Restoration Action Strategy (WRAS) using EPA's then-current format (WRAS 2001). It was prepared as the RPMC's "business plan" for a variety of planning, reporting, and funding purposes. The WRAS discussed the group's initial watershed characterization. Using remotely sensed imagery, the US Geological Survey generated data and a statistical analysis of upland vegetation density, riparian vegetation, bare ground, and channel incision depth for nine sub-basins of the Rio Puerco basin. Using this along with other existing basin-wide data, the RPMC ranked each of these nine watersheds against five issues. These were upland function, riparian function, erosion/sediment, water quality, and roads (density). As a result of this ranking, the RPMC chose two of the nine watersheds as priorities for treatment. These were the Upper Main Stem and Torreon Wash. Although the majority of RPMC projects have been targeted at the priority watersheds, a small number of projects have been funded elsewhere in the basin. The WRAS defined three major goals: sediment reduction, vegetation and habitat improvement, and support and promotion of other watershed factors. The latter includes interjurisdictional and interagency cooperation, socio-economic benefits, recognition and protection of cultural resources, and public awareness, education, and participation.

To date, implementation of the 2001 WRAS has been notable. The RPMC has instituted a number of programs to train project implementers to gather and report monitoring data. RPMC has held a number of workshops on grazing management, erosion control, riparian protection, and road maintenance. The committee created the non-profit Rio Puerco Alliance, hired a full-time outreach coordinator, and developed a website. RPMC has sponsored the production of a video in Navajo to promote landowner interest and stewardship. Through a CWA § 319 grant, RPMC fabricated a mobile Rangeland Health Kiosk that is widely used as an educational tool. Four field guides about applying various BMPs have been published.

Two specifically identified projects which were underway in 2001 have been successfully completed. The Rio Puerco Channel Restoration Project located at La Ventana that begun by the RPMC in 1997 (Coleman, et al. 1998) was finished in 2006. The New Mexico Department of Transportation constructed two bridges to accommodate the flow as a part of the Highway 550 widening project. RPMC used $900,000 from EPA and partners to build the structures that were needed to protect the banks and step down the flow and removed the berm blocking the old channel. The river now flows within the natural meandering channel while the artificial channelized portion has been closed. The Pueblo of Jemez also completed a successful multi-year project on the Thompson Spring Range Unit to improve grazing management and control erosion.

Another on-the-ground priority of the initial WRAS was the development of “showcase project(s) to remediate an impaired area using a mix of … practices” along Torreon Wash and Cebolla Creek. The $700,000 EPA Watershed Initiative grant in 2003 gave the RPMC an opportunity to begin implementing BMPS such as capturing water and sediment in upland sites before it has a chance to run off, restoring stream channels using induced meandering and other methods, and promoting effective grazing management. The project demonstrated the utility of goats in removing sagebrush and other invasive species. A series of techniques for draining and harvesting water from dirt roads was demonstrated and promoted. The grant also gave the RPMC a jump-start in its ability to reach out to landowners and communities. It was able to hire a Project/Outreach Coordinator, develop a website, reprint a series of field guides, hold a number of workshops, and sponsor summer youth projects at four Navajo chapters and at Cuba High School. Through the $700,000 EPA Targeted Watershed grant received in 2008, RPMC continued watershed improvement measures largely in the Upper Torreon Wash sub-basin.

A number of other RPMC-sponsored projects have become showcase efforts. For example, the Ojo Encino Ranchers Committee's persistence in improving grazing management won them recognition by being the 2007 recipients of Quivira Coalition's Clarence Burch Award.

Data gathering and monitoring has centered on training committee members and project proponents in data collection techniques to monitor project results. In 2005, USGS and BLM reestablished the gaging station on the Arroyo Chico that had not been operational since 1986. Some road inventory data was gathered in the upper watershed as part of the Rio Puerco Watershed Initiative. Other inventories called for in the WRAS were not accomplished as they were lower priorities.

Watershed Setting

The Rìo Puerco Watershed, in west central New Mexico, is the largest tributary to the middle Rìo Grande Basin. The major water bodies in the watershed are the Rìo Puerco, Arroyo Chico and the Rìo San Jose. The Río Puerco Basin includes nine large physiographically defined sub-watersheds, draining portions of seven counties, west of the greater Río Grande Basin in the northwest and west-central portion of New Mexico. Originating along the eastern edge of the Continental Divide, the watershed encompasses approximately 7,350 square miles (4.7 million acres / over 1.9M hectares) that contribute flow to the Rìo Grande at Bernardo, NM (see Figures 1 and 2).

The Rìo Puerco has acquired renown worldwide as a severely impacted and degraded watershed, synonymous with accelerated erosion processes. While the watershed contributes less than 10% of the total water flow, it is a primary source of sediment to the Rìo Grande, contributing a disproportionately large percentage of silt and debris to that system, up to 80%.

The region has historically been used for agriculture, grazing, logging, mining, and a wide range of recreational purposes, and though sparse, urban development is increasing. Presently, agriculture is the dominant watershed-wide activity. The specific causes of watershed decline result from the combination of these land uses and their impact on a relatively vulnerable landscape. The listed causes are reflected in the Rio Puerco Management Committee's stated watershed restoration priorities, and they essentially define the general targets for improvement that this plan is pursuing. Specific sites for project implementation within certain prioritized sub-watersheds are as described in subsequent chapters.

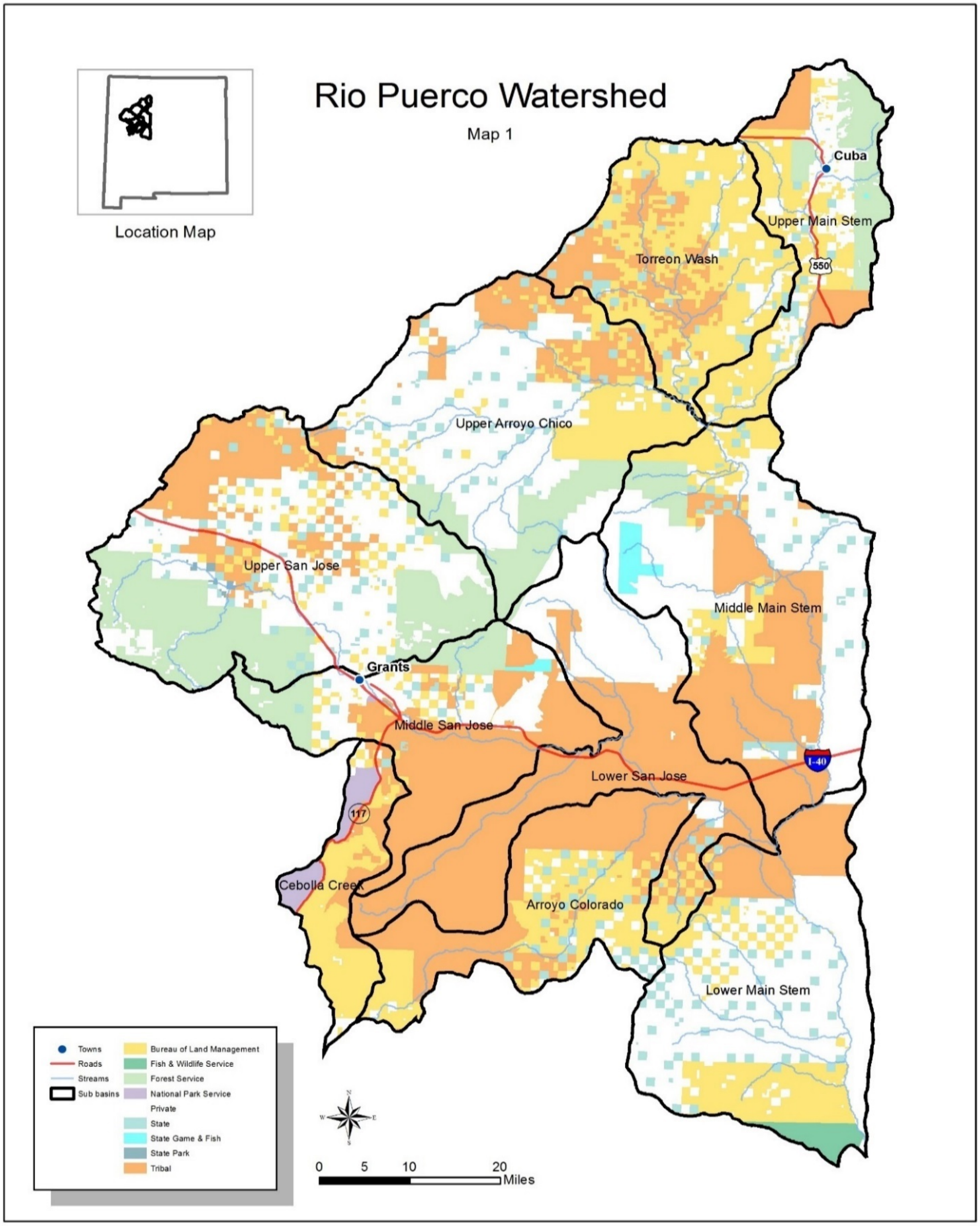


Figure 1. Map of the Greater Rio Puerco Watershed.

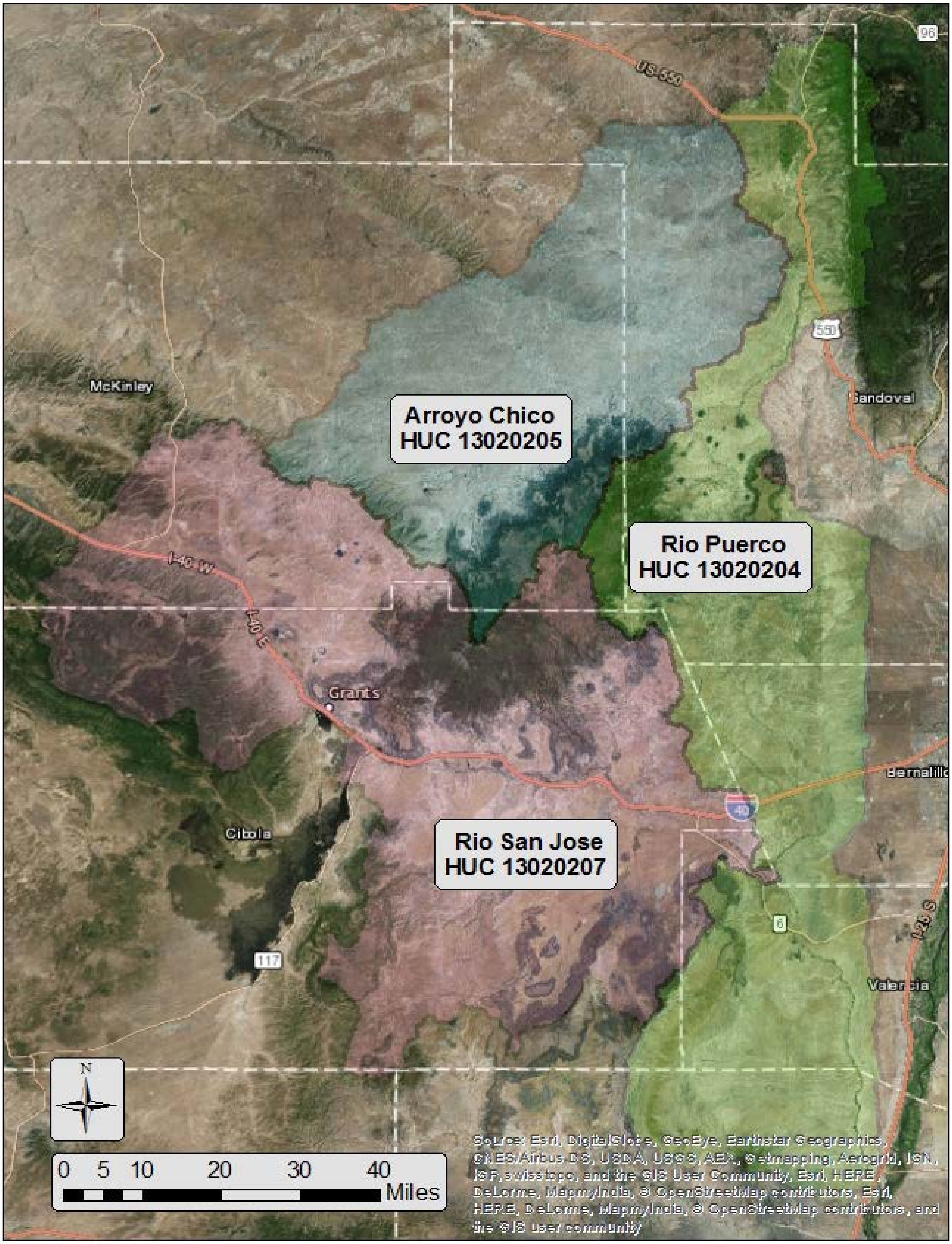


Figure 2. Area covered by the Rio Puerco Watershed Based Plan.

Chapter 1: Element A, Rio Puerco AUs and Nacimiento Creek

Introduction

Assessment Unit Name:	NM SWQB Assessment Unit ID:	HUC- 8	HUC-12s within the area of the Assessment Unit	Acreage of each HUC-12	Impairments applicable to each AU:	Length of AU:
Rio Puerco (Perennial part N bnd Cuba to headwaters)	NM-2107.A_44	Rio Puerco Watershed 13020204	1) Arroyo San Jose-Rio Puerco 130202040106	1) 33,554 - Sandoval Co.	**Sediment**	22.51 km
Rio Puerco (Arroyo Chijuilla to N Bnd Cuba)	NM-2107.A_40	Rio Puerco Watershed 13020204	1) Arroyo San Jose-Rio Puerco 130202040106 2) Outlet Arroyo San Jose 130202040102	1) 33,554 – Sandoval Co. 2) 19,881 – Sandoval Co.	**Nutrients, Sediment,** Ammonia	13.62 km
Nacimiento Creek (Perennial part Hwy 126 to San Gregorio Rvr)	NM-2107.A_42	Rio Puerco Watershed 13020204	1) Arroyo San Jose-Rio Puerco 130202040106	1) 33,554 - Sandoval Co.	Uranium, Turbidity	10.9 km

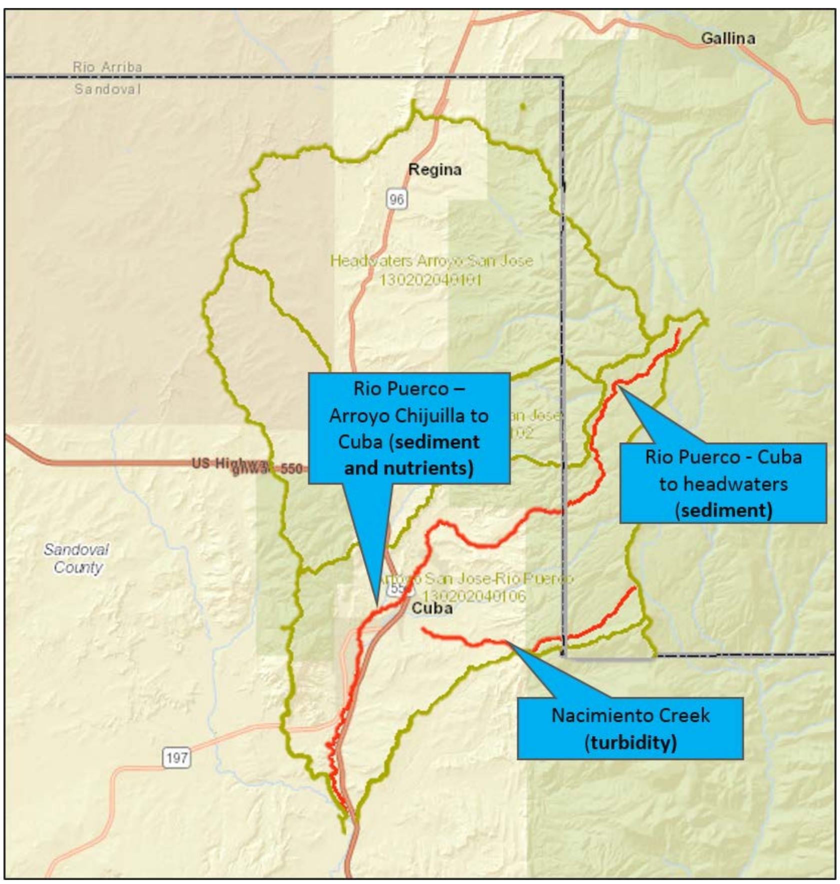


Figure 3. Assessment Units of the Rio Puerco and tributary.

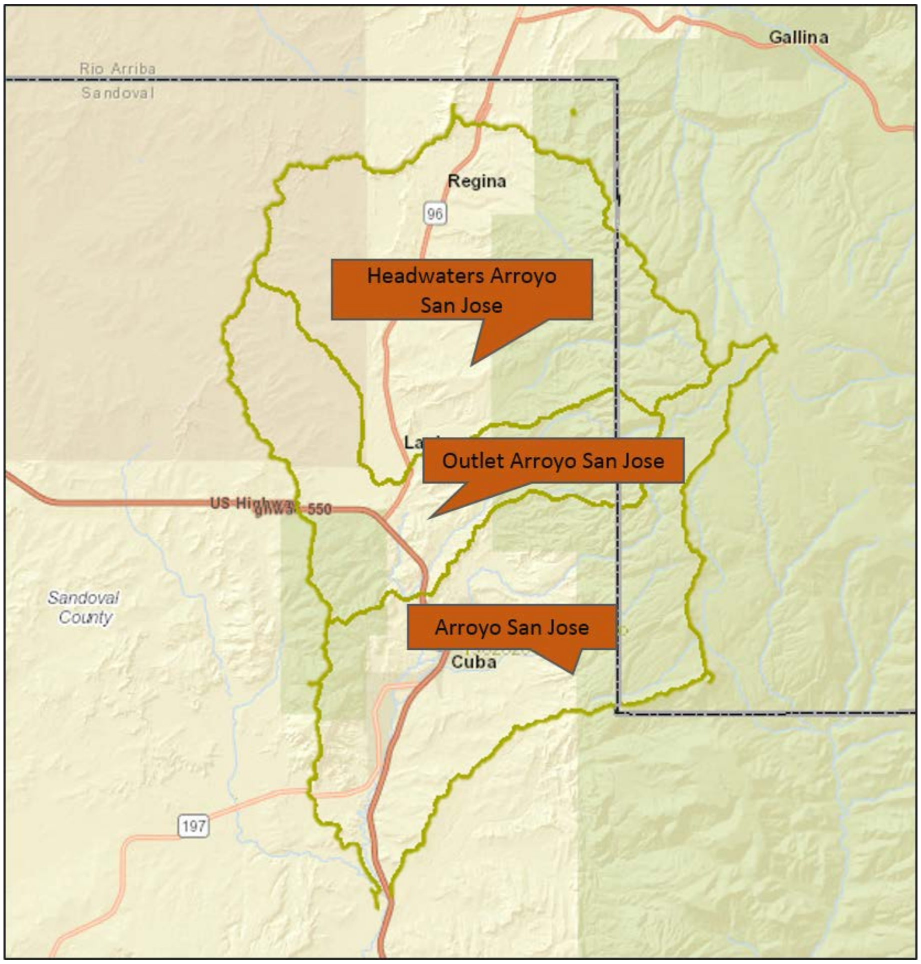


Figure 4. HUC 12 names along the Rio Puerco

These AUs will be addressed concurrently, as they were in the TMDL document, since they consist of very similar geomorphology, stream condition, land use and impairments. Assessment Unit NM2107.A_44 consists of the Rio Puerco from upstream of Cuba to its headwaters in the San Pedro Parks Wilderness. Assessment Unit NM_2107.42 consists of Nacimiento Creek, from Highway 126 to San Gregorio Reservoir, also in the San Pedro Parks Wilderness. Approximately half of each reach exists in either the Santa Fe National Forest or the San Pedro Parks Wilderness (under the jurisdiction of the Cuba Ranger District) on the west side of the Jemez mountains. The remaining 50% is privately owned. Assessment Unit NM2107.40 (Rio Puerco south of Cuba) is somewhat different; it lacks the large forest land cover, and is home to prior restoration projects such as La Ventana (which moved the stream from an artificial channel back into its natural streambed). Otherwise, many land uses and geologic characteristics are the same as Nacimiento Creek and the headwaters of the Rio Puerco.

Land ownership throughout the eight-digit HUC is 43% private, 23% tribal, 20% Bureau of Land Management (BLM), 6% state(1). Land uses throughout the eight-digit HUC is 58% rangeland, 40% forest, <1% urban build-up(1). The downstream basin of the Rio Puerco is one of the nation's most actively eroding watersheds(1). The Rio Puerco Basin has been shown to transport one the highest known average annual sediment loads, and is the major source of suspended sediment entering the Rio Grande above Elephant Butte Reservoir(1). Average annual rainfall in the basin varies from 30.5 to 51 cm, mostly arriving in late summer monsoons that create violent flash flooding that contributes to greatly incised stream channels- in some places, the stream bed is now 1.5 to 3m below the original floodplain (1). Such disconnection between means increased flows cannot spread across the floodplain where they would lose speed, water vegetation, and deposit sediment. This effect in turn creates a vicious cycle, as increased flows will further erode and incise the channel.

Land uses along all three reaches include recreation, cattle grazing, wildlife habitat, and agriculture. Designated uses for waters in this AU include: coldwater aquatic life, domestic water supply, fish culture, irrigation, livestock watering, wildlife habitat, and primary contact. The area in the upper watershed, surrounding the Rio Puerco Headwaters and Nacimiento Creek is dominated by rangeland, making up 58% of land use. Forest is still quite large, with many watersheds containing part of the Santa Fe National Forest. Forested areas make up 40% of land use. The remaining 2% include the residential/semi-urban areas, including the town of Cuba. Rio Puerco downstream of Cuba, however, presents quite a different picture of land use- almost 90% is rangeland, with 8% being forested/riparian forest area, and 2% being residential. Therefore, modeling of load reductions will be done once for Nacimiento Creek and Rio Puerco headwaters, and once for the downstream Rio Puerco on its own, in order to accurately represent characteristic areas together.

Friable or poorly indurate sedimentary strata dominate the geologic setting of the area, as well continental and marine sandstones, shales, mudstones, and carbonate rocks which are particularly vulnerable to erosion (1). The topography is generally flat lying, often faulted, and shaped into broad alluvial valleys surrounded by mesas and mountains. The mountainous areas along the northeast and western sides of the watershed are made up of igneous and metamorphic rocks.

Element A, Identifying Impairment and Probable Sources

Impairment:

The New Mexico Environment Department (NMED) has assessed these AUs and completed a Total Maximum Daily Load report, which includes identification of probable sources. NMED's Surface Quality Bureau (SWQB) intensively surveyed the Rio Puerco basin in 2011.

The only pollutant found to be impairing AU: NM_2107.44 (headwaters Rio Puerco) reach beyond acceptable levels for its designated uses is **sediment/siltation** (1). The single designated use affected by this impairment is Coldwater Aquatic Life (1). Nacimiento Creek is found to be impaired for uranium and turbidity; Rio Puerco downstream of Cuba is impaired for **sediment** and **nutrients (3)**.

Probable Sources:

SWQB staff assessed the probable sources of impairment, including input from a variety of stakeholders included by not limited to: landowners, watershed groups, members of the public during public meetings, and local, state, tribal, and federal agencies. In addition, PSIAC estimates were used to estimate sediment and nutrient loading, and were broken down by probable sources for each 12-digit watershed.

The results found:

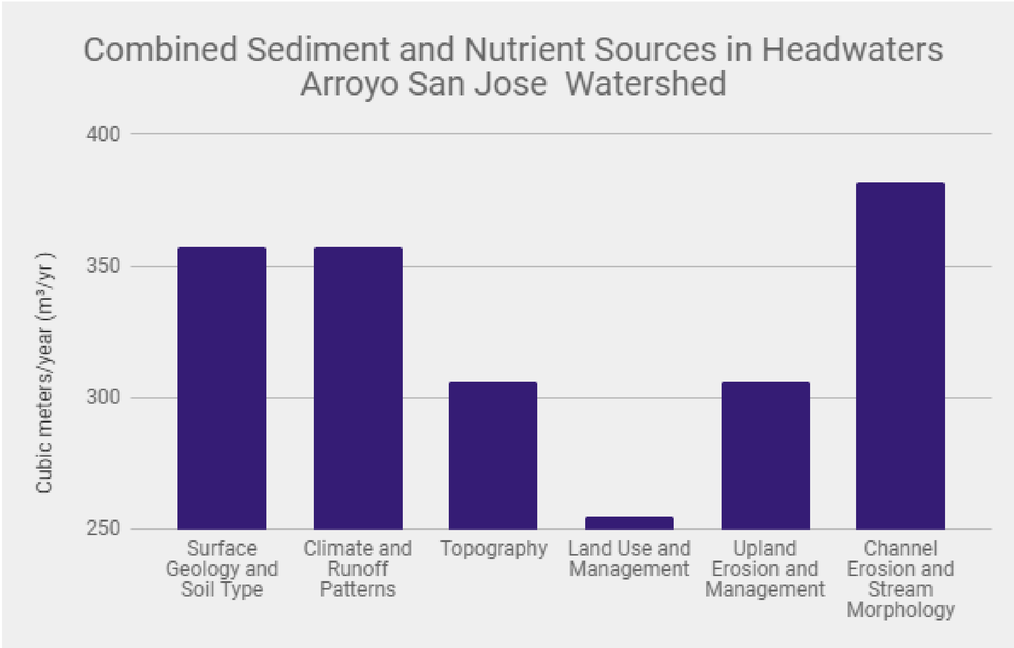
Probable source summary for sedimentation impairment – Rio Puerco (Cuba to headwaters) (NMED, 2016) (1)

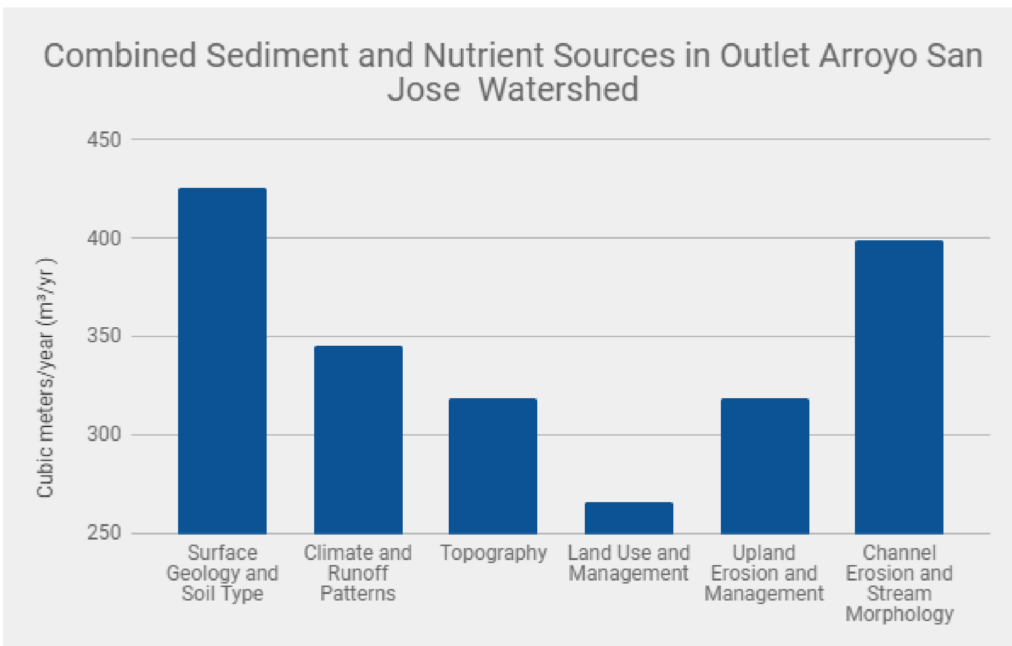
Probable Anthropogenic Sources	Probable Natural Sources
• Irrigation return drains	
• Dams/diversion	• Waterfowl
• Flow alteration from water	• Wildlife other than waterfowl
• Highway/road/bridge runoff	
• Stream channel incision	
• On-site treatment systems	
• Residences/buildings	
• Rangeland grazing (livestock & wildlife)	
• Low water crossings/bridges/culverts/railroad crossing	
• Logging (active harvesting & historical)	
• Gravel dirt roads	
• Crop production (dry land)	

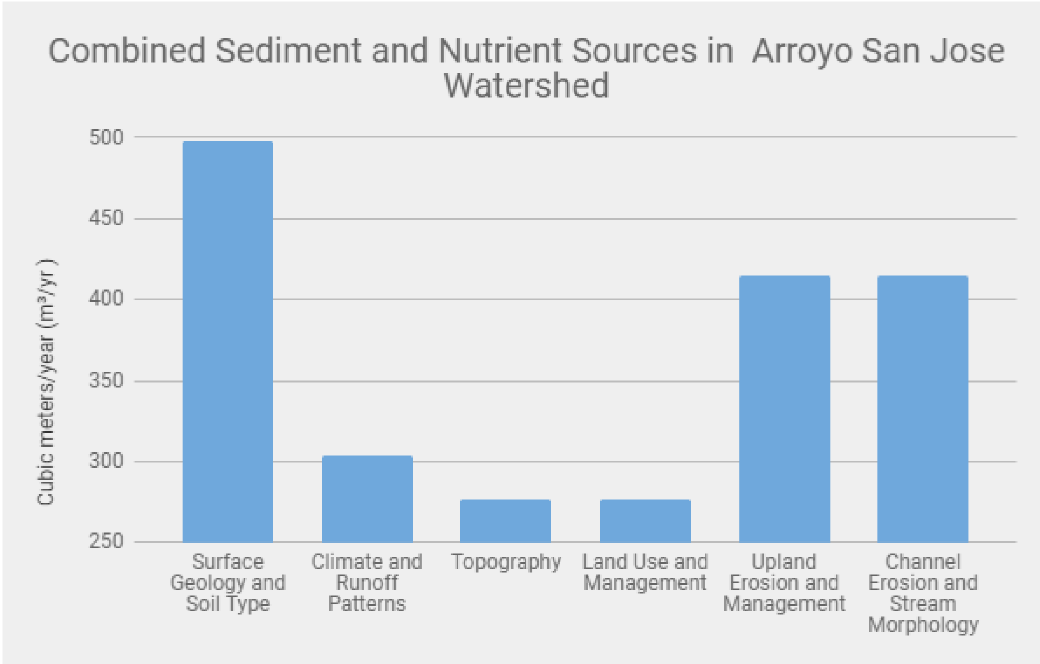
Probable source summary for turbidity impairment – Nacimiento Creek (NMED, 2016) (1)

Probable Anthropogenic Sources	Probable Natural Sources
• Channelization	
• Dams/diversion	• Drought-related impacts
• Riprap wall	• Wildlife other than waterfowl
• Highway/road/bridge runoff	• Recent bankfull or overbank flows
• Impervious surfaces	• High clay content in soils
• Inappropriate waste disposal	
• Residences/buildings	
• Rangeland grazing (livestock & wildlife)	
• Low water crossings	
• Exotic species	

In addition, SWQB staff performed a PSIAC analysis of each 12-digit watershed, which found the likely pollutant sources for each area to be due to the following:


Combined Sediment and Nutrient Sources in Headwaters Arroyo San Jose Watershed
Cubic meters/year (m³/yr)
400
350
300
250
Surface Geology and Soil Type
Climate and Runoff Patterns
Topography
Land Use and Management
Upland Erosion and Management
Channel Erosion and Stream Morphology


Combined Sediment and Nutrient Sources in Outlet Arroyo San Jose Watershed
Cubic meters/year (m³/yr)
450
400
350
300
250
Surface Geology and Soil Type
Climate and Runoff Patterns
Topography
Land Use and Management
Upland Erosion and Management
Channel Erosion and Stream Morphology



As these results show, a great deal of each watershed's pollutants (sediment, nitrogen, and phosphorus) can be contributed to the area's highly erodible soil type and geology, and these loading levels cannot be addressed. However, in each watershed upland erosion, channel erosion, and stream morphology were consistently among the highest contributing sources. Therefore, the Rio Puerco WBP will recommend Best Management Practices to address and remediate channel erosion, upland management strategies, and techniques to manage stream morphology.

Load Reduction Required (Headwaters Rio Puerco & Nacimiento Creek):

The existing TMDL document (1) for outlines the target load for sediment on AU: NM-2107.A_44 (Headwaters Rio Puerco) as 3,873.6 lbs/day. The measured load was 5,690.3 lbs/day. Therefore, meeting the TMDL standard would require a 32% reduction, equivalent to 1,817 lbs per day.

Percent reduction for TSS to meet target load in the upper Rio Puerco

Assessment Unit	Target Load (lbs/day)	Measured Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction (%)
Rio Puerco (Perennial part northern boundary Cuba to headwaters)	3873.6	5690.3	1816.7	31.9

Table 3. Load Reduction Requirements for Total Suspended Solids (TSS) in the Upper Rio Puerco, NMED 2016 (1).

Nacimiento creek is covered in the same TMDL document, but since there is no turbidity model in STEPL, this plan will lay out how much sediment reduction can be expected from the recommended BMPs, and extrapolate to the Nacimiento. Given the very close correlation between sediment and turbidity impairments, the same BMPs, if applied on Nacimiento Creek, will likely result in a great improvement (or even removal) of the turbidity impairment.

The load reduction estimates from STEPL estimate that the TMDL reduction can be met under the recommendations of this plan and are provided in Chapter 3.

Load Reduction Required (Rio Puerco downstream of Cuba):

The existing TMDL document (2) for outlines the target load for sediment on, setting a goal of only 20% fine sediment- which would require a 40% reduction from the current measure levels. Note: This TMDL is much older than the TMDL for the headwaters AU, and changing methodologies in the creation of TMDLs within NMED accounts for the difference in units (where the newer TMDL sets a goal in lbs/day, the older one merely states a reduction in percentage). Therefore, the STEPL model outputs for effects of recommended BMPs will also be interpreted solely for percent reduction in sedimentation.

Calculation of Target Loads for Sedimentation/Siltation

Location	Sedimentation Standard[a] (% fines)	Sedimentation Target Load Capacity (% fines)
Río Puerco (Arroyo Chijuilla to Northern boundary of Cuba)	20	20

Table 3.4 Calculation of Measured Loads for Sedimentation/Siltation

Location	Sedimentation/ Siltation Measured Load (% fines)
Río Puerco (Arroyo Chijuilla to Northern boundary of Cuba)	68

Table 4. Sediment load reduction requirements for the Upper Rio Puerco from the NMED TMDL (2).

This AU is also impaired for plant nutrients: the TMDL for this was published along with the Bluewater TMDLs (3). It states the required load reductions as the following:

Calculation of Load Reduction for TP and TN

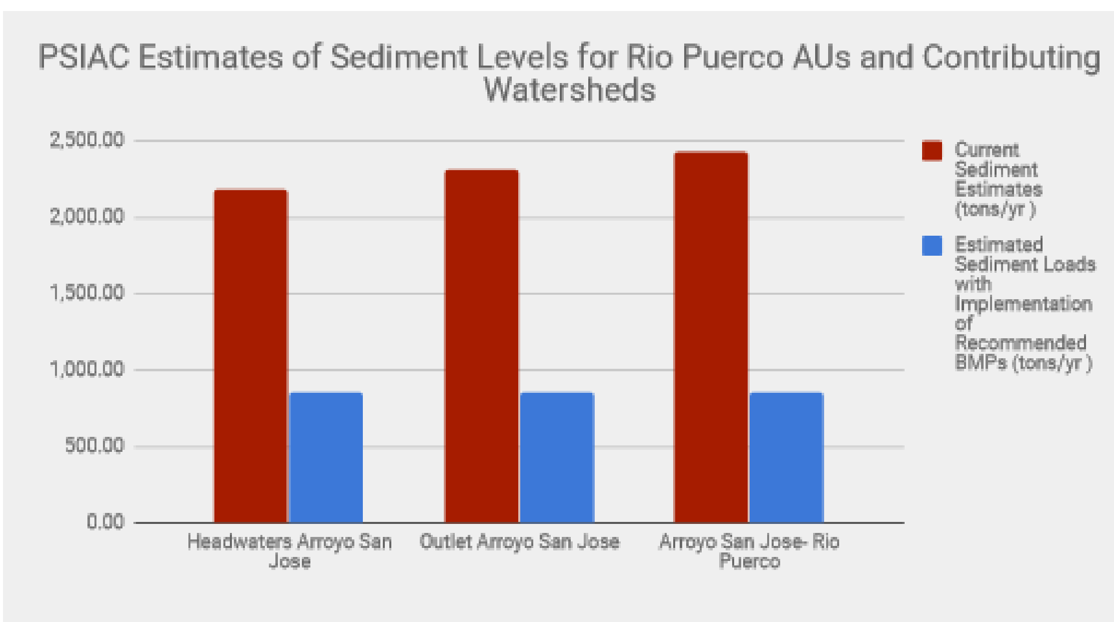
Assessment Unit	Parameter	Target Load[a] (lbs/day)	Measured Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction [b]
Rio Puerco (Arroyo Chijuilla to northern bnd of Cuba)	TP	0.490	4.855	4.365	90%
	TN	2.613	19.63	17.02	87%

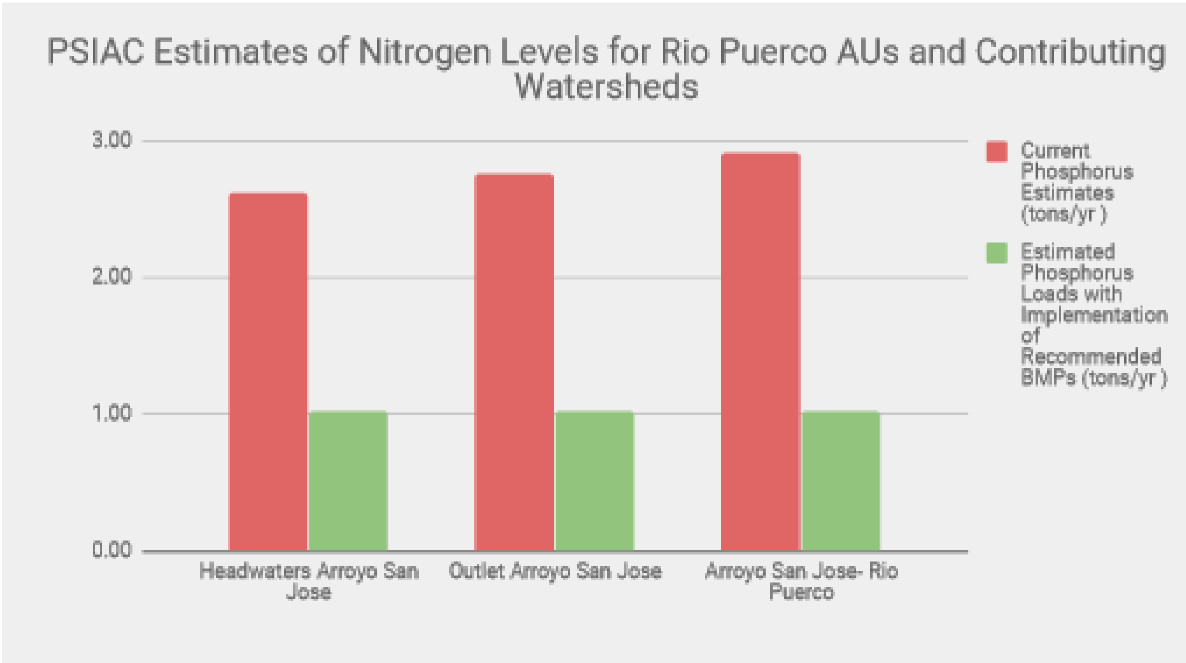
Table 5. Nutrient reduction requirements for the Upper Rio Puerco from the NMED TMDL (3).

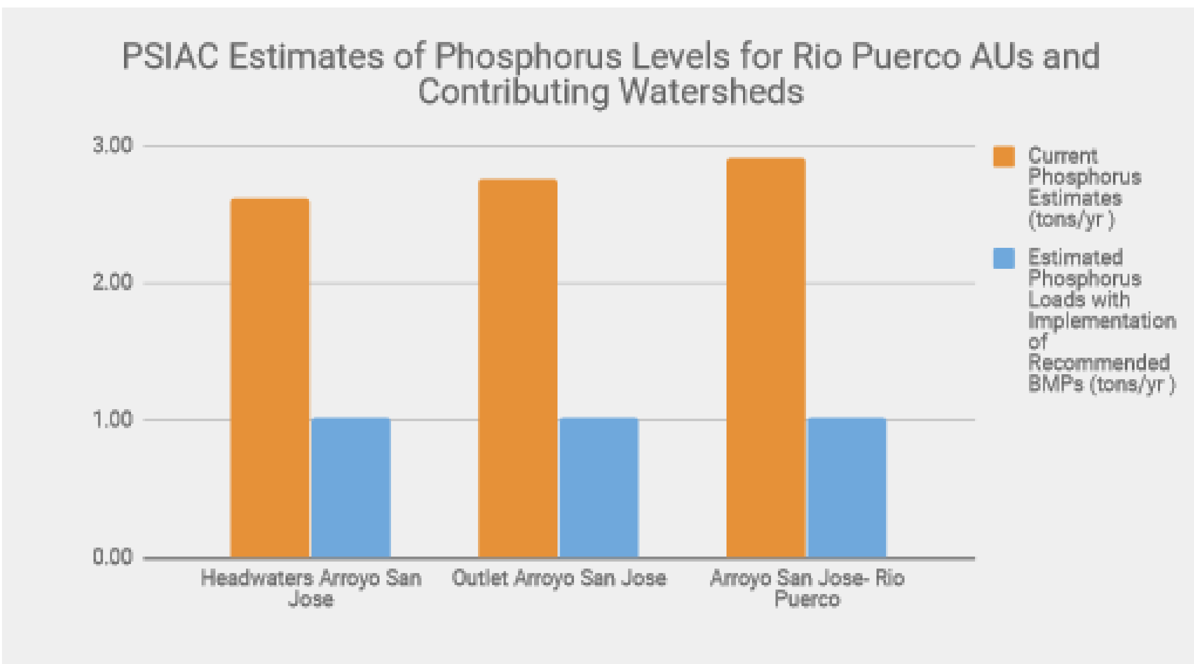
The load reduction estimates from STEPL estimate that the TMDL reduction will not be be met under the recommendations of this plan. However, as can be seen in Chapter __, the recommendations of this plan will bring the load reduction down to within just a few percentage points of the TMDL (the TMDL lists reduction of 90% TP and 87% TN; the STEPL analysis estimate reductions of 86% TP and 82.1% TN). Therefore, this plan represents a large potential increase in water quality which could be expanded upon to achieve the minor remaining load reductions need.

Pollutant Loading Sites (by 12-digit Watershed):

SWQB staff conducted a PSIAC analysis in order to estimate where the pollutants are entering each AU (it should be noted that AUs are determined by ecoregion and do not always line up with watershed boundaries). It is important to note that PSIAC estimates the total pollutant load entering the waterbody each year, the majority of which occurs at high flows. The TMDL sampling, on the other hand, measure the amount of suspended pollutant (for both sediment and nutrients) and aims to do so at the average low flow. Therefore, the watershed-approach using PSIAC produced much larger numbers than the AU-approach using water samples. It is the opinion of the RMPC that PSIAC, while a useful model, should only be used when funds and time do not allow for actual water samples, as was the case when writing this plan. Future projects may use PSIAC as a reference point to monitor pollutant load, but will measure success toward achieving the TMDL with actual water sample analysis. Here PSIAC is used to estimate which areas, by watershed, are contributing the highest pollutant load in order to prioritize restoration efforts and monitoring in those areas. The PSIAC analysis produced the following estimates for the Rio Puerco AUs and their contributing watersheds:







The results of this PSIAC analysis clearly show that each watershed will benefit from the implementation of the BMPs recommended in this plan. While all three priority watersheds contribute similar amounts of pollutants, the Arroyo San Jose contributes the greatest amount of both sediment and nutrients.

Chapter 2: Element A, Bluewater Creek and Rio Moquino

Introduction

Assessment Unit Name:	NM SWQB Assessment Unit ID:	HUC- 8	HUC-12s within the area of the Assessment Unit	Acreage of each HUC-12	Impairments applicable to each AU:	Length of AU:
Bluewater Creek (non-tribal Rio San Jose to Bluewater Rvr)	NM-2107.A_00	Rio San Jose Watershed 13020207	1) Reynold Draw-Bluewater Creek 130202070207 2) Outlet Cottonwood Creek 130202070204 3) Sawyer Creek 130202072023 4) Headwaters Cottonwood Creek 130202070202	1) 13,876 -McKinley & Cibola Co. 2) 24,077 -McKinley & Cibola Co. 3) 14,430 -McKinley & Cibola Co. 4) 35,654 -McKinley & Cibola Co.	**Nutrients,** Temp	11.35 km
Bluewater Creek (Bluewater Rvr to headwaters)	NM-2107.A_01	Rio San Jose Watershed 13020207	1) Bluewater Lake-Bluewater Creek 130202070206 2) Ojo Redondo- Bluewater Creek 130202070205 3) Agua Medio- Bluewater Creek 130202070201	1) 20,034 -Cibola Co. 2) 16,893 -Cibola Co. 3) 23,848 -Cibola Co.	**Nutrients,** Temp	27.1 km
Rio Moquino (Laguna Pueblo to Seboyetita Creek)	NM-2107.A_10	Rio San Jose Watershed 13020207	1) Rio Paquate 130202070704 2) Seboyetita Creek 130202070701 3) Seboyeta Creek 130202070702	1) 10,663 -Cibola Co 2) 12,674 -Cibola Co 3) 26,684 -McKinley & Cibola Co.	**Nutrients,** Temp	3.22 km

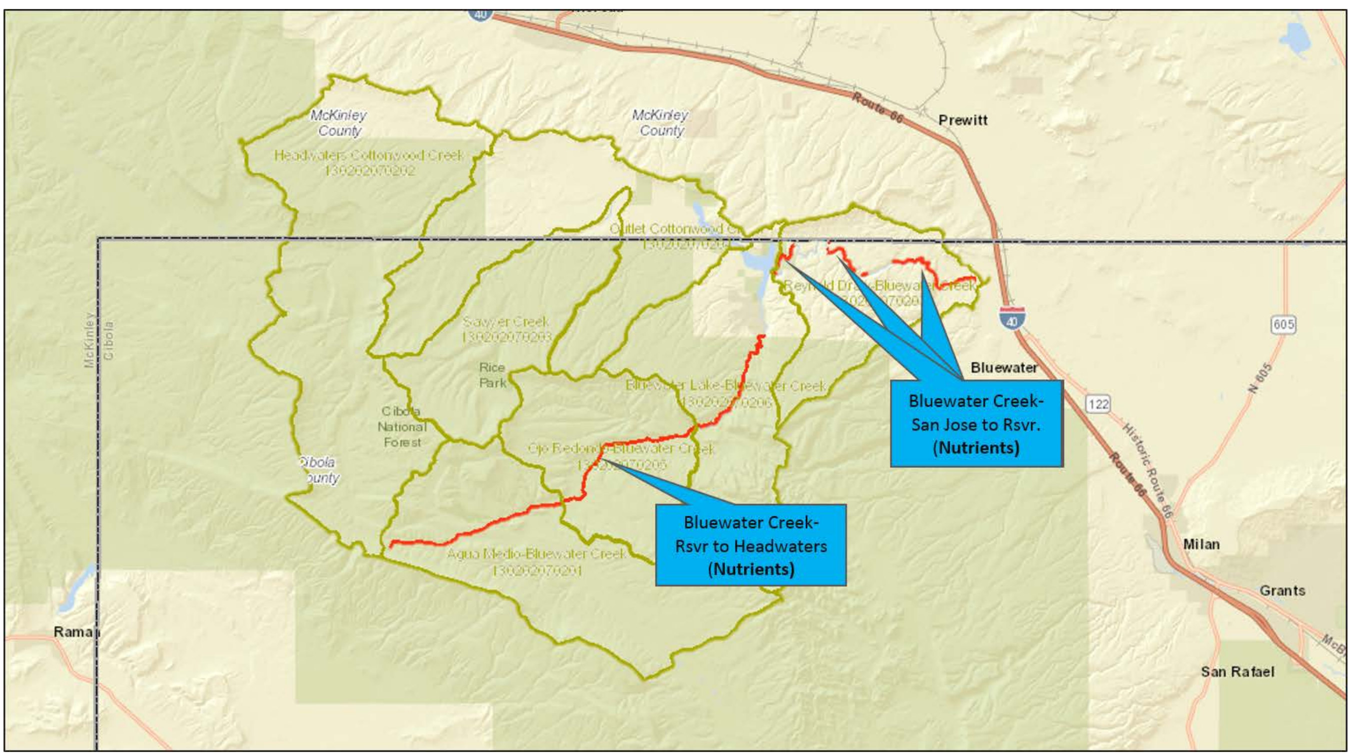


Figure 5. Assessment Units of Bluewater Creek

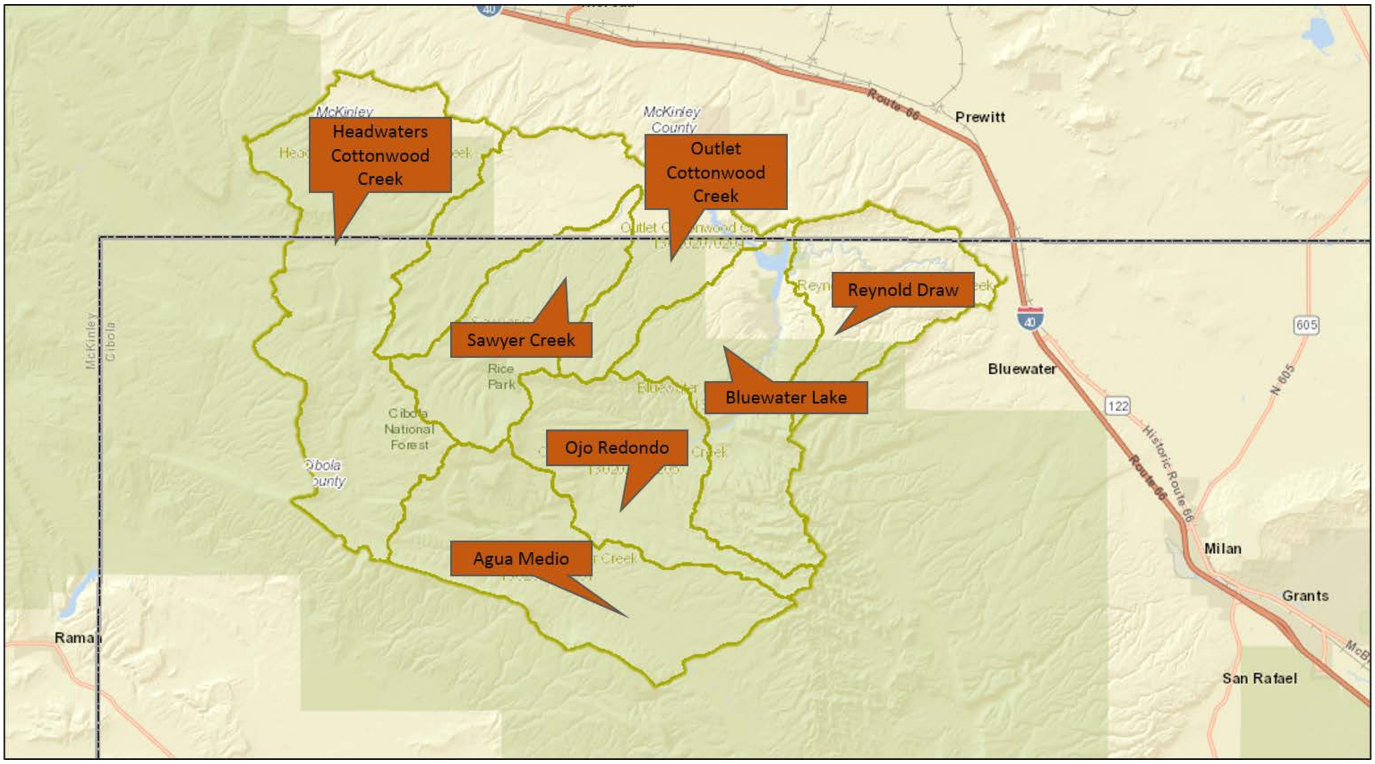


Figure 6. HUC 12 names along Bluewater Creek

Land ownership through the watersheds for the Bluewater AUs is dominated by national forest, with the notable exceptions of Bluewater State Park. These areas are generally dominated by sandstones, shales, mudstones, and siltstones- all of which are highly erodible in stormwater events.

Throughout the 80 square miles of land covered by HUC-12s directly containing the AU NM-2107.A_01 (Bluewater Rvr to headwaters), 88% of land is owned by the U.S. Forest Service, 12% is privately owned, and the state owns <1% (primarily Bluewater State Park. Land cover is 89% forest, 8% shrub land and 4% grassland.

The lower reach, NM-2107.A_00, drains over two hundred and thirty square miles from Bluewater Reservoir to the non-tribal portions of the Rio San Jose. Throughout this area, land cover is also primarily forest, but unlike the upper reaches also contains higher percentages of residential area and shrub lands.

Forest is still a high percentage, 80%, with shrubland as 15%, grassland as 4% and low intensity residential <1%. U.S. Forest Service owns 68% of the land, 25% is private, the state owns 4%, tribes own 2%, and BLM <1%.

Rio Moquino, however, is quite different in land cover and ownership from either of the Bluewater AUs. Throughout its corresponding watershed, the land is 96% privately owned (with the U.S. Forest Service owning the other 4%). The land cover is 47% forest, 44 shrubland, and 8% grassland, with <1% residential.

Identifying Impairments and Probable Sources

Impairments:

While the plan will focus on the impairment of **nutrients**, all three are also impaired for solar loading (temperature impairment) and suspected to be large sources of sediment runoff during stormwater events. However, the authors of this plan have, after reviewing the literature, decided to focus on the temperature impairment as an indicator of overall stream health. Evidence from restoration projects across the region shows that certain water quality impairments interdisciplinarily. Where several impairments have the same/similar probable causes, BMPs meant to address one will also likely address another, and the connections between impairment sources will be laid out in this plan. The following summary of existing knowledge, combined with BMP modeling for these specific AUs, will demonstrate how addressing **nutrients** impairments can also address the impairments of **sediment**, **temperature**, and **turbidity.** Therefore, utilizing one impairment as an "indicator target" appears to be worthwhile when resources for monitoring several impairments are limited.

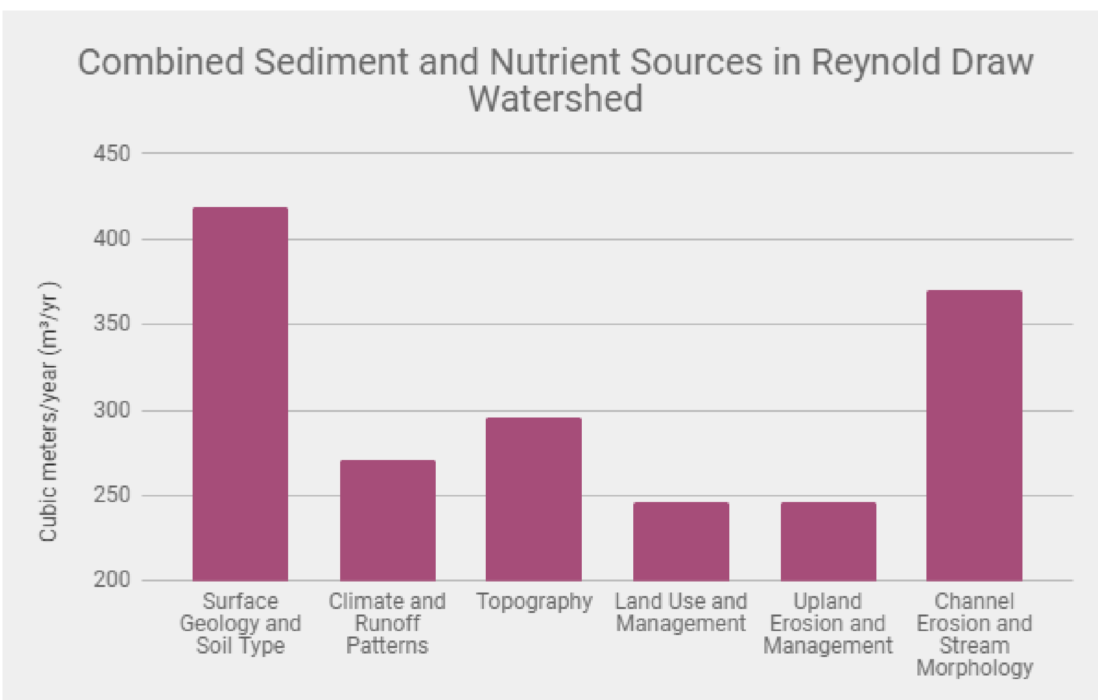
Probable Sources:

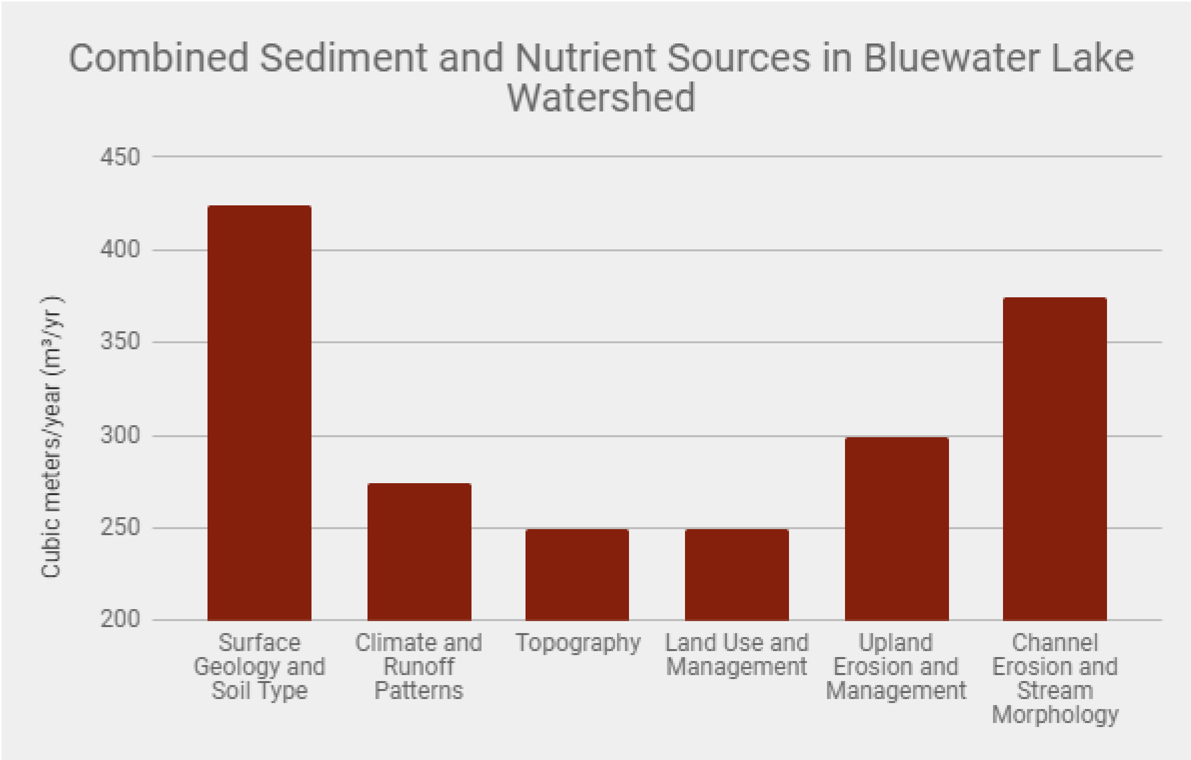
Across all three reaches, the probable sources for the impairments of nutrients and temperature, as determined by local stakeholders and NMD, and listed in the 2007 TMDL document (3) include the following:

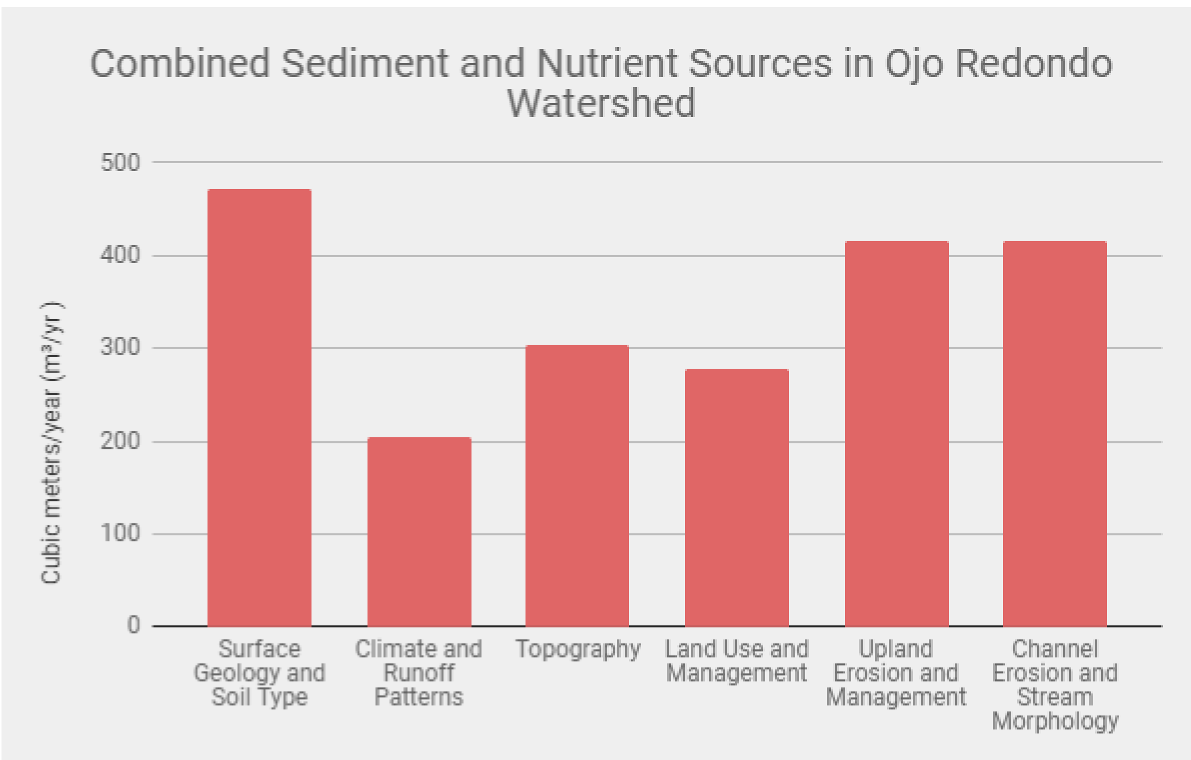
Probable source summary for nutrient and temperature impairments – Bluewater Creek (both assessment units) and Rio Moquino, NMED, 2007. (3)

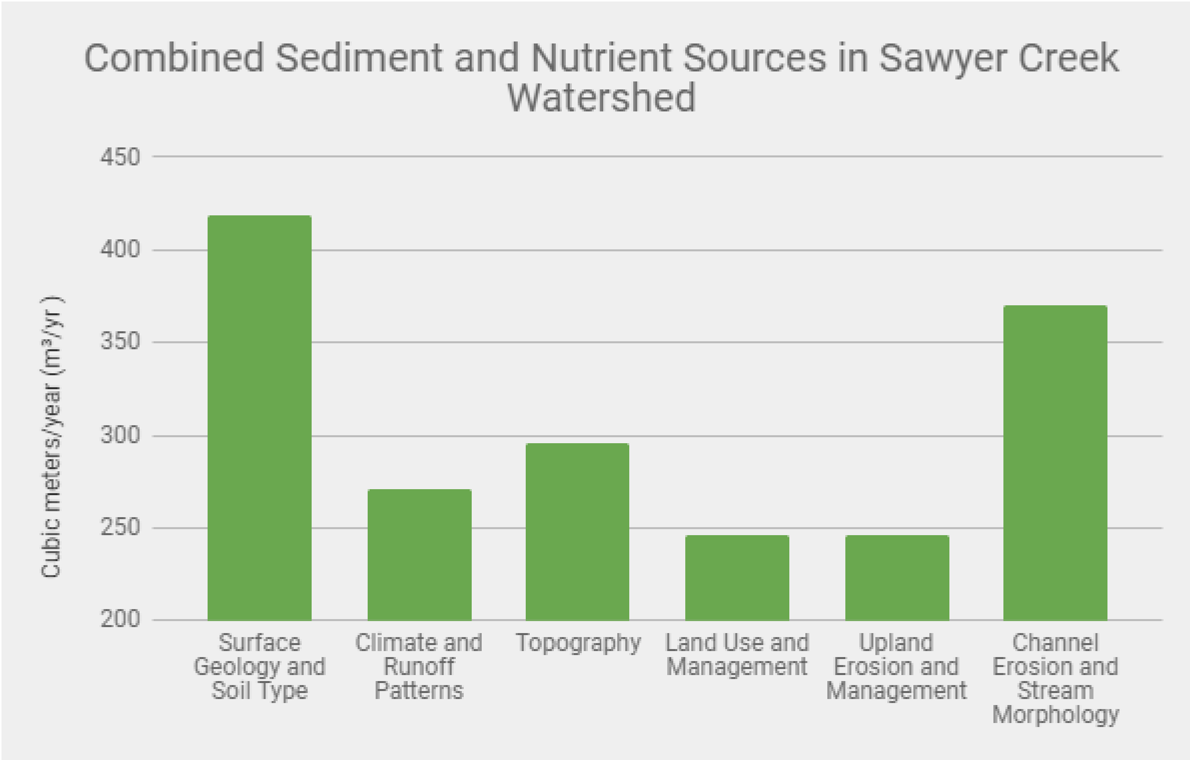
Anthropogenic Sources	Natural Sources
- Municipal Point Source Discharge	- Drought-related Impacts
- Stream Channelization	- Wildlife other than Waterfowl
- Highway/Road/Bridge Runoff	
- Loss of Riparian Habitat	
- Rangeland Grazing	
- Forest Roads (construction and use)	
- Streambank Modifications/destabilizations	

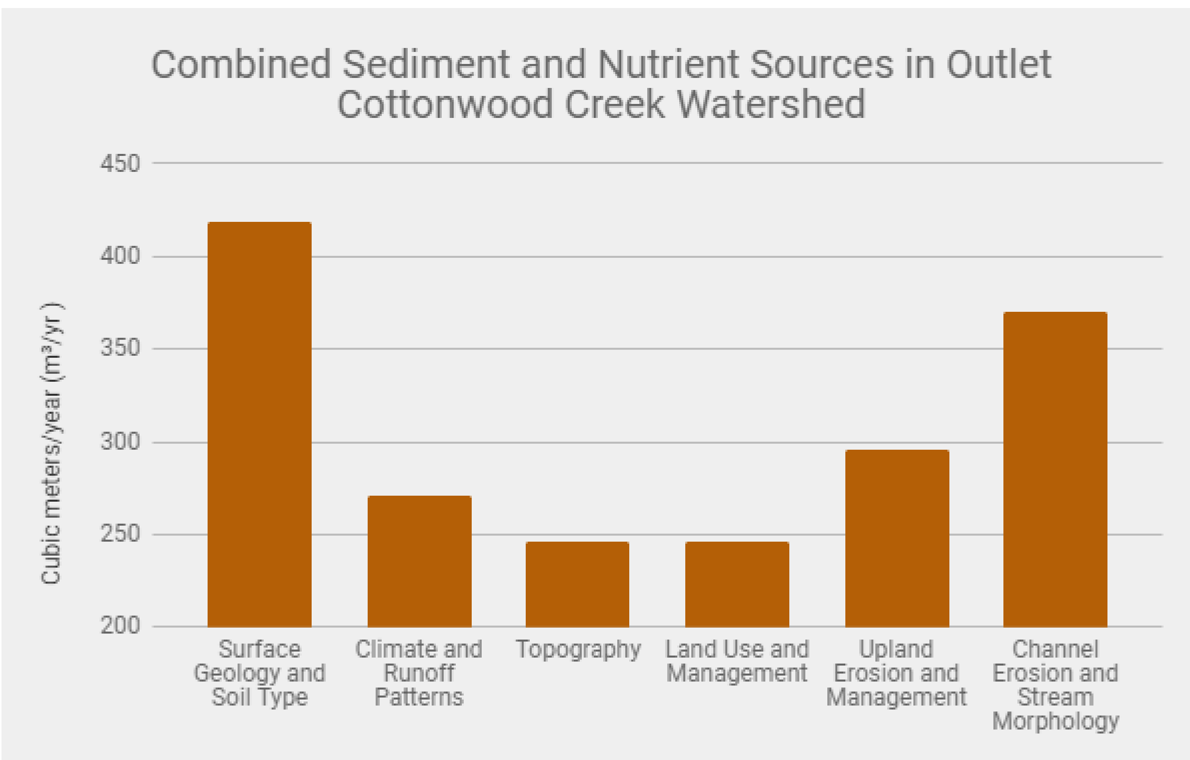
In addition, SWQB staff performed a PSIAC analysis of each 12-digit watershed, which found the likely pollutant sources for each area to be due to the following:

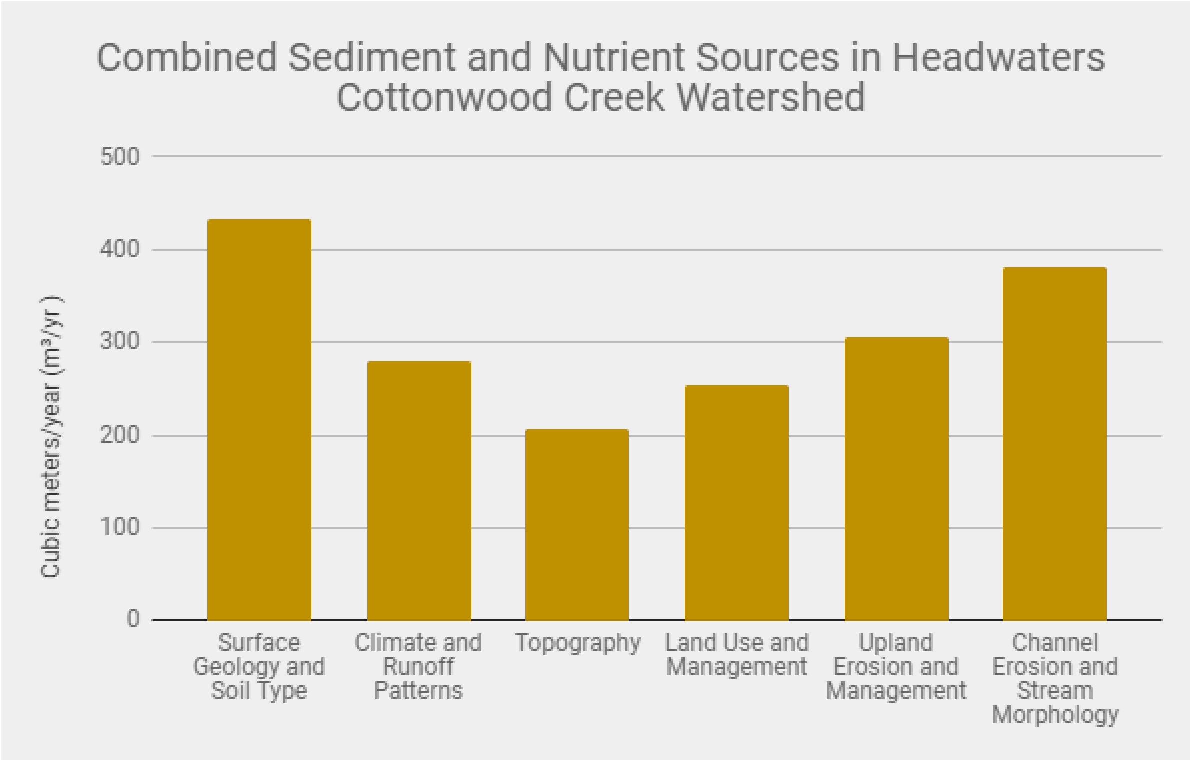


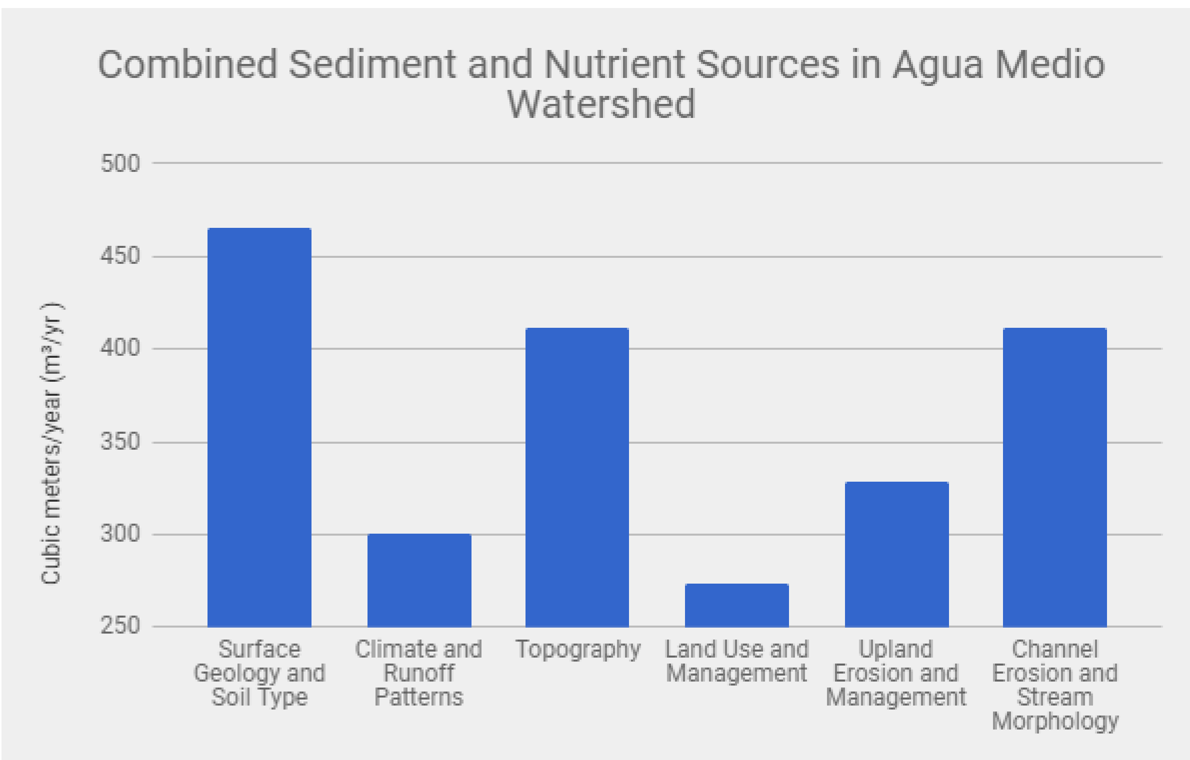

Combined Sediment and Nutrient Sources in Bluewater Lake Watershed
Cubic meters/year (m³/yr)
450
400
350
300
250
200
Surface Geology and Soil Type
Climate and Runoff Patterns
Topography
Land Use and Management
Upland Erosion and Management
Channel Erosion and Stream Morphology


Combined Sediment and Nutrient Sources in Ojo Redondo Watershed
Cubic meters/year (m³/yr)
500
400
300
200
100
0
Surface Geology and Soil Type
Climate and Runoff Patterns
Topography
Land Use and Management
Upland Erosion and Management
Channel Erosion and Stream Morphology


Combined Sediment and Nutrient Sources in Sawyer Creek Watershed
Cubic meters/year (m³/yr)
450
400
350
300
250
200
Surface Geology and Soil Type
Climate and Runoff Patterns
Topography
Land Use and Management
Upland Erosion and Management
Channel Erosion and Stream Morphology


Combined Sediment and Nutrient Sources in Outlet Cottonwood Creek Watershed
Cubic meters/year (m³/yr)
450
400
350
300
250
200
Surface Geology and Soil Type
Climate and Runoff Patterns
Topography
Land Use and Management
Upland Erosion and Management
Channel Erosion and Stream Morphology


Combined Sediment and Nutrient Sources in Headwaters Cottonwood Creek Watershed
Cubic meters/year (m³/yr)
500
400
300
200
100
0
Surface Geology and Soil Type
Climate and Runoff Patterns
Topography
Land Use and Management
Upland Erosion and Management
Channel Erosion and Stream Morphology


Combined Sediment and Nutrient Sources in Agua Medio Watershed
Cubic meters/year (m³/yr)
500
450
400
350
300
250
Surface Geology and Soil Type
Climate and Runoff Patterns
Topography
Land Use and Management
Upland Erosion and Management
Channel Erosion and Stream Morphology

This PSIAC analysis found that, similarly to the Rio Puerco watersheds, a large portion of the pollutant loading in each watershed can be attributed to natural sources, such as geology, topography and soil type. Yet, again similarly to the Rio Puerco, sources within human influence such channel erosion, upland land management, and stream morphology are major sources for pollutant loading.

Load reduction estimates, and whether the proposed measures will likely meet the local TMDL, have been included in the subsequent chapters. A more in-depth analysis of STEPL methods can be found in the attached spreadsheet. In this analysis BMP areas were predicted using stakeholder input, then applied to each sub-watershed in STEPL using all relevant information about the land use, size, climate and geology of the sub-watershed. The resulting prediction of pollutant load reductions have been included. The load reduction estimates from STEPL estimate that the TMDL reduction can be met under the recommendations of this plan and, once again, are provided in Chapter 3.

Load Reduction Required (Upper Bluewater Creek):

Based on the TMDL document published in 2007 (3), in order to meet the nutrient TMDL this AU would have to reduce the nutrient loading by 60% for total phosphorous and 41% for total nitrogen. Therefore, the BMPs laid out in this plan would be successful in meeting the TMDL, and remove the nutrient impairment. Should this occur as planned, the reach could then be listed as a EPA Success Story for 319 funding in New Mexico. As well, it is clear that the BMPs implemented for nutrient reduction would also reduce sediment by a large margin, improving fish habitat and water quality.

Table 5.9. Calculation of Load Reduction for TP and TN

Assessment Unit	Parameter	Target Load[(a)] (lbs/day)	Measured Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction [(b)]
Bluewater Creek (Bluewater Reservoir to headwaters)	TP	0.0008	0.002	0.0012	60%
	TN	0.013	0.022	0.009	41%

Table 6. TMDL Load Reduction requirements for Bluewater Rvr to headwaters, (3)

Load Reduction Required (Lower Bluewater Creek):

Based on the TMDL document published in 2007 (3), in order to meet the nutrient TMDL this AU would have to reduce the nutrient loading by 45% for total nitrogen. Therefore, the BMPs laid out in this plan would be *also* successful in meeting *this* TMDL, and remove the nutrient impairment. Should this occur as planned, the reach could then also be listed as a EPA Success Story for 319 funding in New Mexico. Likewise, sediment would again be reduced greatly, reinforcing the value of such BMPs in addressing multiple water quality issues.

Table 5.9. Calculation of Load Reduction for TP and TN

Assessment Unit	Parameter	Target Load[a] (lbs/day)	Measured Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction [b]
Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir)	TP	0.029	< Target Load	0	0%
	TN	0.205	0.375	0.170	45%

Table 7. TMDL Load Reduction requirements for Non-tribal Rio San Jose to Bluewater Rvr, (3)

Load Reductions for Rio Moquino

Based on the TMDL document published in 2007 (3), in order to meet the nutrient target loading amounts, this AU would need a 41% reduction in total nitrogen. The load reduction estimates from STEPL estimate that the TMDL reduction can be met under the recommendations of this plan and, once again, are provided in Appendix B.

Table 5.9. Calculation of Load Reduction for TP and TN

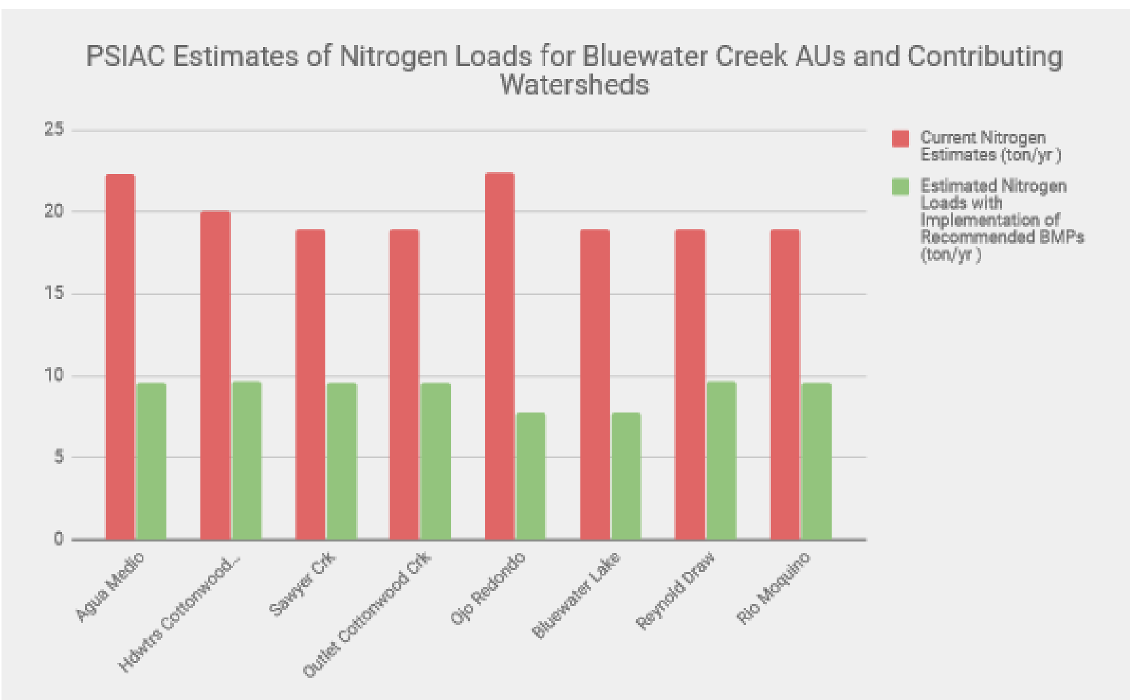
Assessment Unit	Parameter	Target Load[a] (lbs/day)	Measured Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction [b]
Rio Moquino (Laguna Pueblo to Seboyetita Creek)	TP	0.0034	< Target Load	0	0%
	TN	0.044	0.074	0.030	41%

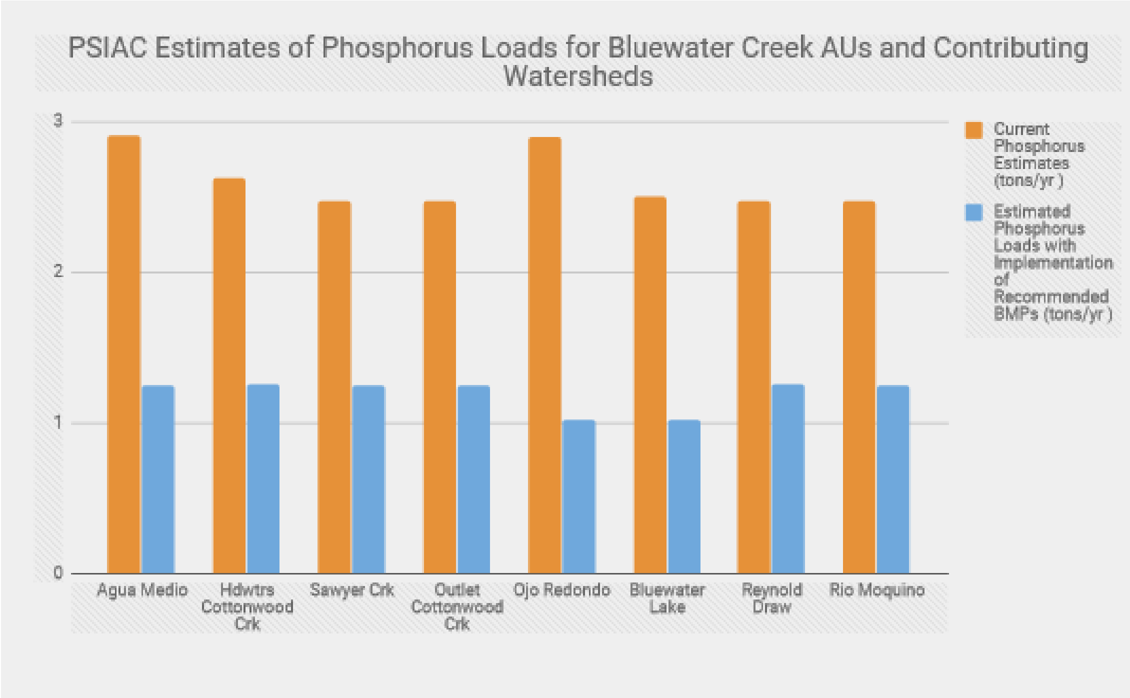
Table 8. TMDL load reduction requirements for Rio Moquino, Laguna Pueblo to Seboyetita Creek (3).

Therefore, once again, implementing the following BMPs would lead to this AU meeting its water quality standards, as well as a drastic reduction in the amount of sediment loading it would contribute to downstream water bodies.

Pollutant Loading Sites (by 12-digit Watershed):

Just as with the Rio Puerco watersheds, SWQB staff conducted a PSIAC analysis in order to estimate where the pollutants are entering each AU (it should be noted that AUs are determined by ecoregion and do not always line up with watershed boundaries). Once again it is important to note that PSIAC estimates the total pollutant load entering the waterbody each year, the majority of which occurs at high flows. The TMDL sampling, on the other hand, measure the amount of suspended pollutant (for both sediment and nutrients) and aims to do so at the average low flow. Therefore, the watershed-approach using PSIAC produced much larger numbers than the AU-approach using water samples. The PSIAC assessments found the following loading in watersheds contributing to Bluewater Creek:





The results of this PSIAC analysis show that each watershed will benefit from implementing the BMPs in this plan. While all watersheds contribute similar amounts of pollutants, the Ojo Redondo and Agua Medio contribute the greatest amount of both sediment and nutrients and should be prioritized.

Chapter 3: Stakeholder-Identified BMP Priority Sites & Load Reduction Estimates (Element B)

In addition to the probable sources identified in Chapters 1 and 2, the RPMC has historically identified pollutant loading sources through previous surveys, including the Rio Puerco WRAS published in 2001. To supplement the WRAS the RPMC held several public meetings throughout the process of creating a WBP in which stakeholders were the primary source for identifying the natural resource concerns in their communities. The mapping of pollutant sources shown below directly reflects this stakeholder input. Feedback was solicited from all stakeholders identified in Figure __ (Chapter 5, Education and Outreach) and any other natural resource organizations known to the RPMC to be active in the Rio Puerco watershed area. The historical context and institutional knowledge contained by members of the RPMC were invaluable in this process, and the identification of loading sources were primarily identified through this knowledge. NMED staff then worked with stakeholders to determine the best BMP to recommend at each loading site. These BMPs and loading sites are overlaid in the maps below. These locations in Figures 5 - 8 will be the priorities for on-the-ground work done under EPA 319 proposals.

Note that Figures 7 and 8 are large-sized JPEGS that can be downloaded and zoomed in for more detail, and can also be provided as file attachments in future formats. Where the WBP is provided in PDF form Figures 7 and 8 will be provided as "Appendix C, Pollutant Loading Sources."

Approximate Pollutant Loading Sites and Future BMP Locations:

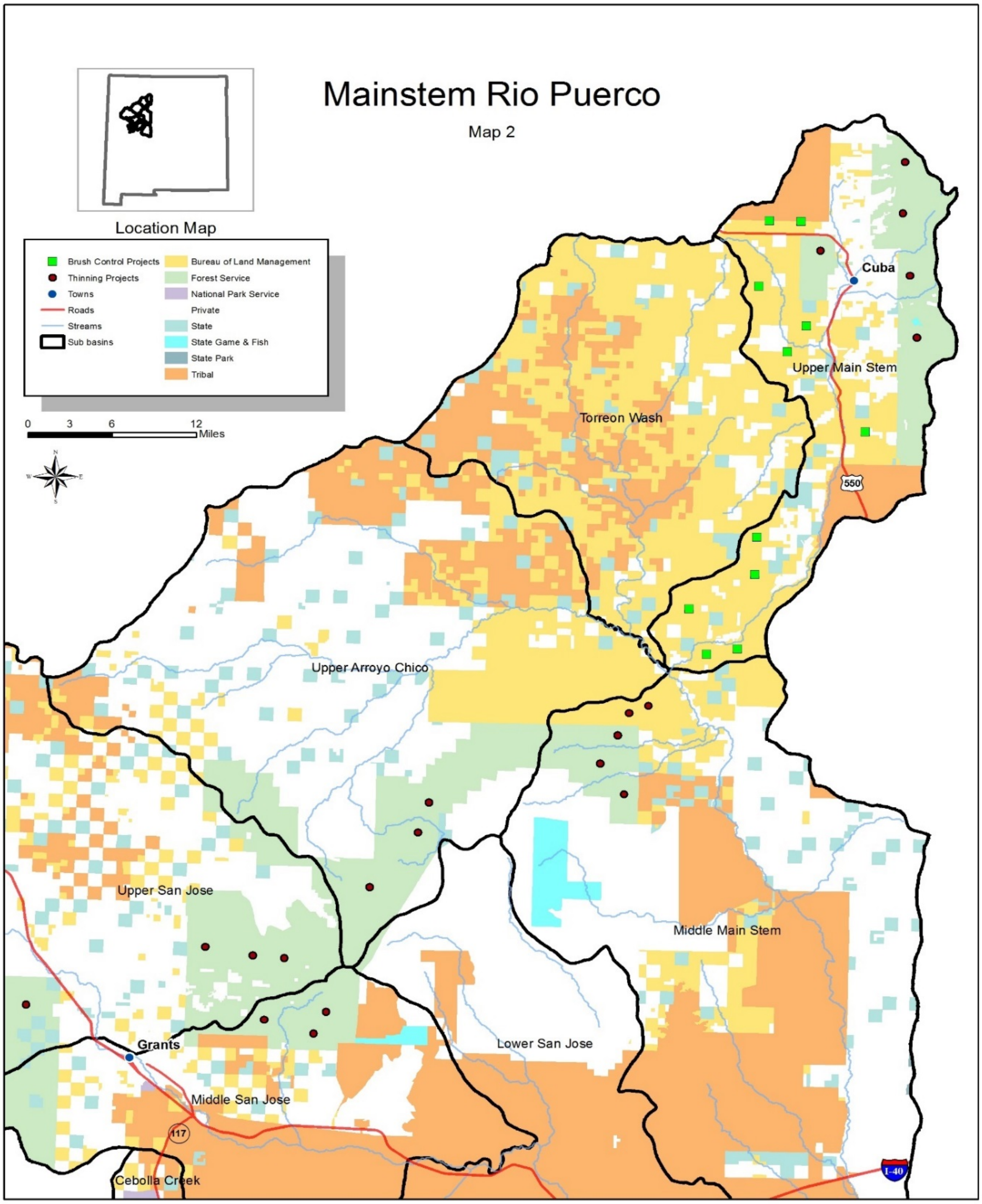


Figure 7. BMP Locations as Identified in the Rio Puerco WRAS, part 1.

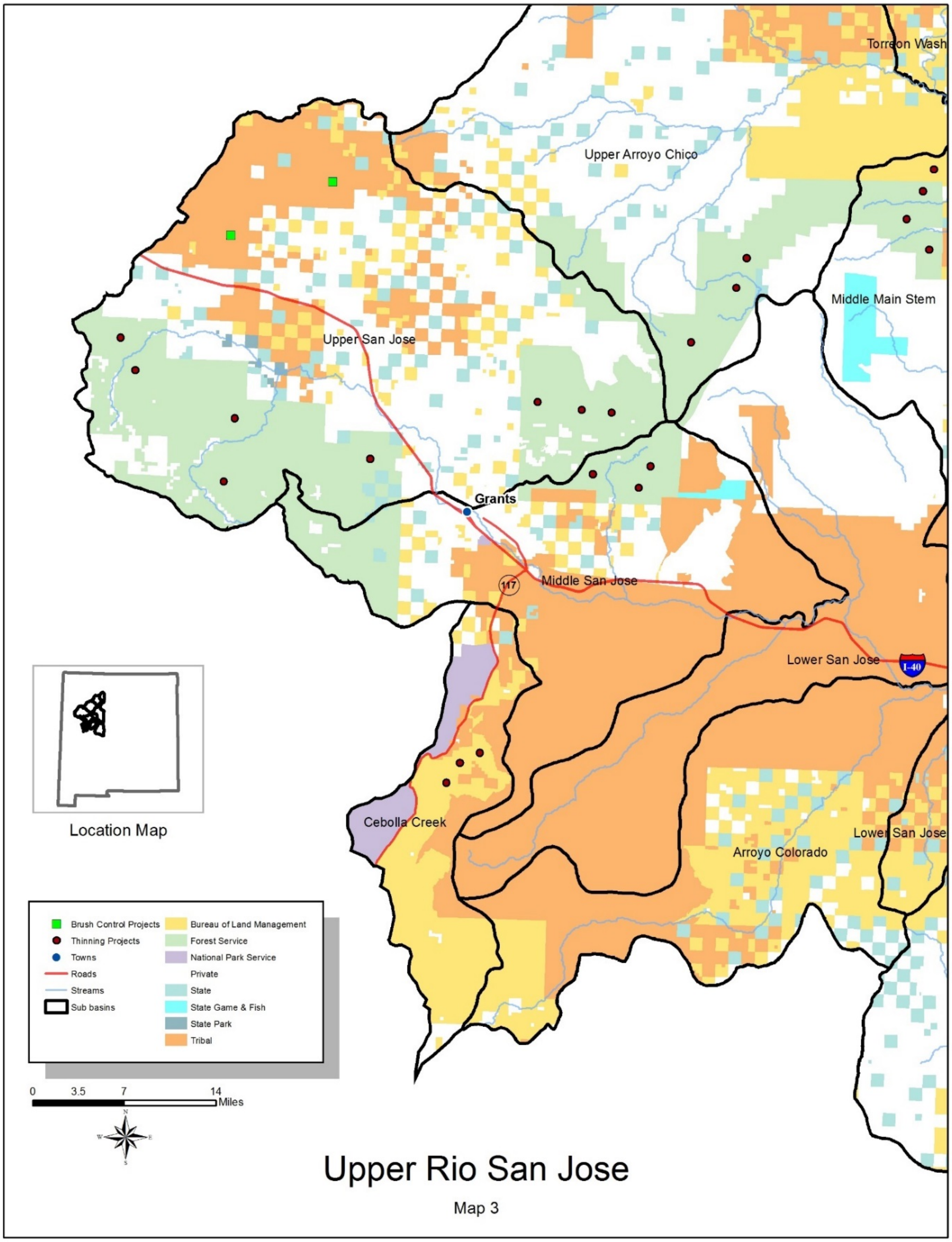


Figure 8. BMP Locations as Identified in the Rio Puerco WRAS, part 2.

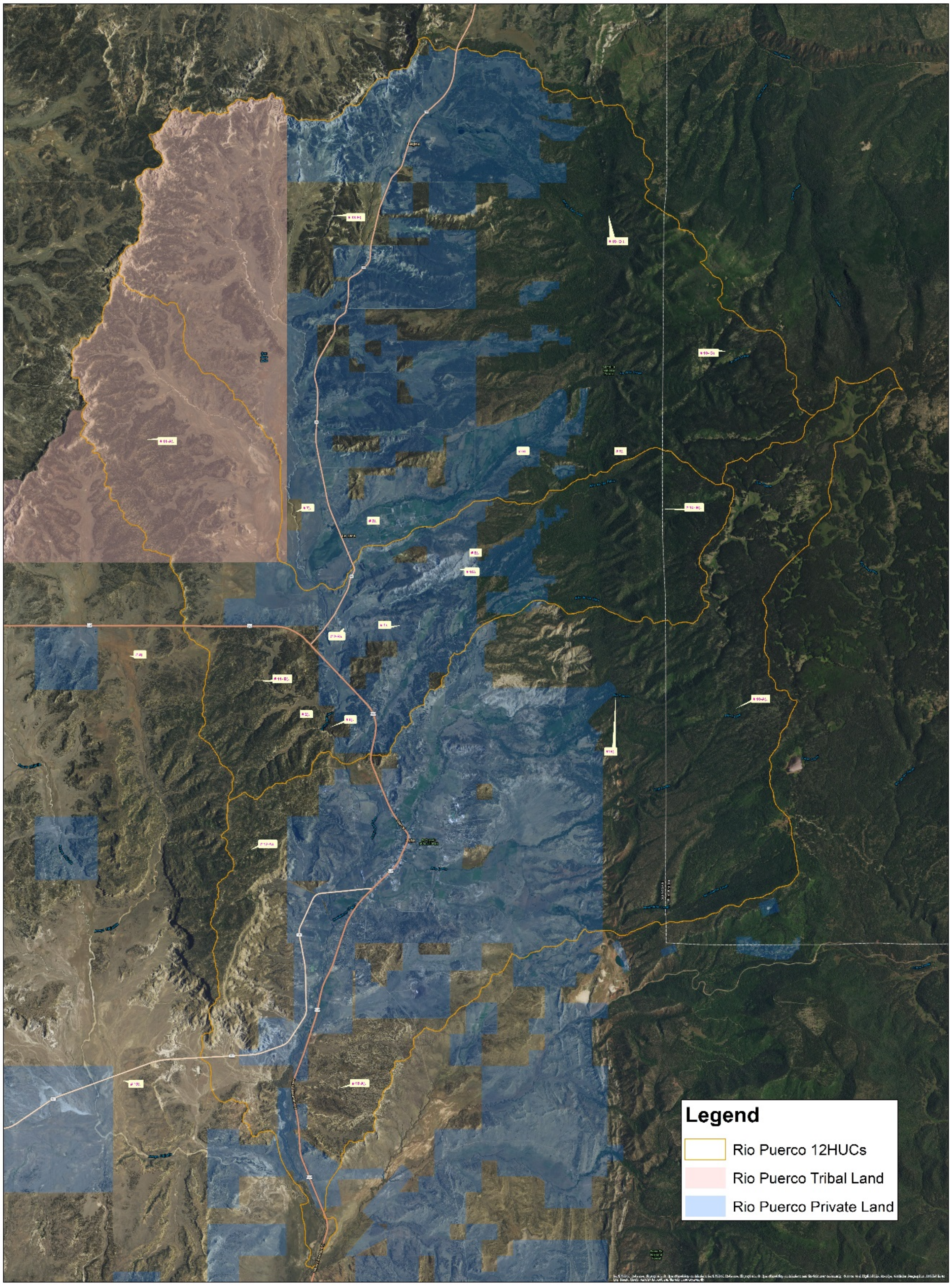


Figure 9. BMP locations as identified by stakeholders, Rio Puerco mainstem & Nacimiento Creek.

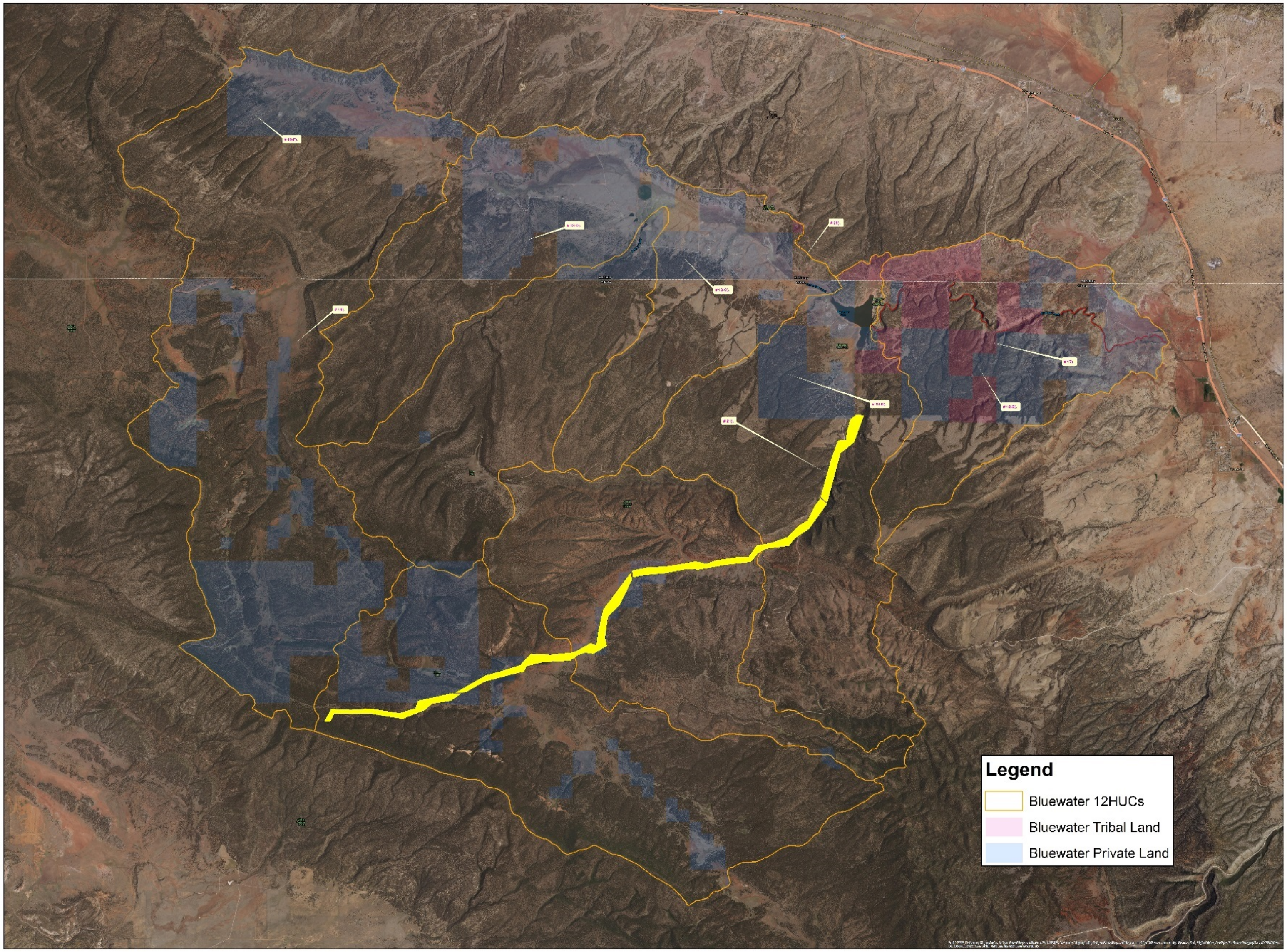


Figure 10. BMP locations as identified by stakeholders, Bluewater Creek.

Pollutant Loading Sources and approximate future BMP locations

The following is a description of each pollutant loading source as located in Figures 7 and 8. These are direct summaries of stakeholder feedback combined with BMP recommendations by NMED staff.

1.) Arroyo Aranal is a short tributary of the Rio San Jose. Erosion below a culvert has cut the arroyo to a depth of 30-40ft. Private land along some of the tributary has been badly eroded. San Jose Arroyo (from Arroyo Aranal to the Hwy 96 has a lot of sediment in high water. Some private lands along the way are overgrazed and almost bare of vegetation.

2.) and 2-B.) San Jose Arroyo from Arroyo Aranal south to Hwy 550 has an area where several projects have previously been done, but erosion is still a problem. These projects could be expanded upon.

3.) San Pedro Wilderness, west slope of Nacimiento Mountains- the area is heavily forested and overgrown, ripe for catastrophic wildfire to burn through the whole western slope, with potential drastic post-fire flooding.

4.) Chuvilla Arroyos (Big & Little): Cattle are grazed on the BLM lands in the winter and on Cuba Mesa in the summer. The BLM lands have been heavily overgrazed (though the uplands have slightly better grass cover) and are contributing sediment, especially during high water events. Upland water tanks here would reduce pressure on the creek.

5.) Acequia de las Jara: The ditch is badly eroded from its headgate (at the diversion of La Jara Creek) throughout its reach. Previously a very expensive project was done in the upper portion, placing tire bales to reduce or slow flow, but these bales are now coming apart. The La Jara Water Users Association has about three or four thousand dollars of infrastructure near the diversion that could be expanded upon. The ditch erosion has heavily incised the channel. Some thinning projects have taken place upland, on Forest Service lands, and those could be expanded upon as well to reduce fuel loads in case of wildfire. Potential partner organizations in the area include La Jara Ditch Association.

6.) In this vicinity, tributaries coming off Cuba Mesa and entering the Rio San Jose exhibit substantial gullying and downcutting. Streambank stabilization is needed.

7.) This reach of Arroyo San Jose has steep eroding cut banks that could be stabilized with some combination of: post vanes to strategically protect banks; induced meandering to reduce incision; and potentially grazing protection using riparian fencing.

8.) Sediment contribution site, streambank stabilization and/or upland BMPs required.

9.) Gravel pits in this area may have reduced wetland functioning, specifically concerning denitrification. Some or all of the gravel pits are no longer used and the wetland area could be restored or increased.

10-A) 10-B) 10-C). Forest thinning needed, approximately 5,000 acres at each site.

11-A) 11-B). Forest thinning needed, approximately 5,000 acres at each site.

12-A) 12-B). Forest thinning, ~1,000 acre each

13-A) 13-B) 13-C) 13-D) 13-E) 13-F). Forest thinning, ~ 500 acre each

14). Grazing management needed, and erosion control along the reach.

15.) Highway crossings contribute sediment; small headcuts or gullies could be treated with Zuni bowls or one-rock dams.

16). Los Pinos Acequia follows a ridge on the Circle A Ranch; this Acequia is deeply incised and way too steep, generating tons of sediment, which then flows to the Rio Puerco through its tributaries. Streambank restoration and erosion control measures are needed.

17). (Generalized issues): HUC1030202070207: Tribal lands need to research and determine impacts from recreation and livestock to identify how to meet the current impairments for nutrients and temperature.

18). (Generalized issues): The north of the Rio Puerco needs erosion control/sediment reduction infrastructure, road treatments to reduce sediment, and forest thinning to prevent massive erosion from post-fire flooding.

19). (Generalized issues): Route 197 contributes a great deal of sediment and is vulnerable to erosion. Sedimentation from livestock and gravel pits is also a contributor. Many dirt tanks need to be fixed or plugged. Forest thinning is also needed in the area.

20). (Generalized issues): Forest thinning is needed in greatly overgrown areas, livestock overgrazing is reducing upland vegetation cover (contributing to erosion), roads in the area are contributing sediment, dirt tanks need to be fixed, and tribal lands need more assessment.

21). Streambank stabilization, riparian fencing and re-vegetation BMPs are needed all along the stream channel from Bluewater Lake to its headwaters.

Other concerns for Torreon Wash and Arroyo Chico Wash:

- Maintenance of existing BMPs; Public outreach and education; native revegetation; and sagebrush treatment.

Other concerns for Rio Moquino

- Sediment erosion and streambank stabilization is needed along the entire impaired reach and contributing uplands.

Load Reduction Estimates for the Recommended BMPs

The following data table contains the results of STEPL analysis, conducted by NMED staff, of the impact the recommended BMPs would have on water quality if applied to the entire area recommended by stakeholders. The STEPL analysis of the previously listed BMPs, found that all but one AU would reach the TMDL goal for load reductions. The one AU that does not meet its goal comes within a few percentage points of the TMDL goal, and therefore would still benefit from a great improvement in water quality.

It should be noted that STEPL analysis uses pre-measured load reduction values for certain BMPs. The BMPs included in this plan, while industry-supported and widely researched, have not had STEPL reduction values calculated. Therefore, using the best knowledge and interpretation of available data NMED staff used a combination of STEPL pre-measured values to achieve a best estimate for each BMP. These combined BMP values were found using STEPL's BMP Calculator, and can be found by scrolling down on Spreadsheet 1. All STEPL load reductions should be found by downloading or scrolling throughout Spreadsheet 1. Where the WBP is provided as a PDF the spreadsheet will be provided as "Appendix D, Load Reduction Estimates."

Spreadsheet 1. STEPL Analysis of the Potential Load Reductions under the Rio Puerco WBP:

HUC 12	130202040106	130202040106	130202040102	130202070207	130202070206
AU (s)	NM- 2107.A_44	NM-2107.A_40	NM-2107.A_40	NM-2107.A_00	NM-2107.A_01
AU Name	Rio Puerco Headwaters &	Rio Puerco downstream of Cuba	Rio Puerco downstream of Cuba	Bluewater Creek (Rio San Jose to Rvr)	Bluewater Creek (Rvr to headwaters)
Impairment	Sediment	Sediment	Nutrients	Nutrients	Nutrients
TMDL Reduction Go	32%	48%	90% P ; 87% N	0 % P ; 45% N	60% P ; 41% N
BMP #1&4 : Streambank Stabilization/Headc	20%/area = 13.4 %	20%/area = 12% Sed	20%/area = 10.5% P and 7.9% N	20%/area = 9.5% P and 7.2% N	20%/area = 10.3% P and 7.9 % N
BMP #2: Riparian Fencing & Planting	20%/area = 14.7%	20%/area = 15% Sed	20%/area = 15% P and 15% N	20%/area = 15% P and 15% N	20%/area = 15% P and 15% N
BMP #3: Arroyo/Headgate Control	5%/area = 4%	5%/area = 3.7% Sed	5%/area = 3.5% P and 3.1% N	5%/area = 3% P and 3.3% N	5%/area = 3.5% P and 3.1% N
BMP #5: Brush Control	30%/area = 18.4%	30%/area = 19.5% Sed	30%/area = 21% P and 20.7% N	30%/area = 3% P and 3.3% N	30%/area = 21.2% P and 20.7% N
BMP #6: Forest Thinning	50%/ area = 3.2 %	50%/area = 32.5 %Sed	50%/area = 34.9% P and 34.6% N	50%/area = 36.7% P and 34.3% N	50%/area = 35.4% P and 34.6% N

Chapter 4: Elements C & D, Management Measures & Assistance/Cost Required

Introduction

Throughout New Mexico nutrient impairments on water bodies have most frequently been observed as the result of upland and riparian vegetation loss.

Overgrazing, both by wildlife and livestock, can have heavy impacts on the amount of vegetation available to naturally bio-filter **nutrient-heavy runoff** throughout a watershed. Removal of vegetation in a riparian area is especially damaging, as riparian areas are a last line of protection for filtration before pollutants enter the water body. Such vegetation loss has many implications for other impairments as well - plant roots stabilize streambanks to prevent **erosion**, can catch **sediment** and woody debris from heavy flows, and absorb solar loading which prevents stream **temperature**s from rising.

Healthy communities of riparian plants often occupy the entire floodplain, resulting in an ecosystem that is highly resilient to flooding, can replace plant loss along the streambank to maintain bank stability, catches sediment runoff from upland sources before it enters the stream, and provides crucial habitat for wildlife species such as beaver that can have a disproportionately positive effect on water quality and quantity.

However, due to many the probable causes listed below, particularly overgrazing, riparian vegetation on the three reaches covered by the Rio Puerco WBP is extremely reduced, and in many places almost non-existent. Grazing in meadows is particularly harmful, as grasses are the primary vegetation there and once lost there are no other plant types to retain soil. Grazing in upland forests reduces vegetation cover as well, but the remaining tree root system persists.

Many restoration practitioners have found the most effective BMPs to address temperature impairments are: riparian plantings within a riparian fence; in-stream stabilizing rock and wood structures to raise the water table and deepen pools (where hydrologically appropriate); and streambank structures to prevent channel widening(SOURCE). Streambank structures and their native equivalent, beaver dams, have been shown to drastically reduce flow speed allowing sediment to fall out of the water, reducing both the **turbidity** of the stream and the potential for channel erosion. While these three reaches do not have an impairment for turbidity, Nacimiento Creek does, and the probable sources for turbidity there are similar to the probable sources for temperature here. As well, turbidity is an important factor to consider for quality fish habitat, and fishing is one of the most common public uses of Bluewater Creek.

In addition, many of the upland forests have been subjected to decades of fire suppression, resulting in much higher tree densities than would exist without human interference. Such high densities of trees create much darker understories and absorb more water, resulting in poor growth of understory grass populations. Without the roots of those widespread grass populations, high rainfalls erode much greater amounts of sediment from these forest ecosystems and deliver it to the streambodies. Selected thinning of these forests not only prevents erosion but also drastically reduces the risks of catastrophic wildfire. This view has been widely accepted throughout New Mexico and there is great community, agency, and public support for forest thinning, but the limiting factors are simply funding and time.

Further detail on the rational and effects of each BMP can be found in Appendix A, which contains information sourced directly from the Rio Puerco WRAS.

Therefore, the list of <u>Best Management Practices</u> this plan endorses for are as follows:

1. Streambank Stabilization

Image 1. Typical streambank erosion.

Streambank stabilization measures can be divided into two categories:

A) Vegetative management prescription would be indicated if the river has marginally degraded streambanks that are un-stable and are showing signs of actively eroding streambanks. Vegetative management includes shaping the streambanks, using an erosion control fabric, if appropriate and planting the critical vegetation area. The purpose is to stabilize and protect against bank scour and erosion.

B) Streambank bioengineering would be prescribed for moderately degraded streambanks that are unstable and are showing signs of actively eroding streambanks. Streambank bioengineering includes reshaping the streambanks and utilizing plant materials such as root wads, logs, branches and brush mats as structural components, and may also include terracing and revetment.

Image 2. Typical channel downcutting.

We estimate that approximately ten miles of streambank engineering and approximately 50 miles of vegetative management prescriptions will be need to be implemented to restore the river channel to a more stable state. It is not likely that any streambank stabilization project will be an entire mile in length, but rather smaller sections in the most severely eroded areas and where a willing landowner would like to participate. It is important to improve the upland conditions before engaging in a large-scale streambank stabilization effort, as the stream channel is affected by the greater conditions within the watershed.

<u>Streambank Stabilization Cost Estimates:</u>

Price per unit- Bioengineering techniques $248,160 per mile, Vegetative management $95,040 per mile

Potential Funding Sources- NRCS EQIP, EPA 319, NMGF, NMED Wetlands

Technical Assistance- NRCS, NM State Engineer, NM Interstate Stream Commission, NM Forestry Plant Center, NRCS Native Plant Center s and Regulation - USACE

2. Riparian Fencing and/or Planting

Image 3. Typical Riparian Exclosure Fence.

Once of the most effect ways to treat multiple water quality impairments is to limit access to the stream to herbivores by fencing off the riparian corridor, and jump-starting the recovery of the riparian ecosystem by planting native vegetation in the floodplain. These riparian exclosures should be built with either cattle or elk-appropriate fencing, depending on the area, and include pedestrian access points. Large-scale planting efforts within the fenced area are much more likely to succeed than in areas without a fence. Such planting efforts are also a critical complementary component to the exclosure, providing soil stabilization and future riparian habitat. Exclosures like these have been used extensively throughout New Mexico by private, state, and federal agencies and have been very successful in preventing bank de-stabilization (from animal trampling and devegetation) and restoring the riparian ecosystem. Wildlife have been observed moving into and using the enclosed area, as the plantings provide greater habitat and the fence provides protection from the effects of herbivore access, OHV use, and other human activities. Subsequent restoration projects, such as in-stream structures or streambank stabilization efforts, also benefit from the same protection and are therefore more likely to have positive results.

Riparian Fencing and/or Planting Cost Estimates:

Price per Unit- Fencing: $11,000/mile   Planting: $5,000/mile

Potential Funding Sources- EPA 319, NRCS EQIP, private planting material donations

Technical Assistance- USDA Forest Service, USACE

3. Headgate Repair

Image 4. Headgate Repair.

Headgate repairs or replacements will frequently be prescribed with the addition of rock check dams or other streambank stabilization techniques or erosion control practices. The failure of headgates in a watershed are all related to land erosion created by degraded streambanks, disconnection of the stream from the floodplain, or other effects of watershed degradation that can result in flooding or overloading of the headgate. Once a headgate fails it becomes an additional source of erosion, and can even create a new valley-eating headcut. It should be noted that while STEPL does not always contribute much load reduction to this BMP (since it does not cover much acreage), its effects are not well represented within STEPL's data, and remains a crucial management measure to prevent road failures, infrastructure damage, and further erosion.

Repairing a headgate can include suggestions for rock check dams, re-using or re-structuring original parts, upgrading or resizing original parts, streambank engineering upstream of the headcut and management. Approximately 10-15 headgates need to be repaired throughout this plan's priority reaches.

<u>Headgate Repair Cost Estimates:</u>

Price per Unit- Estimated cost of $8,000 to include some erosion control practices

Potential Funding Sources- EPA 319, NRCS EQIP, SWCDs, NM State Capital Outlay, NM Interstate Stream Commission, NM Infrastructure Capital Improvement, Bureau of Reclamation

Technical Assistance- USDA NRCS, NM State Engineer, NM Acequia Association, USACE

Permits and Regulation- USACE

Responsible Party- Landowner

4. Arroyo/Headcut Repair

Image 5. Typical Headcut.

Several actively eroding gullies, arroyos, and headcuts have been identified throughout priority reaches, and these are major sources of sediment loading. Many degraded arroyos have previously been treated, often by installing dirt tanks as sediment catchments, however this is often insufficient. Proper

BMPs include regrading the gully, installing in-stream structures such as Rosgen or Zeedyk structures, and replanting riparian vegetation. Some of the larger headcuts will require a more extensive engineering design, sometimes using heavy equipment, to correct the erosion problem.

Arroyo/Headcut Repair Cost Estimates:

Price per Unit-$5,000-$20,000 per repair

Potential Funding Sources- NRCS EQIP (size restrictions), EPA 319

Technical Assistance- NRCS

Permits and Regulation- USACE, FEMA floodplain, County can consult

Responsible Party- Landowner or Lessee

5. Brush Control

Image 6. Typical Treated Sagebrush.

The areas within these watersheds that have had sagebrush eradication have significantly greater grass biomass and groundcover. Removing the invasive brush creates better habitat conditions and inhibits sheet and rill erosion. We estimate that there are approximately 15,000 acres of invasive brush in these priority watersheds that could be treated. Practice method would depend on size of the treatment area and preference of the landowner. Treatment could be mechanical using a brush hog or other equipment to manually remove the brush, or could be chemical application with an aerial spraying of herbicide. The most effective treatment is a combination of both; however treating with just the herbicide has the added benefits of leaving brush skeletons in place that hold soil while they decompose.

<u>Brush Control Cost Estimates:</u>

Price per Unit-$35/ac for aerial chemical treatment, $100/ac for mechanical treatment

Potential Funding Sources- NRCS EQIP, EPA 319, NMGF Habitat Stamp, NM State Responsible Party-

Technical Assistance – NRCS *Permits – NRCS, BLM, USFS*

6. Forest Thinning

Image 7. Example of Overgrown Tree Stand.

Forest stands have become very overgrown in parts of the watershed due to decades of fire suppression in a fire-adapted ecosystem. The result has been closed canopy conditions where natural forest understory and ground cover cannot grow beneath the trees, resulting in greater runoff and less nutrient bio-filtering. These conditions are also much more likely to lead to catastrophic wildfire, and pose a risk to human health and safety, not only water quality. Prescribed treatments include thinning tree densities to appropriate ecological densities (often 40 trees/acre) with hand tools, mastication, and controlled/prescribed burns where necessary.

Forest Thinning Cost Estimates:

Price per Unit- $1,850/ac for heavy thinning, $1,030/ac for light thinning and $1,000-$800/ac for mastication.

Potential Funding Source- NRCS EQIP, ENMRD hazardous fuels nonfederal lands, USFS Secure Rural Schools title II, USFS CFRP, NMED River

Technical Assistance – NRCS, NMSF, USFS, NM Watershed Institute

7. Water Infrastructure Improvements

Image 8. Trick Tank for collecting rainwater.

Riparian impairments that have grazing as a probable source can partially be addressed by providing alternative drinking sources for animals that are located outside the riparian area/floodplain. If animals spend less time trying to access the stream for drinking there will be reduced erosion effects from trampling and reduced likelihood of riparian plants being consumed since the animals spend more time away from the stream area. This is an important BMP to implement in conjunction with any riparian fencing project, since without alternative water sources animals are likely to damage or destroy the fence to access the stream, which would nullify the effects of the fencing. It should therefore be noted that while STEPL's load calculations do not contribute much sediment reduction to this BMP (as it covers little acreage), implementing this BMP is crucial to the success of other management measures. This BMP also covers addressing dam maintenance and improvement. The Bureau of Land Management manages approximately 650 earthen dam structures. Most of the dam structures have outlived their design life expectancy and are in critical need of maintenance to save these important watershed stabilization structures, and protect upstream and downstream watersheds. Some of these structures are failing and will need engineering designs, evaluations, and funding to complete the work. The average cost to breach, repair and stabilize a dam structure is estimated to be $300,000 per structure.

Image 9. Example of Dam Repair.

Water Infrastructure Cost Estimates:

Price per Unit- $300,000 for clearing and breaching the dam and stabilizing the spillway to maintain structural integrity. $10,000- $40,000 per watering tank, depending on location, design, and specifications.

Potential Funding Source – BLM, USFS, NRCS EQIP, NMED, EPA § 319.

Technical Assistance – BLM, USFS, NRCS EQIP, NMED, NM Water Institute.

Permits not usually needed for maintenance.

SUMMARY OF COST ESTIMATES

Best Management Approximate Number of Units	Description and Practices	Estimated Costs per Unit	Total Estimated Costs
Headgate Repair/Replacement	10-15 Headgates and Associated Erosion Control Structures	$8,000 per structure	$80,000- $120,000
Forest Thinning (USFS and BLM)	20,000 acres	$1,200 per acre	$24,000,000
Forest Thinning (Private Lands)	2,000 acres	$1,200 per acre	$2,400,000

Best Management	Description and Practices Approximate Number of Units	Estimated Costs per Unit	Total Estimated Costs
Fencing and Planting	10 Miles	$16,000 per mile	$160,000
Invasive Brush Control	Chemical or Mechanical Treatment 30,000 acres	$35-$100 per acre	$525,000- $3,000,000
Water Development	7 Wells and Infrastructure 10 Ponds	$25,000 per well $7,000 per pond	$175,000 $70,000
Arroyo/ Headcut Repair	40 Arroyos or Headcuts Various size and depths	$5,000-$20,000 per repair	$200,000- $800,000
Streambank Stabilization	Bioengineering Methods 10 miles Critical Vegetation Area 50 miles	$248,000 per mile $95,040 per mile	$2,480,000 - $950,000
Dam Maintenance	Repair/maintain 51 priority dams	$300,000 each (10 highest priority dams)	$3,000,000
Project Monitoring	Pre- and Post-Implementation Project Monitoring/Long-Term Range Monitoring	$15,000 per year	$150,000
Project Outreach and Project Administration	Technical Assistance /Communications/Capacity Building/ Engaging Partnerships/ Financial Assistance/Fundraising/	$25,000 per year	$250,000

Chapter 5: Element E, Education and Outreach

Stakeholder Outreach and Participation

Outreach for this planning process included identifying the landowners within the watershed and requesting their mailing addresses to initiate communication. Meeting flyers were distributed by the RPMC and the Cuba and Lava Soil and Water Conservation Districts. Planning workshops were held in Cuba and Milan, New Mexico, to discuss the planning process and strategy for completing the WBP and incorporating public input. In addition, we spoke directly with landowners to answer questions. We scheduled site visits and held interviews with families in the watershed, and we identified potential sources of erosion, discussed previously implemented best management practices and created ideas for future projects on their properties.

Stakeholders met with us on an individual level to discuss their objectives and impediments to land restoration. Most landowners have been actively implementing restoration projects on their land over time. Stakeholders have already attended RPMC meetings to discuss land and water management issues and to engage in discussions about the most appropriate methods for approaching the needed restoration work. The watershed group meetings provided an opportunity for the community to learn about new best management practices, to discover funding sources and a chance for the group to make consensus decisions on the priorities for actions within the watershed.

Future Stakeholder Outreach and Participation Activities

Future outreach and participation activities will include:

- Continue the watershed group meetings at least quarterly or as needed. Meetings will continue to be advertised by mailings, phone calls and word of mouth.
- The RPMC will continue outreach with landowners who have not yet participated.

- Assist the private landowners with funding applications and implementation projects.
- Hold workshops for group funding applications.
- Hold workshops on monitoring to make it easier for landowners to complete project specific monitoring pre and post implementation.
- Have field days to learn about innovative BMP installations.
- Hold workshops on BMP maintenance.
- Have field days to visit completed or ongoing restoration projects to share technical information among the stakeholders.
- Continue to host guest speakers as needed to learn about new topics such as innovative BMP's, funding sources, regulations and success stories from other restoration projects.
- Maintain current partnerships and create new partnerships to identify collaborative efforts and funding sources.
- Engage in efforts with the local agencies to pursue management options and encourage NEPA planning where appropriate.

Specifically, the RPMC would like to hold workshops in the following areas for the following topics:

- Sandoval County; road maintenance/repair to prevent erosion and harvest rainwater
- Streambank stabilization/induced meandering/Zeedyk methods on one or all of the following locations: Upper Rio Puerco, BLM land on the continental divide, Jicaria on the continental divide, Upper Jemez Pueblo
- Monitoring workshop, flexible location, for adaptive monitoring using photopoints
- Holistic grazing systems, flexible location, with a rangeland ecologist, possibly Kurt Gadzia
- Native plant harvesting and revegetation, possibly on the Upper Rio Puerco

Figure 11. Stakeholders in the Rio Puerco Watershed:

Tri-Chapters of the Navajo Nation, Navajo Nation Water Resources

Acoma Pueblo, Jemez Pueblo, Laguna Pueblo

Private Landowners

Cuba and Lava Soil and Water Conservation Districts

New Mexico Association of Conservation Districts

New Mexico State Forestry

Cuba and Grants NRCS

BLM Rio Puerco Field Office

USFS Cuba and Mt. Taylor Ranger Districts

New Mexico State Land Office

Sandoval and Cibola Counties

New Mexico Game and Fish, New Mexico Environment Department

Chapter 6: Elements F & G, Schedule & Milestones

Predicted Planning Schedule:

Spring 2017: Watershed-Based Plan submitted to EPA.

Summer 2017: Request for Proposals (RFP) for the NM River Stewardship Program is published. The RPMC plans to submit a proposal to begin work- these funds are non-federal and can provide match for EPA 319 funds.

Fall/Winter 2017: NM 319 RFP for On-the-Ground projects is likely published. If the WBP is approved, RPMC will submit a proposal to carry out the WBP.

Spring 2018: River Stewardship Program proposals will likely begin restoration work in the field. Project Managers will be hired to oversee all work, including quarterly reports to the RPMC Steering Committee.

Summer 2018: 319 projects will likely begin work in the field. Likewise, all projects will have project managers that will report quarterly to the RPMC Steering Committee.

Summer 2020: The first round of projects completed under River Stewardship funds will likely be complete.

Possible course corrections:

If for any reason funds are not available or awarded under a particular RFP, the RPMC will submit another proposal under the next possible RFP. Each project will include planning and schedule updates to the RPMC and a NMED Project Manager. For public lands, NEPA clearances will be scheduled and coordinated with the appropriate agencies. NMED Project Managers routinely work with other agencies to oversee project scheduling/clearances, and will adjust for any delays.

10-YEAR IMPLEMENTATION PLAN

Project	2016	2017	2018	2019	2020	2021	2022	2023	2024
Hire a Coordinator		x							
Continue Watershed Group Meetings	x	x	x	x	x	x	x	x	x
Apply for EPA 319 Grant		x		x		x		x	
NRCS EQIP Funding for Private Landowners	x	x	x	x	x	x	x	x	x
USFS Forest Thinning		x	x	x	x	x	x	x	x
Private lands Forest Thinning		x	x	x	x	x	x	x	x
Water Development Projects		x	x	x	x	x	x	x	x
Headgate Repair or Replacement	x	x	x	x					
Brush Control Projects	x	x	x	x	x	x	x	x	x
Streambank Stabilization Projects		x	x	x	x	x	x	x	x
Arroyos and Headcuts Repair	x	x	x	x					
Fencing	x x	x	x	x	x	x	x	x	x
PSAIC Watershed Assessment	x		x		x		x		x

Project	2016	2017	2018	2019	2020	2021	2022	2023	2024
NMED Water Quality Assessment						x			
Restoration Pre and Post Project Monitoring	x	x	x	x	x	x	x	x	x

PROJECT MILESTONES

Listed below are project milestones for implementation of the Watershed Based Plan (BMP milestones apply only to years in which funding is secured:

- Treat 300 acres/year with forest thinning
- Treat 2 miles/year with one/more of the following; streambank stabilization, riparian fencing and planting, or arroyo repair
- Address at least 1 water infrastructure or headgate repair need per year
- Treat at least 300 acres per year with either mechanical or chemical brush control
- Hold at least 1 field day per year per project, including volunteer days and field trips for all members of the RPMC.
- Hold at least 1 workshop per year on implementation of BMPs or the topics listed in the Outreach/Education section.
- Facilitate watershed group meetings at minimum on a quarterly basis.
- Apply for EPA CWA 319- Project Funding every two years or as needed.
- Assist five landowners per year in applying for NRCS EQIP funding.
- Assist two landowners per year to apply for NMSF thinning projects on Non Federal Lands.
- Complete PSIAC Watershed Assessment every two years.
- Create an annual report every year to track metrics to provide for adaptive management.

CRITERIA

The measurement of success for this watershed management plan will be attainment of water quality standards. The NMED will perform water quality sampling on the Rio Puerco again in 2020. Once the data becomes available we can reevaluate our program and make course corrections if needed.

The most decisive criteria in determining the success of the Watershed Based Plan will be attainment of water quality standards, yet it is unlikely that the turbidity levels in the Rio Puerco will change in a short time period, we may need to complete many watershed restoration projects to begin to see a change. Watershed restoration projects are subject to funding availability. We are also dependent on climatic conditions to see a positive change, for example the drought is currently contributing to the conditions of the watershed, and if the drought does not end or gets worse it will continue to effect the water quality.

To have effective and timely adaptive management for this plan we will also define alternative criteria to measure interim success. We will use the following interim qualitative criteria to continue to assess watershed conditions: change in land use, change in erosion, change in vegetative cover and change in streambank/channel conditions. We will use the data we collected for the current watershed assessment as a baseline. We will also use the PSIAC model to measure the sediment yields using our current data as a baseline. The PSIAC watershed assessment and measurement of sediment yields will be performed at two-year intervals and can provide a measurement of progress towards the water quality goals and provide for more timely adaptive management if needed.

Any milestones/goals that are not met by the estimated date will increase in priority for the following year. Collaborative agency support by both NMED and BLM will be advantageous in pursuing funding and overseeing progress reports at the monthly RPMC meetings. However, the RPMC has a history of successful projects in the area, and this plan reflects the urgent priorities that have great support by local stakeholders, and therefore smooth implementation is predicted.

While full BMP implementation is not expected for several years, if any particular BMP is found to not be producing the expected results the RPMC Steering Committee and NMED Project Managers will be notified through monitoring reports. If a BMP is consistently producing poor results then alternative BMPs will be researched (including consultation with BLM and NMED) and submitted to EPA. Since the WBP is intended to be a living document, the RPMC is open to field-testing new methods. The RPMC is also recognized to consist of many knowledgeable local stakeholders, who routinely attend restoration workshops and trainings, who will be invaluable if the milestones or BMPs need to be changed.

Interim success criteria can also include the following quantitative criteria to measure our success in meeting our project milestones;

- Number of meetings, project participation and outreach events
- Valuable partnerships created and maintained
- Amount of funding received per year to implement restoration projects
- Number of BMP's implemented as gauged by number of acres, or feet of restoration work in a percentile to our overall goal

A report will be produced by the RPMC Steering Committee at the end of each calendar year and will summarize all of the criteria indicators, problems encountered and project successes.

Chapter 7: Elements H & I, Load Reduction Evaluations & Monitoring

Load Reduction Evaluations

Sediment loading into the Rio Puerco watershed streams is of primary concern. Sediment delivery reduction resulting from projects (especially if it corrects a human-induced problem) is likely to be an effective measure. Any such projects that are tributary to the 303(d) or Total Maximum Daily Load (TMDL)-listed reaches would be good candidates for collaborative projects. Implementation of both upland and instream measures are needed for effective improvement of the watersheds.

The Rìo San Jose's listed reach has a drinking water source (DWS) designation, and tributaries to the Rìo Puerco UMS are known to provide water for irrigation purposes. The monitored or evaluated impairments of concern include temperature exceedances, stream bottom deposits, plant nutrients, metals, turbidity, dissolved oxygen, and pH.

RPMC plans to rely primarily on STEPL, PSIAC, and water quality samples monitoring methods to measure water quality improvements and success of all implemented BMPs. Both STEPL and PSIAC are widely supported within the natural resource management field and have been used to provide initial load reduction estimates for this plan. Water quality samples will be analyzed by the state lab or facility meeting the NMED SQWB's analysis standards. Where appropriate (or where the stream has an active impairment), water samples will be analyzed for total suspended nitrogen, turbidity, or total suspended phosphorus.

Monitoring Plan:

All projects will conduct pre-and post-project monitoring to determine if water quality standards are being met. The RPMC steering committee will review the results of this monitoring through a quarterly report for each project, and will be responsible for determining if water quality standards are improving at a rate that is acceptable for the scope and nature of each project.

However, given the size of the watersheds, the high extent of pollutant loading, the amount of money available for restoration and the capacity of the RPMC to conduct projects, it is highly likely that reductions in water quality within each AU will take years. Instead, each project proposal will include its own definition for measures of success, and the monitoring will reflect if the project indeed meets its own success criteria. For example, a riparian revegetation project may have the goal of increasing shade on the stream to reduce temperature loading; monitoring reports would include densiometer measurements to indicate if shade does increase.

There will be two types of monitoring utilized in this implementation plan: a biannual watershed assessment and measurement of sediment yields, and pre-/post-individual restoration project monitoring.

Watershed Monitoring and Assessment: This will focus on the cause of water quality impairment and will utilize the methods we have established in this document. The PSIAC watershed assessment model will be applied to assess long-term trends in watershed health and potential changes in land use, vegetation, upland erosion and channel stability. The model will also be used to estimate sediment yields. This assessment will be done by the watershed coordinator and will be done every two years always in the same month so ground conditions will be similar. Further detail on the PSIAC model can be found in Appendix B. PSIAC estimates should be taken every two years, as funding and staff time allow, in order to track overall changes throughout the watershed that may be occurring naturally or to efforts outside of the RPMC, the Rio Puerco WBP, or subsequent projects.

Restoration Project Specific Monitoring Program: The RPMC (or assigned project manager) will assess the parameters of each project pre- and post-restoration to monitor the effectiveness of restoration projects over time. This is necessary to inform and develop adaptive management strategies should the implementation not have the anticipated results. This will also provide a catalog of completed restoration projects and ensure that all BMPs are maintained. The watershed coordinator will work with the project funder and the landowner to implement these protocols at each restoration site. The post-restoration monitoring will also take place as near to the same time of year to ensure similar ground cover and vegetation conditions as the pre-project monitoring

A photo-point monitoring protocol and project quality assurance plan will be developed, approved by the Environmental Protection Agency (EPA) and followed for each restoration project. Photo points will be taken upstream and downstream of each structure built or BMP implemented, and will be updated yearly to track the effectiveness of each measure. In addition, streams that are impaired for nutrients will be monitored using water quality samples, taken annually from the NMED SQWB sampling site, and assessed for total suspended nitrogen and total suspended phosphorus. Individual project grantees may conduct additional monitoring by their choice.

The NMED Surface Water Quality Bureau (SWQB) will conduct water quality monitoring on the Rio Puerco in 2020. The RPMC and any project grantees working under this plan should work with the SWQB to coordinate data collection and incorporate all new data into restoration efforts.

All monitoring data will be logged in standardized forms and will be stored in an electronic file and a binder in accordance with the PQAPP. Monitoring data will be published in the annual report, as well as provided to the NMED project officer in quarterly assessments as a deliverable. Proper training in an established monitoring protocol will take place before any data are collected.

Chapter 8: Potential Data Gaps

Water Quality Data

Substantial attention has been paid to watershed stability and water quality concerns, especially sediment, in the Rio Puerco. Important long-term collection of stream flow data and sediment comes from the USGS under its stream gaging activities, and from the New Mexico Environment Department (NMED) in its administration of the federal Clean Water Act. In addition, there are other sources of data and information that serve as indicators for watershed and water quality conditions. These subjects are discussed below.

The U. S. Geological Survey (USGS) collects streamflow and sediment data at three gauging stations within the WBP area. While a decrease in downstream sediment loads was noted by Gellis using these three gauging stations on a large basin scale, the smaller tributary basins as exemplified by the Arroyo Chavez study seem to be significant sources of erosion and sediment delivery.

The TMDLs created by the NMED in 2006, 2007, and 2016 were based on one sampling point at the lower end of the upper Mainstem Rio Puerco sub-watershed including La Jara Creek, Arroyo Chijulla, and Nacimiento Creek. TMDLs were also created by the NMED in 2007 for the Rio San Jose sub-watershed including Bluewater Creek and the Rio Moquino (see table below).

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Appendixes

APPENDIX A. Support for Best Management Practices (Rio Puerco WRAS, 2001)

GOAL 1: RESTORE AND MANAGE THE WATERSHEDS ON PUBLIC AND PRIVATE LAND TO REDUCE THE THREAT OF WILDFIRE, TO ENHANCE WATER RETENTION AND QUALITY, AND TO PRESERVE THE NATURAL SYSTEMS THAT ARE DEPENDENT ON WATER.				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Restore a fire-adapted watershed	Within forests and woodlands treat grassland brush in an ecologically sound manner. Develop a network of natural and artificial fire and fuel breaks to define 5000+ acre fire management units throughout the watershed. Manage forage utilization to maintain ground cover and carry fire. Apply prescribed fire frequently and extensively to established fire management units. Create defensible spaces around all dwellings and structures. Provide for adequate fire protection of structures to facilitate prescribed burning.	Within 30 years	Use federal fuel reduction and fire prevention funds for public lands. Use state fuel reduction and fire prevention funds for state lands. Use tax rebates, credits and matching funds for private land.	Protects watershed, land and property values. Reduces potential of catastrophic wildfires. Saves costs in suppression of catastrophic fires. Creates many local jobs. Creates value added industry and permanent jobs.

GOAL 1: RESTORE AND MANAGE THE WATERSHEDS ON PUBLIC AND PRIVATE LAND TO REDUCE THE THREAT OF WILDFIRE, TO ENHANCE WATER RETENTION AND QUALITY, AND TO PRESERVE THE NATURAL SYSTEMS THAT ARE DEPENDENT ON WATER.				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Decrease soil erosion and increase water retention and infiltration	Expand watershed management programs. Promote good soil management practices. Use low impact agricultural methods such as shallow or no plowing. Apply soil conservation techniques such as installation of field borders. Laser level irrigated fields. Line or pipe irrigation ditch systems, or segments most prone to erosion. Reduce and prevent surface water runoff on grazed lands. Improve grazing management through methods such as fencing, pasturing, and rotational grazing. Improve ground cover on rangeland.	Within 15 years	Use federal soil erosion funds for public lands. Use state soil erosion funds for state lands. Use tax rebates and credits, and matching funds for private land.	Reduces deterioration of the land. Increases productivity of land. Increases benefit to landowners and producers. Retains soil nutrients, topsoil and seed. Reduces flash runoff and gullying.
Reduce and prevent habitat destruction from aging retention & detention structures, and diversion dams and dikes	Create a database of all large earthen structures within the watershed. (approximately 250 retention, 120 detention structures and 280 diversion dams and dikes). All of the structures have reached their design life (25 years) and many are developing breaches or major structural problems. Redesign, and modify 51 earthen dam structures to allow for controlled discharge to prevent catastrophic occurrences and to increase water retention and infiltration.	Within 25 years	Develop federal, state, local, and charitable funding. Work with relevant agencies and non-profit organizations to develop monitoring and maintenance programs. See Appendix D for 10 highest priority dams needing redesign and modification.	Retention ponds maintain a pool of water throughout the year. Detention ponds hold water for short periods of time. Both hold storm water runoff to reduce peak flows, allow for settling of sediment, stabilization of stream channels and reduced erosion. Provides water for wildlife and livestock.

GOAL 1: RESTORE AND MANAGE THE WATERSHEDS ON PUBLIC AND PRIVATE LAND TO REDUCE THE THREAT OF WILDFIRE, TO ENHANCE WATER RETENTION AND QUALITY, AND TO PRESERVE THE NATURAL SYSTEMS THAT ARE DEPENDENT ON WATER.				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Reduce, and prevent, soil and habitat destruction along paved and unpaved roads and highways	Reduce development and in- creasing use of unpaved roads. Use proper road construction standards including culverts, and bridging and drainage for both paved and unpaved roads and maintenance standards for unpaved roads, which can be found in USDI & USDA, Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development, 2007, and Zeedyke, Water Harvesting from Low-Standard Rural Roads, 2006. Instruct public and private heavy equipment operators in proper maintenance of unpaved roads. Design roadways to enhance water spreading. Create low maintenance road drainage systems. Harvest runoff water. Increase the use of rolling dips on unpaved roads.	Within 10 years	Develop federal, state, local, and charitable funding. Work with land management agencies to develop plans. Work with relevant agencies and non-profit organizations to initiate training of operators.	Reduces the need for and cost of road maintenance. Retains road surfacing materials. Helps eliminate mudholes and sinks. Increases productivity on rangelands and farmlands.
Reduce, prevent and repair incising of arroyos	Reduce formation of, and stabilize head cuts, gullies and arroyos. Use Best Management Practices to catch soils and fill arroyos. Repair deeply eroded cuts with heavy equipment. Repair smaller cuts with grade stabilization structures such as weirs, net wire diversions, rock and brush dams. Monitor and maintain all structures.	Within 30 years	Use federal erosion funds for public lands. Use state erosion funds for state lands Use tax rebates and credits, and matching funds for private land.	Reduces general deterioration of the land. Increases benefit to landowners and producers. Retains soil nutrients, topsoil and seed. Raises the water table and recharges springs and seeps
Reduce, prevent, and repair habitat loss along streams, arroyos, and in wetland and riparian areas	Re-vegetate along streams and ephemeral waterways, plant willow and cottonwood trees at unstable banks and along non-vegetated segments. Construct fencing to protect ri- parian and wetland areas, and plantings	Within 15 years	Develop federal, state, local, and charitable funding. Work with relevant agencies and non-profit organizations. Use tax rebates and credits,	Reduces loss of important plant species in drought years. Improves functioning of vegetation for flood and sediment control.

GOAL 1: RESTORE AND MANAGE THE WATERSHEDS ON PUBLIC AND PRIVATE LAND TO REDUCE THE THREAT OF WILDFIRE, TO ENHANCE WATER RETENTION AND QUALITY, AND TO PRESERVE THE NATURAL SYSTEMS THAT ARE DEPENDENT ON WATER.				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
	from livestock and wildlife until they take hold. Stabilize channel banks. Re-create and induce stream meanders. Enhance and protect floodplains. Prohibit development in areas within flood plains, or which have hydrologic problems such as storm water ponding, poor drainage, high water table. Prohibit development in wetlands or riparian areas.		and matching funds for private land.	Reduces flooding damages. Provides habitat for numerous wildlife species, and migratory birds. Increases opportunities for wildlife viewers and hunters.
Increase bio-diversity and production on public and private lands including both wild and domestic species	Manage sagebrush monocultures and reduce numbers of juniper trees. Remove non-native vegetation from riparian areas. Control noxious, invasive, and non-native weed species. Seed with native grasses, and plants. Develop grass banks and other cooperative programs. Develop drought management plans for grazing.	Within 20 years	Develop federal, state, local, and charitable funding. Work with relevant agencies and non-profit organizations. Use tax rebates and credits, and matching funds for private land	Healthy and productive plant and animal communities in an ecosystem with a diversity of species, size classes, and ages: Increases drought resistance. Increases forage, native grass production, and ground cover. Increases benefits to landowners and producers. Creates local jobs.
Provide consistent and sustainable sources, and adequate distribution of rangeland water	Drill wells for development of alternative upland water. Install improved well pump technology on existing wells. Install water pipelines and drinking troughs. Use various methods to reduce competition for forage between livestock and wildlife.	Within 15 years	Develop federal, state, local, and charitable funding. Work with relevant agencies and non-profit organizations. Use tax rebates and credits, and matching funds for private land.	Achieves a balanced animal-use pattern across the landscape to reduce overgrazing, and increase size and productivity of wildlife and livestock. Increases water availability and distribution to reduce competition for water resources between livestock and wildlife.

GOAL 2: SUPPORT THE CULTURAL AND SPIRITUAL VALUES OF WATER AND THE IMPORTANCE OF WATER TO ECOSYSTEMS IN THE WATERSHED				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Realize the spiritual benefits of the watershed's ecosystems aside from the economic benefits	Promote appreciation of the dependence of all life on water. Promote the sanctity of watercourses. Promote a spring water festival in which knowledge of water as a sacred gift is restored by blessing of the local acequias and streams by priests and medicine men. Promote a fall harvest festival linked to the County Fair to celebrate the perseverance and cohesion of rural agricultural communities. Promote water events throughout the year to keep people focused on the importance of water and soil management. Integrate community and spiritual leaders around water and ecosystem health. Develop public parks and interpretive areas along perennial streams near villages. Develop Adopt-a-Watercourse programs. Develop community gardens. Maintain local cultural and religious traditions.	Within 10 years	Develop federal, state, local, and charitable funding. Work with relevant agencies, non-profit organizations, and land management agencies to develop plans. Work with local planners to create and maintain relevant zoning.	Promotes cohesion of the community regarding care for the ecosystems that sustain us: Ancient forests, Free-flowing rivers, Living deserts, and The abundance of life flourishing in all these areas

GOAL 2: SUPPORT THE CULTURAL AND SPIRITUAL VALUES OF WATER AND THE IMPORTANCE OF WATER TO ECOSYSTEMS IN THE WATERSHED				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Maintain agriculture and ranching as part of the whole ecosystem	Implement management practices that are environmentally friendly and sustainable. Create and implement local management plans. Promote an attitude of stewardship of the integrity of the ecosystems.	Over the next 50 years	Develop federal, state, local, and charitable funding. Work with relevant agencies, non-profit organizations, and land management agencies to develop plans. Work with local planners to create and maintain relevant zoning.	Increases sustainability of farming and ranching. Increases benefits to landowners and producers.
Integrate the twelve design principles of Permaculture into the development of watershed projects	Observe and interact. Catch and store energy. Obtain a yield. Apply self-regulation and accept feedback. Use and value renewable resources and services. Produce no waste. Design from patterns to details. Integrate rather than segregate. Use small and slow solutions. Use and value diversity. Use edges and value the marginal. Creatively use and respond to change.	Within 25 years	Develop federal, state, local, and charitable funding. Work with relevant agencies, non-profit organizations, and land management agencies to develop plans. Work with local planners to create and maintain relevant zoning.	Designs solutions that suit our particular situation. Collects resources at peak abundance for use in times of need. Ensures useful rewards from the work done. Discourages inappropriate activity to ensure systems continue to function well. Reduces consumptive behavior & dependence on non-renewable resources. Makes use of all resources available to us so nothing goes to waste. Puts the right things in the right place to work together to support each other. Small, slow systems that are easier to maintain than big ones. Reduces vulnerability to threats due to system diversity.

GOAL 2: SUPPORT THE CULTURAL AND SPIRITUAL VALUES OF WATER AND THE IMPORTANCE OF WATER TO ECOSYSTEMS IN THE WATERSHED				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
				Allows a positive impact from the inevitability of change.

GOAL 3: ENSURE TREATY, WATER, AND ACEQUIA RIGHTS TO PRESERVE AND PROTECT LOCAL AGRICULTURAL TRADITIONS				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Promote agriculture and its beneficial use of water	Form local agricultural cooperatives to work fallow land. Support acequia and agricultural land improvement programs.	Over the next 50 years	Develop federal, state, local, and charitable funding. Work with relevant agencies and non-profit organizations. Work with legislators and local officials to develop mechanisms and legislation which integrates and expands on ways to protect water for agriculture.	Maintains productivity of agricultural lands. Maintains agricultural water rights. Protects and preserves areas presently and historically used for agricultural practices.
Maintain the integrity of the traditional acequia (ditch) systems that have existed for generations	Protect acequia priority of rights-of-way. Encourage acequias to pass bylaws to review any change of diversion in accord with § 73-2-21(E) NMSA 1978. Encourage acequias to pass bylaws to create a water bank in accord with § 73-2-55.1 NMSA 1978. Map, catalog, and describe acequias including annual water use. Identify, quantify, and adjudicate surface water rights and order of water utilization.	Over the next 50 years	Develop federal, state, local, and charitable funding. Work with relevant agencies and non-profit organizations. Work with legislators and local officials to develop mechanisms and legislation which integrates and expands on ways to protect acequias.	Maintains the diversity of historic, and prehistoric cultures and traditions. Increases benefits to landowners and producers.
Increase efficiency of irrigation ditch systems	Develop a consistent and sustained supply and distribution of irrigation water. Provide annual maintenance to all irrigation ditches. Line or pipe irrigation ditch systems. Construct head and farm gates for water control. Maintain and repair culverts, flumes, head, and farm gates. Re-contour and repair segments of ditches to reduce gradient and prevent incising. Laser level fields.	Within 10 years	Develop federal, state, local, and charitable funding. Work with relevant agencies and non-profit organizations. Work with legislators and local officials to develop mechanisms and legislation which integrates and expands on ways to maintain acequias. Use tax rebates and credits, and matching funds for private land.	Increases productivity of irrigated land. Increases availability of water during drought. Provides a topography that makes application of water to fields more efficient.

GOAL 3: ENSURE TREATY, WATER, AND ACEQUIA RIGHTS TO PRESERVE AND PROTECT LOCAL AGRICULTURAL TRADITIONS				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Keep water with the land	Establish a severance fee to discourage removal of water and land from an acequia system. Develop mechanisms to ensure water rights are not lost if water is kept in or returned to a waterway. Develop mechanisms to prevent transfer of surface and ground water rights from their locality. Prevent sale of water out of sub-regions. Promote customary laws & practices in existence prior to the Treaty of Guadalupe Hidalgo, 1848, that promote agriculture and communal property.	Over the next 50 years	Work with relevant agencies and non-profit organizations. Work with legislators and local officials to develop mechanisms and legislation which integrates and expands on ways to maintain traditional communal concepts.	Maintains a link to the customary laws and practices of historic and prehistoric cultures and traditions. Increases options for the use of agricultural water without loss of water rights.
Promote respect for rural, tribal, farming, and ranching lifestyles	Form lobbying groups. Form local and regional acequia and agricultural associations. Educate about the importance of farming and ranching.	Over the next 50 years	Work with legislators and local officials to develop mechanisms and legislation which integrates and expands on ways to maintain rural, tribal, farming, and ranching lifestyles. Work with school officials to develop curricula.	Promotes recognition of the importance of agriculture and rural areas.

GOAL 4: RETAIN LAND USE PATTERNS THAT SUPPORT AND ENSURE A RURAL LIFESTYLE AND ECONOMY				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Base regional growth, planning, and zoning on retaining the health of the ecosystems within the watershed	Tie land use to demonstrated availability of water. Manage growth within the limits of water, and a rural landscape. Require water availability before land subdivision. Manage growth by putting geographical or numerical limits on population. Implement land use plans that differentiate between rural, suburban, and urban areas. Maintain large areas of mostly vacant and predominantly undeveloped land, with limited low-density housing. Encourage designated areas for higher density housing with clean, eco-friendly, nearby businesses, and industries. Use creative planning that does not require commuting. Include the cost of environmental damage when assessing planning alternatives. Consider the cumulative effects of development.	Over the next 50 years	Work with local and county planners. Work with legislators	Promotes the general well-being of residents. Provides a sustainable economy. Increases the ability to withstand drought.
Develop programs that systematically foster cooperation among the various stakeholders in the watershed	Adopt policies to integrate land use planning and water resource management. Create an inter-water-systems board. Enhance cooperation and coordinate water use among area water systems. Promote local control and discretionary authority. Implement and apply the right of self-determination in local governance of water issues.	Within 10 years	Work with federal, state, county, and local agencies and officials.	Shares experience and knowledge. Coordinates projects and activities. Prevents duplication of effort.

GOAL 4: RETAIN LAND USE PATTERNS THAT SUPPORT AND ENSURE A RURAL LIFESTYLE AND ECONOMY				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Create a sustainable economy that bolsters self-sufficiency of communities and the agrarian lifestyle	Develop local agricultural cooperatives. Encourage development of a wide diversity of crops throughout the sub-regions such as native and traditional crops, contemporary crops, and new and emerging crops. Develop markets for locally grown produce and meat. Promote farmers' markets. Develop creative and certified marketing of livestock. Implement new farming technologies that will help to increase production. Plan and maintain a schedule for rotation of fallow acres. Reduce the amount of presently fallow cropland. Manage the numbers of livestock and tilled acres that best benefits the environment and economy together.	Over the next 50 years	Work with legislators and local officials to develop legislation and mechanisms which integrate county, state, and federal policies and processes. Promote a "Very-Small-Business Center". Promote locally owned businesses. Work with local banks, and agricultural associations to aid local agricultural producers who lack financial resources. Provide low interest loans for enterprises that promote a rural lifestyle, cottage industries, ecotourism, and cooperatives.	Agricultural cooperatives can promote and sustain agriculture through education, financial support, improved farming methods, crop diversity, shared use of equipment and teaching children about the importance and benefit of agriculture and good agricultural conservation methods. Allows farmers and ranchers to work on the land and maintain it, rather than working elsewhere. Enables future generations to farm and ranch. Provides a sustainable tourist industry. Creates new markets that are organic, predator friendly and low-impact.
Protect agricultural lands from housing and industrial development	Develop "Rural Agricultural Areas". Develop protective zoning for acequia irrigated lands. Require that planning and zoning consider impacts on traditional cultures and lifestyles, and cumulative effects. Prevent paving over and building on agricultural lands.	Over the next 50 years	Work with legislators and local officials to develop laws. Work with land trusts to develop mechanisms to retain agricultural land. Work with officials to develop land use management tools to prevent development on irrigated and non-irrigated farmland.	Maintains an agricultural land base. Promotes the general well-being of residents. Maintains a rural atmosphere.

GOAL 4: RETAIN LAND USE PATTERNS THAT SUPPORT AND ENSURE A RURAL LIFESTYLE AND ECONOMY				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Protect and improve the quality of the domestic supply of surface and ground water	Identify and protect groundwater recharge areas. Ensure modernized, well maintained water systems. Limit and reduce vehicular water crossings. Clean up watercourses, remove garbage, trash, and vehicles from arroyos. Require sewage treatment systems in higher density communities. Use constructed wetlands for final sewage treatment. Remove trace elements.	Within 10 years	Work with federal, state, county, and local agencies and officials. Develop federal, state, local, and charitable funding. Work with relevant agencies and non-profit organizations. Tax rebates and credits, and matching funds for private land. Create programs to aid rural water organizations with the proposal writing and funding process.	Ensures satisfactory water quality.
Provide for increased, consistent and sustainable sources of both domestic and agricultural water	Implement projects to thin trees and brush on public and private land. Implement controlled burn projects on constructed water storage reservoirs and tanks. Install community domestic supply wells. Identify and provide for residential fire-fighting water. Limit domestic wells to 16 per section. Address ground/surface water interactions in state water-rights statutes. Limit wells that could impair surface or groundwater. Develop local drought plans.	Within 10 years	Work with federal, state, county, and local agencies and officials. Develop federal, state, local, and charitable funding. Work with relevant agencies and non-profit organizations. Tax rebates and credits, and matching funds for private land. Create programs to aid rural water organizations with the proposal writing and funding process.	Matches water use to water supply. Increases the ability to withstand drought.

GOAL 4: RETAIN LAND USE PATTERNS THAT SUPPORT AND ENSURE A RURAL LIFESTYLE AND ECONOMY				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Maintain the scenic and ecological conditions which attracted our ancestors & us to the area	Create and implement local management plans. Include forests, rangelands wetland/riparian areas, ranching and agriculture.	Over the next 50 years	Work with land management agencies to develop plans. Work with local planners to create and maintain relevant zoning.	Promotes general well-being of residents. Provides sustainable tourist industry.

GOAL 5: PROMOTE CONSERVATION OF WATER				
OBJECTIVE	**ACTIONS**	**LENGTH**	**FUNDING/POLICIES**	**BENEFITS**
Develop water-wise residents and communities	Disseminate water-saving information. Develop local water budgets to understand water recharge and water use. Develop local water conservation and drought plans. Adopt graduated water rates in all domestic systems. Institute incentives for water conservation and recycling. Adopt a conservation fee added to all water systems for promotion of water conservation. Meter all water supply wells. Meter all surface water diversions.	Within 15 years	Work with federal, state, county, and local agencies and officials. Develop federal, state, local, and charitable funding. Work with relevant agencies and non-profit organizations. Tax rebates and credits, and matching funds for private land.	Increases public understanding of water use and conservation. Increases water conservation.
Promote efficient use of water	Encourage use of new water-saving technologies. Encourage grey water reuse. Encourage rainwater harvesting. Improve storm water management. Capture flood flows. Reduce water loss in acequias. Increase irrigation efficiency. Reduce artificial open water evaporation. Fund domestic water cooperatives to improve their water systems. Fund acequias to increase operating efficiency.	Within 15 years	Work with federal, state, county, and local agencies and officials. Develop federal, state, local, and charitable funding. Work with relevant agencies and non-profit organizations. Tax rebates and credits, and matching funds for private land.	Reduces water waste.

APPENDIX B. PSIAC MODEL

Rio Puerco Watershed Current Sediment Loading Estimates and Potential Sediment Load Reduction Estimates Under Proposed Best Management Practices Using Pacific Southwest Interagency Committee Report Method (2013).

Description of the Model Methodology

The pollutant loading and reduction modeling for the Rio Puerco was done using the "Pacific Southwest Interagency Committee Report of the Water Management Subcommittee; *factors for affecting sediment yield and measures for reduction of erosion and sediment yields*" model. The model was created to provide estimations of sediment yield in variety of conditions found in the Pacific Southwest. The intent is to provide soil loss estimates for broad planning purposes. The use of this model can be an economic and non-technical method to evaluate small watersheds.

The PSIAC model assigns a numeric value for each of the following categories: surface geology, soils, climate, runoff, topography, ground cover, land use, upland erosion and channel erosion/sediment transport. This model is not an exact science but rather a rough estimate as the trained observer applies a value to each of these factors determining what a value might be when given a series of similar examples.

Rio Puerco Watershed

The watershed runs northeast to southwest starting in a high-elevation, mixed-conifer forest environment and terminates in open sagebrush and grasslands. The elevation, climate and vegetation changes drastically from the top to the bottom. The perennial segments of the watershed was grouped into two areas for purposes of modeling. The Upper Main Stem Rio Puerco, is approximately 600,000 acres in size. The Upper Rio San Jose is about 800,000 acres in size. The combined acreage for the entire Rio Puerco Watershed including the Rio San Jose is 4.7 million acres.

Upper Main Stem Rio Puerco

The upper section of the watershed includes USFS, BLM, and private lands. The vegetation is primarily forested lands including Ponderosa pine, oak brush and some meadows that have a high percentage of grass cover. The topography is steep and the precipitation averages between 14 – 25 inches a year, some in snow and other summer monsoon storms.

Upper Rio San Jose

This section of the watershed is mostly USFS, BLM, NPS, and tribal lands with some private and state trust lands. The vegetation is mixed conifer at the highest elevations with a transition to primarily piñon and juniper and sagebrush and grasslands at the lowest elevations. The precipitation averages 14 - 22 inches a year.

Applying the Model

To apply this model we visited the field and found vantage points to assess the different factors in the model. For upper elevations, points on USFS lands was used and for the lower elevations of the watershed a site over-looking BLM lands was selected. Also included were extensive experiences in the many site visits previously completed in the Rio Puerco watershed in the rating process.