USEPA-APPROVED
TOTAL MAXIMUM DAILY LOAD (TMDL)
FOR THE
Río PUERCO WATERSHED – PART 2

SEPTEMBER 21, 2007

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***COVER PHOTO**: Downstream view of Rio Puerco channel and riparian vegetation below Village of Cuba SWCD gabions, July 17, 2003*

LIST OF ABBREVIATIONS AND DEFINITIONS

AU	Assessment Unit
ADB	Assessment Database version 2
BLM	Bureau of Land Management
BMP	Best management practices- effective, practical, structural or nonstructural methods which prevent or reduce the movement of pollutants from the land to surface water.
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CGP	Construction general storm water permit
CWA	Clean Water Act
^{o}C	Degrees Celsius
^{o}F	Degrees Fahrenheit
Ecoregion	Ecological regions based on geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology.
EQIP	Environmental Quality Incentive Program
GIS	Geographic Information Systems
HUC	Hydrologic unit code- a way of identifying all of the drainage basins in the United States in a catalogued arrangement from largest (Regions) to smallest (Cataloging Units).
km^2	Square kilometer
LA	Load allocation
mg/L	Milligrams per Liter
mi^2	Square miles
mL	Milliliters
mm	Millimeters
MOS	Margin of safety
MOU	Memorandum of Understanding
MS4	Municipal Separate Storm Sewer System
MSGP	Multi-Sector General Storm Water Permit
NM	New Mexico
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System-as authorized by the Clean Water Act, permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States.
%	Percent
QAPP	Quality Assurance Project Plan
RFP	Request for proposal
SBD	Stream bottom deposits
STORET	Storage and Retrieval Database- a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and others.
SWPPP	Storm Water Pollution Prevention Plan-a written document that describes the construction operator's activities to comply with the requirements in the construction general permit

SWQB	Surface Water Quality Bureau
TMDL	Total maximum daily load
TSS	Total suspended solids
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WLA	Waste load allocation
WQCC	Water Quality Control Commission- The commission is the state water pollution control agency for NM, and for all purposes of the federal Clean Water Act and the wellhead protection and sole source aquifer programs of the federal Safe Drinking Water Act.
WQS	Water quality standards (NMAC 20.6.4 as amended through February 16, 2006)
WRAS	Watershed Restoration Action Strategy
WWTP	Wastewater treatment plant

EXECUTIVE SUMMARY

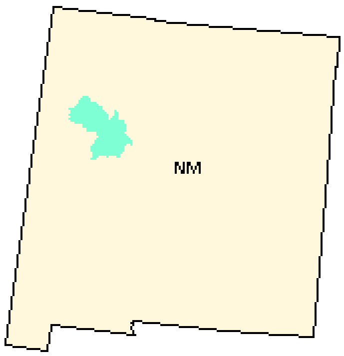
Section 303(d) of the Federal Clean Water Act requires states to develop Total Maximum Daily Load (TMDL) management plans for waterbodies determined to be water quality limited. A TMDL documents the amount of a pollutant a waterbody can assimilate without violating a state's water quality standard. It also allocates the load capacity to known point sources and nonpoint sources at a given flow. Total maximum daily loads are defined in 40 Code of Federal Regulations Part 130 as the sum of the individual Waste Load Allocations (WLAs) for point sources and Load Allocations (LAs) for nonpoint sources and background conditions, and includes a Margin of Safety (MOS).

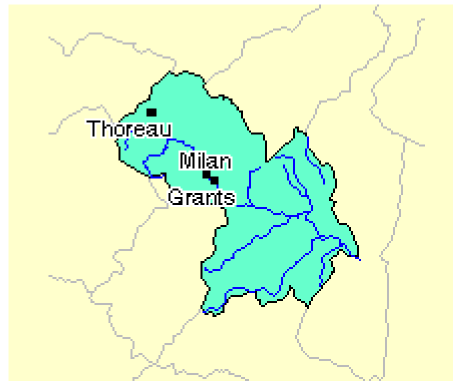
The Río Puerco (from its confluence with the Río Grande), together with its tributaries and headwaters, define the Río Puerco Watershed. The Surface Water Quality Bureau (SWQB) held a pre-survey public meeting in Cuba, NM and conducted an intensive surface water quality survey of the Río Puerco watershed in 2004. Sampling stations were established along the streams in the watershed to evaluate the impact of tributary streams and to work toward establishing background conditions. As a result of assessing data generated during this monitoring effort, SWQB staff documented impairments of New Mexico water quality standards for nutrients and temperature for both Bluewater Creek (Bluewater Reservoir to headwaters) and Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir), aluminum on La Jara Creek (perennial reaches above Arroyo San Jose), temperature and nutrient on Rio Moquino (Laguna Pueblo to Seboyettia Creek), and nutrient and aluminum on Rio Puerco (Arroyo Chijuilla to northern boundary Cuba). This TMDL document addresses the above noted impairments as summarized in the tables below. The data used to develop this TMDL were collected during the 2004 survey and 2006. TMDLs for assessment units in these watersheds not included in this document are discussed in the individual watershed sections.

The 2004 Río Puerco Watershed study also identified other potential water quality impairments in this watershed which are not addressed in this document. Additional data needs for verification of those impairments are being identified and data collection will follow. Subsequent TMDLs will be prepared in the near future in a separate TMDL document.

Additional water quality data will be collected by New Mexico Environment Department during the standard rotational period for intensive stream surveys. As a result, targets will be re-examined and potentially revised as this document is considered to be an evolving management plan. In the event that new data indicate that the targets used in this analysis are not appropriate and/or if new standards are adopted, the load capacity will be adjusted accordingly. When water quality standards have been achieved, the reach will be moved to the appropriate attainment category on the Clean Water Act Integrated §303(d)/§305(b) list of waters (NMED/SWQB 2007).

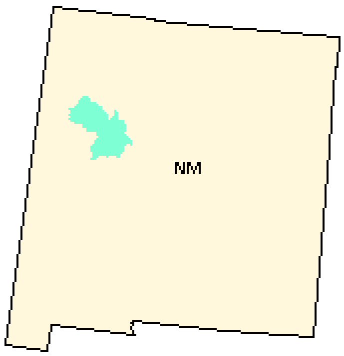
TOTAL MAXIMUM DAILY LOAD FOR NUTRIENTS AND TEMPERATURE BLUEWATER CREEK (BLUEWATER RESERVOIR TO HEADWATERS)

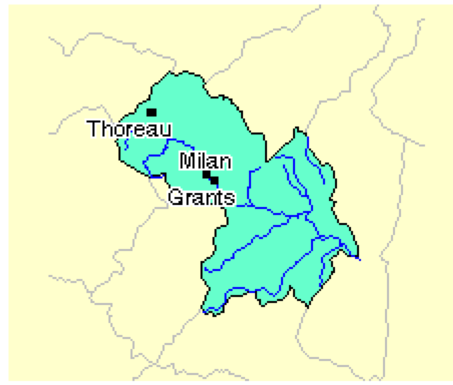




New Mexico Standards Segment	Río Grande Basin 20.6.4.109
Assessment Unit Identifier	Bluewater Creek (Bluewater Reservoir to headwaters), NM-2107.A_01 (formerly NM-MRG7-Bluewater)
Assessment Unit Length	17.8 miles
Parameters of Concern	Nutrients, temperature
Designated Uses Affected	Coldwater Aquatic Life
Geographic Location	Río San Jose USGS Hydrologic Unit Code 13020207
Scope/size of Watershed	80 square miles
Land Type	Arizona/New Mexico Mountains Ecoregion (23)
Land Use/Cover	Forest (89%), Shrubland (8%), Grassland (4%), Barren (<1%)
Probable Sources	Forest Roads (road construction and use), loss of riparian habitat, natural sources, rangeland grazing, silviculture harvesting, streambank modifications/destabilization.
Land Management	U.S. Forest Service (88%), Private (12%), State (<1%)
IR Category	5/5A
TMDL for:	**WLA + LA + MOS = TMDL**
Plant Nutrients	
Total Phosphorus	**0 + 0.0008 + 0.0002 = 0.001 lbs/day**
Total Nitrogen	**0 + 0.013 + 0.002 = 0.015 lbs/day**
Temperature	**0 + 24.8 + 2.8 = 27.6 j/m^2/sec/day**

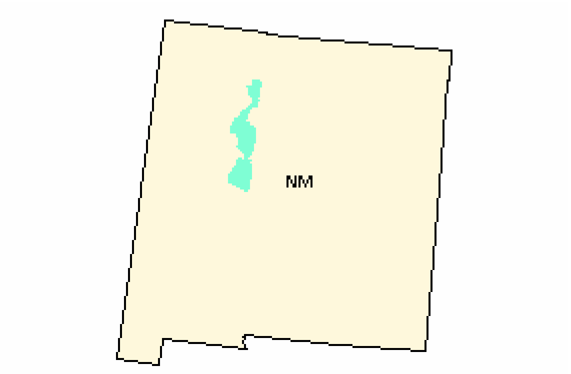
TOTAL MAXIMUM DAILY LOAD FOR NUTRIENTS AND TEMPERATURE
BLUEWATER CREEK (NON-TRIBAL RIO SAN JOSE TO BLUEWATER RSRV)

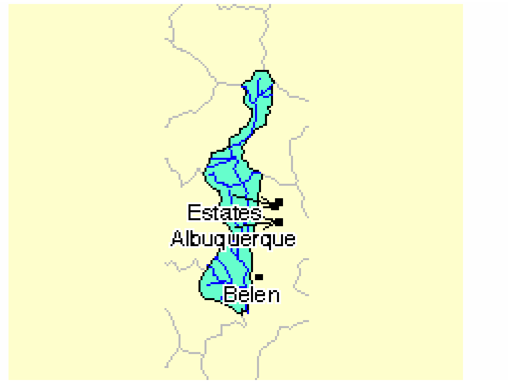




New Mexico Standards Segment	Río Grande Basin 20.6.4.109
Assessment Unit Identifier	Bluewater Creek (non-tribal Rio San Jose to Bluewater Rsrv), NM-2107.A_00 (formerly NM-MRG7-20100)
Assessment Unit Length	10.5 miles
Parameters of Concern	Nutrients, temperature
Designated Uses Affected	Coldwater Aquatic Life
Geographic Location	Río San Jose USGS Hydrologic Unit Code 13020207
Scope/size of Watershed	232 square miles
Land Type	Arizona/New Mexico Plateau Ecoregion (22)
Land Use/Cover	Forest (80%), Shrubland (15%), Grassland (4%), Barren (<1%), Water (<1%), Recreational grasses (<1%), Wetlands (<1%), Low intensity residential (<1%)
Probable Sources	Loss of riparian habitat, rangeland grazing, streambank modifications/destabilization.
Land Management	U.S. Forest Service (68%), Private (25%), State (3%), Native (2%), State Park (1%), BLM (<1%)
IR Category	5/5A
TMDL for: Nutrients *Total phosphorus* *Total nitrogen* Temperature	**WLA + LA + MOS = TMDL** **0 + 0.029 + 0.005 = 0.034 lbs/day** **0 + 0.256 + 0.045 = 0.301 lbs/day** **0 + 85.9 + 9.54 = 95.4 j/m^2/sec/day**

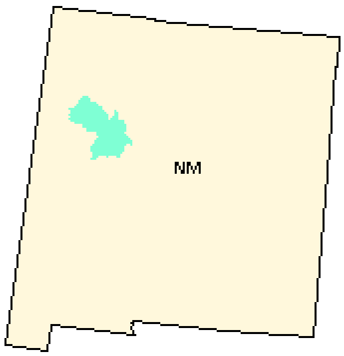
TOTAL MAXIMUM DAILY LOAD FOR ALUMINUM
LA JARA CREEK (PERENNIAL REACHES ABOVE ARROYO SAN JOSE)

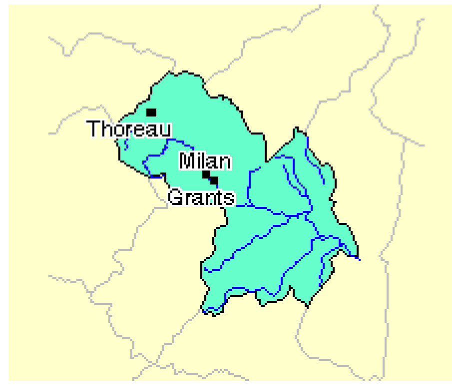




New Mexico Standards Segment	Río Grande Basin 20.6.4.109
Assessment Unit Identifier	La Jara Creek (perennial reaches above Arroyo San Jose), NM-2107.A_46
Assessment Unit Length	8.28 miles
Parameters of Concern	Chronic aluminum
Designated Uses Affected	Coldwater Aquatic Life
Geographic Location	Río Puerco USGS Hydrologic Unit Code 13020204
Scope/size of Watershed	12.28 square miles
Land Type	Southern Rockies Ecoregion (21)
Land Use/Cover	Forest (71%), Shrubland (6%), Grassland (8%), Agriculture (14%), Developed (<1%), Barren (<1%)
Probable Sources	Unknown, Natural Sources
Land Management	U.S. Forest Service (64%), Private (32%), BLM (4%)
IR Category	5/5A
TMDL for: Chronic aluminum	**WLA + LA + MOS = TMDL** **0 + 1.33 + 0.443 = 1.77 lbs/day**

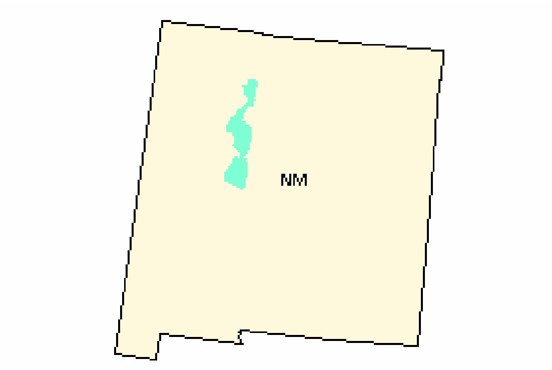
TOTAL MAXIMUM DAILY LOAD FOR NUTRIENTS AND TEMPERATURE RÍO MOQUINO (LAGUNA PUEBLO TO SEBOYETTIA CREEK)

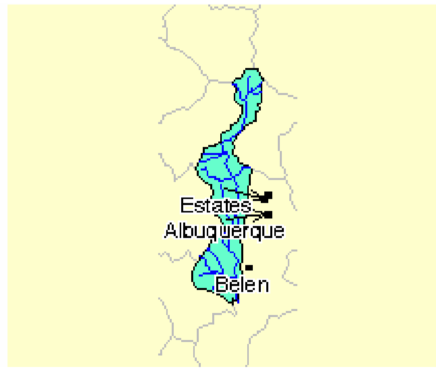




New Mexico Standards Segment	Río Grande Basin 20.6.4.109
Assessment Unit Identifier	Río Moquino (Laguna Pueblo to Seboyettia Creek), NM-2107.A_10 (NM-MRG7-10110)
Assessment Unit Length	3 miles
Parameters of Concern	Nutrients, temperature
Designated Uses Affected	Coldwater Aquatic Life
Geographic Location	Río San Jose USGS Hydrologic Unit Code 13020207
Scope/size of Watershed	74 square miles
Land Type	Arizona/New Mexico Mountains Ecoregion (23)
Land Use/Cover	Forest (47%), Shrubland (44%), Grassland (8%), Pasture (<1%), Barren/mines (<1%), Residental/commercial (<1%), Recreational grasses (<1%), Water (<1%)
Probable Sources	Loss of riparian habitat, mine tailings, rangeland grazing, surface mining.
Land Management	Private (96%), U.S. Forest Service (4%), Native (<1%)
IR Category	5/5A
TMDL for:	
Plant Nutrients	**WLA + LA + MOS = TMDL**
Total Phosphorus	**0 + 0.0034 + 0.0006 = 0.004 lbs/day**
Total Nitrogen	**0 + 0.44 + 0.08 = 0.052 lbs/day**
Temperature	**0 + 71.1 + 7.8 = 78.9 j/m^2/sec/day**

TOTAL MAXIMUM DAILY LOAD FOR AMMONIA, ALUMINUM, AND NUTRIENTS RÍO PUERCO (ARROYO CHIJUILLA TO NORTHERN BOUNDARY CUBA)





New Mexico Standards Segment	Río Grande Basin 20.6.4.99
Assessment Unit Identifier	Río Puerco (Arroyo Chijuilla to Northern Boundary Cuba), NM-2107.A_40 (formerly NM-MRG4-20000)
Assessment Unit Length	8.2 miles
Parameters of Concern	Chronic aluminum, nutrients
Designated Uses Affected	Aquatic Life *(existing use- Marginal Warmwater AL)*
Geographic Location	Río Puerco USGS Hydrologic Unit Code 13020204
Scope/size of Watershed	138 square miles
Land Type	Arizona/New Mexico Plateau Ecoregion (22)
Land Use/Cover	Forest (62%), Shrubland (21%), Grassland (12%), Agriculture (4.4%), Developed (0.14%), Barren (0.15%), Mining (0.04%), Water (0.01%)
Probable Sources	Highway/Road/Bridge Runoff (Non-construction related), Channelization, Rangeland Grazing, Loss of Riparian Habitat, Streambank Modification/destabilization, Natural Sources, Wildlife other than Waterfowl, Drought-related Impacts
Land Management	U.S. Forest Service (38%), Private (37%), Native (14%), BLM (10.5%), State (0.38%)
IR Category	5/5A
TMDL for: Chronic Aluminum	**WLA + LA + MOS = TMDL** **0 + 3.95 + 1.32 = 5.27 lbs/day**
Plant Nutrients: *Total Phosphorus*	**0.447 + 0.043 + 0.087 = 0.577 lbs/day**
Total Nitrogen	**1.357 + 1.256 + 0.461 = 3.074 lbs/day**

1.0 INTRODUCTION

Under Section 303 of the Clean Water Act (CWA), states establish water quality standards, which are submitted and subject to approval of the U.S. Environmental Protection Agency (USEPA). Under Section 303(d)(1) of the CWA, states are required to develop a list of waters within a state that are impaired and establish a total maximum daily load (TMDL) for each pollutant. A TMDL is defined as "*a written plan and analysis established to ensure that a waterbody will attain and maintain water quality standards including consideration of existing pollutant loads and reasonably foreseeable increases in pollutant loads*" (USEPA 1999). A TMDL documents the amount of a pollutant a waterbody can assimilate without violating a state's water quality standards. It also allocates that load capacity to known point sources and nonpoint sources at a given flow. TMDLs are defined in 40 Code of Federal Regulations (CFR) Part 130 as the sum of the individual Waste Load Allocations (WLAs) for point sources and Load Allocations (LAs) for nonpoint sources and natural background conditions, and includes a margin of safety (MOS). This document provides TMDLs for assessment units within the Río Puerco watershed that are impaired based on a comparison of measured concentrations and conditions with water quality criteria and numeric translators for narrative standards.

This document is divided into several sections. Section 2.0 provides background information on the location and history of the Río Puerco watershed, provides applicable water quality standards for the assessment units addressed in this document, and briefly discusses the intensive water quality survey conducted in the Río Puerco and Rio San Jose watersheds in 2004. Section 3.0 presents individual watershed descriptions. Section 4.0 presents the TMDLs developed for aluminum in the Río Puerco watershed. Section 5.0 presents the TMDLs for nutrients and Section 6.0 presents the TMDLs for temperature. Pursuant to Section 106(e)(1) of the Federal CWA, Section 7.0 provides a monitoring plan in which methods, systems, and procedures for data collection and analysis are discussed. Section 8.0 discusses implementation of TMDLs (phase two) and the relationship between TMDLs and Watershed Restoration Action Strategies (WRAS). Section 9.0 discusses assurance, Section 10.0 public participation in the TMDL process, and Section 11.0 provides references.

2.0 BACKGROUND

The Rio Puerco was intensively sampled by the Surface Water Quality Bureau (SWQB) from March to November 2004 with additional collections in 2006. The Rio Puerco Basin includes the Rio Puerco from its confluence with the Rio Grande as well as its tributaries. Surface water quality monitoring stations were selected to characterize water quality of the stream reaches. Assessment units that will have a TMDL prepared in this document are discussed in their respective individual watershed sections. A number of assessment units could not be assessed due to insufficient data. These impairments will remain on the CWA Integrated §303(d)/§305(b) list of waters until additional data are available.

2.1 Description and Land Ownership

The Río Puerco is the largest tributary to the middle Río Grande Basin and has headwaters located in the Nacimiento Mountains east of Cuba, NM. The mainstem of the Río Puerco begins in a wetland on the southwest side of San Pedro Peak. This mountain range is fully contained within the San Pedro Peak Wilderness area of the Santa Fe National Forest. From its 10,500-foot beginning, the stream flows to the southwest for almost 7 miles through high elevation forests then into a series of wet meadows to the edge of the wilderness area at 8,500-foot elevation. The greater Rio Puerco watershed (US Geological Survey [USGS] Hydrologic Unit Codes[HUCs] 13020204 and 13020207) is located in Valencia, Socorro, Bernalillo, Sandoval, Cibola, and McKinley Counties in northcentral New Mexico (NM). This survey included the non-tribal reaches of the Rio Puerco and its tributaries, including the Rio San Jose and its tributaries.

The Río Puerco Watershed covers approximately 4,736 square miles (mi^2) in northwestern New Mexico (NM). Land use for the Rio Puerco HUC includes 62% forest, 21% shrubland, 12% grassland, 4% agriculture, and less than 1% developed, water, wetlands, bare rock, and mines/quarries (Figure 2.1). As presented in Figure 2.2, land ownership for the Río Puerco watershed is 7% U.S. Forest Service (USFS), 44% private, 19% Bureau of Land Management (BLM), 23% Native Lands, and 6% State.

Land use for the Rio San Jose HUC is 31% forest, 45% shrubland, 20% grasslands, and 4% barren (Figure 2.4). As presented in Figure 2.5, land ownership for the Rio San Jose HUC is 40% native lands, 30% private, 15% Forest Service, 11% Bureau of Land Management, and 4% State. Twenty-two water quality sites were sampled during this survey (Figures 2.1 through 2.6). Table 2.1 details location descriptions of sampling stations in each assessment unit (AU), station numbers, and STORET identification codes. A Waste Load Allocation was developed in the 1989 document, *Point Source Load Allocation for the City of Grants, Cibola County, New Mexico (NMED/SWQB 1989),* for the Grants WWTP (NM 0020737). This WWTP no longer discharges to the Rio San Jose.

Several species within this watershed are listed as either threatened or endangered by both state and federal agencies. Federally listed threatened species in HUC 13020204 include the Mexican spotted owl (*Strix occidentalis lucida*). Additional species listed by the State as endangered include the Parkish's Alkali Grass (*Puccinellia parishii*) and listed as threatened include the

Gray Vireo (*Vireo vicinior*). Federally listed endangered species in HUC 13020207 include the Southwestern Willow Flycatcher (*Empidonax traillii extiums*). Federally listed threatened species include the Pecos Sunflower (*Helianthus paradoxus*) and Mexican Spotted Owl (*Strix occidentalis lucida*). State listed endangered species include the Parish's Alkali Grass (*Puccinellia parishii*), Pecos Sunflower (*Helianthus paradoxus*), and the Southwestern Willow Flycatcher (*Empidonax traillii extimus*). State listed threatened species include the American Peregrine Falcon (*Falco peregrinus anatum*) and the Spotted Bat (*Euderma maculatum*). http://nhnm.unm.edu/query_bcd/bcd_watershed_query.php5

2.2 History and Geology

The Río Puerco is the largest tributary to the middle Río Grande Basin and has headwaters located in the Nacimiento Mountains east of Cuba, NM. From the forest boundary downstream approximately 6 miles to the Village of Cuba, domestic and wildlife grazing, road construction, and maintenance activities on private and public lands have impacted riparian vegetation and initiated discontinuous stream channel incision. In some local segments the stream bed is now five to ten feet below its original floodplain, while adjacent reaches remain relatively stable. At and below the Village of Cuba, flows from a series of small streams draining the west face of the Sierra Nacimiento Range on the Santa Fe National Forest combine with effluent from the Cuba WWTP to provide perennial flow in the Río Puerco downstream towards the confluence with Arroyo Chijuilla. This reach of the Río Puerco as well as the downstream reach flows through a complex mixture of private, State and Federal lands in a wide, deeply incised, vertical-walled canyon with banks up to 35 feet high. Erosional processes within this reach of the stream are extensive. Significant landscape and channel erosion, and channel incision are unfortunate realities throughout the majority of the Rio Puerco Watershed. When these conditions occur, soil is lost, the landscape is vulnerable to sheet attrition and rilling, vegetation vigor declines, streams and tributaries become sediment-filled, the availability of accessible water for irrigation diversions decreases or disappears, the river beds are lowered, the banks extended, riparian resources and related habitat is impacted, water quality deteriorates, and this process is inevitably accompanied by a drop in the local water table. None of these resulting conditions are conducive to healthy land productivity. Photos 2.1 and 2.2 provide a general visual overview of the area and show the extent to which portions of the watershed have experienced erosion and cut banks.

In the mid-1960s a segment of the reach between La Ventana and Cuba was diverted from its original meandering channel into a straight channel on the west side of the highway during the original construction of this valley segment of State Highway 44. This channelization has resulted in an estimated 14.1 million cubic feet of sediment erosion of the local river bed and banks (Coleman, et al. 1998), has put the highway at risk, and has destroyed several County roads and bridges. In 1999, the multi-agency process of widening the highway to four lanes and transitioning it to federal Highway 550 also committed to restore the Río Puerco to its original channel and initiate riparian restoration efforts. These restoration activities, along with many other upstream and downstream projects, are ongoing and demonstrate favorable potential to improve water quality in the Río Puerco and Río Grande.

The Río Puerco Basin includes ten large subwatersheds draining portions of eight counties, west of the greater Río Grande Basin, in the northwest and west central portion of NM. Encompassing approximately 4,736 mi^2, it is by far the largest in-state tributary to the Río Grande.

The watershed lies along the east-southeast margin of the Colorado Plateau, along a transition zone with the Río Grande Rift (Basin and Range Province). Soft upper Paleozoic, Mesozoic, and lower Cenezoic sedimentary strata dominantly characterize the geologic setting of the area, displaying Permian through Tertiary age continental and marine sandstones, shales, mudstones, and carbonate rocks. Strata are generally flat lying, often faulted, and carved into broad valleys flanked by mesas and mountains. The mountainous areas along the margins of the northeast and west-central watershed are made up of intrusive igneous rocks (granitic plutonic rocks, gneiss, and schists). Younger Tertiary or Quaternary volcanic rocks intrude the sediments and occasionally cap high standing mesas. Tertiary and Quaternary valley fill, pediment gravels, talus, and alluvial deposits mantle the geologic section.

Numerous geomorphic elements combine to form the watershed's present structural, fluvial, and topographic settings. Existing landforms are an indication of the large amounts of surface materials that have been removed from the region by wind and water. Elevations range from the 11,301 foot peak of Mt. Taylor, to the terrain at 10,500 feet in the Sierra Nacimiento - San Pedro Parks Wilderness headwaters area, to 9,120 feet along the Continental Divide in the Zuni Mountains, to less than 4,700 feet at the lower Río Puerco / Río Grande confluence at Bernardo north of Socorro. The change in elevation, a rather high regional surface gradient, and an excess of straight drainage channel segments combines with the region's climatic setting and vulnerable sedimentary lithologies to exacerbate the watershed's well-documented reputation for dramatic erosion.

The distribution of soils and vegetation is also strongly influenced by topography and geology. Digitally processed satellite images show many parts of the basin are very responsive to seasonal variations in precipitation, while scattered riparian corridors in main stem and tributary drainages are recognized as increasingly stable and less prone to displaying significant vegetation changes given annual or seasonal precipitation variation. Natural vs. human controls on vegetation distribution aid in assessing impacts of grazing and other concentrated land use practices on erosion and sediment production.

The headwaters source area of the upper Río Puerco gathers snow melt and summer showers from forested terrain and meadows at the crest of the Nacimiento Uplift, approximately twelve miles above the Village of Cuba. Relatively low-discharge perennial tributaries coalesce and drop off the western face of the Nacimiento (one of the most prominent linear fault scarps in the southwest) as mostly straight and steep bedrock, boulder, or large cobble-lined channels. The foothills areas north and northeast of Cuba are composed of erodable sedimentary units (clay and mudstones), so while stream incision becomes a component of this drainage system very close to its headwaters area, the downstream reach's sand-dominated setting and decreased gradient allows for some recovery of stable channel dimension, pattern, and profile.

The least incised, best vegetated, and most stable segment occurs one to three miles upstream of the Village of Cuba, below which deep incision and a broad meandering pattern becomes

characteristic across the wide flat valleys, on to the distant confluence with the Río Grande. A few discontinuous bedrock zones or recent manmade grade control structures are occasionally observed controlling the incision.
The waters of the Rio San Jose watershed generally have headwaters on Mt. Taylor. These waters are on the west side of the Zuni Uplift and flow through the Cretaceous Mesaverde Group sandstones and shales, Jurassic sandstone, and Triassic mudstones and siltstones (Chronic 1987). The area around Grants has long been a center for uranium mining, mainly in the Morrison Formation. The JJ No. 1/L-Bar Mine 2.25 miles east/northeast of Moquino produced uranium from 1976-1981. This mine was operated in conjunction with the L-Bar uranium mill and mine tailings facility. The mine was closed and reclaimed in 1986-1987 (Intera, Inc 2006).

A large lava field exists near Grants within the El Malpais National Monument, the youngest flow being within the last 1,000 years. Cretaceous sandstones are capped by basalt east of the Zuni uplift into the Rio San Jose watershed (Chronic 1987). Mt. Taylor (at 11,301 feet) dominates this area and is comprised of dacite, andesite, and basalt flows. The wetland-type area near Laguna is the original lake that led to the Spanish name for that town (Chronic 1987).

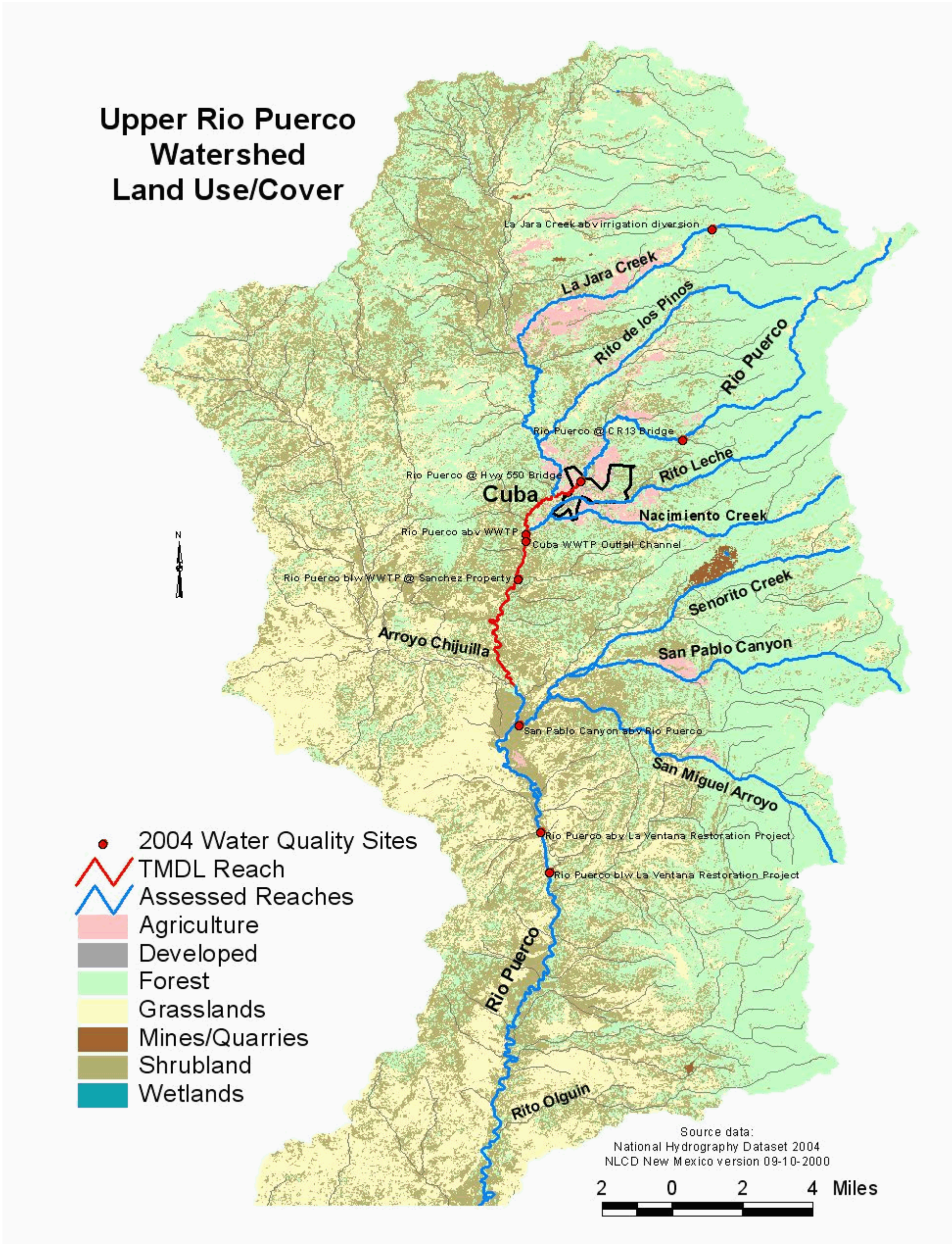


Figure 2.1 Río Puerco Watershed Land Use/Land Cover and Sampling Stations

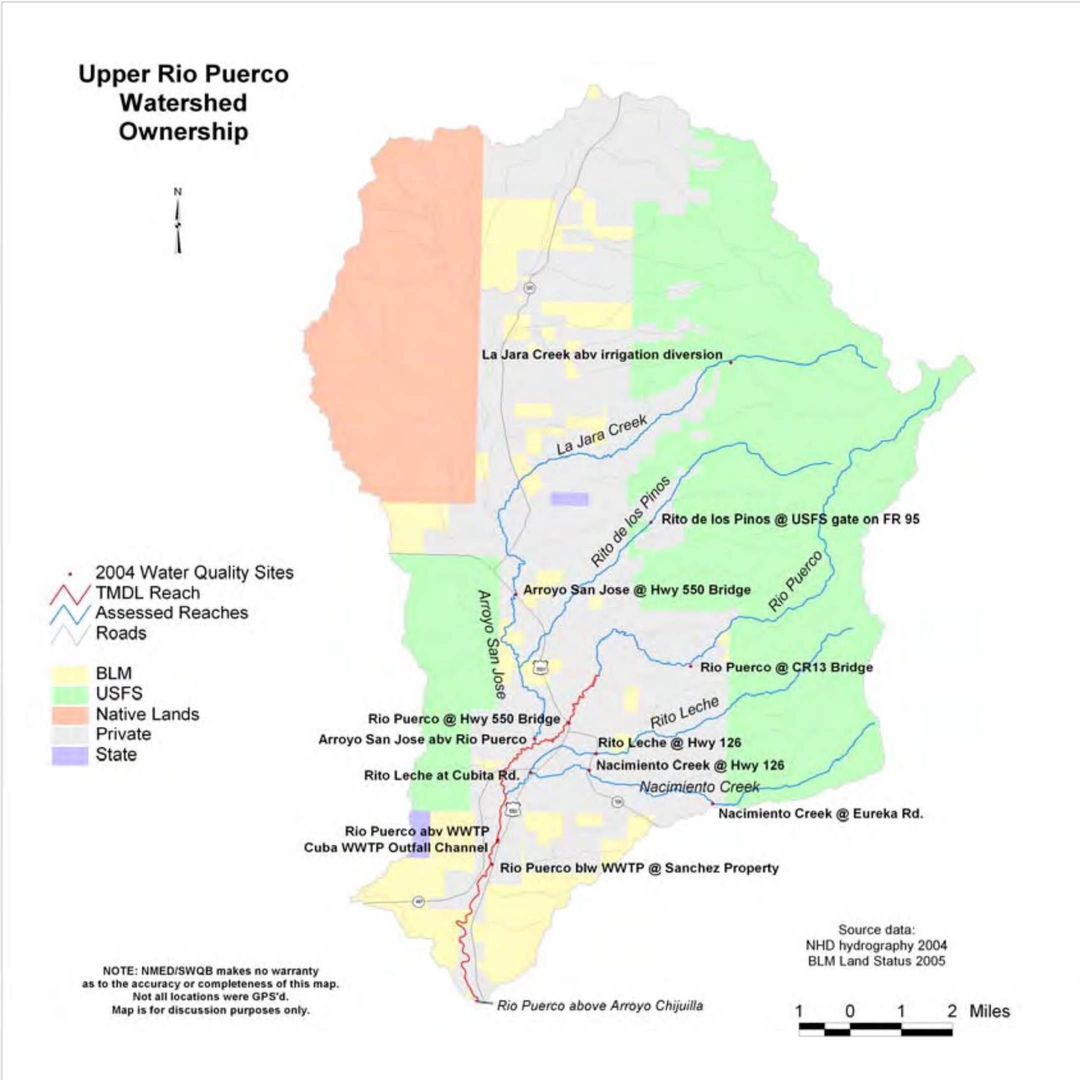


Figure 2.2 Río Puerco Watershed Land Ownership and Sampling Stations

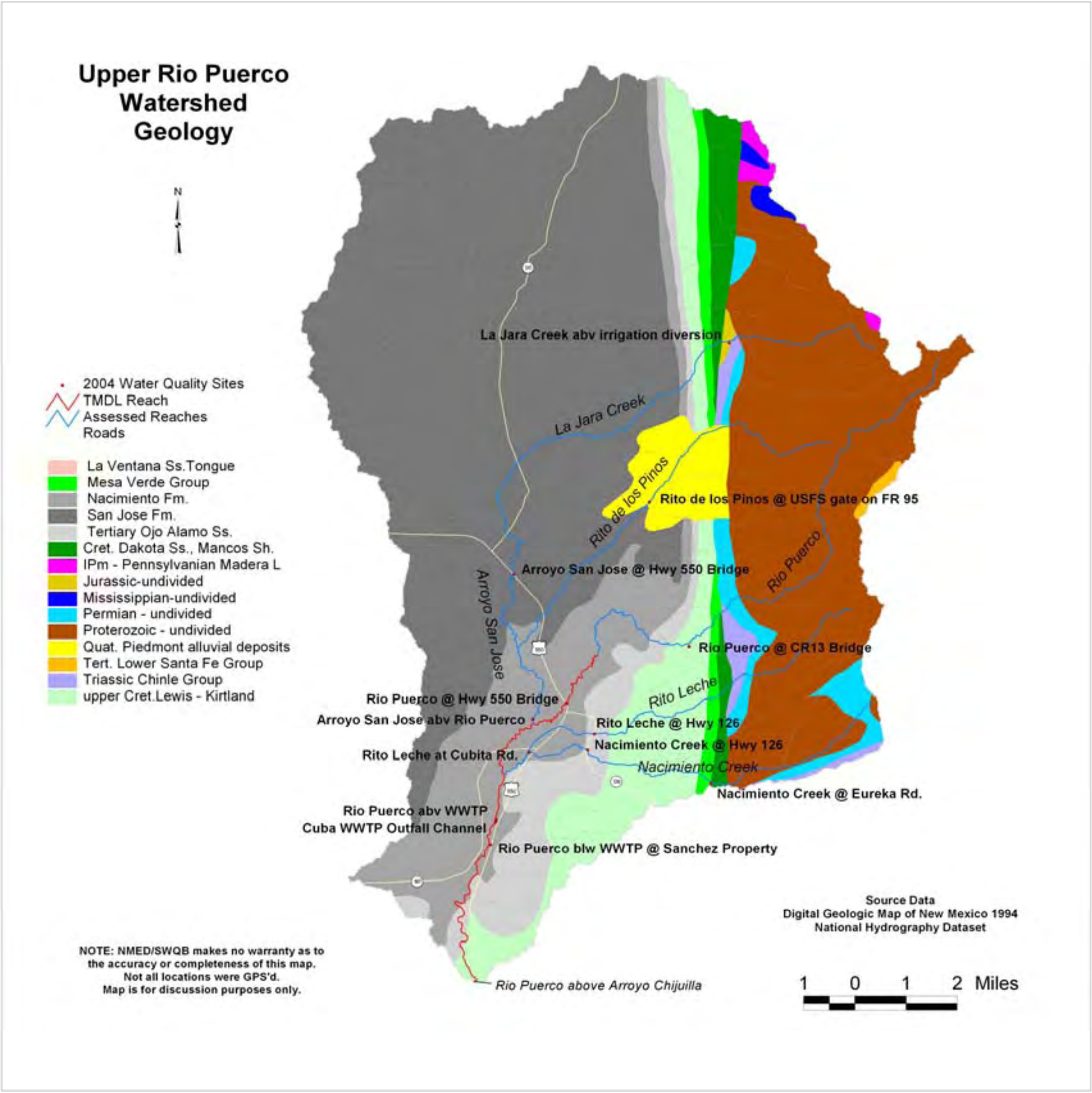


Figure 2.3 Río Puerco Watershed Geology

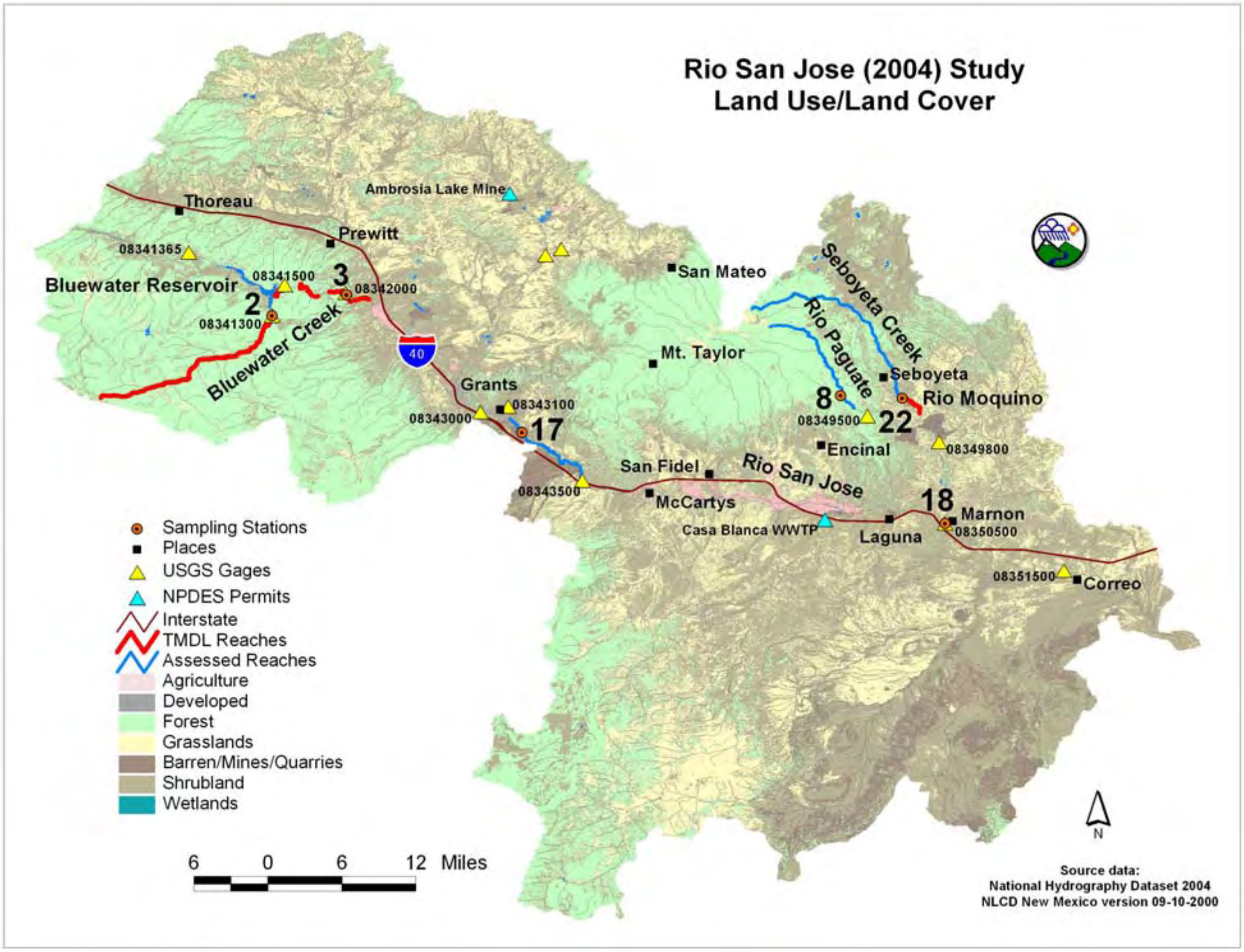


Figure 2.4 Río San Jose Watershed Land Use/Land Cover and sampling stations

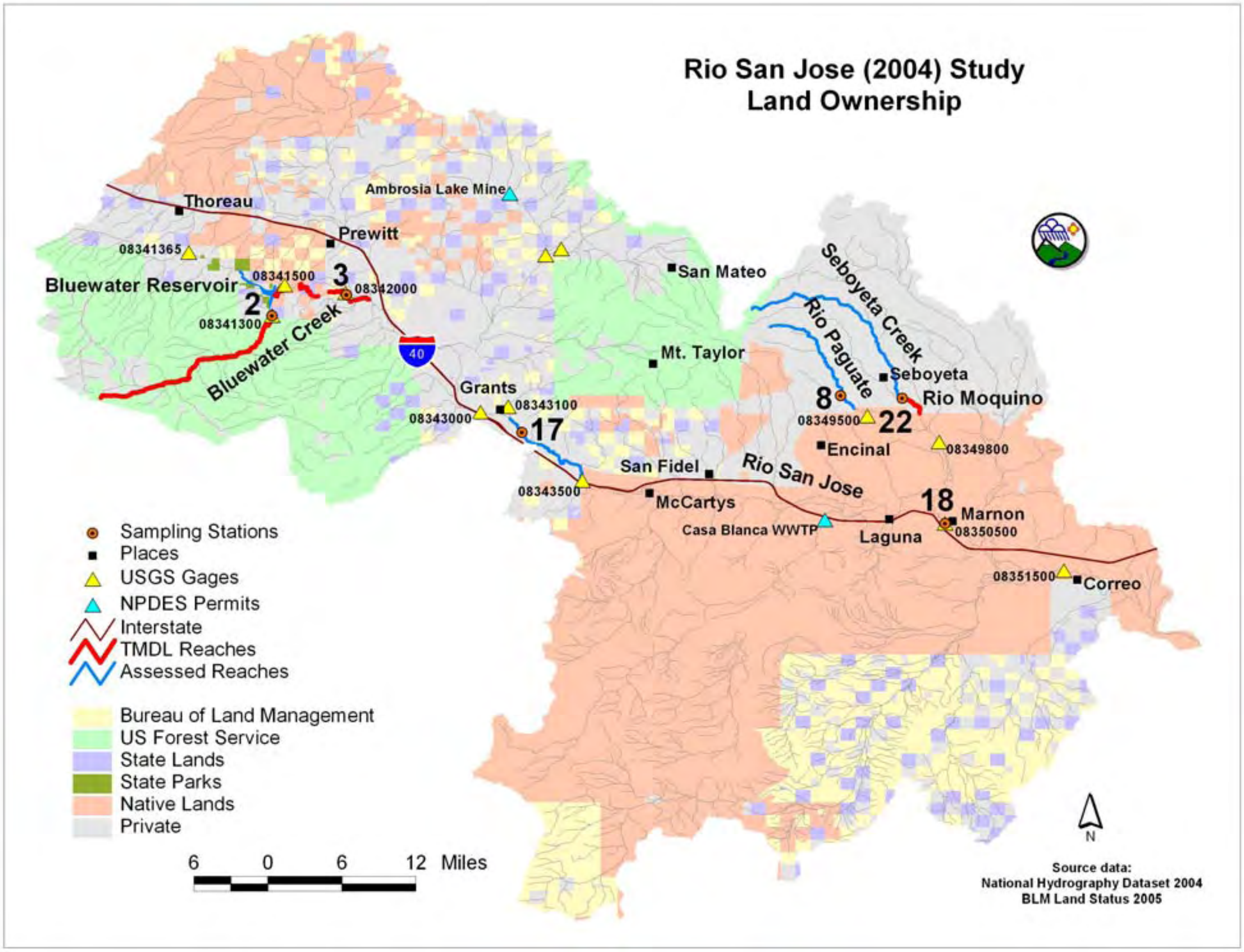


Figure 2.5 Río San Jose Watershed Land Ownership

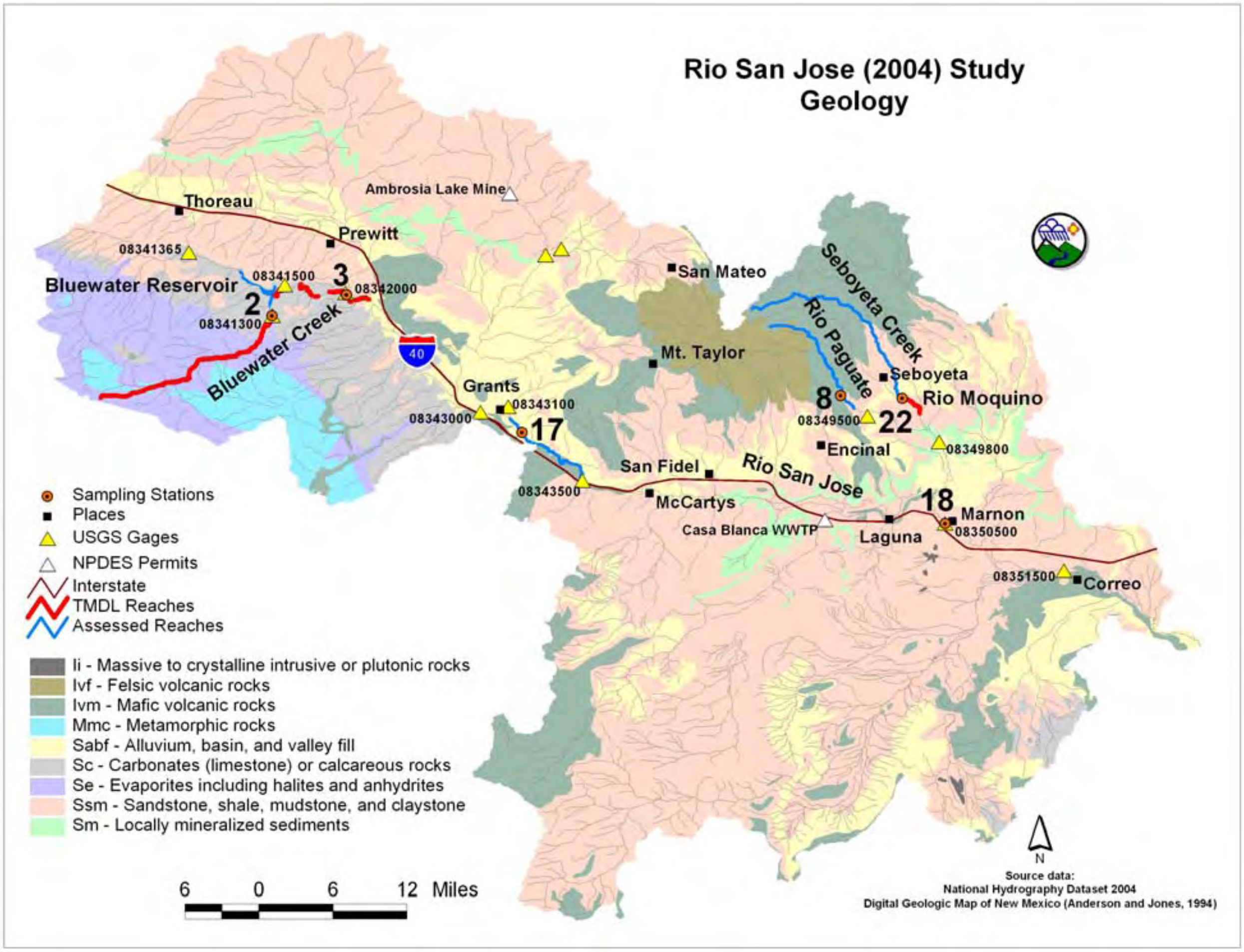


Figure 2.6 Río San Jose Watershed Geology

2.3 Water Quality Standards

Water quality standards (WQS) for the Río Puerco are set forth in the following sections of *New Mexico Standards for Interstate and Intrastate Surface Waters* (NM Administrative Code [NMAC] 20.6.4) (NMAC 2006):

20.6.4.105 RIO GRANDE BASIN – The main stem of the Río Grande from the headwaters of Elephant Butte reservoir upstream to Alameda Bridge (Corrales-bridge) and intermittent water below the perennial reaches of the Río Puerco that enters the main stem of the Río Grande.

A. Designated Uses: irrigation, marginal warmwater aquatic life, livestock watering, wildlife habitat, and secondary contact.

B. Criteria:

(1) In any single sample: pH within the range of 6.6 to 9.0 and temperature 32.2°C (90°F) or less. The use-specific criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses listed above in Subsection A of this section.

(2) The monthly geometric mean of E. coli bacteria 126 cfu/100 mL or less; single sample 410 cfu/100 mL or less (see Subsection B of 20.6.4.14 NMAC).

(3) At mean monthly flows above 100 cfs, the monthly average concentration for: TDS 1,500 mg/L or less, sulfate 500 mg/L or less and chloride 250 mg/L or less.

20.6.4.109 RIO GRANDE BASIN – Perennial reaches of Bluewater creek, Río Moquino, Seboyeta creek, Río Paguate, the Río Puerco above the village of Cuba and all other perennial reaches of tributaries to the Río Puerco including the Río San Jose in Cibola county from the USGS gaging station at Correo upstream to Horace springs.

A. Designated Uses: coldwater aquatic life, domestic water supply, fish culture, irrigation, livestock watering, wildlife habitat, and primary contact.

B. Criteria:

(1) In any single sample: pH shall be within the range of 6.6 to 8.8, temperature 20°C (68°F) or less and total phosphorus (as P) 0.1 mg/L. The use-specific criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses listed above in Subsection A of this section.

(2) The monthly geometric mean of E. coli bacteria 126 cfu/100 mL or less; single sample 235 cfu/100 mL or less (see Subsection B of 20.6.4.14 NMAC).

The assessment unit Río Puerco (Arroyo Chijuilla to northern boundary Cuba) does not fall into either of the specific Río Puerco standards listed above. This is a perennial reach of the Río Puerco within and below the Village of Cuba and therefore is not covered in 20.6.4.109 NMAC which only applies to perennial reaches of the Río Puerco above the Village of Cuba. In addition 20.6.4.105 NMAC does not apply because it relates to intermittent portions of the Río Puerco below perennial portions. Since neither of these standards apply to this particular reach of the Río Puerco, the general water quality standard for perennial waters (20.6.4.99 NMAC) with an existing use of marginal warmwater aquatic life will be the applicable standard for this TMDL document.

20.6.4.99 PERENNIAL WATERS – All perennial surface waters of the state that are not included in a classified water of the state in 20.6.4.101 through 20.6.4.899 NMAC.

A. **Designated Uses**: aquatic life, livestock watering, wildlife habitat, and secondary contact.

B. **Criteria**:

(1) Temperature shall not exceed 34°C (93.2°F). The use-specific criteria in 20.6.4.900 NMAC are applicable to the designated uses listed above in Subsection A of this section.

(2) The monthly geometric mean of E. coli bacteria shall not exceed 548 cfu/100 mL; no single sample shall exceed 2507 cfu/100 mL (see Subsection B of 20.6.4.14 NMAC).

20.6.4.900 NMAC provides standards applicable to attainable or designated uses unless otherwise specified in 20.6.4.101 through 20.6.4.899 NMAC. 20.6.4.13 NMAC lists general criteria that apply to all surface waters of the state at all times, unless a specified criterion is provided elsewhere in 20.6.4 NMAC.

2.4 Intensive Water Quality Sampling

The Río Puerco watershed was intensively sampled by the SWQB in 2004. A brief summary of the survey and the hydrologic conditions during the intensive sample period is provided in the following subsections. A more detailed description of the Río Puerco intensive survey can be found in the pending *Water Quality Survey Summary for the Río Puerco and Tributaries* NMED/SWQB 2007a). Survey summary reports are also available by contacting SWQB at 505-827-0187 or by emailing the contacts listed on the SWQB website at http://www.nmenv.state.nm.us/swqb.

2.4.1 Survey Design

Surface water quality samples were collected monthly between March and November during the 2004 intensive SWQB study. Surface water quality monitoring stations were selected to characterize water quality of various assessment units (i.e., stream reaches) throughout the watershed (Table 2.1, Figures 2.1 through 2.3). Stations were located to evaluate the impact of tributary streams and to determine ambient and background water quality conditions. Surface water grab samples were analyzed for a variety of chemical/physical parameters. Data from grab samples and field measurements are housed in the SWQB provisional water quality database and were uploaded to USEPA's Storage and Retrieval (STORET) database.

Table 2.1 SWQB 2004 Río Puerco Sampling Stations

Site Number	Assessment Unit	STORET ID	Station Description
2	Bluewater Creek (Bluewater reservoir to headwaters)	36Bluewa018.9	Bluewater Creek above Bluewater Lake @ USGS Gage 8341300
3	Bluewater Creek (non-tribal Rio San Jose to Bluewater Rsrv)	36Bluewa003.5	Bluewater Creek @ mouth of Bluewater Canyon
22	Rio Moquino (Laguna Pueblo to Seboyetita Creek)	36RMoqui006.4	Rito Moquino below confl of Seboyetita Creek and Seboyeta Creek
17	Rio San Jose (Horrace Springs to Grants WWTP)	N/A	Rio San Jose blw Grants WWTF Discharge[1]
18	Rio San Jose (Laguna Pueblo)	36RSanJo40.6	Rio San Jose near Laguna, NM
5	La Jara Creek (Perennial reaches abv Arroyo San Jose)	33LaJara009.7	La Jara Creek abv irrigation diversion
1	Arroyo San Jose (Rio Puerco to La Jara Creek)	33ASanJo006.5	Arroyo San Jose @ Hwy 550
19	Rito de los Pinos (Perennial reaches abv Arroyo San Jose)	33RPinos006.8	Rito de los Pinos @ USFS gate on FR 95
20	Rito Leche (Perennial reaches above Rio Puerco)	33RLeche002.6	Rito Leche @ Hwy 126
21		33RLeche001.3	Rito Leche @ Cubita Rd
6	Nacimiento Creek (Rio Puerco to USFS bnd)	33Nacimi008.0	Nacimiento Creek @ Eureka Rd
7	Nacimiento Creek (Rio Puerco to USFS bnd)	33 Nacimi003.4	Nacimiento Creek @ Hwy 126
25	Senorito Creek (Perennial Reaches above San Pablo Canyon)	33 Senori006.8	Senorito Creek blw Nacimiento Mine
23	San Miguel Arroyo (San Pablo Canyon to headwaters)	33SanMig005.7	San Miguel Arroyo @ old Hwy 44
24	San Pablo Canyon (Rio Puerco to headwaters)	33SPablo000.2	San Pablo Canyon abv Rio Puerco
8	Rio Paguate (Laguna Pueblo bnd to headwaters)	36RPagua019.8	Rio Paguate above Laguna Pueblo
9	Rio Puerco (northern bnd Cuba to headwaters)	33RPuerc256.0	Rio Puerco @ CR 13
11	Rio Puerco(Arroyo Chijuilla to northern bnd Cuba)	33RPuerc248.7	Rio Puerco @ Hwy 550
14		33RPuerc244.0	Rio Puerco abv WWTP
16		33RPuerc241.8	Rio Puerco blw WWTP @ Sanchez Property
4		33RPuerc243.7	Cuba WWTP outfall channel
13	Rio Puerco (non-pueblo Rio Grande to Arroyo Chijuilla)	33RPuerc224.8	Rio Puerco abv La Ventana Restoration Project
15		33RPuerc222.9	Rio Puerco blw La Ventana Restoration Project
10		33RPuerc198.4	Rio Puerco @ Hwy 279 Bridge near San Luis
12		33RPuerc004.6	Rio Puerco @ I-25

[1]No data collected, only photographs. Grants WWTP went to land application and channel now dry year-round.

All sampling and assessment techniques used during the 2004 intensive SWQB survey are detailed in the *Quality Assurance Project Plan* (QAPP) (NMED/SWQB 2004a) and assessment protocols (NMED/SWQB 2006b) both of which are available online or may be obtained by contacting the SWQB at 505-827-0187. As a result of the 2004 SWQB monitoring effort, several surface water impairments were verified. Accordingly, these impairments will remain and several new determined impairments were added to the 2006-2008 Integrated CWA §303 (d)/305(b) list (NMED/SWQB 2007).

2.4.2 Hydrologic Conditions

There are no real-time USGS gaging stations in the Río Puerco watershed associated with the La Jara Creek, Rio Puerco, or Rio Moquino assessment units presented in this document. The only two active gages on the entire Rio Puerco are the USGS gages at 08334000 Rio Puerco above Arroyo Chico near Guadalupe, NM and 08353000 Rio Puerco near Bernardo, NM. Two USGS gaging stations on Bluewater Creek, 08341300 Bluewater Creek above Bluewater Dam Bluewater, NM and 08341500 Bluewater Creek below Bluewater Dam, were last active in 2001.

The 2004 SWQB intensive survey was performed over varying flow conditions from March to November. Flows during the 2004 survey year were below average based on the period of record. As stated in the Assessment Protocol (NMED/SWQB 2006b), data collected during all flow conditions, including low flow conditions (i.e., flows below the 4-day, 3-year low flow frequency [4Q3]), will be used to determine attainment status of designated or existing uses . In terms of assessing designated use attainment in ambient surface waters, WQS apply at all times under all flow conditions, unless the WQS specify a qualifier.

3.0 INDIVIDUAL WATERSHED DESCRIPTIONS

TMDLs were developed for assessment units for which constituent (or pollutant) concentrations measured during the 2004 water quality survey indicated impairment. Because characteristics of each subwatershed, such as geology, land use, and land ownership provide insight into probable sources of impairment, they are presented in this section for the individual subwatersheds within the Rio Puerco basin. In addition, the 2006-2008 Integrated CWA §303(d)/§305(b) list for waters within the Rio Puerco basin are discussed (NMED/SWQB 2007) below.

3.1 Bluewater Creek Subwatershed

The headwaters of the 231 mi^2 Bluewater Creek subwatershed originate on Mount Taylor. According to available Geographic Information System (GIS) coverages, the Bluewater Creek watershed has an average elevation of 7,400 feet above sea level and receives approximately 17.5 inches of precipitation a year. As presented in Figure 2.1, land uses include 80% forest, 15% shrubland, 4% grassland, and less than 1% barren, wetlands, and residential. Land ownership is 68% Forest Service, 25% private, 3% State, 2% Native, 1% State Park, and less than 1% BLM (Figure 2.2). The geology of the Bluewater Creek watershed is predominantly comprised of evaporates, carbonates, sandstones, and metamorphic rocks (Figure 2.6).

Bluewater Creek (Bluewater Reservoir to headwaters) is approximately 18 miles in length. SWQB established one station along this assessment unit and deployed one thermograph during the 2004 intensive survey. Bluewater Creek (Bluewater Reservoir to headwaters) was included on the 2006-2008 Integrated CWA §303(d)/§305(b) list for sedimentation/siltation, turbidity, temperature, and nutrients. The sedimentation/siltation and turbidity listings will remain on the List pending further data collection and refinement of assessment protocols.

Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir) is approximately 11 miles in length. SWQB established one station along this assessment unit and deployed one thermograph during the 2004 intensive survey. Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir) was included on the 2006-2008 Integrated CWA §303(d)/§305(b) list for temperature and nutrients.

No TMDLs have previously been established for Bluewater Creek. Therefore, TMDLs were developed for inclusion in this document for the following assessment units in the Bluewater Creek subwatershed:

- ***Temerature, nutrients*:** Bluewater Creek (Bluewater Reservoir to headwaters)
- ***Temerature, nutrients*:** Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir)

Photo 3.1 Bluewater Creek above Bluewater Lake (February 2004)

3.2 La Jara Creek Subwatershed

The headwaters of the 12 mi^2 La Jara Creek subwatershed originate in the Naciemento Mountains. According to available Geographic Information System (GIS) coverages, the La Jara Creek watershed has an average elevation of 8,228 feet above sea level and receives approximately 22.8 inches of precipitation a year. As presented in Figure 2.1, land uses include 71% forest, 14% agriculture, 8% grassland, 6% shrubland and less than 1% of the land use in this watershed is developed or barren. Land ownership is 64% Forest Service, 32% Private, and 4% BLM (Figure 2.2). The geology of the La Jara Creek watershed is predominantly comprised of metamorphic rocks, carbonates, and sandstones (Figure 2.3).

La Jara Creek (perennial reaches above Arroyo San Jose) is approximately 10 miles in length. SWQB established one station along this assessment unit and deployed one thermograph during the 2004 intensive survey. La Jara Creek (perennial reaches above Arroyo San Jose) was included on the 2006-2008 Integrated CWA §303(d)/§305(b) list for aluminum.

No TMDLs have previously been established for La Jara Creek. Therefore, TMDLs were developed for inclusion in this document for the following assessment unit in the La Jara Creek subwatershed:

- ***Aluminum*:** La Jara Creek (perennial reaches above Arroyo San Jose)

Photo 3.2 La Jara Creek above Irrigation Diversion (March 2004)

3.3 Rio Moquino Subwatershed

The headwaters of the 74 mi^2 Rio Moquino subwatershed originate on Mount Taylor. According to available Geographic Information System (GIS) coverages, Rio Moquino watershed has an average elevation of 8,189 feet above sea level and receives
approximately 13 inches of precipitation a year. As presented in Figure 2.1, land uses include 47% forest, 44% shrubland, 8% grassland, and less than 1% pasture, mines and residential. Land ownership is 96% private, 4% Forest Service, and less than 1% native (Figure 2.2). The geology of the Rio Moquino watershed is predominantly comprised intrusive or plutonic rocks, sandstones, alluvium, and localized mineralized rocks(Figure 2.6).

Rio Moquino (Laguna Pueblo to Seboyettia Creek) is approximately 2 miles in length.
SWQB established one station along this assessment unit and deployed one thermograph during the 2004 intensive survey and subsequent 2006 redeployments. Rio Moquino (Laguna Pueblo to Seboyettia Creek) was included on the 2006-2008 Integrated CWA §303(d)/§305(b) list for nutrients, sedimentation/siltation, and temperature. The sedimentation/siltation listing will remain on the List pending further data collection and refinement of assessment protocols.

No TMDLs have previously been established for Rio Moquino. Therefore, TMDLs were developed for inclusion in this document for the following assessment unit in the Rio Moquino subwatershed:

- ***Nutrients, temperature*:** Rio Moquino (Laguna Pueblo to Seboyetita Creek)

Photo 3.3 Rio Moquino below confl of Seboyetita Creek and Seboyeta Creek (August 2006)

3.4 Rio Puerco Subwatershed

The headwaters of the 4,736 mi^2 Rio Puerco HUC originate in the Naciemento Mountains. According to available Geographic Information System (GIS) coverages, the Rio Puerco HUC has elevations that range from 4,700 feet to 11,000 feet above sea level and receives approximately 12-20 inches of precipitation a year. As presented in Figure 2.1, land uses for this reach include 62% forest, 21% shrubland, 4% agriculture, and less than 1% developed, barren, and mining. Land ownership for this reach is 38% Forest Service, 37% private, 14% native, 11% BLM, and less than 1% State(Figure 2.2). The geology of the Rio Puerco watershed in this reach is predominantly comprised of metamorphic rocks, alluvium, and intrusive or plutonic rocks (Figure 2.3).

Rio Puerco (Arroyo Chijuilla to northern boundary Cuba) is approximately 8 miles in length. SWQB established three stations along this assessment unit during the 2004 intensive survey and deployed one water thermograph during the 2006 redeployment. Rio Puerco (Arroyo Chijuilla to northern boundary Cuba) was included on the 2006-2008 Integrated CWA §303(d)/§305(b) list for nutrients, ammonia, sedimentation/siltation, and aluminum. The ammonia impairment is addressed in the plant nutrients TMDL.

A TMDL for sedimentation/siltation was developed by SWQB in 2006 for this assessment unit. TMDLs were developed for inclusion in this document for the following assessment unit in the Rio Puerco watershed:

- ***Aluminum, nutrients*:** Rio Puerco (Arroyo Chijuilla to northern boundary Cuba)

4.0 ALUMINUM

Assessment of the data from the 2004 SWQB intensive water quality survey in the Rio Puerco watershed identified several exceedences of the New Mexico water quality standards for dissolved aluminum in La Jara Creek and Rio Puerco. Consequently, these waterbodies were listed on the 2006-2008 Integrated CWA §303(d)/§305(b) (NMED/SWQB 2007) list for aluminum.

4.1 Target Loading Capacity

Target values for these aluminum TMDLs will be determined based on 1) the presence of numeric criteria or appropriate numeric translator to a narrative standard, 2) the degree of experience in applying the indicator, and 3) the ability to easily monitor and produce quantifiable and reproducible results. This TMDL is also consistent with New Mexico's antidegradation policy.

According to the New Mexico water quality standards (20.6.4.900 NMAC), the dissolved aluminum chronic criterion is 0.087 mg/L and the dissolved aluminum acute criterion is 0.75 mg/L for aquatic life uses. The chronic criterion was exceeded 3 of 7 times on La Jara Creek (perennial reaches above Arroyo San Jose) and 5 of 19 times on Rio Puerco (Arroyo Chijuilla to northern boundary Cuba). These exceedences are presented in Tables 4.1-4.2 and Figures 4.3-4.6.

High chronic levels of dissolved aluminum can be toxic to fish, benthic invertebrates, and some single-celled plants. Aluminum concentrations from 0.100-0.300 mg/L increase mortality, retard growth, gonadal development and egg production of fish (http://www.bae.ncsu.edu/programs/extension/wqg/). High acute levels of dissolved aluminum can be especially detrimental to aquatic life increasing mortality rates for many species of fish and macroinvertebrates.

Table 4.1 Dissolved aluminum and flow data for La Jara Creek

Sample Date	Dissolved Al (mg/L)	Flow (cfs)
La Jara above irrigation diversion (33LaJara009.7)		
3/30/04	0.26*	3.425
4/14/04	0.23*	4.23
5/25/04	0.4*	3.722
6/29/04	<0.01	1.42
7/27/04	<0.01	0.85
9/1/04	<0.01	n/a
11/18/04	<0.01	n/a

*denotes exceedence of dissolved aluminum chronic criterion
n/a = not available

Table 4.2 Dissolved aluminum and flow data for Rio Puerco (Arroyo Chijuilla to northern boundary Cuba)

Sample Date	Dissolved Al (mg/L)	Flow (cfs)
Rio Puerco @ Hwy 550 bridge (33RPuerc248.7)		
4/14/2004	0.12*	6.597
6/29/2004	<0.01	0.25
11/18/2004	<0.01	0.9
Rio Puerco above WWTP (33RPuerc244.0)		
3/30/2004	0.16*	3.73
4/14/2004	0.4*	27.969
5/25/2004	2*	6.684
6/29/2004	<0.01	1
7/27/2004	0.08	n/a
9/1/2004	<0.01	0.05
9/30/2004	<0.01	1
11/18/2004	0.02	1
Rio Puerco below WWTP @ Sanchez property (33RPuerc241.8)		
3/30/2004	<0.01	n/a
4/14/2004	0.19*	n/a
5/26/2004	0.02	5.5
6/29/2004	<0.01	1
7/27/2004	0.04	1
9/1/2004	0.01	0.1
9/30/2004	<0.01	0.02
11/18/2004	<0.01	1
Cuba WWTP outfall (NM 0024848) [a]		
3/30/2004	<0.01	0.05[b]
4/14/2004	<0.01	0.05[b]
5/25/2004	<0.01	0.05[b]
6/29/2004	<0.01	0.04[b]
7/27/2004	<0.01	0.05[b]
9/1/2004	<0.01	0.05[b]
9/30/2004	<0.01	0.05[b]
11/18/2004	<0.01	0.06[b]

*denotes exceedence of dissolved aluminum chronic criterion
n/a = not available
[a] The design flow is 0.144 mgd (0.223 cfs)
[b] 30day reported average for given month in 2004 (originally reported in mgd)

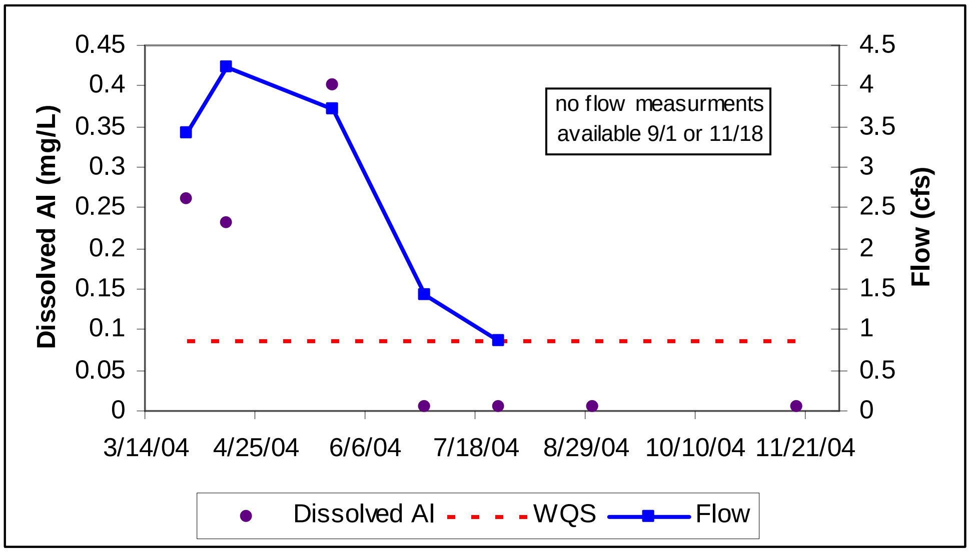


Figure 4.1 Dissolved aluminum chronic criterion exceedences at 33LaJara009.7

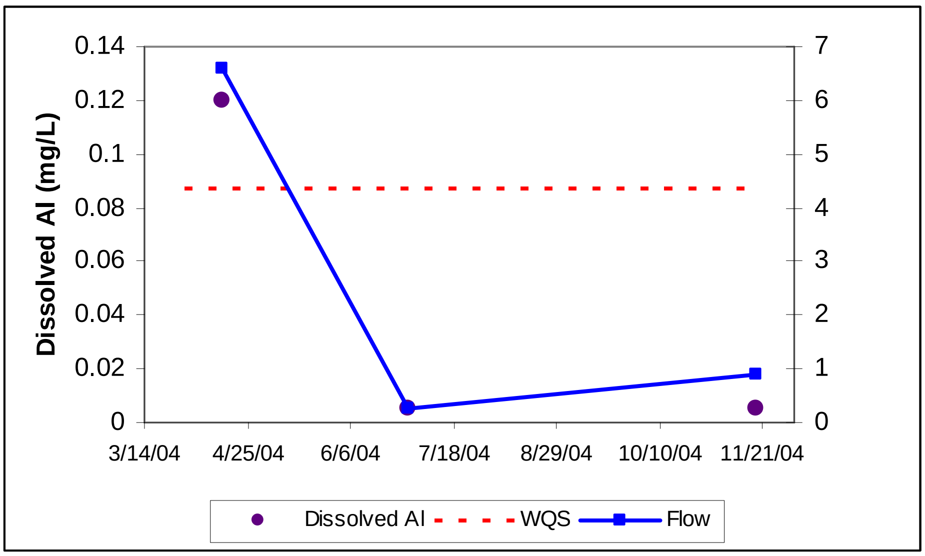


Figure 4.2 Dissolved aluminum chronic criterion exceedences at 33RPuerc248.7

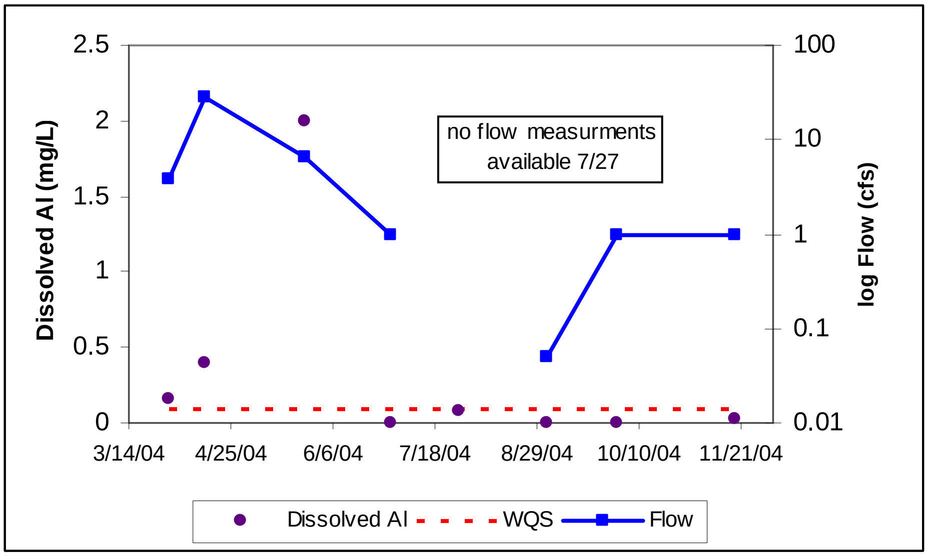


Figure 4.3 Dissolved aluminum chronic criterion exceedences at 33RPuerc244.0

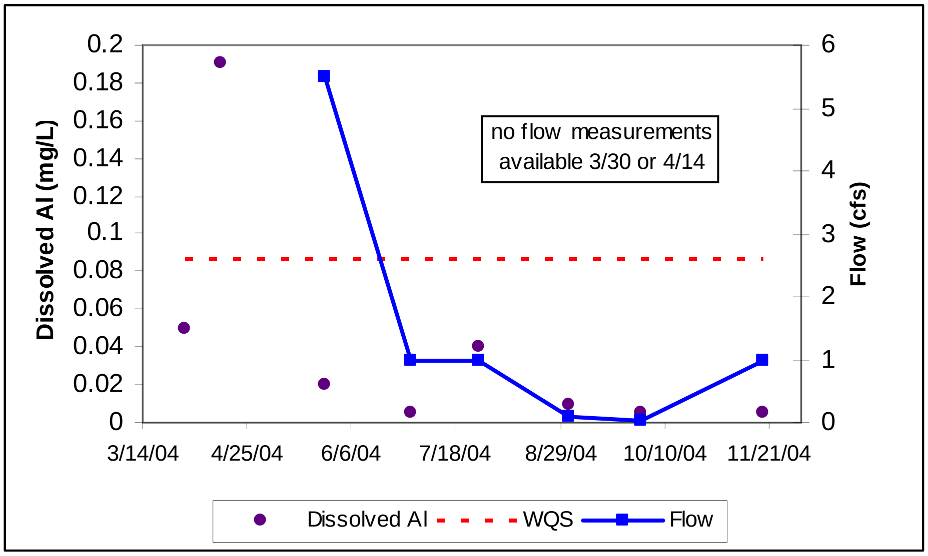


Figure 4.4 Dissolved aluminum chronic criterion exceedences at 33RPuerc241.8

4.2 Flow

TMDLs are calculated for te Rio Puerco and La Jara assessment units at a specific flow. Metal concentrations in a stream vary as a function of flow. As flow increases, the concentration of metals can increase. When available, USGS gages are used to estimate flow. Where gages are absent, geomorphologic cross section field data are collected at each site and actual flow measurements are taken. There are no active gages on La Jara Creek and no relevant active gages on the Rio Puerco (see Section 2.4.2), therefore, gage data was not available for these TMDL calculations and actual flow measurements were used. For these reaches, flow was measured by SWQB during the 2004 sampling runs using standard USGS procedures (NMED/SWQB 2001a).

Flows were measured at La Jara Creek above the irrigation diversion 5 times during the 2004 sampling season (Figure 4.3 and Table 4.1). WQS exceedences occurred only during high flows, so the critical flow was determined to be the average of the 3 high flows (3.425 cfs, 4.23 cfs, and 3.722 cfs) during the 2004 sampling year. Flow was measured 16 times at sites in the Rio Puerco (Arroyo Chijuilla to northern boundary Cuba) assessment unit during the 2004 sampling season (Table 4.2 and Figures 4.4-4.6). Given the available flow data, WQS exceeded only during high flows, so the critical flow was determined to be the average of the 4 available high flows (6.597 cfs, 3.73 cfs, 27.969 cfs, 6.684 cfs).

Therefore the critical flows for these TMDLs were:

- La Jara Creek (perennial reaches above Arroyo San Jose) = 3.79 cfs
- Rio Puerco (Arroyo Chijuilla to northern boundary Cuba) = 11.25 cfs

The flow value for La Jara Creek (perennial reaches above Arroyo San Jose) was converted from cfs to units of mgd as follows:

$$3.79\,\frac{ft^3}{\sec} \times 1{,}728\,\frac{in^3}{ft^3} \times 0.004329\,\frac{gal}{in^3} \times 86{,}400\,\frac{\sec}{day} \times 10^{-6} = 2.44\,mgd$$

Using the above equation, the flow value for Rio Puerco (Arroyo Chijuilla to northern boundary Cuba) was converted from 11.25 cfs to 7.27 mgd.

4.3 Calculations

A target load for dissolved aluminum is calculated based on a flow, the current water quality criterion, and a conversion factor (8.34) that is used to convert mg/L units to lbs/day (see Appendix B for Conversion factor derivation). The target loading capacity is calculated using **Equation 1**. The results are shown in Table 4.3.

Critical flow (mgd) x Criterion (mg/L) x 8.34 = Target Loading Capacity (Eq. 1)

Table 4.3 Calculation of target loads for dissolved aluminum

Location	Flow (mgd)	Dissolved Aluminum (mg/L)	Conversion Factor	Target Load Capacity (lbs/day)
La Jara Creek (perennial reaches abv Arroyo San Jose)	2.44	0.087	8.34	1.77*
Río Puerco (Arroyo Chijuilla to Northern boundary of Cuba)	7.27	0.087	8.34	5.27*

Notes: *values rounded to three significant figures

It is important to remember that the TMDL is a planning tool to be used to achieve water quality standards. Since flows vary throughout the year in these systems the target load will vary based on the changing flow. Management of the load to improve stream water quality and meet water quality criteria should be a goal to be attained. Meeting the calculated TMDL may be a difficult objective.

The measured loads for dissolved aluminum were similarly calculated. The arithmetic mean of the data used to determine the impairment was substituted for the criterion in Equation 1. The same conversion factor of 8.34 was used. Results are presented in Table 4.4.

Table 4.4 Calculation of measured loads for dissolved aluminum

Location	Flow (mgd)	Dissolved Aluminum Arithmetic Mean (mg/L)	Conversion Factor	Measured Load (lbs/day)
La Jara Creek (perennial reaches abv Arroyo San Jose)	2.44	0.297	8.34	6.04*
Río Puerco (Arroyo Chijuilla to Northern boundary of Cuba)	7.27	0.574	8.34	34.8*

Notes: *values rounded to three significant figures

4.4 Waste Load Allocations and Load Allocations

4.4.1 Waste Load Allocation

There are no individually permitted point source facilities on La Jara Creek. The Village of Cuba Wastewater Treatment Plant (WWTP) (NM0024848) is located within the impaired Río Puerco AU and discharges directly to the Río Puerco. The NPDES permit (NM0024848) does not have a limit for aluminum. Additionally, the 8 samples collected from the Cuba WWTP outfall during 2004 (Table 4.2) show results below the dissolved aluminum water quality criterion; therefore a WLA was not calculated for this facility.

There are no Municipal Separate Storm Sewer System (MS4) storm water permits in these Assessment Units. Sediment may be a component of some industrial and construction storm water discharges covered under General NPDES Permits, so the load from these discharges should be addressed. In contrast to discharges from other industrial storm water and individual process wastewater permitted facilities, storm water discharges from construction activities are transient because they occur mainly during the construction itself, and then only during storm events. Coverage under the NPDES construction general storm water permit (CGP) for construction sites greater than one acre requires preparation of a Storm Water Pollution Prevention Plan (SWPPP) that includes identification and control of all pollutants associated with the construction activities to minimize impacts to water quality. In addition, the current CGP also includes state specific requirements to implement best management practices (BMPs) that are designed to prevent to the maximum extent practicable, an increase in sediment, or a parameter that addresses sediment (e.g., TSS, turbidity, siltation, SBDs, etc.) and water velocity during and after construction compared to pre-construction conditions. In this case, compliance with a SWPPP that meets the requirements of the CGP is generally assumed to be consistent with this TMDL.

Other industrial storm water facilities are generally covered under the current NPDES Multi-Sector General Storm Water Permit (MSGP). This permit also requires preparation of an SWPPP that includes identification and control of all pollutants associated with the industrial activities to minimize impacts to water quality. In addition, the current MSGP also includes state specific requirements to further limit (or eliminate) pollutant loading to water quality impaired/water quality limited waters from facilities where there is a reasonable potential to contain pollutants for which the receiving water is impaired. In this case, compliance with a SWPPP that meets the requirements of the MSGP is generally assumed to be consistent with this TMDL.

Individual wasteload allocations for the General Permits were not possible to calculate at this time in this watershed using available tools. Loads that are in compliance with the General Permits from facilities covered are therefore currently calculated as part of the watershed load allocation.

4.4.2 Load Allocation

In order to calculate the LA, the WLA and MOS were subtracted from the target capacity TMDL following **Equation 1**:

$$WLA + LA + MOS = TMDL \qquad \text{(Eq. 2)}$$

The MOS is estimated to be 25 percent of the target load calculated in Table 4.5. Results are presented in Table 4.5. Additional details on the MOS chosen are presented in Section 4.7.

Table 4.5 TMDL for dissolved aluminum

Location	WLA (lbs/day)	LA (lbs/day)	MOS (25%) (lbs/day)	TMDL (lbs/day)
La Jara Creek (perennial reaches abv Arroyo San Jose)	0	1.33	0.443	1.77*
Río Puerco (Arroyo Chijuilla to Northern boundary of Cuba)	0	3.95	1.32	5.27*

Notes: *values rounded to three significant figures

The extensive data collection and analyses necessary to determine background dissolved aluminum loads for this AU was beyond the resources available for this study.

It is important to reiterate that TMDLs are planning documents that provide a framework for working towards the goal of achieving water quality criteria or appropriate numeric translators.

Management of the load to improve stream water quality is a goal to be attained, rather than a regulatory requirement.

4.5 Identification and Description of Pollutant Source(s)

Probable nonpoint sources that may be contributing to the observed load are displayed in Table 4.6:

Table 4.6 Pollutant source summary for Aluminum

Pollutant Sources	Magnitude[(a)]	Location	Probable Sources[(b)]
Point:			
Dissolved Aluminum	none	La Jara Creek (perennial reaches abv Arroyo San Jose)	0%
	none	Río Puerco (Arroyo Chijuilla to Northern boundary of Cuba)	0%
Nonpoint:			
Dissoslved Aluminum	6.04	La Jara Creek (perennial reaches abv Arroyo San Jose)	100% Unknown Natural sources [(c)]
	34.8	Río Puerco (Arroyo Chijuilla to Northern boundary of Cuba)	100% Highway/Road/Bridge Runoff (non-construction related) Loss of Riparian Habitat Rangeland Grazing Streambank Modification/destabilization Channelization Natural Sources Wildlife other than Waterfowl Drought-related Impacts

Notes:
(a) Measured Load.
(b) From the 2006-2008 Integrated CWA 303(d)/305(b) list (NMED/SWQB 2007). This list of probable sources is based on staff observation and known land use activities in the watershed. These sources are not confirmed or quantified at this time.
(c) As noted in the "assessment unit comments" on the 2006-2008 Integrated CWA 303(d)/305(b) list (NMED/SWQB 2007).

Probable sources of dissolved aluminum for this assessment unit will be evaluated, refined, and changed as necessary through the Watershed Restoration Action Strategy (WRAS) process.

4.6 Linkage of Water Quality and Pollutant Sources

SWQB fieldwork includes an assessment of the potential sources of impairment. The Pollutant Source(s) Documentation Summary included in Appendix A provides documentation of a visual analysis of probable sources along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. Staff completing these forms identify probable sources of nonpoint source impairments along each reach as determined by field reconnaissance. It is important to consider not only the land directly adjacent to the stream, but also to consider upland and upstream areas in a more holistic watershed approach to implementing these TMDLs.

In general, increased metals in the water column can commonly be linked to sediment transport and accumulation, where the metals are a constituent part of the stream. This does not appear to be the case for either La Jara Creek or Rio Puerco as evidenced by the fact that there is a very weak relationship between the dissolved aluminum and TSS concentrations according to the data used to determine the impairment (Figures 4.7 and 4.8). However, the degree to which sediment delivery and transport in these watershed is a natural phenomenon, has been exacerbated by human activities, or is the result of a combination of both should be considered. Even though the highly erodible soils of the Río Puerco Watershed are the primary source of sediment transport, the anthropogenic influence of the highway construction, channelization, land development, and historical rangeland grazing practices could be contributing to impairment, particularly in the Río Puerco. The geology in the watershed contributes to the amount of sediment available for transport.

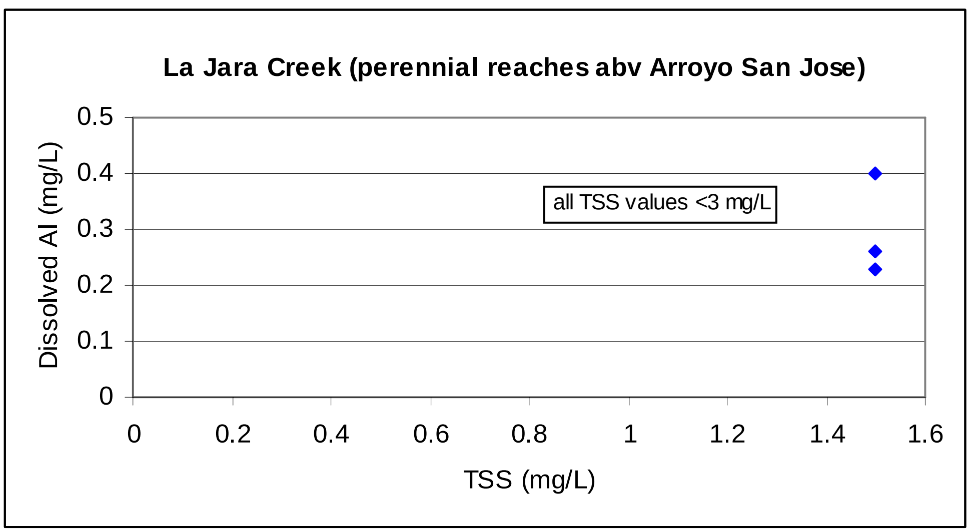


Figure 4.5 Relationship between dissolved aluminum and TSS in La Jara

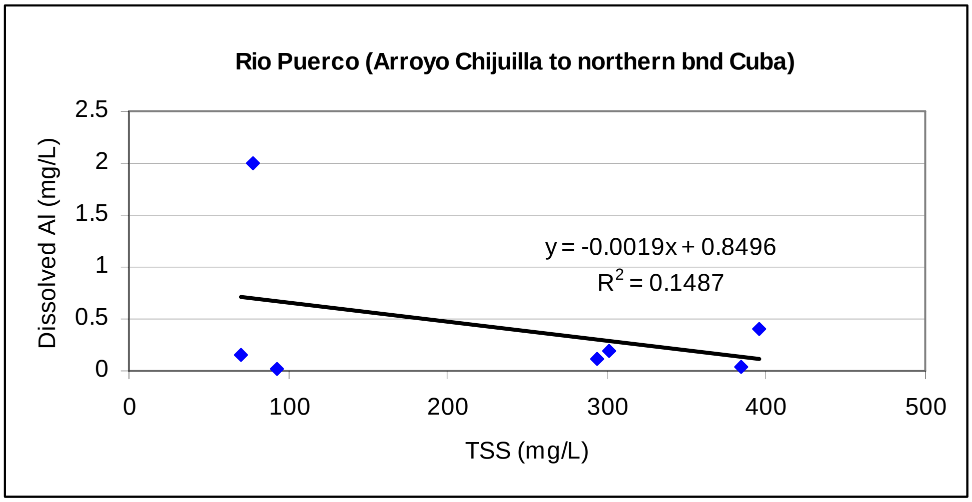


Figure 4.6 Relationship between dissolved aluminum and TSS in Rio Puerco

Higher aluminum is characteristic of the spring snowmelt/runoff period and is not pronounced during baseflow conditions in La Jara Creek or Rio Puerco. Exceedences occurred only during March-May in these assessment units. Normal aqueous chemical process, enhanced by the slight natural acidity of snow and rain, are capable of rendering any naturally occurring aluminum available to the stream system. The fact that dissolved aluminum concentrations above the chronic aluminum criterion were measured during the spring sampling runs as opposed to the lower concentrations found during fall sampling runs are indicative of a landscape source. Acidic anions as well as carbonic acid carried in snow are released into the soil as the snow melts and bring aluminum species into solution. Thus, aluminum concentrations are often high during spring runoff in many areas in New Mexico despite the expected diluting effects of high flow.

4.7 Margin of Safety

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there will be no MOS for point sources since none were accounted for in the TMDL calculation. However, the MOS is estimated to be 25% for dissolved aluminum. This MOS incorporates several factors:

- *Errors in calculating nonpoint source loads*

  A level of uncertainity exists in sampling nonpoint sources of pollution. Techniques used for measuring metals concentrations in stream water can lead to inaccuracies in the data. Therefore, a conservative MOS for metals increases the TMDL by **15%.**

- *Errors in calculating flow*

  Flow estimates were based on field measurements. There is a potential to have errors in measurements of flow due to equipment accuracy, time of sampling, etc. To be conservative, an additional MOS of **10%** will be included to account for accuracy of flow computations.

4.8 Consideration of Seasonal Variation

Data used in the calculation of this TMDL were collected during the spring, summer, and fall of 2004 in order to ensure coverage of any potential seasonal variation in the system. Critical condition was set to the flow estimate determined during snowmelt/runoff when exceedences occurred from March-May 2004.

4.9 Future Growth

Estimations of future growth are not anticipated to lead to a significant increase for dissolved aluminum that cannot be controlled with BMP implementation in the watershed, continued improvement of road conditions, and proper land management.

5.0 PLANT NUTRIENTS

The potential for excessive nutrients in the Rio Puerco, Bluewater Creek, and Rio Moquino were noted through visual observation during the 2004 SWQB intensive watershed survey. Assessment of various water quality parameters indicated nutrient impairment in Rio Puerco (Arroyo Chijuilla to northern boundary of Cuba), Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir), Bluewater Creek (Bluewater Reservoir to headwaters), and Rio Moquino (Laguna Pueblo to Seboyetita Creek).

5.1 Target Loading Capacity

The target values for nutrient loads are determined based on 1) the presence of numeric and narrative criteria, 2) the degree of experience in applying the indicator, and 3) the ability to easily monitor and produce quantifiable and reproducible results. For this TMDL document the target value for plant nutrients is based on both narrative and numeric translators. This TMDL is consistent with the New Mexico State antidegradation policy.

The New Mexico WQCC has adopted a narrative water quality criterion for plant nutrients to sustain and protect existing or attainable uses of the surface waters of the state. This general criterion applies to surface waters of the state at all times unless a specific criterion is provided elsewhere. The general water quality criteria require that a stream have water quality, streambed characteristics, and other attributes of habitat sufficient to protect and maintain coldwater aquatic life. The narrative plant nutrient criterion leading to an assessment of use impairment is as follows (Subsection E of 20.6.4.13 NMAC):

> ***Plant Nutrients:*** *Plant nutrients from other than natural causes shall not be present in concentrations which will produce undesirable aquatic life or result in the dominance of nuisance species in surface waters of the state.*

There are two potential contributors to nutrient enrichment in a given stream: excessive nitrogen and/or phosphorus. The reason for controlling plant growth is to preserve aesthetic and ecologic characteristics along the waterway. The intent of numeric criteria for phosphorus and nitrogen is to control the excessive growth of attached algae and higher aquatic plants that can result from the introduction of these plant nutrients into streams. Numeric criteria also are necessary to establish targets for total maximum daily loads (TMDLs), to develop water quality-based permit limits and source control plans, and to support designated uses within the watershed.

Nutrient criteria development in the State of New Mexico has taken place in three steps, thus far. First, the EPA compiled nutrient data from the national nutrient dataset, divided it by waterbody type, grouped it into nutrient ecoregions, and calculated the 25^{th} percentiles for each aggregate and Level III ecoregion. EPA published these recommended water quality criteria to help states and tribes reduce problems associated with excess nutrients in waterbodies in specific areas of the country (USEPA 2000). Next a U.S. Geological Survey (USGS) employee, Evan Hornig, who assisted EPA Region 6 with nutrient criteria development, refined the recommended ecoregional nutrient criteria. Hornig used regional nutrient data from EPA's Storage and Retrieval System (STORET), the USGS, and the SWQB to create a regional dataset for New Mexico. Threshold values were calculated based on EPA procedures and the median for each Level III ecoregion.

The third round of analysis was conducted by SWQB to produce nutrient threshold values for streams based on ecoregion and designated aquatic life use. For this analysis, total phosphorus (TP), total Kjeldahl nitrogen (TKN), and nitrate plus nitrite (N+N) data from the National Nutrient Dataset (1990-1997) was combined with Archival STORET data from 1998, and 1999-2006 data from the SWQB in-house database. The data were then divided by waterbody type, removing all rivers, reservoirs, lakes, wastewater treatment effluent, and playas. For all of the stream data, Level III and IV Omernik ecoregions (Omernik 2006) as well as the designated aquatic life use were assigned to all stream data using GIS coverages and the station's latitude and longitude. Medians were calculated for each ecoregion/aquatic life use group using Excel. For comparison purposes, values below the detection limit were estimated in two ways; using the substitution method (one half the detection limit) in Excel and using the nonparametric Kaplan-Meier method in Minitab. Interestingly, the results from the different analysis produced very similar results. However, the threshold values that will be incorporated into the SWQB Stream Nutrient Assessment Protocol were calculated using the Kaplan-Meier method and are shown in Table 5.1.

Table 5.1. SWQB's Recommended Nutrient Targets for streams (in mg/L)

	ECOREGION									
Parameter	21-Southern Rockies		23-AZ/NM Mountains		22-AZ/NM Plateau		24-Chihuahuan Desert	26-SW Tablelands		
TP	0.02		0.02		0.05		0.04	0.03		
TN	0.25		0.25		0.35		0.53	0.38		
ALU	CW	T/WW (volcanic)	CW	T/WW	CW	T/WW	T/WW	CW	T	WW
TP	0.02	0.02 (0.05)	0.02	0.05	0.04	0.09	0.04	0.02	0.03	0.03
TN	0.25	0.25	0.25	0.29	0.28	0.48	0.53	0.25	0.38	0.45

NOTES:
TP = Total Phosphorus
TN = Total Nitrogen
ALU = Designated Aquatic Life Use
CW = Coldwater (those water quality segments having only coldwater uses)
T = Transitional (those water quality segments with marginal coldwater or both cold and warmwater uses)
WW = Warmwater (those water quality segments having only warmwater uses)

The Rio Puerco (Arroyo Chijuilla to northern boundary of Cuba) is located in Ecoregion 22 (Arizona/New Mexico Plateau). In addition, this assessment unit is covered by the water quality standards in 20.6.4.99 NMAC, which has an aquatic life use designation. According to Table 5.1, the Rio Puerco (Arroyo Chijuilla to northern boundary of Cuba) should have numeric nutrient targets of 0.09 mg/L for total phosphorus and 0.48 mg/L for total nitrogen.

Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir) is located in Ecoregion 22 (Arizona/New Mexico Plateau). In addition, this assessment unit is classified under 20.6.4.109 NMAC and has a designated aquatic life use of coldwater aquatic life. According to Table 5.1, Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir) should have numeric nutrient targets of 0.04 mg/L for total phosphorus and 0.28 mg/L for total nitrogen.

Bluewater Creek (Bluewater Reservoir to headwaters) is located in Ecoregion 23 (Arizona/New Mexico Mountains). In addition, this assessment unit is classified under 20.6.4.109 NMAC and has a designated aquatic life use of coldwater aquatic life. According to Table 5.1, Bluewater Creek (Bluewater Reservoir to headwaters) should have numeric nutrient targets of 0.02 mg/L for total phosphorus and 0.25 mg/L for total nitrogen.

Rio Moquino (Laguna Pueblo to Seboyetita Creek) is located in Ecoregion 23 (Arizona/New Mexico Mountains). In addition, this assessment unit is classified under 20.6.4.109 NMAC and has a designated use of coldwater aquatic life (20.6.4.109 NMAC). According to Table 5.1, Rio Moquino (Laguna Pueblo to Seboyetita Creek) should have numeric nutrient targets of 0.02 mg/L for total phosphorus and 0.25 mg/L for total nitrogen.

Total Nitrogen is defined as the sum of Nitrate+Nitrite (N+N), and Total Kjeldahl Nitrogen (TKN). At the present time, there is no USEPA-approved method to test for Total Nitrogen, however a combination of USEPA method 351.2 (TKN) and USEPA method 353.2 (Nitrate + Nitrite) may be appropriate for monitoring Total Nitrogen.

Table 5.2. Nutrient TMDL Target Concentrations

Assessment Unit	Total Phosphorus	Total Nitrogen
Rio Puerco (Arroyo Chijuilla to northern boundary of Cuba)	0.09 mg/L	0.48 mg/L
Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir)	0.04 mg/L	0.28 mg/L
Bluewater Creek (Bluewater Reservoir to headwaters)	0.02 mg/L	0.25 mg/L
Rio Moquino (Laguna Pueblo to Seboyetita Creek)	0.02 mg/L	0.25 mg/L

5.2 Flow

The presence of plant nutrients in a stream can vary as a function of flow. As flow decreases, the stream cannot effectively dilute its constituents, which causes the concentration of plant nutrients to increase. Thus, a TMDL is calculated for each assessment unit at a specific flow.

The *critical condition* can be thought of as the "worst case" scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence. The critical flow is used in calculation of point source (National Pollutant Discharge Elimination System [NPDES]) permit WLA and in the development of TMDLs.

The critical flow condition for these TMDLs occurs when the ratio of effluent to stream flow is the greatest and was obtained using a 4Q3 regression model. The 4Q3 is the minimum average four consecutive day flow that occurs with a frequency of at least once every 3 years. Low flow was chosen as the critical flow because of the negative effect decreasing, or low, flows have on nutrient concentrations and algal growth.

The 4Q3s for Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir) and Bluewater Creek (Bluewater Reservoir to headwaters) are based on USGS Gage data. USGS Gage 08341500: Bluewater Creek at Bluewater Dam, NM was used to calculate the 4Q3 for Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir). USGS Gage 083413000: Bluewater Creek above Bluewater Dam, NM was used to calculate the 4Q3 for Bluewater Creek (Bluewater Reservoir to headwaters). The 4Q3s were estimated using the USGS A193 calculation for Log Pearson Type III distribution through DFLOW software, Version 3.1 (USEPA 2006). DFLOW 3.1 is a Windows-based tool developed to estimate user selected design stream flows for low flow analysis. The calculated 4Q3 is as follows:

- Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir) = 0.16 cfs
- Bluewater Creek (Bluewater Reservoir to headwaters) = 0.01 cfs

It is often necessary to calculate a critical flow for a portion of a watershed where there is no active flow gage. The 4Q3 derivations for the Rio Puerco and Rio Moquino were based on analysis methods described by Waltemeyer (2002). In this analysis, two regression equations for estimating 4Q3 were developed based on physiographic regions of NM (i.e., statewide and mountainous regions above 7,500 feet in elevation). The following statewide regression equation is based on data from 50 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 \quad = \quad 1.2856 \times 10^{-4} \; DA^{0.42} \; P_w^{\;3.16} \qquad \text{(Eq. 3)}$$

where,

4Q3 = Four-day, three-year low-flow frequency (cfs)
DA = Drainage area (mi^2)
P_w = Average basin mean winter precipitation (inches)

The average standard error of estimate (SEE) and coefficient of determination are 126 and 48 percent, respectively, for this regression equation (Waltemeyer 2002). The following regression equation for mountainous regions above 7,500 feet in elevation is based on data from 40 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 \quad = \quad 7.3287 \times 10^{-5} \; DA^{0.70} \; P_w^{\;3.58} \; S^{1.35} \qquad \text{(Eq. 4)}$$

where,

S = Average basin slope (percent).

The average SEE and coefficient of determination are 94 and 66 percent, respectively, for this regression equation (Waltemeyer 2002). The 4Q3 for the Rio Puerco was estimated using the statewide regression equation because the mean elevation for this assessment unit was below 7,500 feet in elevation. On the other hand, the 4Q3 for the Rio Moquino was estimated using the regression equation for mountainous regions because the mean elevation for this assessment unit was above 7,500 feet in elevation (Table 5.3).

Table 5.3 Calculation of 4Q3 Low-Flow Frequencies

Assessment Unit	Average Elevation (ft.)	Drainage Area (mi^2)	mean winter precipitation (in.)	Average basin slope (percent)	4Q3 (cfs)
Rio Puerco (Arroyo Chijuilla to northern boundary of Cuba)	7398	137.98	8.75	14.7	0.965
Rio Moquino (Laguna Pueblo to Seboyetita Creek)	8189	74.27	5.7	11	0.039

The 4Q3 values were converted from cubic feet per second (cfs) to units of million gallons per day (MGD) as follows:

$$\_\_\_\_\_ \; \frac{\text{ft}^3}{\text{sec}} \times 1{,}728 \frac{\text{in}^3}{\text{ft}^3} \times 0.004329 \frac{\text{gal}}{\text{in}^3} \times 86{,}400 \; \frac{\text{sec}}{\text{day}} \times 10^{-6} = \_\_\_\_\_ \; \text{MGD} \qquad \text{(Eq. 4)}$$

It is important to remember that the TMDL is a planning tool to be used to achieve water quality standards. Since flows vary throughout the year in these systems the target load will vary based on the changing flow. Management of the load to improve stream water quality and meet water quality criteria should be a goal to be attained.

5.3 Calculations

This section describes the relationship between the numeric target and the allowable pollutant-level by determining the waterbody's total assimilative capacity, or loading capacity, for the pollutant. The loading capacity is the maximum amount of pollutant loading that a waterbody can receive while meeting its water quality objectives.

As a river flows downstream it has a specific carrying capacity for nutrients. This carrying capacity, or TMDL, is defined as the mass of pollutant that can be carried under critical low-flow conditions without violating the target concentration for that constituent. These TMDLs were developed based on simple dilution calculations using 4Q3 flow, the numeric target, and a conversion factor. The specific carrying capacity of a receiving water for a given pollutant, may be estimated using **Equation 1**.

4Q3 (in MGD) x Numeric Target (in mg/L) x 8.34 = TMDL (pounds per day [lbs/day]) (Eq. 1)

The annual target loads for TP and TN are summarized in Table 5.4.

Table 5.4. Estimates of Annual Target Loads for TP & TN

Assessment Unit	Parameter	4Q3 Flow (MGD)	Numeric Target (mg/L)	Conversion Factor	Target Load (lbs/day)
Rio Puerco (Arroyo Chijuilla to northern bnd of Cuba)	Total Phosphorus	0.768+	0.09	8.34	0.577
	Total Nitrogen	0.768+	0.48	8.34	3.074
Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir)	Total Phosphorus	0.103	0.04	8.34	0.034
	Total Nitrogen	0.103	0.28	8.34	0.241
Bluewater Creek (Bluewater Reservoir to headwaters)	Total Phosphorus	0.007	0.02	8.34	0.001
	Total Nitrogen	0.007	0.25	8.34	0.015
Rio Moquino (Laguna Pueblo to Seboyetita Creek)	Total Phosphorus	0.025	0.02	8.34	0.004
	Total Nitrogen	0.025	0.25	8.34	0.052

Notes:
+ *Combined Flow = 4Q3 low-flow (0.624 MGD) + WWTP design capacity (0.144 MGD)*

The measured loads for TP and TN were similarly calculated. In order to achieve comparability between the target and measured loads, the same flow value was used for both calculations. The geometric mean of the collected data that exceeded the numeric targets (Table 5.5) was substituted for the numeric target in **Equation 1**. The same conversion factor of 8.34 was used. The results are presented in Table 5.6.

Table 5.5 SWQB nutrient data

Sample site	Collection date/time	TP (mg/L)	TN (mg/L)
Bluewater Creek above Bluewater Lake @ USGS gage 8341300	4/5/2004 16:35	0.0344	0.459
Bluewater Creek above Bluewater Lake @ USGS gage 8341300	5/3/2004 11:35	<0.03	0.513
Bluewater Creek above Bluewater Lake @ USGS gage 8341300	6/8/2004 17:20	0.03035	0.434
Bluewater Creek above Bluewater Lake @ USGS gage 8341300	7/13/2004 15:00	<0.03	0.33
Bluewater Creek above Bluewater Lake @ USGS gage 8341300	8/10/2004 18:10	0.0334	0.42
Bluewater Creek above Bluewater Lake @ USGS gage 8341300	11/2/2004 15:45	0.02	0.31
Bluewater Creek above Bluewater Lake @ USGS gage 8341300	11/15/2004 15:06	0.022	0.27
GEOMETRIC MEAN of Exceedences		**0.033**	**0.382**
BLUEWATER CREEK AT MOUTH OF BLUEWATER CANYON	4/5/2004 15:20	<0.03	0.352
BLUEWATER CREEK AT MOUTH OF BLUEWATER CANYON	5/3/2004 10:05	<0.03	0.325
BLUEWATER CREEK AT MOUTH OF BLUEWATER CANYON	6/8/2004 15:00	<0.03	0.489
BLUEWATER CREEK AT MOUTH OF BLUEWATER CANYON	7/13/2004 13:30	<0.03	0.451
BLUEWATER CREEK AT MOUTH OF BLUEWATER CANYON	8/10/2004 17:00	0.0311	0.534
BLUEWATER CREEK AT MOUTH OF BLUEWATER CANYON	9/13/2004 13:00	<0.03	0.381
BLUEWATER CREEK AT MOUTH OF BLUEWATER CANYON	11/2/2004 14:20	0.011	0.33
BLUEWATER CREEK AT MOUTH OF BLUEWATER CANYON	11/15/2004 16:30	0.007	0.32
GEOMETRIC MEAN of Exceedences		**n/a**	**0.436**
Rio Puerco @ Hwy 550 Bridge	3/31/2004 7:30	0.111	0.61
Rio Puerco @ Hwy 550 Bridge	4/14/2004 17:10	0.178	0.652
Rio Puerco @ Hwy 550 Bridge	6/29/2004 11:15	<0.03	0.34
Rio Puerco @ Hwy 550 Bridge	7/27/2004 13:40	<0.03	0.28
Rio Puerco @ Hwy 550 Bridge	9/1/2004 13:10	<0.03	0.401
Rio Puerco @ Hwy 550 Bridge	11/17/2004 12:00	0.004	0.3
Rio Puerco @ Hwy 550 Bridge	3/7/2006 16:35	0.078	0.53
Rio Puerco abv WWTP	3/30/2004 14:10	0.102	0.6
Rio Puerco abv WWTP	4/14/2004 12:41	0.21	0.764
Rio Puerco abv WWTP	6/29/2004 14:30	0.0341	0.644
Rio Puerco abv WWTP	7/27/2004 14:28	3.06	12.1
Rio Puerco abv WWTP	9/1/2004 16:33	1.60	8.7
Rio Puerco abv WWTP	9/30/2004 12:40	3.27	18.9
Rio Puerco abv WWTP	11/18/2004 14:20	1.53	8.09
Rio Puerco blw WWTP @ Sanchez Property	3/30/2004 15:15	0.172	1
Rio Puerco blw WWTP @ Sanchez Property	4/14/2004 16:34	0.185	0.837
Rio Puerco blw WWTP @ Sanchez Property	6/29/2004 16:15	1.76	11.01
Rio Puerco blw WWTP @ Sanchez Property	7/27/2004 15:10	1.40	6.27
Rio Puerco blw WWTP @ Sanchez Property	9/1/2004 17:25	1.17	13.27
Rio Puerco blw WWTP @ Sanchez Property	9/30/2004 13:26	1.40	8.75
Rio Puerco blw WWTP @ Sanchez Property	10/14/2004 14:25	4.05	4.27
Rio Puerco blw WWTP @ Sanchez Property	11/18/2004 15:22	1.00	6.59
Rio Puerco blw WWTP @ Sanchez Property	3/7/2006 11:55	1.67	9.2
GEOMETRIC MEAN of Exceedences		**0.758**	**3.064**

Sample site	Collection date/time	TP (mg/L)	TN (mg/L)
Cuba WWTP Outfall Channel	3/30/2004 14:00	2.88	23.8
Cuba WWTP Outfall Channel	4/14/2004 12:40	3.72	231.83
Cuba WWTP Outfall Channel	6/29/2004 14:40	6.72	40.2
Cuba WWTP Outfall Channel	7/27/2004 14:25	3.74	37
Cuba WWTP Outfall Channel	9/1/2004 16:30	2.55	15.8
Cuba WWTP Outfall Channel	9/30/2004 12:36	1.64	9.43
Cuba WWTP Outfall Channel	11/18/2004 14:16	4.25	20.7
	AVERAGE	**3.64**	**24.5**
Rio Moquino blw confluence with Seboyetita Crk and Seboyeta Crk	6/8/2004 11:05	<0.03	0.329
Rio Moquino blw confluence with Seboyetita Crk and Seboyeta Crk	7/13/2004 9:35	<0.03	0.466
Rio Moquino blw confluence with Seboyetita Crk and Seboyeta Crk	8/10/2004 11:30	<0.03	0.403
Rio Moquino blw confluence with Seboyetita Crk and Seboyeta Crk	9/13/2004 9:45	0.0413	0.373
Rio Moquino blw confluence with Seboyetita Crk and Seboyeta Crk	11/2/2004 11:45	0.017	0.32
Rio Moquino blw confluence with Seboyetita Crk and Seboyeta Crk	11/16/2004 11:00	0.007	0.28
GEOMETRIC MEAN of Exceedences		**n/a**	**0.357**

Notes:
TP = Total Phosphorus
TN = Total Nitrogen
mg/L = Milligrams per liter
n/a = not applicable because less than two exceedences in the Assessment Unit
Exceedences of the nutrient targets are highlighted in **YELLOW**.

Table 5.6. Estimates of Annual Measured Loads for TP and TN

Assessment Unit	Parameter	Flow (MGD)	Geometric Mean Conc. * (mg/L)	Conversion Factor	Measured Load (lbs/day)
Rio Puerco (Arroyo Chijuilla to northern bnd of Cuba)	Total Phosphorus	0.768+	0.758	8.34	4.855
	Total Nitrogen	0.768+	3.064	8.34	19.63
Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir)	Total Phosphorus	0.103	n/a	8.34	< Target Load
	Total Nitrogen	0.103	0.436	8.34	0.375
Bluewater Creek (Bluewater Reservoir to headwaters)	Total Phosphorus	0.007	0.033	8.34	0.002
	Total Nitrogen	0.007	0.382	8.34	0.022
Rio Moquino (Laguna Pueblo to Seboyetita Creek)	Total Phosphorus	0.025	n/a	8.34	< Target Load
	Total Nitrogen	0.025	0.357	8.34	0.074

Notes:
+ Combined Flow = 4Q3 low-flow (0.624 MGD) + WWTP design capacity (0.144 MGD)
* Geometric mean of TP and TN exceedences (See Table 5.5 for data).
n/a Not Applicable because less than two exceedences

5.4 Waste Load Allocations and Load Allocations

5.4.1 Waste Load Allocation

The only existing point source along these assessment units is the NPDES-permitted WWTP owned and operated by the Village of Cuba (NM0024848). There are no individually permitted Municipal Separate Storm Sewer System (MS4) storm water permits in these assessment units.

Excess nutrient levels may be a component of some (primarily construction) storm water discharges so these discharges should be addressed. In contrast to discharges from other industrial storm water and individual process wastewater permitted facilities, storm water discharges from construction activities are transient because they occur mainly during the construction itself, and then only during storm events. Coverage under the NPDES construction general storm water permit (CGP) requires preparation of a Storm Water Pollution Prevention Plan (SWPPP) that includes identification and control of all pollutants associated with the construction activities to minimize impacts to water quality. In addition, the current CGP also includes state specific requirements to implement BMPs that are designed to prevent to the maximum extent practicable, an increase in sediment, or a parameter that addresses sediment (e.g., total suspended solids, turbidity, siltation, stream bottom deposits, etc.) and flow velocity during and after construction compared to preconstruction conditions. In this case, compliance with a SWPPP that meets the requirements of the CGP is generally assumed to be consistent with this TMDL.

Other industrial storm water facilities are generally covered under the current NPDES Multi-Sector General Storm Water Permit (MSGP). This permit also requires preparation of an SWPPP that includes identification and control of all pollutants associated with the industrial activities to minimize impacts to water quality. In addition, the current MSGP also includes state specific requirements to further limit (or eliminate) pollutant loading to water quality impaired/water quality limited waters from facilities where there is a reasonable potential to contain pollutants for which the receiving water is impaired. In this case, compliance with a SWPPP that meets the requirements of the MSGP is generally assumed to be consistent with this TMDL.

Therefore, this TMDL does not include a specific WLA for storm water discharges for these assessment units. However, because the Village of Cuba owns and operates an NPDES-permitted wastewater treatment plant a WLA for the WWTP is included in this TMDL.

A simple mixing model was used to calculate the WLA for NM0024848. Effluent limitations for TP and TN were calculated using the following equation:

$$C_e = \frac{C_s(Q_a + Q_e) - C_a Q_a}{Q_e}$$

where C_e = allowable WWTP effluent concentration (mg/L)

C_s = target concentration (mg/L)
C_a = average concentration of non-exceedence values at Hwy 550 Bridge (mg/L)
Q_e = design capacity of WWTP (million gallons per day)
Q_a = critical 4Q3 low-flow of stream (million gallons per day)

The equation is based on a simple steady-state mass balance model. The target threshold value and ambient upstream concentrations used to calculate the annual effluent limitation are 0.09 and 0.025 mg/L, respectively for TP and 0.48 and 0.33 mg/L, respectively for TN. The data that were used to calculate the ambient upstream concentration (C_a) are found in Table 5.5. The results of this mixing calculation for the Rio Puerco are presented in Table 5.7.

Table 5.7 Effluent concentrations and WLAs to meet WQS in the Rio Puerco

Parameter	Q_a (MGD)	Q_e (MGD)	C_s (mg/L)	C_a (mg/L)	C_e (mg/L)	WLA (lbs/day)
Total Phosphorus	0.624	0.144	0.09	0.025	0.372	0.447
Total Nitrogen	0.624	0.144	0.48	0.33	1.13	1.36

NOTES: Q_a = critical 4Q3 low-flow of stream (MGD)
Q_e = design capacity of Cuba WWTP (MGD)
C_s = target concentration (mg/L)
C_a = average concentration of non-exceedence values at Hwy 550 Bridge (mg/L)
C_e = allowable WWTP effluent concentration (mg/L)
WLA = Waste Load Allocation (lbs/day) = C_e x Q_e x 8.34

Current loading from the WWTP was estimated from seven grab samples collected by SWQB staff during 2004. The TP and TN concentrations measured at the WWTP outfall pipe averaged 3.64 and 24.5 mg/L, respectively. Assuming that discharge was at current design capacity (0.144 MGD), the current phosphorus loading from the plant into the Rio Puerco is 4.37 lbs/day and the current nitrogen loading from the plant into the Rio Puerco is 29.4 lbs/day. The current phosphorus loading from the WWTP is approximately 9 times the level that it should be to maintain the chemical and biological integrity of the stream. Similarly, the nitrogen loading is approximately 22 times the appropriate level.

Implementation suggestions for the WLA are included in Section 8.1

5.4.2 Load Allocation

In order to calculate the LAs for phosphorus and nitrogen, the WLAs and MOSs were subtracted from the target capacity (TMDL) using the following equation:

$$WLA + LA + MOS = TMDL \qquad \textbf{(Eq.2)}$$

The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors in flow calculations. Results using an explicit MOS of 15% (see Section 5.7 for details) are presented in Table 5.8.

Table 5.8. Calculation of Annual TMDL for TP and TN

Assessment Unit	Parameter	WLA (lbs/day)	LA (lbs/day)	MOS (15%) (lbs/day)	TMDL (lbs/day)
Rio Puerco (Arroyo Chijuilla to northern bnd of Cuba)	TP	0.447	0.043	0.087	0.577
	TN	1.357	1.256	0.461	3.074
Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir)	TP	0	0.029	0.005	0.034
	TN	0	0.205	0.036	0.241
Bluewater Creek (Bluewater Reservoir to headwaters)	TP	0	0.0008	0.0002	0.001
	TN	0	0.013	0.002	0.015
Rio Moquino (Laguna Pueblo to Seboyetita Creek)	TP	0	0.0034	0.0006	0.004
	TN	0	0.044	0.008	0.052

The load reductions that would be necessary to meet the target loads were calculated to be the difference between the calculated target load allocation (Table 5.4) and the measured load (Table 5.6), and are shown in Table 5.9.

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 Puerco (Arroyo Chijuilla to northern bnd of Cuba)	TP	0.490	4.855	4.365	90%
	TN	2.613	19.63	17.02	87%
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%
Bluewater Creek (Bluewater Reservoir to headwaters)	TP	0.0008	0.002	0.0012	60%
	TN	0.013	0.022	0.009	41%
Rio Moquino (Laguna Pueblo to Seboyetita Creek)	TP	0.0034	< Target Load	0	0%
	TN	0.044	0.074	0.030	41%

Note: The MOS is not included in the load reduction calculations because it is a set aside value which accounts for any uncertainty or variability in TMDL calculations and therefore should not be subtracted from the measured load.
(a) Target Load = TMDL - MOS
(b) Percent reduction is the percent the existing measured load must be reduced to achieve the target load, and is calculated as follows: (Measured Load – Target Load) / Measured Load x 100.

5.5 Identification and Description of Pollutant Sources

Probable sources of impairment for TP that could contribute to these assessment units are listed in Table 5.10. Probable sources of impairment for TN are listed in Table 5.11.

Table 5.10 Pollutant Source Summary for Total Phosphorus

Assessment Unit	Pollutant Sources	Magnitude (lbs/day)	Probable Sources* (% from each)
Rio Puerco (Arroyo Chijuilla to northern bnd of Cuba)	Point: NM0024848	4.37[a]	60% Municipal Point Source Discharge
	Nonpoint:	2.94[b]	40% Channelization; Drought-related Impacts; Highway/Road/Bridge Runoff (non-construction related); Loss of Riparian Habitat; Natural Sources; Rangeland Grazing; Streambank Modifications/destabilization; Wildlife other than Waterfowl
Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir)	Point:	0	0%
	Nonpoint:	0.029	100% Loss of Riparian Habitat; Rangeland Grazing; Streambank Modifications/destabilization
Bluewater Creek (Bluewater Reservoir to headwaters)	Point:	0	0%
	Nonpoint:	0.002	100% Forest Roads (Road Construction and Use); Loss of Riparian Habitat; Rangeland Grazing; Silviculture Harvesting; Streambank Modifications/destabilization
Rio Moquino (Laguna Pueblo to Seboyetita Creek)	Point:	0	0%
	Nonpoint:	0.0034	100% Loss of Riparian Habitat; Rangeland Grazing; Surface Mining

Notes:

[a] The magnitude for point sources was calculated by multiplying the average TP concentration from the WWTP outfall pipe (3.64 mg/L) by the WWTP design capacity (0.144 MGD) and the 8.34 conversion factor to get a result in lbs/day.

[b] The magnitude for nonpoint sources was calculated by multiplying the geometric mean of TP exceedences above the WWTP (0.565 mg/L) by the 4Q3 low-flow (0.624 MGD) and the 8.34 conversion factor to get a result in lbs/day.

* From the 2006-2008 Integrated CWA §303(d)/§305(b) List. This list of probable sources is based on staff observation and known land use activities in the watershed. These sources are not confirmed or quantified at this time.

Table 5.11 Pollutant Source Summary for Total Nitrogen

Assessment Unit	Pollutant Sources	Magnitude (lbs/day)	Probable Sources* (% from each)
Rio Puerco (Arroyo Chijuilla to northern bnd of Cuba)	Point: NM0024848	29.4[a]	74% Municipal Point Source Discharge
	Nonpoint:	10.4[b]	26% Channelization; Drought-related Impacts; Highway/Road/Bridge Runoff (non-construction related); Loss of Riparian Habitat; Natural Sources; Rangeland Grazing; Streambank Modifications/destabilization; Wildlife other than Waterfowl
Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir)	Point:	0	0%
	Nonpoint:	0.375	100% Loss of Riparian Habitat; Rangeland Grazing; Streambank Modifications/destabilization
Bluewater Creek (Bluewater Reservoir to headwaters)	Point:	0	0%
	Nonpoint:	0.022	100% Forest Roads (Road Construction and Use); Loss of Riparian Habitat; Rangeland Grazing; Silviculture Harvesting; Streambank Modifications/destabilization
Rio Moquino (Laguna Pueblo to Seboyetita Creek)	Point:	0	0%
	Nonpoint:	0.074	100% Loss of Riparian Habitat; Rangeland Grazing; Surface Mining

Notes:

[a] The magnitude for point sources was calculated by multiplying the average TN concentration from the WWTP outfall pipe (24.5 mg/L) by the WWTP design capacity (0.144 MGD) and the 8.34 conversion factor to get a result in lbs/day.

[b] The magnitude for nonpoint sources was calculated by multiplying the geometric mean of TN exceedences above the WWTP (1.996 mg/L) by the 4Q3 low-flow (0.624 MGD) and the 8.34 conversion factor to get a result in lbs/day.

* From the 2006-2008 Integrated CWA §303(d)/§305(b) List. This list of probable sources is based on staff observation and known land use activities in the watershed. These sources are not confirmed or quantified at this time.

5.6 Linkage Between Water Quality and Pollutant Sources

The source assessment phase of TMDL development identifies sources of nutrients that may contribute to both elevated nutrient concentrations and the stimulation of algal growth in a waterbody. Where data gaps exist or the level of uncertainty in the characterization of sources is large, the recommended approach to TMDL assignments requires the development of allocations based on estimates utilizing the best available information.

Phosphorus and nitrogen generally drive the productivity of algae and macrophytes in aquatic ecosystems, therefore they are regarded as the primary limiting nutrients in freshwaters. The main reservoirs of natural phosphorus are rocks and natural phosphate deposits. Weathering, leaching, and erosion are all processes that breakdown rock and mineral deposits allowing phosphorus to be transported to aquatic systems via water or wind. The breakdown of mineral phosphorus produces inorganic phosphate ions ($H_2PO_4^-$, HPO_4^{2-}, and PO_4^{3-}) that can be absorbed by plants from soil or water (USEPA 1999). Phosphorus primarily moves through the food web as organic phosphorus (after it has been incorporated into plant or algal tissue) where it may be released as phosphate in urine or other waste by heterotrophic consumers and reabsorbed by plants or algae to start another cycle (Nebel and Wright 2000).

The largest reservoir of nitrogen is the atmosphere. About 80 percent of the atmosphere by volume consists of nitrogen gas (N_2). Although nitrogen is plentiful in the environment, it is not readily available for biological uptake. Nitrogen gas must be converted to other forms, such as ammonia (NH_3 and NH_4^+), nitrate (NO_3^-), or nitrite (NO_2^-) before plants and animals can use it. Conversion of gaseous nitrogen into usable mineral forms occurs through three biologically mediated processes of the nitrogen cycle: nitrogen fixation, nitrification, and ammonification (USEPA 1999). Mineral forms of nitrogen can be taken up by plants and algae and incorporated into plant or algal tissue. Nitrogen follows the same pattern of food web incorporation as phosphorus and is released in waste primarily as ammonium compounds. The ammonium compounds are usually converted to nitrates by nitrifying bacteria, making it available again for uptake, starting the cycle anew (Nebel and Wright 2000).

Rain, overland runoff, groundwater, drainage networks, and industrial and residential waste effluents transport nutrients to receiving waterbodies. Once nutrients have been transported into a waterbody they can be taken up by algae, macrophytes, and microorganisms either in the water column or in the benthos; they can sorb to organic or inorganic particles in the water column and/or sediment; they can accumulate or be recycled in the sediment; or they can be transformed and released as a gas from the waterbody (Figure 5.1).

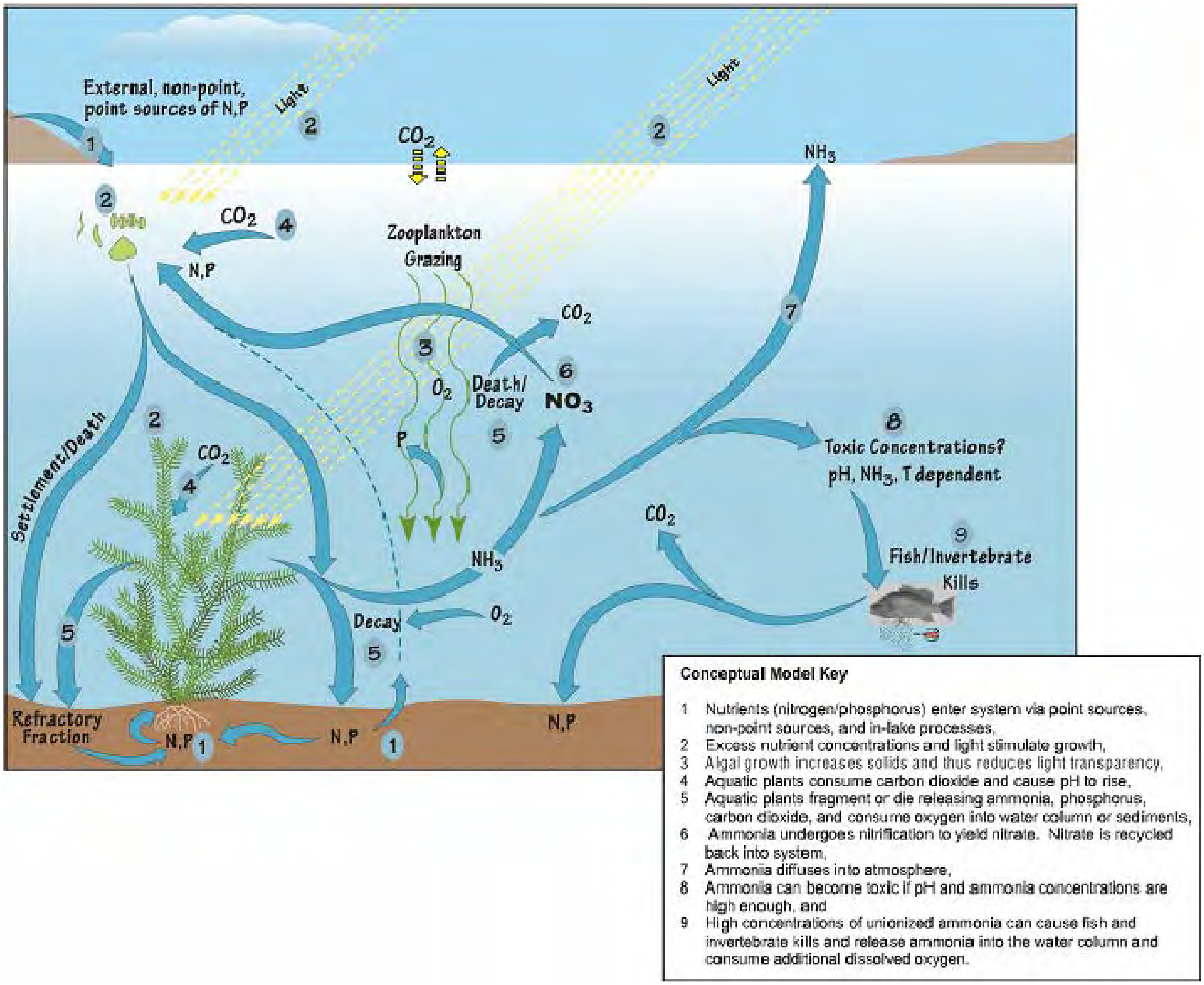


Figure 5.1. Nutrient Conceptual Model (USEPA 1999)

As noted above, phosphorus and nitrogen are essential for proper functioning of ecosystems. However, excess nutrients cause conditions unfavorable for the proper functioning of aquatic ecosystems. Nuisance levels of algae and other aquatic vegetation (macrophytes) can develop rapidly in response to nutrient enrichment when other factors (e.g., light, temperature, substrate, etc.) are not limiting (Figure 5.1). The relationship between nuisance algal growth and nutrient enrichment in stream systems has been well documented in the literature (Welch 1992; Van Nieuwenhuyse and Jones 1996; Dodds et al. 1997; Chetelat et al. 1999). Unfortunately, the magnitude of nutrient concentration that constitutes an "excess" is difficult to determine and varies by ecoregion.

As described in Section 5.2, the presence of plant nutrients in a stream can vary as a function of flow. As flow decreases through water diversions and/or drought-related stressors, the stream cannot effectively dilute its constituents, which causes the concentration of plant nutrients to increase. Nutrients generally reach the a waterbody from land uses that are in close proximity to the stream because the hydrological pathways are shorter and have fewer obstacles than land uses located away from the riparian corridor. However, during the growing season (i.e. in agricultural return flow) and in storm water runoff, distant land uses can become hydrologically connected to the stream, thus transporting nutrients from the hillslopes to the stream during these time periods.

In addition to agriculture, there are several other human-related activities that influence nutrient concentrations in rivers and streams. Residential areas contribute nutrients from septic tank disposal systems, landscape maintenance, as well as backyard livestock (e.g. cattle, horses) and pet wastes. Urban development contributes nutrients by disturbing the land and consequently increasing soil erosion, by increasing the impervious area within the watershed, and by directly applying nutrients to the landscape. Recreational activities such as hiking and biking can also contribute nutrients to the stream by reducing plant cover and increasing soil erosion (e.g. trail network, streambank destabilization), direct application of human waste, campfires and/or wildfires, and dumping trash near the riparian corridor.

Undeveloped, or natural, landscapes also can deliver nutrients to a waterbody through decaying plant material, soil erosion, air deposition, and wild animal waste. Another geographically occurring nutrient source is atmospheric deposition, which adds nutrients directly to the waterbody through dryfall and rainfall. Atmospheric phosphorus and nitrogen can be found in both organic and inorganic particles, such as pollen and dust. The contributions from these natural sources are generally considered to represent background levels.

Water pollution caused by on-site septic systems is a widespread problem in New Mexico (McQuillan 2004). Septic system effluents have contaminated more water supply wells, and more acre-feet of ground water, than all other sources in the state combined. Groundwater contaminated by septic system effluent can discharge into streams gaining from groundwater inflow. Nutrients such as phosphorous and nitrogen released into gaining streams from aquifers contaminated by septic systems can contribute to eutrophic conditions.

SWQB fieldwork includes an assessment of the probable sources of impairment (NMED/SWQB 1999). The completed Pollutant Source(s) Documentation Protocol forms in Appendix A provide documentation of a visual analysis of probable sources along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of probable sources of impairment in this watershed. Data collected during the 2004 survey showed exceedences both above and below the wastewater treatment plant indicating the nutrient problem in the Rio Puerco is attributable to both point and nonpoint sources.

It is important to consider not only the land directly adjacent to the stream, which is predominantly privately held, but also to consider upland and upstream areas in a more holistic watershed approach to implementing TMDLs. These nutrient TMDLs were calculated using the best available methods that were known at the time of calculation and may be revised in the future.

5.7 Margin of Safety (MOS)

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. The MOS can be expressed either implicitly or explicitly. An implicit MOS is incorporated by making conservative assumptions in the TMDL analysis, such as allocating a conservative load to background sources. An explicit MOS is applied by reserving a portion of the TMDL and not allocating it to any other sources.

For these nutrient TMDLs, the margin of safety was developed using a combination of conservative assumptions and explicit recognition of potential errors. Therefore, this margin of safety is the sum of the following two elements:

- *Conservative Assumptions*

    Treating phosphorus and nitrogen as conservative pollutants, that is a pollutant that does not readily degrade in the environment, was used as a conservative assumption in developing these loading limits.

    Using the 4Q3 critical low flow to calculate the allowable load.

    Using the treatment plant design capacity for calculating the point source loading when, under most conditions, the treatment plant is not operating at full capacity.

- *Explicit recognition of potential errors*

    A level of uncertainty exists in sampling nonpoint sources of pollution. Accordingly, a conservative MOS decreases the TMDL by **10 percent**.

    Flow estimates were based on the estimation of the 4Q3 for gaged and ungaged streams and compared to actual flows and cross-sectional information taken in the field. Techniques used for measuring flow in water have a ±5 percent precision. Accordingly, a conservative MOS decreases the TMDL by **5 percent**.

5.8 Consideration of Seasonal Variability

Section 303(d)(1) of the CWA requires TMDLs to be "established at a level necessary to implement the applicable WQS with seasonal variation." Data used in the calculation of these TMDLs were collected during spring, summer, and fall in order to ensure coverage of any potential seasonal variation in the system. Exceedences were observed from March through November, during all seasons, which captured flow alterations related to snowmelt, agricultural diversions, and summer monsoonal rains. Data that exceeded the target concentration for TP and TN were used in the calculation of the measured loads (Table 5.6) and can be found in Table 5.5.

The critical condition used for calculating the TMDL was low-flow. Calculations made at the critical low-flow (4Q3), in addition to using other conservative assumptions as described in the previous section on MOS, should be protective of the water quality standards designed to preserve aquatic life in the stream. It was assumed that if critical conditions were met during this time, coverage of any potential seasonal variation would also be met.

5.9 Future Growth

Growth estimates by county are available from the New Mexico Bureau of Business and Economic Research. These estimates project growth to the year 2030. Growth estimates for Cibola and Sandoval Counties project a 16% and 77% growth rate, respectively, through 2030. Since future projections indicate that nonpoint sources of nutrients will more than likely increase as the region continues to grow and develop, it is imperative that BMPs continue to be utilized and improved upon in this watershed while continuing to improve road conditions and grazing allotments and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

6.0 TEMPERATURE

Monitoring for temperature was conducted by SWQB in 2004 and 2006. Based on available data, several exceedences of the New Mexico WQS for temperature were noted throughout the watershed (Figures 6.1-6.2). Thermographs were set to record once every hour for several months during the warmest time of the year (generally May through October). Thermograph data are assessed using Appendix C of the *State of New Mexico Procedures for Assessing Standards Attainment for the Integrated CWA §303(d)/§305(b) Water Quality Monitoring and Assessment Report* (NMED/SWQB 2006b). Based on 2004 and 2006 data, a new temperature listing was added to the *2006-2008 State of NM §303(d) List for Impaired Waters* (NMED/SWQB 2007) for Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir) and temperature listings were retained for Bluewater Creek (Bluewater Reservoir to headwaters) and Rio Moquino (Laguna Pueblo to Seboyeta Creek). Temperature data from 2004 and 2006 were used to develop these TMDLs.

6.1 Target Loading Capacity

Target values for these temperature TMDLs will be determined based on 1) the presence of numeric criteria, 2) the degree of experience in applying the indicator, and 3) the ability to easily monitor and produce quantifiable and reproducible results. For this TMDL document, target values for temperature are based on the reduction in solar radiation necessary to achieve numeric criteria as predicted by a temperature model. This TMDL is also consistent with New Mexico's antidegradation policy.

The State of New Mexico has developed and adopted numeric water quality criteria for temperature to protect the designated use of coldwater aquatic life (CWAL) (Subsection H of 20.6.4.900 NMAC). These WQS have been set at a level to protect coldwater aquatic life such as trout. The CWAL use designation requires that a stream reach must have water quality, streambed characteristics, and other attributes of habitat sufficient to protect and maintain a propagating coldwater fishery (i.e., a population of reproducing salmonids). The standard leading to an assessment of use impairment is the numeric criterion for temperature of 20°C (68°F). Table 6.1 and Figure 6.1 highlight the 2004 and 2006 thermograph deployments. The following TMDLs address three reaches where temperatures exceeded the criterion (**Appendix C** of this document provides a graphical representation of thermograph data):

> *Bluewater Creek (Bluewater Reservoir to headwaters):* One thermograph was deployed on this reach in 2004 at Bluewater Creek above Bluewater Lake at USGS gage 0841300 (site B). Recorded temperatures from June 10 through December 8 exceeded the CWAL use criterion 656 of 4,352 times (15%) with a maximum temperature of 27.86°C on July 13 at 17:00.
>
> *Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir):* One thermograph was deployed on this reach in 2004 at Bluewater Creek at mouth of Bluewater Canyon (site C). Recorded temperatures from June 10 through December 8 exceeded the CWAL use criterion 582 of 4,353 times (13%) with a maximum temperature of 26.26°C on July 16.

Rio Moquino (Laguna Pueblo to Seboyettia Creek): One thermograph was deployed on this reach in 2006 at Rio Moquino below confl of Seboyetita Creek and Seboyeta Creek (site F). Recorded temperatures from August 23 through September 20 exceeded the CWAL use criterion 196 of 670 times (29%) with a maximum temperature of 28.84°C on August 31.

Table 6.1 Rio Puerco and Rio San Jose Thermograph Sites

Site Number	Site Name	Deployment Dates
A	Arroyo San Jose @ Hwy 550	6/3/2004-12/6/2004
B	Bluewater Creek abv Bluewater Lake at USGS gage 0841300[1]	6/10/2004-12/8/2004
C	Bluewater Creek at mouth of Bluewater Canyon[1]	6/10/2004-12/8/2004
D	La Jara Creek abv irrigation diversion[1]	6/3/2004-12/6/2004
E	Nacimiento Creek @ Hwy 126	6/3/2004-12/6/204
F	Rio Moquino below confl of Seboyetitia Creek and Seboyeta Creek[1]	8/23/2006-9/20/2006
G	Rio Puerco @ CR 13	6/3/2004-12/6/2004
H	Rio Puerco @ Hwy 550 bridge[1]	6/16/2004-12/6/2004
I	Rio Puerco abv La Ventana Restoration Project[1]	6/3/2004-12/6/2004
J	Rio Puerco blw WWTP[1]	3/7/2006-9/20/2006
K	Rito de los Pinos @ USFS gate on FR 95	6/3/2004-12/6/2004
L	Senorito Creek abv Nacimiento Mine[1]	6/3/2004-12/6/2004

[1] *Air thermograph also deployed*

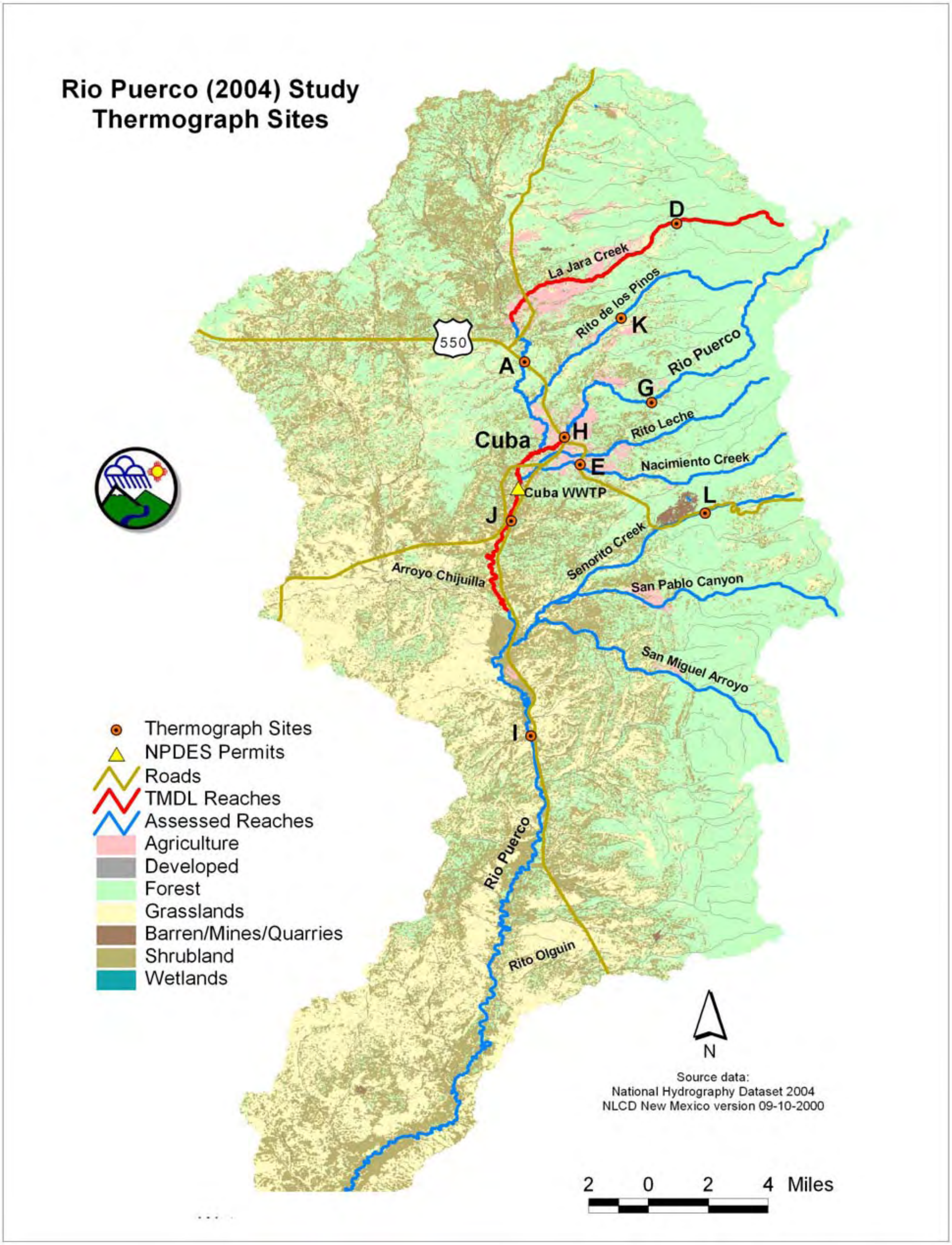


Figure 6.1 Rio Puerco thermograph sites

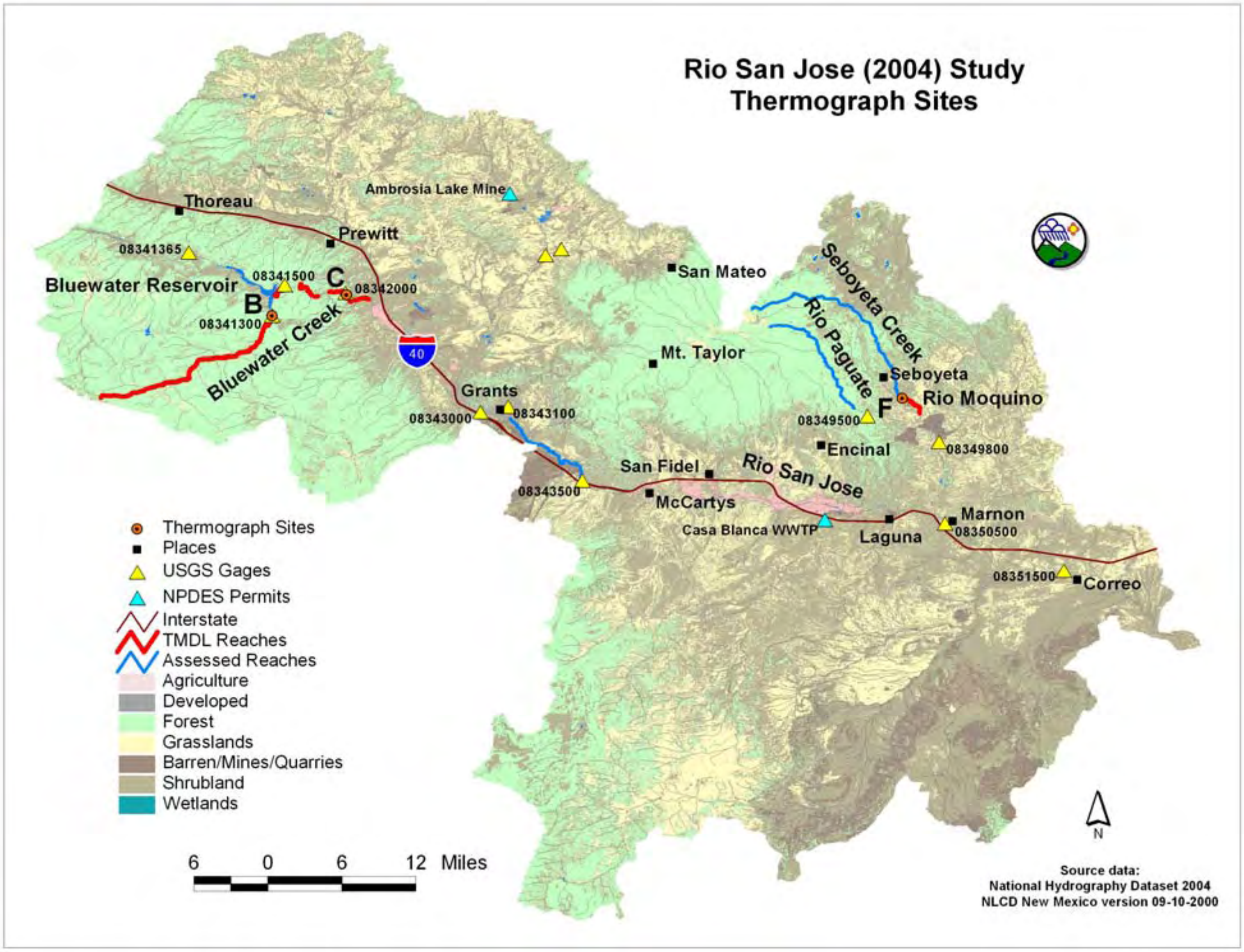


Figure 6.2 Rio San Jose thermograph sites

6.2 Calculations

The Stream Segment Temperature (SSTEMP) Model, Version 2.0 (Bartholow 2002) was used to predict stream temperatures based on watershed geometry, hydrology, and meteorology. The USGS Biological Resource Division developed this model (Bartholow 2002). The model predicts mean, minimum, and maximum daily water temperatures throughout a stream reach by estimating the heat gained or lost from a parcel of water as it passes through a stream segment (Bartholow 2002). The predicted temperature values are compared to actual thermograph readings measured in the field in order to calibrate the model. The SSTEMP model identifies current stream and/or watershed characteristics that control stream temperatures. The model also quantifies the maximum loading capacity of the stream to meet water quality criteria for temperature. This model is important for estimating the effect of changing controls, or constraints, (such as riparian grazing, stream channel alteration, and reduced streamflow) on stream temperature. The model can also be used to help identify possible implementation activities to improve stream temperature by targeting those factors causing impairment to the stream.

6.3 Waste Load Allocations and Load Allocations

6.3.1 Waste Load Allocation

There are no permitted point source contributions associated with these TMDLs.

6.3.2 Load Allocation

Water temperature can be expressed as heat energy per unit volume. SSTEMP provides a daily estimate of heat energy expressed in joules per square meter per second ($j/m^2/s$). Please refer to the SSTEMP User's Manual for complete text relevant to the model runs used to determine temperature TMDLs taken from the SSTEMP documentation (Bartholow 2002). Appendix D details the specific data used in the model as well as the sources of the data.

The program will predict the minimum, mean, and maximum daily water temperature for the set of variables you provide. The theoretical basis for the model is strongest for the mean daily temperature. The maximum is largely an estimate and likely to vary widely with the maximum daily air temperature. The minimum is computed by subtracting the difference between maximum and mean from the mean; but the minimum is always positive. (Bartholow 2002).

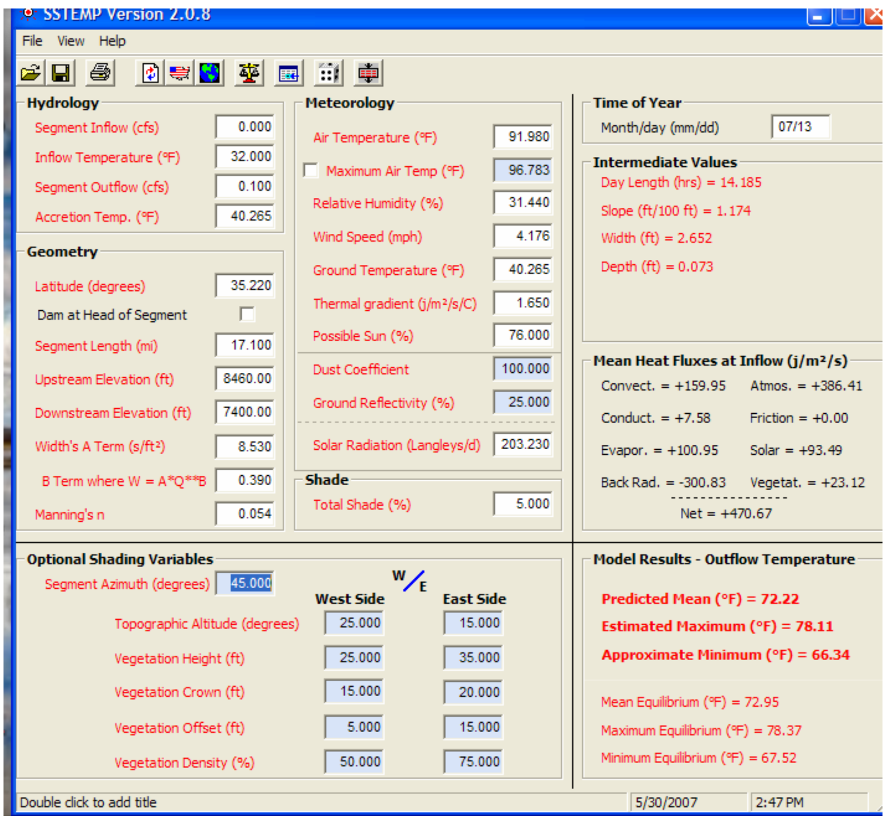


Figure 6.3 Example of SSTEMP input and output for Bluewater Creek (NM-2107.A_01)

SSTEMP may be used to compute a one-at-a-time sensitivity of a set of input values. This simply increases and decreases most active input (i.e., non-grayed out values) by 10% and displays a screen for changes to mean and maximum temperatures. The schematic graph that accompanies the display gives an indication of which variables most strongly influence the results. (Bartholow 2002). See Figure 6.4 for an example of a sensitivity analysis.

6.3.2.1 Temperature Allocations as Determined by % Total Shade and Width-to-Depth Ratios

Table 6.2 details model run outputs for segments on Bluewater Creek and Rio Moquino. SSTEMP was first calibrated against thermograph data to determine the standard error of the model. Initial conditions were determined. As the percent total shade was increased and the Width's A term was decreased, the maximum 24-hour temperature decreased until the segment-specific standard of 20ºC was achieved. The calculated 24-hour solar radiation component is the maximum solar load that can occur in order to meet the WQS (i.e., the target capacity). In order to calculate the actual LA, the WLA and MOS were subtracted from the target capacity (TMDL) following **Equation 2**.

$$WLA + LA + MOS = TMDL \qquad \text{(Eq. 2)}$$

The allocations for each assessment unit requiring a temperature TMDL are provided in the following tables.

Temperature Load Allocation for Bluewater Creek (Bluewater Reservoir to headwaters)
For Bluewater Creek (Bluewater Reservoir to headwaters), the WQS for temperature is achieved when the percent total shade is increased to 72%. According to the SSTEMP model, the actual LA of 24.80 $j/m^2/s$ is achieved when the shade is further increased to 75.5% (Table 6.2).

Table 6.2 SSTEMP Model Results for Bluewater Creek (Bluewater Reservoir to headwaters),

Rosgen Channel Type	WQS (HQCW Aquatic Life)	Model Run Dates	Segment Length (miles)	Solar Radiation Component per 24-Hours (+/-)	% Total Shade	Width's A Term	Modeled Temperature °C (24 hour)
n/a	20°C (68°F)	7/13/04	17.1	**Current Field Condition** +93.49 $j/m^2/s$	5	8.53	Minimum: 15.62 Mean: 19.01 Maximum: 22.41
TEMPERATURE ALLOCATIONS FOR Bluewater Creek (Bluewater Reservoir to headwaters) [a] **24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE** [b] 24-HOUR LOAD ALLOCATION (LA) NEEDED TO ACHIEVE SURFACE WQS WITH A 10% MARGIN OF SAFETY Actual reduction in solar radiation necessary to meet surface WQS for temperature: Current Condition – Load Allocation = 93.49 $j/m^2/s$ – 24.80 $j/m^2/s$ **=68.69 $j/m^2/s$**				**Run 1** +73.81 $j/m^2/s$	25	8.53	Minimum: 15.79 Mean: 18.75 Maximum: 21.71
				Run 2 +27.56 [a] $j/m^2/s$	72	8.53	Minimum: 16.25 Mean: 18.13 Maximum: 20.00
				Actual LA 24.80 [b] $j/m^2/s$	75.5	8.53	Minimum: 16.29 Mean: 18.08 Maximum: 19.87

Temperature Load Allocation for Bluewater Creek (non-tribal Rio San Jose to Bluwater Rsrv)

For Bluewater Creek (non-tribal Rio San Jose to Bluwater Rsrv), the WQS for temperature is achieved when the percent total shade is increased to 14%. According to the SSTEMP model, the actual LA of 85.89 $j/m^2/s$ is achieved when the shade is further increased to 23% (Table 6.3).

Table 6.3 SSTEMP Model Results for Bluewater Creek (non-tribal Rio San Jose to Bluwater Rsrv)

<table>
<tr><th>Rosgen Channel Type</th><th>WQS (HQCW Aquatic Life)</th><th>Model Run Dates</th><th>Segment Length (miles)</th><th>Solar Radiation Component per 24-Hours (+/-)</th><th>% Total Shade</th><th>Width's A Term</th><th>Modeled Temperature °C (24 hour)</th></tr>
<tr><td>n/a</td><td>20°C (68°F)</td><td>7/16/04</td><td>2.4</td><td>Current Field Condition
+102.09 $j/m^2/s$</td><td>8</td><td>6.56</td><td>Minimum: 11.76
Mean: 16.02
Maximum: 20.29</td></tr>
<tr><td colspan="4" rowspan="3">TEMPERATURE ALLOCATIONS FOR Bluewater Creek (non-tribal Rio San Jose to Bluwater Rsrv

[a] 24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE

[b] 24-HOUR LOAD ALLOCATION (LA) NEEDED TO ACHIEVE SURFACE WQS WITH A 10% MARGIN OF SAFETY

Actual reduction in solar radiation necessary to meet surface WQS for temperature:

Current Condition – Load Allocation =

102.09 $j/m^2/s$ – 85.89 $j/m^2/s$

=16.2 $j/m^2/s$</td><td>Run 1
+99.87
$j/m^2/s$</td><td>10</td><td>6.56</td><td>Minimum: 11.78
Mean: 15.99
Maximum: 20.19</td></tr>
<tr><td>Run 2
+95.43 [a]
$j/m^2/s$</td><td>14</td><td>6.56</td><td>Minimum: 11.82
Mean: 15.91
Maximum: 20.00</td></tr>
<tr><td>Actual LA
85.89 [b]
$j/m^2/s$</td><td>23</td><td>6.56</td><td>Minimum: 11.91
Mean: 15.74
Maximum: 19.57</td></tr>
</table>

Temperature Load Allocation for Rio Moquino (Laguna Pueblo to Seboyettia Creek)

For Rio Moquino (Laguna Pueblo to Seboyettia Creek), the WQS for temperature is achieved when the percent total shade is increased to 40.5%. According to the SSTEMP model, the actual LA of 71.06 j/m^2/s is achieved when the shade is further increased to 46.5% (Table 6.4).

Table 6.4 SSTEMP Model Results for Rio Moquino (Laguna Pueblo to Seboyettia Creek)

<table>
<tr><th>Rosgen Channel Type</th><th>WQS (HQCW Aquatic Life)</th><th>Model Run Dates</th><th>Segment Length (miles)</th><th>Solar Radiation Component per 24-Hours (+/-)</th><th>% Total Shade</th><th>Width's A Term</th><th>Modeled Temperature °C (24 hour)</th></tr>
<tr><td>n/a</td><td>20°C (68°F)</td><td>8/31/06</td><td>3</td><td>Current Field Condition
+92.88 j/m^2/s</td><td>30</td><td>5.64</td><td>Minimum: 13.30
Mean: 16.98
Maximum: 20.64</td></tr>
<tr><td colspan="4" rowspan="3">TEMPERATURE ALLOCATIONS FOR
Rio Moquino (Laguna Pueblo to Seboyetita Creek)

(a) 24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE

(b) 24-HOUR LOAD ALLOCATION (LA) NEEDED TO ACHIEVE SURFACE WQS WITH A 10% MARGIN OF SAFETY

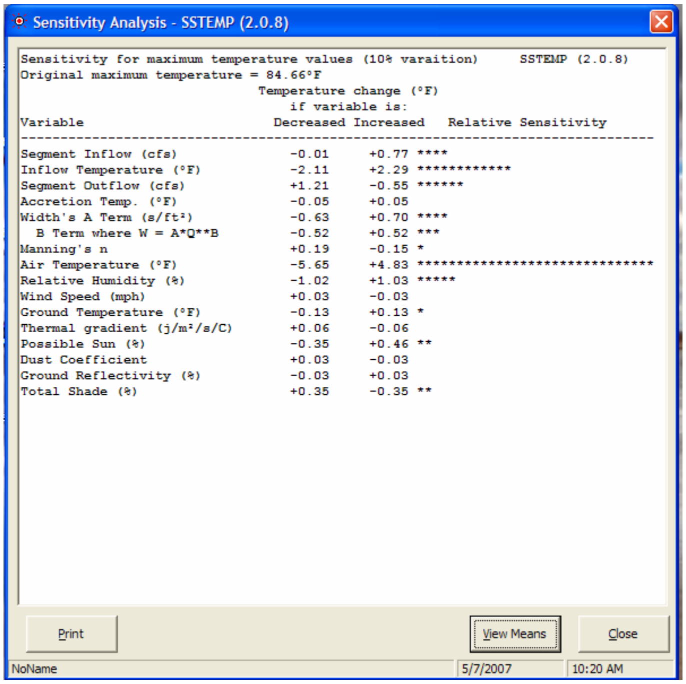
Actual reduction in solar radiation necessary to meet surface WQS for temperature:

Current Condition – Load Allocation =

92.88 j/m^2/s – 71.06 j/m^2/s

=21.82 j/m^2/s</td><td>Run 1
+86.24
j/m^2/s</td><td>35</td><td>5.64</td><td>Minimum: 13.38
Mean: 16.86
Maximum: 20.33</td></tr>
<tr><td>Run 2
+78.95 (a)
j/m^2/s</td><td>40.5</td><td>5.64</td><td>Minimum: 13.43
Mean: 16.72
Maximum: 20.00</td></tr>
<tr><td>Actual LA
71.06 (b)
j/m^2/s</td><td>46.5</td><td>5.64</td><td>Minimum: 13.48
Mean: 16.56
Maximum: 19.64</td></tr>
</table>

According to the Sensitivity Analysis feature of the model runs (Figure 6.4), mean daily air temperature and inflow temperature had the greatest influence on the predicted outflow temperatures. However, reducing Width's A term had an insignificant effect on the predicted maximum temperature. The relationship between air and water temperature can be seen in Figures 6.5 and 6.6. The figures display the air and water thermograph readings on the day with the highest recorded water temperature (as well as the day before and the day after) at sites in both an impaired (Figure 6.5) and unimpaired assessment unit (Figure 6.6). The impaired reach experienced diurnal swings of approximately 12ºC while the unimpaired reach only experienced a diurnal swing of less than 5ºC.



Sensitivity Analysis - SSTEMP (2.0.8)

Sensitivity for maximum temperature values (10% varaition)   SSTEMP (2.0.8)
Original maximum temperature = 84.66°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	-0.01	+0.77	****
Inflow Temperature (°F)	-2.11	+2.29	************
Segment Outflow (cfs)	+1.21	-0.55	******
Accretion Temp. (°F)	-0.05	+0.05	
Width's A Term (s/ft²)	-0.63	+0.70	****
B Term where W = A*Q**B	-0.52	+0.52	***
Manning's n	+0.19	-0.15	*
Air Temperature (°F)	-5.65	+4.83	******************************
Relative Humidity (%)	-1.02	+1.03	*****
Wind Speed (mph)	+0.03	-0.03	
Ground Temperature (°F)	-0.13	+0.13	*
Thermal gradient (j/m²/s/C)	+0.06	-0.06	
Possible Sun (%)	-0.35	+0.46	**
Dust Coefficient	+0.03	-0.03	
Ground Reflectivity (%)	-0.03	+0.03	
Total Shade (%)	+0.35	-0.35	**

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Figure 6.4 Example of SSTEMP sensitivity analysis for Rio Moquino

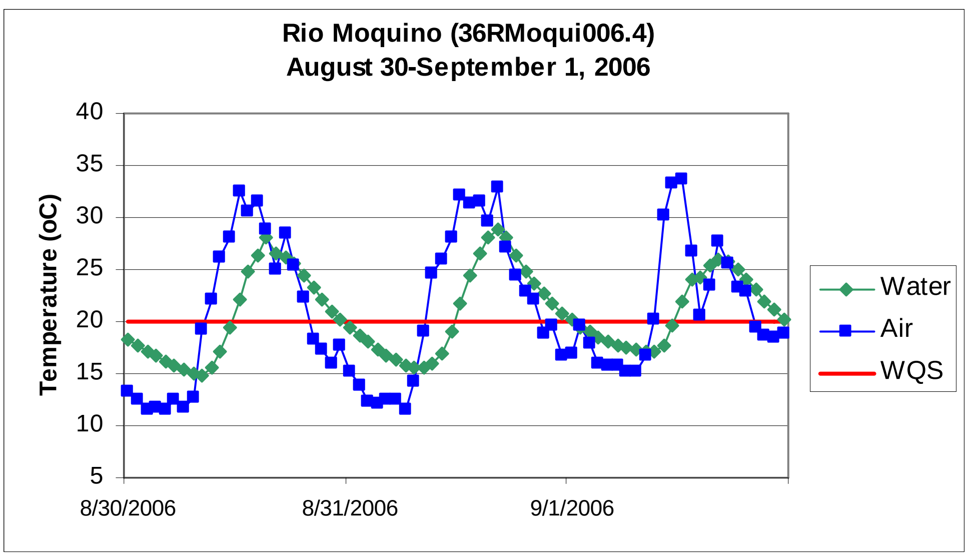

Figure 6.5 Air and water thermograph data for Rio Moquino

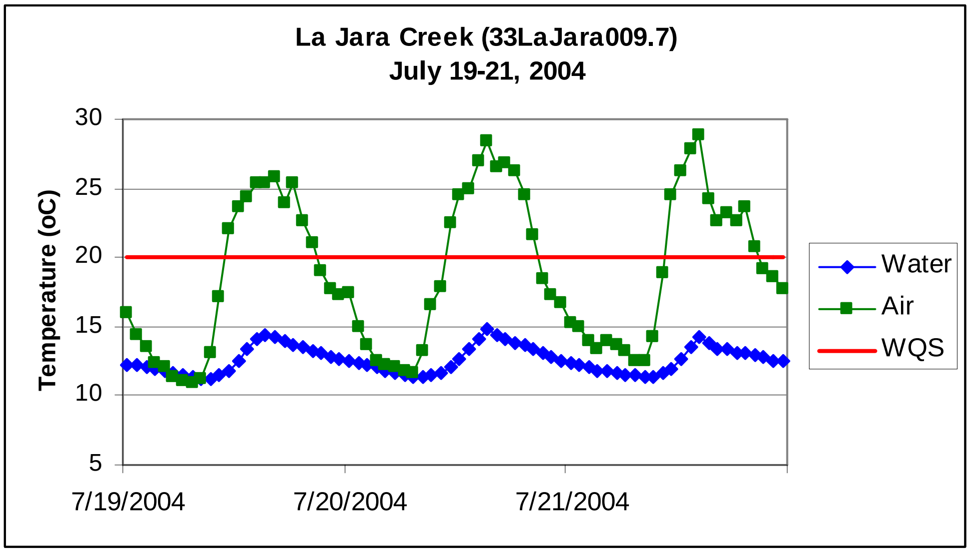

Figure 6.6 Air and water thermograph data for La Jara Creek

The estimate of total shade used in the model calibration was based on densiometer readings (field notes) (see **Appendix D**). Target loads as determined by the modeling runs are summarized in Tables 6.2-6.4. The MOS is estimated to be 10% of the target load calculated by the modeling runs. Results are summarized in Table 6.5. Additional details on the MOS are presented in Section 6.7 below.

Table 6.5 Calculation of TMDLs for Temperature

Assessment Unit	**WLA ($j/m^2/s$)**	**LA ($j/m^2/s$)**	**MOS (10%)[(a)] ($j/m^2/s$)**	**TMDL ($j/m^2/s$)**
Bluewater Creek (Bluewater Rsrv to headwaters)	0	24.8*	2.8*	27.6*
Bluewater Creek (non-tribal Rio San Jose to Bluewater Rsrv)	0	85.9*	9.54*	95.4*
Rio Moquino (Laguna Pueblo to Seboyettia Creek)	0	71.1*	7.8*	78.9*

Notes:
(a) Actual MOS values may be slightly greater than 10% because the final MOS is back calculated after the Total Shade value is increased enough to reduce the modeled solar radiation component to a value less than the target load minus 10%.
* Values rounded to three significant figures.

The load reductions that would be necessary to meet the target loads were calculated to be the difference between the calculated target load and the measured load (i.e., current field condition in Tables 6.2-6.4), and are shown in Table 6.6.

Table 6.6 Calculation of Load Reduction for Temperature

Location	Target Load[a] ($j/m^2/s$)	Measured Load ($j/m^2/s$)	Load Reduction ($j/m^2/s$)	Percent Reduction[b]
Bluewater Creek (Bluewater Rsrv to headwaters)	24.8*	93.5*	68.7*	73
Bluewater Creek (non-tribal Rio San Jose to Bluewater Rsrv)	85.9*	102*	16.1*	16
Rio Moquino (Laguna Pueblo to Seboyettia Creek)	71.1	92.9	21.8	23

Notes: The MOS is not included in the load reduction calculations because it is a set aside value which accounts for any uncertainty, or variability, in TMDL calculations and therefore should not be subtracted from the measured load.
(a) Target Load = LA + WLA
(b) Percent reduction is the percent the existing measured load must be reduced to achieve the target load, and is calculated as follows: (Measured Load – Target Load) / Measured Load x 100.
* Values rounded to three significant figures.

6.4 Identification and Description of pollutant source(s)

Pollutant sources that could contribute to each segment are listed in Table 6.7.

Table 6.7 Pollutant source summary for Temperature

Pollutant Sources	Magnitude[a]	Location	Potential Sources[b] (% from each)
Point:			
None	0	--------	0%
Nonpoint:			
	93.5	Bluewater Creek (Bluewater Rsrv to headwaters)	100% Forest Roads (Road Construction and Use) Loss of Riparian Habitat Rangeland Grazing Silviculture Harvesting Streambank Modifications/destabilization
	102	Bluewater Creek (non-tribal Rio San Jose to Bluewater Rsrv)	100% Loss of Riparian Habitat Rangeland Grazing Streambank Modifications/destabilization
	92.9	Rio Moquino (Laguna Pueblo to Seboyettia Creek)	100% Loss of Riparian Habitat Mine Tailings Rangeland Grazing Surface Mining

Notes:
(a) Measured Load as $j/m^2/s$. Expressed as solar radiation.
(b) From the 2006-2008 Integrated CWA §303(d)/305(b) list unless otherwise noted.

6.5 Linkage of Water Quality and Pollutant Sources

Water temperature influences the metabolism, behavior, and mortality of fish and other aquatic organisms. Natural temperatures of a waterbody fluctuate daily and seasonally. These natural fluctuations do not eliminate indigenous populations, but may affect existing community structure and geographical distribution of species. In fact, such temperature cycles are often necessary to induce reproductive cycles and may regulate other aspects of life history (Mount 1969). Behnke and Zarn (1976) in a discussion of temperature requirements for endangered western native trout recognized that populations cannot persist in waters where maximum temperatures consistently exceed 21-22°C, but they may survive brief daily periods of higher temperatures (25.5-26.7°C). Anthropogenic impacts can lead to modifications of these natural temperature cycles, often leading to deleterious impacts on the fishery. Such modifications may contribute to changes in geographical distribution of species and their ability to persist in the presence of introduced species. Of all the environmental factors affecting aquatic organisms in a waterbody, temperature is always a factor. Heat, which is a quantitative measure of energy of molecular motion that is dependent on the mass of an object or body of water is fundamentally different than temperature, which is a measure (unrelated to mass) of energy intensity. Organisms respond to temperature, not heat.

Temperature increases, as observed in SWQB thermograph data, show temperatures that exceed the State water quality criterion for the protection of aquatic habitat, namely the CWAL designated use. Through monitoring, and pollutant source documentation, it has been observed that the most probable causes for these temperature exceedences are removal of riparian vegetation, streambank modification, livestock grazing, and natural causes. Alterations can be historical or current in nature.

A variety of factors impact stream temperature (Figure 6.5). Decreased effective shade levels result from reduction of riparian vegetation. When canopy densities are compromised, thermal loading increases in response to the increase in incident solar radiation. Likewise, it is well documented that many past hydromodification activities have lead to channel widening. Wider stream channels also increase the stream surface area exposed to sunlight and heat transfer. Riparian area and channel morphology disturbances are attributed to past and to some extent current rangeland grazing practices that have resulted in reduction of riparian vegetation and streambank destabilization. These nonpoint sources of pollution primarily affect the water temperature through increased solar loading by: (1) increasing stream surface solar radiation and (2) increasing stream surface area exposed to solar radiation.

Riparian vegetation, stream morphology, hydrology, climate, geographic location, and aspect influence stream temperature. Although climate, geographic location, and aspect are outside of human control, the condition of the riparian area, channel morphology and hydrology can be affected by land use activities. Specifically, the elevated summertime stream temperatures attributable to anthropogenic causes in Bluewater Creek and Rio Moquino basins can result from the following conditions:

1. Channel widening (i.e., increased width to depth ratios) that has increased the stream surface area exposed to incident solar radiation,

2. Riparian vegetation disturbance that has reduced stream surface shading, riparian vegetation height and density, and

3. Reduced summertime base flows that result from instream withdrawals and/or inadequate riparian vegetation. Base flows are maintained with a functioning riparian system so that loss of a functioning riparian system may lower and sometimes eliminate baseflows. Although removal of upland vegetation has been shown to increase water yield, studies show that removal of riparian vegetation along the stream channel subjects the water surface and adjacent soil surfaces to wind and solar radiation, partially offsetting the reduction in transpiration with evaporation. In losing stream reaches, increased temperatures can result in increased streambed infiltration, which can result in lower base flow (Constantz et al. 1994).

Analyses presented in these TMDLs demonstrate that defined loading capacities will ensure attainment of New Mexico WQS. Specifically, the relationship between shade, channel dimensions, solar radiation, and water quality attainment was demonstrated. Vegetation density increases will provide necessary shading, as well as encourage bank-building processes in severe hydrologic events.

Where available data are incomplete or where the level of uncertainty in the characterization of sources is large, the recommended approach to TMDL assignments requires the development of allocations based on estimates utilizing the best available information.

SWQB fieldwork includes a determination of the potential sources of impairment (NMED/SWQB 1999). The completed Pollutant Source(s) Documentation Protocol forms in **Appendix A** provide documentation of a visual analysis of probable sources along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. Table 6.7 identifies probable sources of nonpoint source impairments along each reach as determined by field reconnaissance and assessment. It is important to consider not only the land directly adjacent to the stream, but also to consider upland and upstream areas in a more holistic watershed approach to implementing this TMDL.

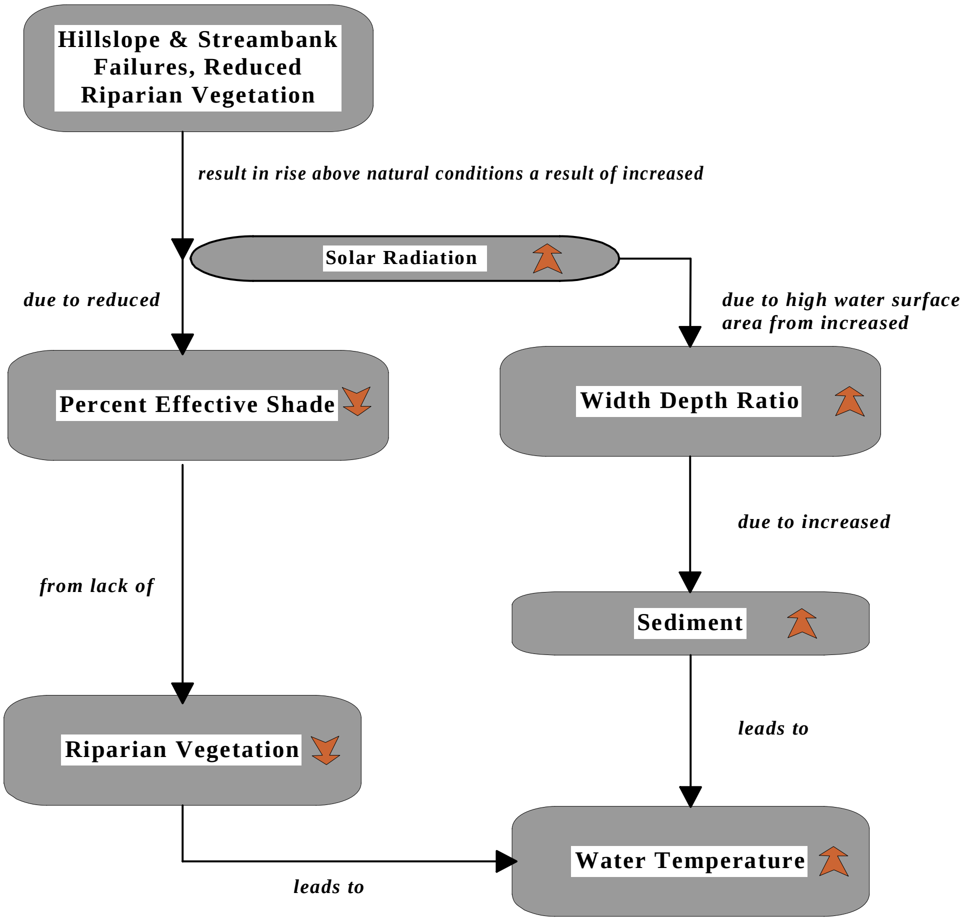

Figure 6.7 Factors That Impact Water Temperature

6.6 Margin of Safety (MOS)

The Federal CWA requires that each TMDL be calculated with a MOS. This statutory requirement that TMDLs incorporate a MOS is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A MOS may be expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions). The MOS may be implicit, utilizing conservative assumptions for calculation of the loading capacity, WLAs, and LAs. The MOS may also be explicitly stated as an added separate quantity in the TMDL calculation.

For this TMDL, there were no MOS adjustments for point sources since there are none.

In order to develop this temperature TMDL, the following conservative assumptions were used to parameterize the model:

- Data from the warmest time of the year were used in order to capture the seasonality of temperature exceedences.

- Critical upstream and downstream low flows were used because assimilative capacity of the stream to absorb and disperse solar heat is decreased during these flow conditions.

- Low flow was modeled using formulas developed by the USGS. One formula (Thomas et al. 1997) is recommended when the ratio between the gaged watershed area and the ungaged watershed area is between 0.5 and 1.5. When the ratio is outside of this range, a different regression formula is used (Waltemeyer 2002). See **Appendix D** for details.

As detailed in **Appendix D,** a variety of high quality hydrologic, geomorphologic, and meteorological data were used to parameterize the SSTEMP model. Because of the high quality of data and information that was put into this model and the continuous field monitoring data used to verify these model outputs, an explicit MOS of 10% is assigned to this TMDL.

6.7 Consideration of seasonal variation

Section 303(d)(1) of the CWA requires TMDLs to be "established at a level necessary to implement the applicable WQS with seasonal variation." Both stream temperature and flow vary seasonally and from year to year. Water temperatures are coolest in winter and early spring months.

Thermograph records show that temperatures exceed State of New Mexico WQS in summer and early fall. Warmest stream temperatures corresponded to prolonged solar radiation exposure, warmer air temperature, and low flow conditions. These conditions occur during late summer and early fall and promote the warmest seasonal instream temperatures. It is assumed that if critical conditions are met, coverage of any potential seasonal variation will also be met.

6.8 Future Growth

Estimations of future growth are not anticipated to lead to a significant increase for temperature that cannot be controlled with BMP implementation in this watershed.

7.0 MONITORING PLAN

Pursuant to Section 106(e)(1) of the Federal CWA, the SWQB has established appropriate monitoring methods, systems and procedures in order to compile and analyze data on the quality of the surface waters of New Mexico. In accordance with the New Mexico Water Quality Act, the SWQB has developed and implemented a comprehensive water quality monitoring strategy for the surface waters of the State.

The monitoring strategy establishes methods for identifying and prioritizing water quality data needs, specifies procedures for acquiring and managing water quality data, and describes how these data are used to progress toward three basic monitoring objectives: to develop water quality-based controls, to evaluate the effectiveness of such controls, and to conduct water quality assessments.

The SWQB utilizes a rotating basin system approach to water quality monitoring. In this system, a select number of watersheds are intensively monitored each year with an established return frequency of approximately every eight years. The next tentatively scheduled monitoring date for the Río Puerco and Rio San Jose watersheds is 2012. The SWQB maintains current quality assurance and quality control plans for the respective sample year to cover all monitoring activities. This document, called the QAPP, is updated and certified annually by USEPA Region 6. In addition, the SWQB identifies the data quality objectives required to provide information of sufficient quality to meet the established goals of the program. Current priorities for monitoring in the SWQB are driven by the CWA Section 303(d) list of streams requiring TMDLs. Short-term efforts were directed toward those waters that are on the USEPA TMDL consent decree list (U.S. District Court for the District of New Mexico 1997), however NMED/SWQB completed the final remaining TMDL on the consent decree in December 2006.

Once assessment monitoring is completed, those reaches showing impacts and requiring a TMDL will be targeted for more intensive monitoring. The methods of data acquisition include fixed-station monitoring, intensive surveys of priority assessment units (including biological assessments), and compliance monitoring of industrial, federal, and municipal dischargers, as specified in the SWQB assessment protocols (NMED/SWQB 2006b).

Long-term monitoring for assessments will be accomplished through the establishment of sampling sites that are representative of the waterbody and which is revisited approximately every eight years. This information will provide time relevant information for use in CWA Section 303(d) listing and 305(b) report assessments and to support the need for developing TMDLs. The approach provides:

- a systematic, detailed review of water quality data which allows for a more efficient use of valuable monitoring resources;
- information at a scale where implementation of corrective activities is feasible;
- an established order of rotation and predictable sampling in each basin which allows for enhanced coordinated efforts with other programs; and

- program efficiency and improvements in the basis for management decisions.

SWQB developed a 10-year monitoring strategy submitted to USEPA on September 30, 2004. The strategy details both the extent of monitoring that can be accomplished with existing resources plus expanded monitoring strategies that could be implemented given additional resources. According to the rotational cycle, which assumes the existing level of resources, the next time SWQB will intensively sample the Río Puerco watershed is during 2010.

It should be noted that a watershed would not be ignored during the years in between intensive sampling. The rotating basin program will be supplemented with other data collection efforts such as the funding of long-term USGS water quality gaging stations for long-term trend data, and on-going studies being performed by USGS and USEPA. Data will be analyzed and field studies will be conducted to further characterize acknowledged problems and TMDLs will be developed and implemented accordingly. Both long-term and intensive field studies can both contribute to the State's Integrated §303(d)/§305(b) listing process for waters requiring TMDLs.

8.0 IMPLEMENTATION OF TMDLS

8.1 NPDES Permitting

The Village of Cuba's current WWTP is an aerated lagoon system that is not designed to treat wastewater for TP or TN removal. The Village contracted with an engineering firm to develop a Preliminary Engineering Review (PER) to design a wastewater treatment plant to improve the water quality of the discharge as a result of an Administrative Order issued by the EPA for effluent violations December 16, 2004 (Village of Cuba, 2006). While the proposed facility is still designed as secondary treatment (i.e., not expressly designed as tertiary treatment to remove nutrients), considerable improvements in nutrient removal are expected if the new facility is constructed as described in the PER. The PER states the effluent quality that would be produced with the proposed facility is TP = 1.0 mg/L (approximately 73% less than the existing lagoons) and TN = 10.0 mg/L (approximately 59% less than the existing lagoons) including reduction of ammonia to 1.0 mg/L or less. These values represent the technologically achievable limits for the proposed extended aeration treatment system as found in Table 10 of the PER (page 15).

Funding of treatment facility modification or replacement needs some consideration in this TMDL. One potential source of funding to carry out a project that embraces the intent of the WLA is the New Mexico Clean Water State Revolving Loan Fund program administered by NMED's Construction Program Bureau. The State of New Mexico Statewide Water Quality Management Plan Work Element 5 (adopted by the WQCC December 17, 2002 and approved by the USEPA April 16, 2003) notes that "…[a]s specified at 40 CFR 130.12(b), CWA Section 201 funding can only be awarded to DMAs [Designated Management Agencies] that are in conformance with the statewide WQMP." The Village of Cuba is a Designated Management Agency (WQMP Work Element 5), thus the first part above requirement has been met. As this WLA is a part of the WQMP, funding will among other factors, be contingent on conformance with this part of the plan as well. This WLA recognizes the technological and economic challenge of meeting the nutrient effluent limitations presented herein and as discussed below and therefore provides three options for the Village of Cuba WWTP.

As noted above the facility discharges to the Rio Puerco under authorization of an NPDES permit. Federal regulations (40 CFR 130.12(a) and 40 CFR 122.44(d)(1)(vii)) clearly require that NPDES permits must be consistent with the WLA of an adopted and approved TMDL. Thus it important to provide direction on implementation of the WLA such that effluent limits and schedules can be readily incorporated within the structure of a permit.

The New Mexico WQS (Subsection J of 20.6.4.12 NMAC) states it is the policy of the WQCC to allow schedules of compliance in NPDES permits where facility modifications need to be made to meet new water quality based requirements.

OPTION 1

The Village of Cuba would replace the existing aerated lagoon system of wastewater treatment with a new system (as discussed in the existing PER) to improve the effluent quality. The following limits are based on the technological design specifications stated as achievable (with manufacturer guarantees) in the PER (Section 7.a, page 23). Even though the effluent quality that can be achieved by the proposed facility would not be sufficient to meet the target concentrations of the WLA, the overall load would be mitigated in addition to the previously described improved treatment by restricting the Village to discharge to the Rio Puerco as follows:

- Interim Effluent Limits from the date of permit issuance through the completion of construction (not to exceed 3-years)
  - Monitor and report TP, TN, and Total Ammonia by 3-hour composite, not less than once per two weeks
- Final Effluent Limits after completion of construction of new WWTP where the 30-day average loading effluent limit (lbs/day) is calculated by multiplying the 30-day average concentration based limit (mg/L) by the facility design flow (MGD) x 8.34:
  - From November 1 through March 31 each year, when instream biological activity is generally at it's lowest due to lower temperatures and shorter periods of daylight the WWTP would be allowed to discharge to the Rio Puerco. The effluent limits would be the design parameters expressed in the PER.
    - TP = 1.2 lbs/day (30-day average), 1.0 mg/L (30-day average), 1.5 mg/L (daily max) measured by 3-hour composite, not less than once per two weeks
    - TN = 12.0 lbs/day (30-day average), 10.0 mg/L (30-day average), 1.5 mg/L (daily max) measured by 3-hour composite, not less than once per two weeks
    - Total Ammonia = 1.0 mg/L (30-day average), 1.5 mg/L (daily max) measured by 3-hour composite, not less than once per two weeks
  - From April 1 through October 31 each year, when instream biological activity is generally at its highest, the WWTP would not be allowed to discharge to the Rio Puerco.
    - Instead of discharging to the Rio Puerco at this time, the WWTP effluent would be stored or disposed through other means (e.g., evaporation, agricultural reuse etc.) in accordance with the State Ground and Surface Water Protection Regulations (20.6.2 NMAC). Note: Ground Water Protection is addressed in the WQMP in Work Element 9.
    - The Village would need to implement Best Management Practices during the time of agricultural reuse to prevent the treated wastewater from draining back into the Rio Puerco as runoff from the irrigated land.

Although the effluent limits would not meet the targets of the TMDL, these restrictions would significantly reduce the load of TP and TN that are introduced into the Rio Puerco. After implementation of these technology based limits and enough time to allow the aquatic to system to respond, NMED would then reevaluate the condition of the Rio Puerco and the Nutrient TMDL. At the time that NMED reevaluates the conditions in the Rio Puerco, if it is found to still be impaired for Total Plant Nutrients, the Village of Cuba WWTP would be required to increase the treatment of the effluent by adding tertiary treatment to remove the nutrients from the effluent or find other means of disposal not in the Rio Puerco.

OPTION 2
The WWTP would be required to meet the TMDL WLA as stated in table 5.7 year round. This would require the Village of Cuba to build an advanced tertiary WWTP (e.g. one that has both biological and chemical treatment processes). A schedule of compliance would be allowed similar to Option 1 above.

- Interim Effluent Limits from the date of permit issuance through the through completion of construction (not to exceed 3-years)
    - Monitor and report TP, TN, and Total Ammonia by 3-hour composite, not less than once per two weeks
- Effluent Limits after completion of construction of new WWTP
    - Year round
        - TP = 0.447 lbs/day (30-day average), 0.375 mg/L (30-day average), 0.56 mg/L (daily max) measured by 3-hour composite, not less than once per two weeks
        - TN = 1.36 lbs/day (30-day average), 1.13 mg/L (30-day average), 1.7 mg/L (daily max) measured by 3-hour composite, not less than once per two weeks

OPTION 3
The WWTP would discontinue discharge to the Rio Puerco entirely.

It is acknowledged that the Village of Cuba WWTP design flow referenced in Tables 5.4, 5.6, and 5.7 and used in Equation 2 has the potential to change given the plans in the PER currently on record with the Village of Cuba. In the event that a new design flow is initiated, the calculated WLA will change; this fact should be noted when developing upcoming permits for the facility. Subsequently, the WLA will also change in Table 5.8 and 5.9.

8.2 WRAS and BMP Coordination

Watershed public awareness and involvement will be crucial to the successful implementation of these plans to improve water quality. Staff from SWQB have worked with stakeholders to develop a WRAS for the Río Puerco Watershed (RPMC 2001). The WRAS is a written plan intended to provide a long-range vision for various activities and management of resources in a watershed. It details opportunities for private landowners and public agencies to reduce and prevent impacts to water quality. This long-range strategy will become instrumental in coordinating and achieving constituent levels consistent with New Mexico’s WQS, and will be used to prevent water quality impacts in the watershed. The WRAS is essentially the Implementation Plan, or Phase Two of the TMDL process. The completion of the TMDLs and WRAS leads directly to the development of on-the-ground projects to address surface water impairments in the watershed.

SWQB staff will continue to assist with technical assistance such as selection and application of BMPs needed to meet WRAS goals. Stakeholder public outreach and involvement in the implementation of this TMDL will be ongoing. Stakeholders in this process will include SWQB and members of the Río Puerco Management Committee. SWQB will actively pursue engagement with land owners, ranchers and acequia associations as stakeholders in the implementation of this TMDL.

Implementation of BMPs within the watershed to reduce pollutant loading from nonpoint sources will be encouraged. Reductions from point sources will be addressed in revisions to NPDES discharge permits. SWQB will communicate to designated federal land management agencies the intent of the TMDL and desire that BMPs be developed through the above coordination process.

8.3 Time Line

The Río Puerco Management Committee (RPMC) was established in 1997 by direction from the Congress of the United States, under the *Río Puerco Watershed Act*, Section 401 of the *Omnibus Parks and Land Management Act of 1996*. Therefore watershed group formation was completed prior to the planning stages for the 2004 intensive survey, and thus prior to any impairment determinations/verifications or TMDL development. As a result, the WRAS was developed and finalized before preparation of these TMDLs. The modified general implementation timeline is detailed below (Table 8.1).

8.4 Clean Water Act §319(h) Funding Opportunities

The Watershed Protection Section of the SWQB manages a grant program of CWA §319(h) funding to assist in implementation of BMPs to address water quality problems on reaches listed as category 4 or 5 waters on the Integrated CWA §303(d)/§305(b) list. These monies are available to all private, for profit and nonprofit organizations that are authenticated legal entities, or governmental jurisdictions including: municipalities, counties, tribal entities, Federal agencies, or agencies of the State. Proposals are submitted by applicants at least once a year through a Request for Proposal (RFP) process and require a non-federal match of 40% of the total project cost consisting of funds and/or in-kind services. Funding is available for both watershed group formation (which includes WRAS development) and on-the-ground projects to improve surface water quality and associated habitat. Further information on funding from the CWA §319 (h) can be found at the SWQB website: http://www.nmenv.state.nm.us/swqb/.

Table 8.1 Proposed Implementation Timeline

Implementation Actions	Year 1 (1997)	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10 (2006)
Public Outreach and Involvement	X	X	X	X	X	X	X	X	X	X
Form watershed groups	X									
TMDL Development								X	X	X
WRAS Development				X	X					
Revise any NPDES permits as necessary (currently USEPA Region 6)				X					X	
Establish Performance Targets		X	X	X						
Secure Funding		X	X	X						
Implement Management Measures (BMPs)				X	X	X	X	X	X	X
Monitor BMPs					X	X	X	X	X	X
Determine BMP Effectiveness					X	X	X	X	X	X
Reevaluate Performance Targets						X	X	X	X	X

8.5 Other Funding Opportunities and Restoration Efforts in the Río Puerco Basin

Several other sources of funding existing to address impairments discussed in this TMDL document. NMED’s Construction Programs Bureau assists communities in need of funding for WWTP upgrades and improvements to septic tank configurations (such as the design of cluster systems). The Construction Programs Bureau can also provide matching funds for appropriate CWA §319(h) projects using state revolving fund monies. The United States Department of Agriculture (USDA) Environmental Quality Incentive Program (EQIP) program can provide assistance to private land owners in the basin. The USDA Forest Service aligns its mission to protect lands it manages with the TMDL process, and is another source of assistance. Also, the BLM has several programs in place to provide assistance to improve unpaved roads and grazing allotments.

9.0 ASSURANCES

New Mexico's Water Quality Act (Act) authorizes the WQCC to "promulgate and publish regulation to prevent or abate water pollution in the state" and to require permits. The Act authorizes a constituent agency to take enforcement action against any person who violates a water quality standard. (§74-6-10(A) NMSA 1978) Several statutory provisions on nuisance law could also be applied to nonpoint source water pollution. The Water Quality Act also states in §74-6-12(A):

> *The Water Quality Act (this article) does not grant to the commission or to any other entity the power to take away or modify the property rights in water, nor is it the intention of the Water Quality Act to take away or modify such rights.*

In addition, the State of New Mexico Surface Water Quality Standards (see Subsection C of 20.6.4.62) (NMAC 2006) state:

> *Pursuant to Subsection A of Section 74-6-12 NMSA 1978, this part does not grant to the water quality control commission or to any other entity the power to take away or modify property rights in water.*

New Mexico policies are in accordance with the federal Clean Water Act §101(g):

> *It is the policy of Congress that the authority of each State to allocate quantities of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this Act. It is the further policy of Congress that nothing in this Act shall be construed to supersede or abrogate rights to quantities of water which have been established by any State. Federal agencies shall co-operate with State and local agencies to develop comprehensive solutions to prevent, reduce and eliminate pollution in concert with programs for managing water resources.*

New Mexico's 319 Program has been developed in a coordinated manner with the State's 303(d) process. All 319 watersheds that are targeted in the annual RFP process coincide with the State's biennial impaired waters list as approved by USEPA. The State has given a high priority for funding, assessment, and restoration activities to these watersheds.

As a constituent agency, NMED has the authority under Chapter 74, Article 6-10 NMSA 1978 to issue a compliance order or commence civil action in district court for appropriate relief if NMED determines that actions of a "person" (as defined in the Act) have resulted in a violation of a water quality standard including a violation caused by a nonpoint source. Proving causation by a nonpoint source of a violation of a water quality standard would be very difficult, and to date NMED has not brought an enforcement action on this basis. Instead, the NMED nonpoint source water quality management program has historically strived for and will continue to promote voluntary compliance to nonpoint source water pollution concerns by utilizing a voluntary, cooperative approach. NMED believes this is the best and most effective approach to addressing impairment of streams as a result of nonpoint source issues. The State provides technical support and grant monies for implementation of BMPs and other nonpoint source prevention mechanisms through §319 of the Clean Water Act. Since portions of this TMDL will be implemented through nonpoint source control mechanisms, the New Mexico Watershed Protection Program will target its efforts towards this and other watersheds with TMDLs.

In order to obtain reasonable assurances for implementation in watersheds with multiple landowners, including federal, State and private land, NMED has previously established Memoranda of Understanding (MOUs) with various federal agencies, in particular the USFS and the Bureau of Land Management. MOUs in the past have also been developed with other State agencies, such as the New Mexico State Highway and Transportation Department. These MOUs provide for coordination and consistency in dealing with nonpoint source issues.

The time required to attain standards for all reaches is estimated to be approximately 10-20 years. This estimate includes watershed projects that may not be starting immediately, and also contemplates response to earlier projects. This timeframe is intended to provide some measure of watershed response to projects but is not intended to be a fixed goal. Stakeholders in this process will include SWQB, and other stakeholders involved with the development and implementation of the WRAS. The cooperation of watershed stakeholders will be pivotal in the implementation of these TMDLs as well.

10.0 PUBLIC PARTICIPATION

Public participation was solicited in development of this TMDL (see Appendix E). The draft TMDL was made available for a 32-day comment period on June 5, 2007. Response to Comments are included as Appendix F of this document. The draft document notice of availability was extensively advertised via newsletters, email distribution lists, webpage postings (http://www.nmenv.state.nm.us/), and press releases to area newspapers. Public meetings in the Río Puerco and Rio San Jose Watersheds were held Wednesday, June 20th from 6-8pm in the Cuba Senior Center and Thursday, June 21st from 1-2pm at the County Courthouse in Grants.

Once the TMDL is approved by the Water Quality Control Commission, the next step for public participation is revision of the Rio Puerco WRAS as described in Section 6.0, and participation in in watershed protection projects including those that may be funded by Clean Water Act Section 319(h) grants. The WRAS development process is open to any member of the public who wants to participate.

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APPENDIX A
SOURCE(S) DOCUMENTATION AND SOURCES SUMMARY TABLE

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Assessment Unit	Parameter [1]	Probable Sources (ADB v.2 terminology)
Bluewater Creek (Bluewater Reservoir to headwaters)	Nutrients, Sedimentation/siltation, temperature, turbidity	Forest roads (road construction and use), loss of riparian habitat, rangeland grazing, silviculture harvesting, streambank modification/destabilization.
Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir)	Nutrients, temperature	Loss of riparian habitat, rangeland grazing, streambank modifications/destabilization.
La Jara Creek (perennial reaches above Arroyo San Jose)	Aluminum	Source unknown, natural sources.
Rio Moquino (Laguna Pueblo to Seboyettia Creek)	Nutrients, sedimentation/siltation, temperature	Loss of riparian habitat, mine tailings, rangeland grazing, surface mining.
Rio Puerco (Arroyo Chijuilla to northern boundary Cuba)	Aluminum, ammonia, nutrients, sedimentation/siltation	Channelization, drought-related impacts, highway/road/bridge runoff (non-construction related), loss of riparian habitat, natural sources, rangeland grazing, streambank modification/destabilization, wildlife other than waterfowl.

[1] *from 2006-2008 Integrated CWA §303 (d)/305(b) List*

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APPENDIX B
CONVERSION FACTOR DERIVATION

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Flow (as million gallons per day [MGD]) and concentration values (milligrams per liter [mg/L]) must be multiplied by a conversion factor in order to express the load in units "pounds per day." The following expressions detail how the conversion factor was determined:

TMDL Calculation:

$$Flow\left(MGD\right)\times Concentration\left(\frac{mg}{L}\right)\times CF\left(\frac{L-lb}{gal-mg}\right)=Load\left(\frac{lb}{day}\right)$$

Conversion Factor Derivation:

$$CF = 10^{6}\times\frac{3.785\,L}{gal}\times\frac{1\,lb}{454{,}000\,mg}=8.34\,\frac{L-lb}{gal-mg}$$

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APPENDIX C
THERMOGRAPH SUMMARY DATA AND GRAPHICS

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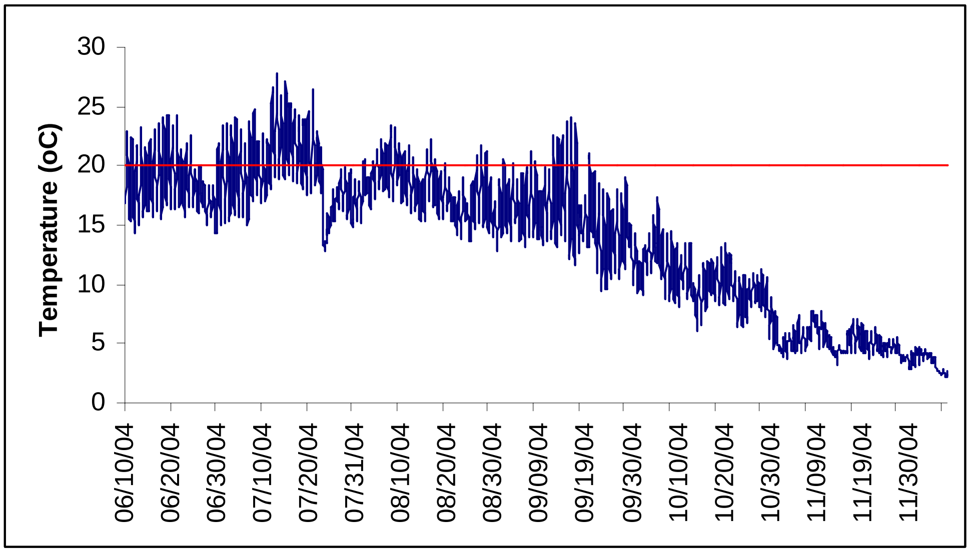
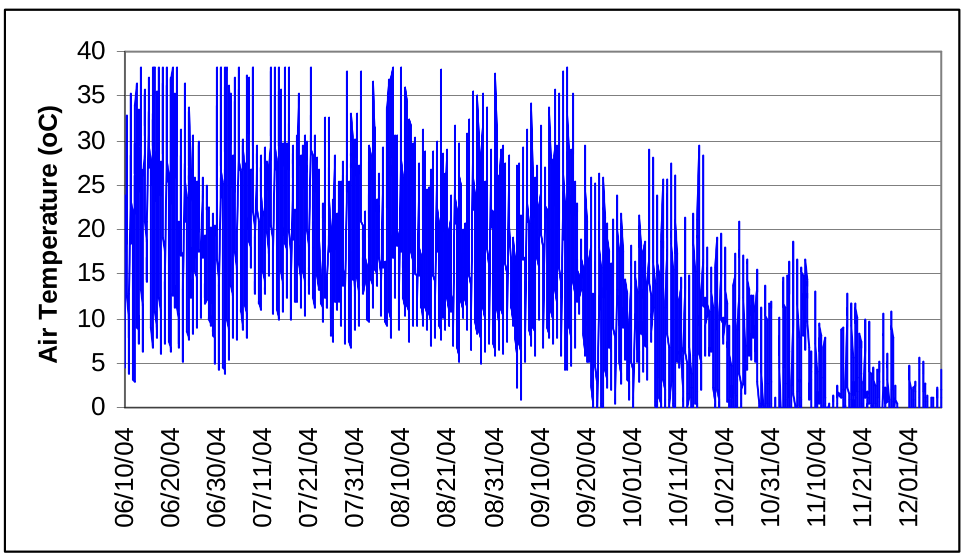
C1.0 Bluewater Creek (Bluewater Reservoir to headwaters)

June 10, 2004 through December 8, 2004:

Number of Data Points:	4,352
Number of Measurements >20^{o}C:	656
Percentage Data Points >20^{o}C:	15%
Minimum Water Temperature (^{o}C):	2.18
Maximum Water Temperature (^{o}C):	27.85

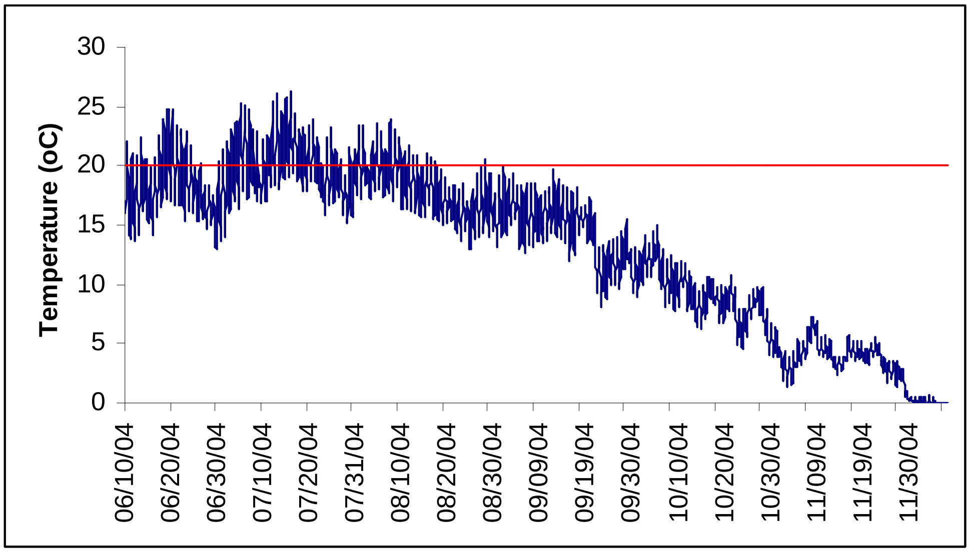


No photo for thermographs at Bluewater Creek above Bluewater Lake at USGS gage 0841300

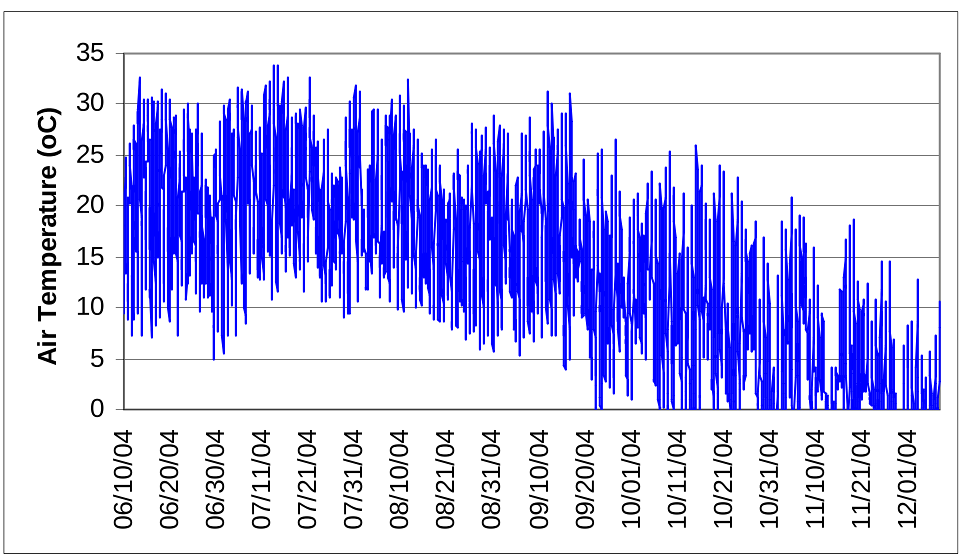


C2.0 Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir)

June 10, 2004 through December 8, 2004:	
Number of Data Points:	4,353
Number of Measurements >20°C:	582
Percentage Data Points >20°C:	13.4%
Minimum Water Temperature (°C):	-0.032
Maximum Water Temperature (°C):	26.26

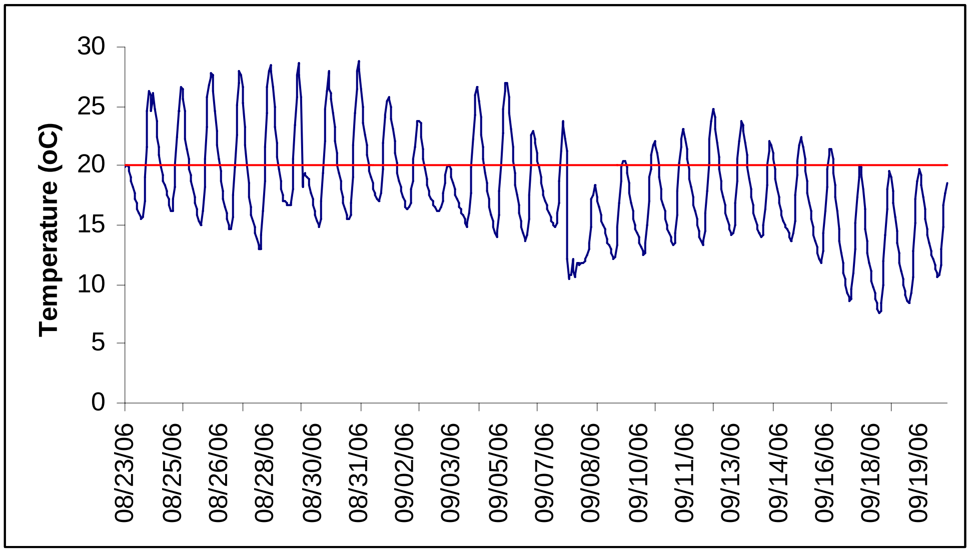


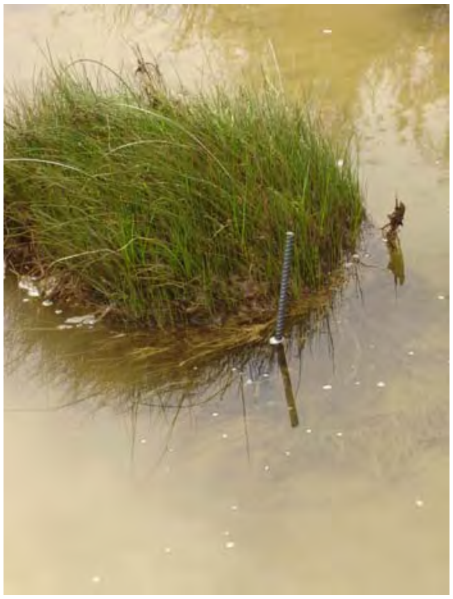
No photo for thermographs at Bluewater Creek at mouth of Bluewater Canyon.



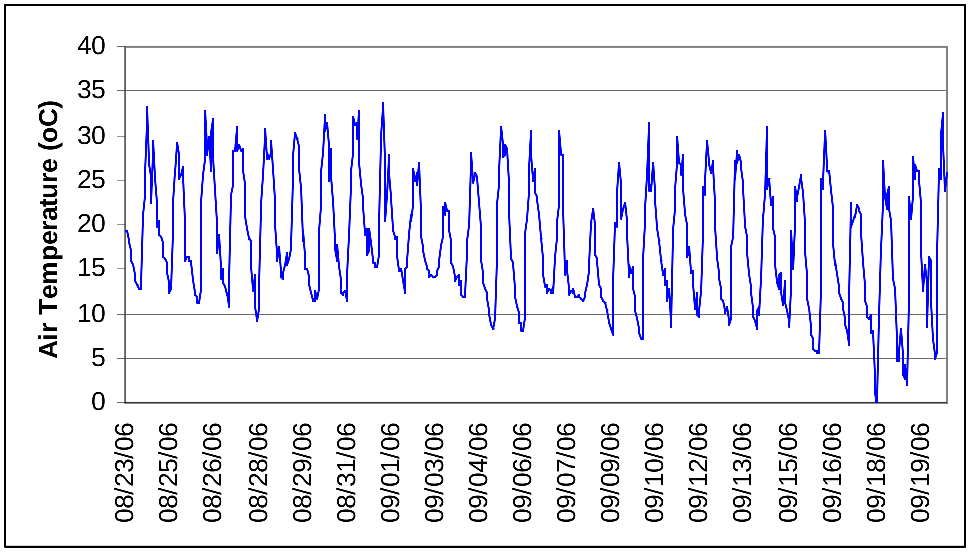
C3.0 Rio Moquino (Laguna Pueblo to Seboyettia Creek)

August 23, 2006 through September 20, 2006:	
Number of Data Points:	670
Number of Measurements >20°C:	196
Percentage Data Points >20°C:	29%
Minimum Water Temperature (°C):	7.65
Maximum Water Temperature (°C):	28.84





Thermograph at Rio Moquino below confluence of Seboyetitia Creek and Seboyeta Creek.



Air thermograph at Rio Moquino below confluence of Seboyetitia Creek and Seboyeta Creek.

APPENDIX D
HYDROLOGY, GEOMETRY, AND METEROLOGICAL INPUT DATA FOR SSTEMP

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LIST OF ACRONYMS

4Q3	Four-consecutive day discharge that has a recurrence interval of three years
cfs	Cubic Feet per Second
GIS	Geographic Information Systems
GPS	Global Positioning System
IOWDM	Input and Output for Watershed Data Management
mi^2	Square Miles
^oC	Degrees Celcius
SEE	Standard Error of Estimate
SSTEMP	Stream Segment Temperature
SWSTAT	Surface-Water Statistics
TMDL	Total Maximum Daily Load
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WinXSPRO	Windows-Based Stream Channel Cross-Section Analysis

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D 1.0 INTRODUCTION

This appendix provides site-specific hydrology, geometry, and meteorological data for input into the Stream Segment Temperature (SSTEMP) Model (Bartholow 2002). Hydrology variables include segment inflow, inflow temperature, segment outflow, and accretion temperature. Geometry variables are latitude, segment length, upstream and downstream elevation, Width's A-term, Width's B-term, and Manning's n. Meterological inputs to SSTEMP Model include air temperature, relative humidity, windspeed, ground temperature, thermal gradient, possible sun, dust coefficient, ground reflectivity, and solar radiation. In the following sections, these parameters are discussed in detail for each assessment unit to be modeled using SSTEMP Model. The assessment units were modeled on the day of the maximum recorded thermograph measurement. The assessment units and modeled dates are defined as follows:

Table D.1 Assessment Units and Modeled Dates

Assessment Unit ID	Assessment Unit Description	Modeled Date
NM-2107.A_01	Bluewater Creek (Bluewater Reservoir to headwaters)	7/13/2004
NM-2107.A_00	Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir)	7/16/2004
NM-2017.A_10	Rio Moquino (Laguna Pueblo to Seboyettia Creek)	8/31/2006

D 2.0 HYDROLOGY

D2.1 Segment Inflow

This parameter is the *mean daily* flow at the top of the stream segment. If the segment begins at an effective headwater, the flow is entered into SSTEMP Model as zero. Flow data from USGS gages were used when available. To be conservative, the lowest four-consecutive-day discharge that has a recurrence interval of three years but that does not necessarily occur every three years (4Q3) was used as the inflow instead of the mean daily flow. These critical low flows were used to decrease assimilative capacity of the stream to adsorb and disperse solar energy. The 4Q3 would be determined for gaged sites using a log Pearson Type III distribution through "*Input and Output for Watershed Data Management*" (IOWDM) software, Version 4.1 (USGS 2002a) and "*Surface-Water Statistics*" (SWSTAT) software, Version 4.1 (USGS 2002b).

Discharges for ungaged sites on gaged streams were estimated based on methods published by Thomas *et al.* (1997). If the drainage area of the ungaged site is between 50 and 150 percent of the drainage area of the gaged site, the following equation is used:

$$Q_u = Q_g \left(\frac{A_u}{A_g} \right)^{0.5}$$

where,

Q_u = Area weighted 4Q3 at the ungaged site (cubic feet per second [cfs])
Q_g = 4Q3 at the gaged site (cfs)
A_u = Drainage area at the ungaged site (square miles [mi^2])
A_g = Drainage area at the gaged site (mi^2)

Drainage areas for assessment units to which this method was applied are summarized in the following table:

Table D.2 Drainage Areas for Estimating Flow by Drainage Area Ratios

Assessment Unit	USGS Gage	Drainage Area from Gage (mi^2)	Drainage Area from Top of AU (mi^2)	Drainage Area from Bottom of AU (mi^2)	Ratio of DA of Ungaged (upstream) to Gaged Site	Ratio of DA of Ungaged (downstream) to Gaged Site
NM-2107.A_01	— [(a)]	80.07 [(c)]	0.001	80.08	— [(a)]	100%
NM-2107.A_00	—	210.13 [(d)]	210.13	231.51	100%	110%
NM-2017.A_10	— [(b)]	—	56.05	74.27	—	—

Notes:
[(a)] Assessment unit begins at headwaters.
[(b)] Regression method developed by Waltemeyer (2002) was used to estimate flows since this is an ungaged stream.
[(c)] USGS gage-Bluewater Creek above Bluewater Dam, NM (083413000)
[(d)] USGS gage-Bluewater Creek at Bluewater Dam, NM (08341500)

mi^2 = Square miles
USGS = U.S. Geological Survey
AU = Assessment Unit

4Q3 derivations for ungaged streams were based on analysis methods described by Waltemeyer (2002). Two regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico (i.e., statewide and mountainous regions above 7,500 feet in elevation). The following statewide regression equation is based on data from 50 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 \quad = \quad 1.2856 \times 10^{-4} \; DA^{0.42} \; P_w^{\;3.16}$$

where,

4Q3 = Four-day, three-year low-flow frequency (cfs)
DA = Drainage area (mi^2)
P_w = Average basin mean winter precipitation (inches)

The average standard error of estimate (SEE) and coefficient of determination are 126 and 48 percent, respectively, for this regression equation (Waltemeyer 2002). The following regression equation for mountainous regions above 7,500 feet in elevation is based on data from 40 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 \quad = \quad 7.3287 \times 10^{-5} \; DA^{0.70} \; P_w^{\;3.58} \; S^{1.35}$$

where,

4Q3 = Four-day, three-year low-flow frequency (cfs)
DA = Drainage area (mi^2)
P_w = Average basin mean winter precipitation (inches)
S = Average basin slope (percent)

The average SEE and coefficient of determination are 94 and 66 percent, respectively, for this regression equation (Waltemeyer 2002). The drainage areas, average basin mean winter precipitation, and average basin slope for assessment units where this regression method was used are presented in the following table:

Table D.3 Parameters for Estimating Flow using USGS Regression Model

Assessment Unit	Regression Model[(a)]	Average Elevation for Assessment Unit (feet)	Mean Basin Winter Precipitation (inches)	Average Basin Slope (unitless)
NM-2107.A_01	Mountainous	8,189	9.5	0.145
NM-2107.A_00	Mountainous	8,084	8.65	0.116
NM-2017.A_10	Mountainous	8,189	5.7	0.11

Notes:
mi^2 = Square miles
[(a)] Waltemeyer (2002)

Based on the methods described above, the following values were estimated for inflow:

Table D.4 Inflow

Assessment Unit	Ref.	4Q3[(1)] (cfs)	DAt (mi^2)	DAg (mi^2)	Pw (in)	S unitless	Inflow (cfs)
NM-2107.A_01	N/A	–	0.001	80.07	9.5	0.145	0.00[(2)]
NM-2107.A_00	(a)	0.16	210.13	210.13	8.65	0.116	0.16
NM-2017.A_10	(b)	–	56.05	–	5.7	0.11	0.03

Notes:
N/A = Not applicable, assessment unit begins at headwaters.
Ref. = Reference
[(a)] Thomas et al. (1997)
[(b)] Waltemeyer (2002), mountainous
cfs = cubic feet per second
mi^2 = Square miles
in = Inches
Pw = Mean winter precipitation
DAt = Drainage area from top of segment
DAb = Drainage area from bottom of segment
DAg = Drainage area from USGS gage
S = Average basin slope
[(1)] Based on period of record for USGS gage-Bluewater Creek at Bluewater Dam, NM (08341500)
[(2)] Inflow is zero because assessment unit begins at headwaters.

D2.2 Inflow Temperature

This parameter represents the *mean daily* water temperature at the top of the segment. 2004 and 2006 data from thermographs positioned at the top of the assessment unit were used when possible. If the segment began at a true headwater, the temperature entered was zero degrees Celcius (^oC) (zero flow has zero heat). The following inflow temperatures for impaired assessment units were modeled in SSTEMP:

Table D.5 Mean Daily Water Temperature

Assessment Unit	Upstream Thermograph Location	Inflow Temp. (ºC)	Inflow Temp. (ºF)
NM-2107.A_01	None (headwaters)	0	32.0
NM-2107.A_00	Bluewater Creek at mouth of Bluewater Canyon	13.1	55.6
NM-2017.A_10	Rio Moquino blw confl of Seboyetitia and Seboyeta Creeks	18.0	64.4

Notes:
ºC = Degrees Celcius
ºF = Degrees Farenheit

D2.3 Segment Outflow

Flow data from USGS gages were used when available. To be conservative, the 4Q3 was used as the segment outflow. These critical low flows were used to decrease assimilative capacity of the stream to adsorb and disperse solar energy. Outflow was estimated using the methods described in Section 2.1. The following table summarizes 4Q3s used in the SSTEMP Model:

$$4Q3 \quad = \quad 7.3287 \times 10^{-5} \; DA^{0.70} \; P_w^{\;3.58} \; S^{1.35}$$

Table D.6 Segment Outflow

Assessment Unit	Ref.	4Q3 (cfs)	DAb (mi^2)	DAg (mi^2)	Pw (in)	S unitless	Outflow (cfs)
NM-2107.A_01	(a)	0.01[(c)]	80.08	80.07	9.5	0.145	0.01
NM-2107.A_00	(a)	0.16[(d)]	231.51	210.13	8.65	0.116	0.17
NM-2017.A_10	(b)	–	74.27	–	5.7	0.11	0.04

Notes:
Ref. = Reference
(a) Thomas et al. (1997)
(b) Waltemeyer (2002)

cfs = cubic feet per second
mi^2 = Square miles
in = Inches
Pw = Mean winter precipitation
DAb = Drainage area from bottom of segment
DAg = Drainage area from USGS gage
S = Average basin slope
[(c)] USGS gage-Bluewater Creek above Bluewater Dam, NM (083413000)
[(d)] USGS gage-Bluewater Creek at Bluewater Dam, NM (08341500)

D2.4 Accretion Temperature

The temperature of the lateral inflow, barring tributaries, generally should be the same as groundwater temperature. In turn, groundwater temperature may be approximated by the mean annual air temperature. Mean annual air temperature for 2004 and 2006 was used in the absence of measured data. The following table presents the mean annual air temperature for each assessment unit:

Table D.7 Mean Annual Air Temperature as an Estimate for Accretion Temperature

Assessment Unit	Ref.	Mean Annual Air Temperature (°C)	Mean Annual Air Temperature (°F)
NM-2107.A_01	(a)	4.59	40.265
NM-2107.A_00	(a)	4.59	40.265
NM-2017.A_10	(b)	7.24	45.038

Notes:
Ref. = References for Weather Station Data are as follows:

(a) *New Mexico State University Climate Network (Grants RAWS, Elevation 2,575 meters; Latitude 35° 14' 30" N, Longitude 107° 40' 12" W),* ***2004***

(b) *New Mexico State University Climate Network (Grants METAR, Elevation 1,987 meters; Latitude 35° 10' N, Longitude 107° 54' W),* ***2006***

ºF = Degrees Farenheit
ºC = Degrees Celcius

D 3.0 GEOMETRY

D3.1 Latitude

Latitude refers to the position of the stream segment on the earth's surface. Latitude is generally determined in the field with a global positioning system (GPS) unit. Latitude for each assessment unit is summarized below:

Table D.8 Assessment Unit Latitude

Assessment Unit	Latitude (decimal degrees)
NM-2107.A_01	35.22
NM-2107.A_00	35.29
NM-2017.A_10	35.16

D3.2 Dam at Head of Segment

The following assessment units have a dam at the upstream end of the segment with a constant, or nearly constant diel release temperature:

Table D.9 Presence of Dam at Head of Segment

Assessment Unit	Dam?
NM-2107.A_01	No
NM-2107.A_00	Yes
NM-2017.A_10	No

D3.3 Segment Length

Segment length was determined with National Hydrographic Dataset Reach Indexing GIS tool. The segment lengths are as follows:

Table D.10 Segment Length

Assessment Unit	Length (miles)
NM-2107.A_01	17.1
NM-2107.A_00	2.4
NM-2017.A_10	3

D3.4 Upstream Elevation

The following upstream elevations were determined with National Hydrographic Dataset Reach Indexing GIS tool.

Table D.11 Upstream Elevations

Assessment Unit	Upstream Elevation (feet)
NM-2107.A_01	8,460
NM-2107.A_00	7,400
NM-2017.A_10	6,100

D3.5 Downstream Elevation

The following downstream elevations were determined with National Hydrographic Dataset Reach Indexing GIS tool.

Table D.12 Downstream Elevations

Assessment Unit	Downstream Elevation (feet)
NM-2107.A_01	7,400
NM-2107.A_00	6,650
NM-2017.A_10	5,980

D3.6 Width's A and Width's B Term

Width's B Term was calculated as the slope of the regression of the natural log of width and the natural log of flow. Width-versus-flow regression analyses were prepared by entering cross-section field data into a Windows-Based Stream Channel Cross-Section Analysis (WINXSPRO 3.0) Program (U.S. Department of Agriculture [USDA] 2005). Theoretically, the Width's A Term is the untransformed Y-intercept. However, because the width versus discharge relationship tends to break down at very low flows, the Width's B-Term was first calculated as the slope and Width's A-Term was estimated by solving for the following equation:

$$W = A \times Q^B$$

where,

W = Known width (feet)
A = Width's A-Term (seconds per square foot)
Q = Known discharge (cfs)

B = Width's B-Term (unitless)

The following table summarizes Width's A- and B-Terms for assessment units requiring temperature TMDLs:

Table D.13 Width's A and Width's B Terms

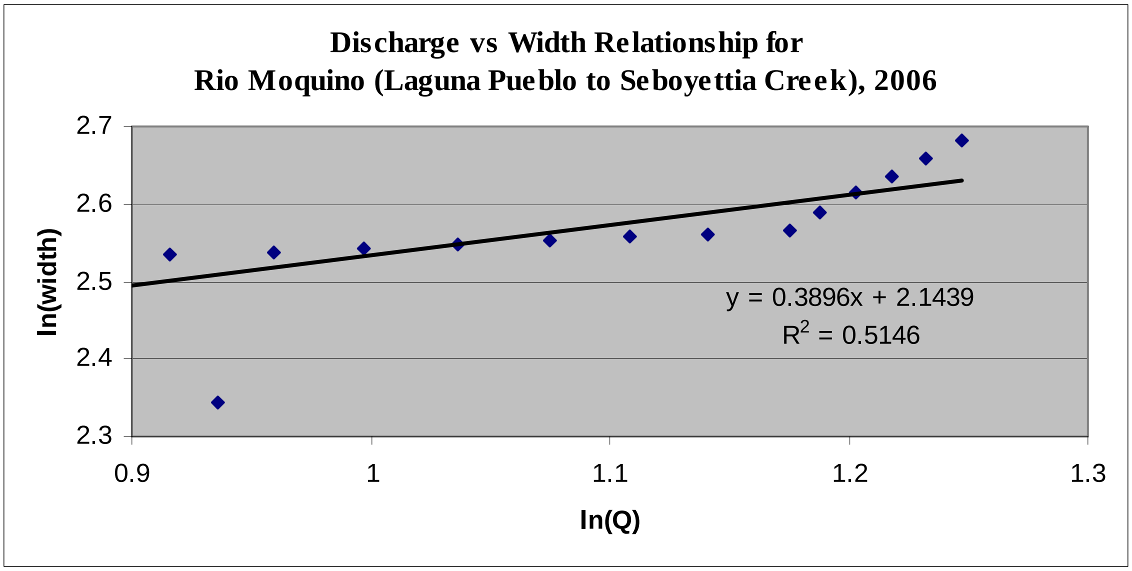
Assessment Unit	Width's B-Term	Width's A-Term [1]
NM-2107.A_01	0.390	8.53
NM-2107.A_00	0.227	6.56
NM-2017.A_10	0.866	5.64

(1) A=e^constant from regression

The following figures present the detailed calculations for the Width's B-Term.

Measurements were collected at one site within these assessment units. Due to lack of pebble count data at both Bluewater Creek assessment units, comparable reference sites were used. The regression of natural log of width and natural log of flow for each location is as follows:

Figure D.1 Wetted Width versus Flow for Assessment Unit NM-2107.A_01



SUMMARY OUTPUT

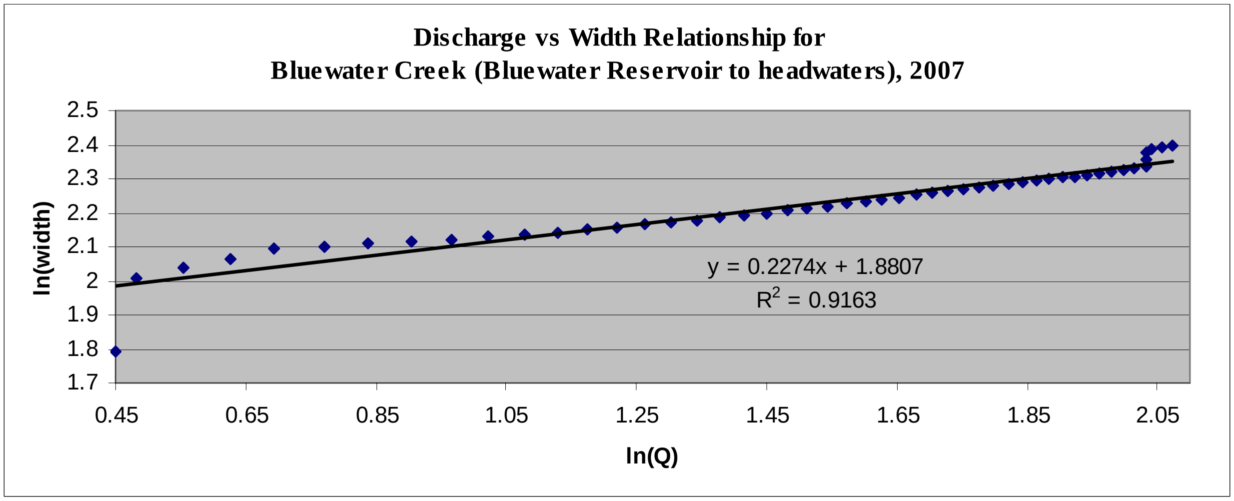
Regression Statistics	
Multiple R	0.71737
R Square	0.514619
Adjusted R Square	0.479949
Standard Error	0.054364
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	1	0.04386896	0.043869	14.84332	0.001758
Residual	14	0.041376541	0.002955		
Total	15	0.085245501			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.143895	0.109103152	19.65016	1.37E-11	1.909892	2.377898	1.909891614	2.377897588
X Variable 1	0.389571	0.101116137	3.852704	0.001758	0.172698	0.606443	0.172697961	0.60644305

Figure D.2 Wetted Width versus Flow for Assessment Unit NM-2107.A_00



SUMMARY OUTPUT

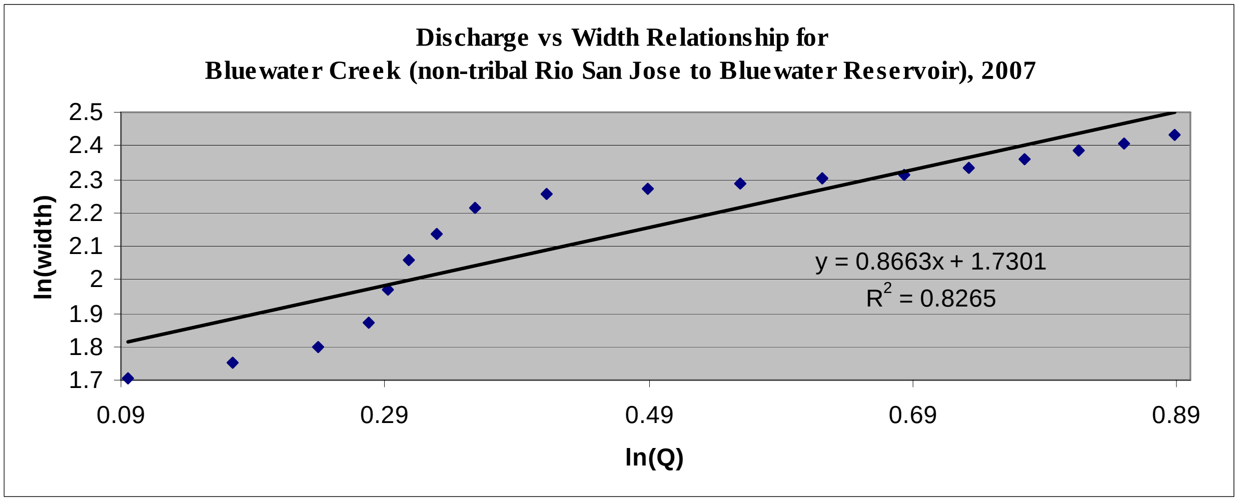
Regression Statistics	
Multiple R	0.957215775
R Square	0.91626204
Adjusted R	0.914553103
Standard E	0.145107626
Observatio	51

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regressior	1	11.28947834	11.28948	536.1588	4.83548E-28
Residual	49	1.031754933	0.021056		
Total	50	12.32123327			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-7.454911157	0.386253283	-19.30058	1.52E-24	-8.231116176	-6.678706	-8.231116176	-6.678706139
X Variable	4.029646447	0.174028446	23.1551	4.84E-28	3.679923197	4.37937	3.679923197	4.379369697

Figure D.3 Wetted Width versus Flow for Assessment Unit NM-2017.A_10



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.909120106
R Square	0.826499367
Adjusted R	0.815655577
Standard E	0.10811652
Observatio	18

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	1	0.890934059	0.890934	76.21868	1.75E-07
Residual	16	0.187026911	0.011689		
Total	17	1.07796097			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.564896808	0.237240395	-6.596249	6.15E-06	-2.067824	-1.0619696	-2.06782397	-1.061969642
X Variable	0.954107778	0.10928655	8.730331	1.75E-07	0.722431	1.18578491	0.722430644	1.185784912

D3.7 Manning's n or Travel Time

Site-specific values generated from WINXSPRO were used for Manning's n. The following table summarizes the input values:

Table D.14 Manning's n Values

Assessment Unit	Manning's n
NM-2107.A_01	0.054
NM-2107.A_00	0.037
NM-2017.A_10	0.035

D 4.0 METEOROLOGICAL PARAMETERS

D4.1 Air Temperature

This parameter is the mean daily air temperature for the assessment unit (or average daily temperature at the mean elevation of the assessment unit). Air temperature will usually be the single most important factor in determining mean daily water temperature. Air temperatures are usually measured directly (in the shade) using air thermographs and adjusted to what the temperature would be at the mean elevation of the assessment unit. The following table summarizes mean daily air temperatures for each assessment unit (for its modeled date) requiring a temperature Total Maximum Daily Load (TMDL):

Table D.15 Mean Daily Air Temperature

Assessment Unit	Elevation at Air Thermograph Location (meters)	Measured Mean Daily Air Temperature (°C)	Mean Elevation for Assessment Unit (meters)	Adjusted Mean Daily Air Temperature (°C)	Adjusted Mean Daily Air Temperature (°F)
NM-2107.A_01	2,259	29.65 [a]	2,417	28.61	83.50
NM-2107.A_00	2,222	22.82	2,141	23.35	74.03
NM-2017.A_10	1,856	21.49	1,841	21.69	71.04

Notes:
°F = Degrees Farenheit
°C = Degrees Celcius
[a] = recorded air temperature at time of highest water temperatures (averaged with the 5 hours before and after highest temperature) was substituted for mean daily air temperature.

The adiabatic lapse rate was used to correct for elevational differences from the met station:

$$T_a = T_o + C_t \times (Z - Z_o)$$

where,

T_a = air temperature at elevation E (°C)
T_o = air temperature at elevation E_o (°C)
Z = mean elevation of segment (meters)
Z_o = elevation of station (meters)
C_t = moist-air adiabatic lapse rate (-0.00656 °C/meter)

D4.2 Maximum Air Temperature

Unlike the other variables, the maximum daily air temperature overrides only if the check box is checked. If the box is not checked, the SSTEMP Model estimates the maximum daily air temperature from a set of empirical coefficients (Theurer et al., 1984 as cited in Bartholow 2002) and will print the result in the grayed data entry box. A value cannot be entered unless the box is checked.

D4.3 Relative Humidity

Relative humidity data were obtained from the New Mexico State University Climate Network (http://weather.nmsu.edu/data/data.htm). The data were corrected for elevation and temperature using the following equation:

$$R_h = R_o \times \left(1.0640^{(To-Ta)}\right) \times \left(\frac{T_a + 273.16}{T_o + 273.16}\right)$$

where,

R_h = relative humidity for temperature T_a (decimal)
R_o = relative humidity at station (decimal)
T_a = air temperature at segment (°C)
T_o = air temperature at station (°C)

The following table presents the adjusted mean daily relative humidity for each assessment unit:

Table D.16 Mean Daily Relative Humidity

Assessment Unit	Ref.	Mean Daily Air Temp. at Weather Station (°C)	Mean Daily Air Temperature at AU (°C)	Mean Daily Relative Humidity at Weather Station (percent)	Mean Daily Relative Humidity for AU (percent)
NM-2107.A_01	(a)	22.06	22.14	31.588	31.44
NM-2107.A_00	(b)	17.66	23.35	44.739	32.05
NM-2017.A_10	(c)	19.55	21.69	55.429	48.89

Notes:
Ref. = References for Weather Station Data are as follows:
(a) *New Mexico State University Climate Network (Grants RAWS, Elevation 2,575 meters; Latitude 35° 14' 30" N, Longitude 107° 40' 12" W)* ***July 13, 2004***
(b) *New Mexico State University Climate Network (Grants RAWS, Elevation 2,575 meters; Latitude 35° 14' 30" N, Longitude 107° 40' 12" W)* ***July 16, 2004***
(c) *New Mexico State University Climate Network (Grants METAR, Elevation 1,987 meters; Latitude 35° 10' N, Longitude 107° 54' W)* ***August 31, 2006***

AU = Assessment Unit
°C = Degrees Celcius

D4.4 Wind Speed

Average daily wind speed data were obtained from the New Mexico State University Climate Network (http://weather.nmsu.edu/data/data.htm). The following table presents the mean daily wind speed for each assessment unit:

Table D.17 Mean Daily Wind Speed

Assessment Unit	Ref.	Mean Daily Wind Speed (miles per hour)	Date
NM-2107.A_01	(a)	4.176	7/13/2004
NM-2107.A_00	(a)	2.739	7/16/2004
NM-2017.A_10	(b)	6.178	8/31/2006

Notes:
Ref. = References for Weather Station Data are as follows:
(a) *New Mexico State University Climate Network (Grants RAWS, Elevation 2,575 meters; Latitude 35° 14' 30" N, Longitude 107° 40' 12" W)*
(b) *New Mexico State University Climate Network (Grants METAR, Elevation 1,987 meters; Latitude 35° 10' N, Longitude 107° 54' W)*

D4.5 Ground Temperature

Mean annual air temperature data for 2004 and 2006 were used in the absence of measured data. The following table presents the mean annual air temperature for each assessment unit:

Table D.18 Mean Annual Air Temperature as an Estimate for Ground Temperature

Assessment Unit	Ref.	Mean Annual Air Temperature (°C)	Mean Annual Air Temperature (°F)
NM-2107.A_01	(a)	4.59	40.265
NM-2107.A_00	(a)	4.59	40.265
NM-2017.A_10	(b)	7.24	45.038

Ref. = References for Weather Station Data are as follows:
(c) *New Mexico State University Climate Network (Grants RAWS, Elevation 2,575 meters; Latitude 35° 14' 30" N, Longitude 107° 40' 12" W),* ***2004***
(d) *New Mexico State University Climate Network (Grants METAR, Elevation 1,987 meters; Latitude 35° 10' N, Longitude 107° 54' W),* ***2006***

°F = Degrees Farenheit
°C = Degrees Celcius

D4.6 Thermal Gradient

The default value of 1.65 was used in the absence of measured data.

D4.7 Possible Sun

Percent possible sun for Albuquerque is found at the Western Regional Climate Center web site http://www.wrcc.dri.edu/htmlfiles/westcomp.sun.html#NEW%20MEXICO. The percent possible sun is 76 percent for July.

D4.8 Dust Coefficient

If a value is entered for solar radiation, SSTEMP Model will ignore the dust coefficient and ground reflectivity and "override' the internal calculation of solar radiation. Solar radiation data are available from the New Mexico State University Climate Network (see Section 4.10).

D4.9 Ground Reflectivity

If a value is entered for solar radiation, SSTEMP Model will ignore the dust coefficient and ground reflectivity and "override' the internal calculation of solar radiation. Solar radiation data are available from the New Mexico State University Climate Network (see Section 4.10).

D4.10 Solar Radiation

Because solar radiation data were obtained from an external source of ground level radiation, it was assumed that about 90% of the ground-level solar radiation actually enters the water. Thus, the recorded solar measurements were multiplied by 0.90 to get the number to be entered into the SSTEMP Model. The following table presents the measured solar radiation at Grants RAWS for 2004 and 2006 as there were no data available for the Grants METAR station:
12.685 L/hour

Table E.19 Mean Daily Solar Radiation

Assessment Unit	Ref.	Date	Mean Solar Radiation (L/day)	Mean Solar Radiation x 0.90 (L/day)
NM-2107.A_01	(a)	7-13-2004	225.816	203.23
NM-2107.A_00	(a)	7-16-2004	254.616	229.15
NM-2017.A_10	(a)	8-31-06	304.44	273.996

Ref. = References for Weather Station Data are as follows:

(a) *(New Mexico State University Climate Network (Grants RAWS, Elevation 2,575 meters; Latitude 35° 14' 30" N, Longitude 107° 40' 12" W)*

D 5.0 SHADE

Percent shade was estimated for the assessment units using field estimations per geomorphological survey field notes from 2007. The measurements may have also been averaged along with visual estimates using USGS digital orthophoto quarter quadrangles downloaded from New Mexico Resource Geographic Information System Program (RGIS), online at http://rgis.unm.edu/. This parameter refers to how much of the segment is shaded by vegetation, cliffs, etc.

In a 2002 study, Optional Shading Parameters and concurrent densiometer readings were measured at seventeen stations in order to compare modeling results from the use of these more extensive data sets to modeling results using densiometer readings as an estimate of Total Shade. The estimated value for Total Shade was within 15% of the calculated value in all cases. Estimated values for Maximum Temperatures differed by less than 0.5% in all cases. The Optional Shading Parameters are dependent on the exact vegetation at each cross section, thus requiring multiple cross sections to determine an accurate estimate for vegetation at a reach scale. Densiometer readings are less variable and less inclined to measurement error in the field. Aerial photos are examined and considered whenever available.

The following table summarizes percent shade for each assessment unit:

Table D.20 Percent Shade

Assessment Unit	Percent Shade
NM-2107.A_01	5%
NM-2107.A_00	14%
NM-2017.A_10	63%

D 6.0 REFERENCES

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Viger, R.J., S.L. Markstrom, G.H. Leavesley and D.W. Stewart. 2000. The GIS Weasel: An Interface for the Development of Spatial Parameters for Physical Process Modeling. Lakewood, CO. Available on the internet at http://wwwbrr.cr.usgs.gov/weasel/.

Waltemeyer, Scott D. 2002. Analysis of the Magnitude and Frequency of the 4-Day Annual Low Flow and Regression Equations for Estimating the 4-Day, 3-Year Low-Flow Frequency at Ungaged Sites on Unregulated Streams in New Mexico. USGS Water-Resources Investigations Report 01-4271. Albuquerque, New Mexico.

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APPENDIX E
PUBLIC PARTICIPATION FLOWCHART

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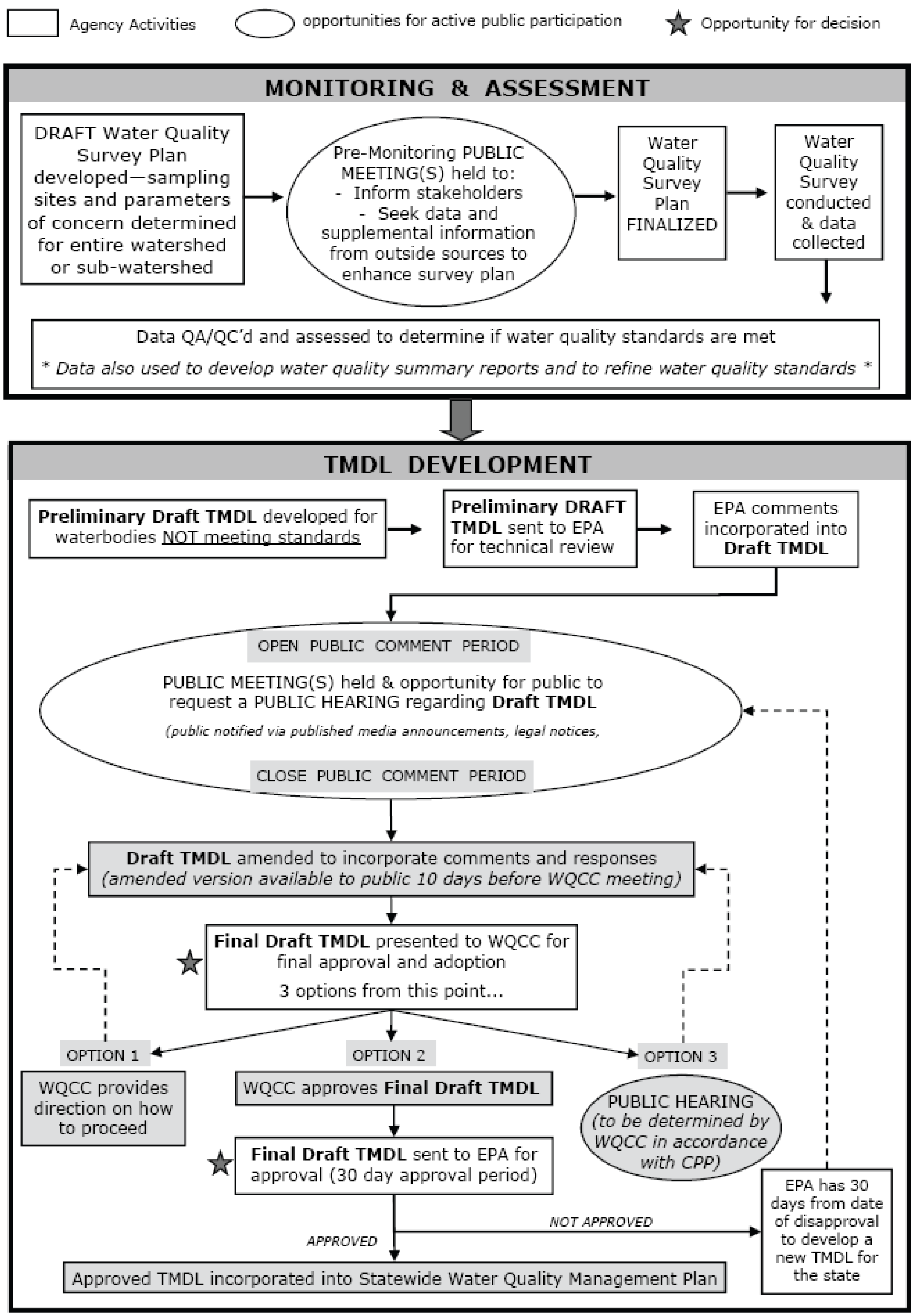
Monitoring, Assessment, & TMDL Development Process



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APPENDIX F
RESPONSE TO COMMENTS

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Changes made during public comment period based on staff review:

1. Added missing site numbers to Table 2.1
2. Moved discussion of options for the Cuba WWTP *Plant Nutrients – Wasteload Allocation* (Section 5.4.1) to *Implementation of TMDLs – NPDES Permitting* (Section 8.1)

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Comment Set A:

From: Leyendecker, W. E. (Gene) [gleyendecker@GFNET.com]
To: Henderson, Heidi, NMENV
Subject: Village of Cuba
Sent: 6/25/2007, 9:19am

The Village of Cuba has requested for me to e mail you regarding wastewater treatment plant effluent discharge to the Rio Puerco. Following construction of a new biological nutrient removal plant, the Village is requesting to discharge effluent to the Rio Puerco for a period of six months beginning on October 1 and ending on march 31 of each year. The remainder of the year the Village will either reuse or dispose of the effluent, and not discharge to the Rio Puerco. If there is any other information that you may require please contact me.

SWQB Response: *Thank you for your comment. After reviewing the available thermograph data, it is reasonable from a biological perspective to extend the dates of discharge into October. There is a reduced potential for algal growth when extending an extra month of discharge into the fall season than into the spring season. The initial suggested months will remain in the TMDL with a footnote regarding this comment. However, the final determination of permit language and months of discharge will be up to EPA Region 6 and NMED NPDES staff.*

Comment Set B:

From: James Ivy [tomivy@swbell.net]
To: Henderson, Heidi, NMENV
Subject: Re: Rio Puerco Part 2 public meeting
Sent: 6/25/2007, 2:55pm

I was impressed with the quality of the document. I thought it was well written. I was a 1970's, eutrophication era, algae student. My masters research thesis was "Eutrophication Potential of Secondary and Tertiary Wastewater Effluents." My conclusion, not particularly accepted at the time, was the more the wastewater was treated, the better the algae grew. I am a summer visitor to Cuba and am not involved in the local water issues, but Cuba was originally a freshwater marsh. I think an artifical wetland is the best solution to water quality problems in the Rio Puerco.

Tom Ivy

SWQB Response: *Thank you for your comment. Through the submittal of your comment, your suggestions and research expertise will be made available to the Village of Cuba, EPA Region 6, and NMED during the WWTP and permit development process.*

Comment Set C: submitted via fax on June 29, 2007 and e-mail on July 2, 2007

Meeting Date: June 21, 2007

Comments Regarding: **Total Maximum Daily Loads for Rio San Jose Watershed**

Instream flows must be considered in order to fulfill the purposes of the Federal Clean Water Act. The Pueblo of Acoma Water Quality Standards (Revised 2005) recognizes that surface and groundwater withdrawals from a stream may cause impairment to surface or groundwater bodies. Section II. Antidegradation Policy and Implementation Plan

SWQB Response: *Thank you for your comment. SWQB likewise agrees that water quantity can affect water quality. However, water quantity issues are addressed through the Office of the State Engineer (OSE). We will forward your comments to them. SWQB suggests the Watershed Restoration Action Strategy (WRAS) process as the mechanism through which the relationship between water quantity and water quality issues can best be addressed.*

Declining water levels in the Rio San Jose have contributed to rising sulfate and total dissolved solids (TDS) levels at Acoma, impacting designated uses. The Rio San Jose is dry below Bluewater Reservoir and springs back to life near the western edge of the Acoma Grant. This resurgence can be attributed to springflows and mountain runoff from Mt. Taylor. Another probable source of rising sulfate and TDS levels at Acoma is the legacy of uranium mining and milling along the San Mateo subwatershed.

SWQB Response: *During the 2004 SWQB survey, the Rio San Jose below Grants WWTF discharge site (#17 in Figures 2.4-2.6) was dry at 3 of the 4 sampling attempts with standing water in November. No samples were taken. Based on this sampling, no TMDLs were prepared for the Rio San Jose.*

It should also be noted that the Pueblo of Acoma Water Quality Standards contain numeric criteria for radioactive materials, such as uranium.

SWQB Response: *The State of New Mexico likewise has numeric criteria for radioactive materials in 20.6.4.900J NMAC.*

These circumstances indicate a need for scheduled releases from Bluewater Reservoir and a moratorium on groundwater withdrawals until instream flows are reestablished. Any discussion of TMDLs for the dry reaches of the Rio San Jose must be combined with the development of Watershed Restoration Action Strategies that first address the restoration of instream flows below Bluewater Reservoir.

SWQB Response: *The issue of instream flows and the impact of ground water withdrawals on streams is one that is best addressed to the Office of the State Engineer. We will forward your comment to them. Additionally, SWQB does not currently draft TMDLs for dry reaches and none have been developed for such reaches of the Rio San Jose. See response below regarding the WRAS process.*

A further recommendation involves the alternative provision of baseline water quality data from the San Mateo subwatershed during the spring runoff and summer monsoon season. The acquisition of background data on ephemeral flows from San Mateo Creek is an essential alternative to simply ignoring an identifiable degraded reach of the river.

SWQB Response: *SWQB staff have recently had meetings with Acoma Pueblo staff regarding the WRAS process and the upcoming potential for 319 (h) grant funding. SWQB encourages the participation of all stakeholders in this process to include the mangers of Bluewater Reservoir and OSE in discussions of water releases. SWQB also encourages the collection of water quality data by watershed groups as a contribution to the water quality data available to SWQB for assessment purposes.*

All watersheds emanating from Mt. Taylor, including the San Mateo watershed, should be protected as unique areas with natural values and habitat in need of restoration and protection through NPDES permitting.

SWQB Response: *The NPDES program regulates point source discharges into watercourses and there are currently no NPDES permits on the Rio San Jose. The Grants WWTP no longer has a NPDES permit but has a land application permit through the Ground Water Quality Bureau. SWQB continues to stay in contact with GWQB staff in regards to this issue. However, the WRAS process described above is an appropriate venue for consideration of watershed restoration of unique areas and natural habitat.*

The Watershed Protection Section (WPS) of NMED's SWQB is available to work with local watershed groups on non point source discharge issues that are not subject to the NPDES permit program. The web site for the WPS is: http://www.nmenv.state.nm.us/swqb/WPS/index.html.

Submitted by: Laura Watchempino
Haaku Water Office
P.O. Box 309
Pueblo of Acoma, NM 87034
haakuwater@yahoo.com

Comment Set D: submitted via e-mail on June 29, 2007; received via postal mail on July 9, 2007

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File Code: 2520-1/2530-4
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Dear Ms. Henderson:

Thank you for the opportunity to comment on the DRAFT Total Maximum Daily Load (TMDL) for the Rio Puerco Watershed – Part 2. Segments of Bluewater Creek (Bluewater Reservoir to headwaters), NM-2107.A_01, is on the Cibola National Forest. This creek is potentially affected by our land management activities so we take great interest in the water quality.

Likewise, part of the watershed that drains into Bluewater Creek (non-tribal Rio San Jose to Bluewater Reservoir), NM-2107.A_00 and Rio Moquino (Laguna Pueblo to Seboyetita Creek), NM-2107.A_10 is on National Forest System lands administered by the Cibola National Forest. These stream segments are much less affected by land management activities on the Cibola National Forest. This reduced connection between National Forest System land management and water quality is due to the proximity of these impaired stream segments to National Forest System land (i.e. no National Forest System land adjacent to the stream bank) and to the lack of perennial and or intermittent flow off National Forest System land into these reaches.

The main focus of our comments will be on Bluewater Creek (Bluewater Reservoir to headwaters). This TMDL addresses Plant Nutrients and Temperature for this reach. On Plant Nutrients the Cibola National Forest has two comments.

The method for determining a numeric equivalent to the narrative standard for plant nutrients appears to be somewhat subjective. Use of the statistical median for nutrient data of Total Phosphorus and Total Nitrogen does give a numeric value to strive for, but there is no physical or biological connection to the narrative "…concentrations which will produce undesirable aquatic life or result in the dominance of nuisance species in surface waters of the state." Likewise, this method does not appear to assess if the plant nutrients (Total P and Total N) are from "other than natural causes" as stated in the narrative.

SWQB Response: *Thank you for your comment. The primary question to be answered during a nutrient assessment is:* ***Is the reach (i.e. assessment unit) impaired due to nutrient enrichment?*** *Or, in other words, is the assessment unit meeting the narrative criterion? The SWQB Nutrient Assessment Protocol for Streams uses a two-tiered approach to nutrient assessment (NMED/SWQB 2006). The two levels of assessment are used in sequential order to determine if there is excessive* *nutrient enrichment. If a Level I assessment indicates nutrient enrichment, a Level II assessment will be used to test this finding and provide more quantitative indicators. If these measurements exceed the numeric nutrient threshold values for phosphorus or nitrogen, indicate excessive primary production (i.e., large dissolved oxygen (DO) and pH fluctuation and/or high chlorophyll a concentration), and/or demonstrate an unhealthy benthic community, the reach is considered to be impaired due to nutrient enrichment.*

SWQB has adopted this multi-indicator approach to conduct a more robust assessment that accounts for the chemical, physical, and biological connections to the narrative standard. Both cause and response variables are used in the assessment. The causal variables include total phosphorus (TP) and total nitrogen (TN) concentrations and the response variables include algal biomass (i.e. chlorophyll a concentration), DO, and pH. SWQB recently revised the Nutrient Assessment Protocol for Streams, which discusses the threshold development process and includes the revised ecoregional threshold values for TP, TN, and chlorophyll a (NMED/SWQB 2007).

SWQB is also currently in the process of developing a regional stream condition index (SCI) and assigning tolerance values for diatom communities of New Mexico, which are known to be good indicators of nutrient enrichment. Once an SCI has been developed for New Mexico and organism tolerance values are verified these biological indicators will be used in the weight-of-evidence nutrient assessment.

Finally, during TMDL development, SWQB has chosen to address the causal indicators of nutrient impairment (TP and TN) because they can be more readily controlled through BMP implementation and NPDES permitting. Through the use of local, ecoregion-specific threshold values, SWQB feels that it is addressing the "other than natural causes" clause in the narrative nutrient criterion. It is assumed that by limiting or reducing phosphorus and nitrogen concentrations to regional levels, undesirable aquatic life, nuisance species, and large fluctuations of DO and pH will also be limited or reduced.

REFERENCES:

NMAC. 2006. State of New Mexico Standards for Interstate and Intrastate Streams. As amended through February 16, 2006. Santa Fe, NM.

NMED/SWQB. 2006. State of New Mexico Procedures for Assessing Standards Attainment for the Integrated §303(d)/§305(b) Water Quality Monitoring and Assessment Report. Available at: http://www.nmenv.state.nm.us/swqb/. Santa Fe, NM.

NMED/SWQB. 2007. Guidance for Nutrient Assessment of Streams. Santa Fe, NM.

USEPA. 2000. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. EPA-822-B-00-002.

On page 57 of the DRAFT TMDL it discusses atmospheric deposition of nutrients as a "background levels." Data from nearby National Atmospheric Deposition Program/National Trend Network collection sites in Cuba, Bandelier National Monument and Petrified Forest National Park indicate nitrate levels well above the Total Nitrogen TMDL concentration of 0.25 mg/L (e.g. weighted mean concentration at Cuba ranged from 0.66 to 1.29 mg/L; at Bandelier from 0.61 to 1.42 mg/L; and at Petrified from 1.15 to 1.51 mg/L). We are concerned that if "background levels" of nitrate are more than double the TMDL for Total Nitrogen it will be impossible to help bring nutrient levels under the TMDL through land management activities.

SWQB Response: *SWQB understands your concern regarding the implementation of this TMDL. However, as stated in the Nutrient Assessment Protocol for Streams, "This… is a dynamic document that will be refined as more data are collected, enabling more precise classification of streams and definition of relationships between nutrient concentrations, indicators, and impairment in New Mexico streams." Nutrient criteria development is an iterative process that will continue to be refined as more data and information are gathered. If, through further analyses, it is found that the ecoregional threshold values are inappropriate for a specific waterbody, they will be adjusted accordingly and the TMDL will be revised with the new values. Nevertheless, SWQB feels confident about its nutrient criteria development program thus far. EPA Region 6 and the regional technical advisory group support the decisions and processes that SWQB has gone through to develop the threshold values defined in the nutrient assessment protocol for streams.*

Concerning the Temperature TMDL, (p. 64) a load allocation in terms of joules per square meter per second ($j/m^2/s$) is not very useful in guiding non-point source management practices.

A temperature load allocation in terms of percent effective shade would be much more useful than one in terms of heat energy ($j/m^2/s$). Fortunately, percent effective shade is a directly corresponding surrogate measure that can be calculated from the loading allocation. The maximum level of shade practical at a particular site is termed the 'system potential effective shade'. System potential is an estimate of the condition where anthropogenic activities that cause stream warming are minimized. Primary factors that affect shade are near stream vegetation height and channel width. The use of 'effective shade' as a surrogate to thermal load is allowed under EPA regulations defined as "other appropriate measure" in 40 CFR 130.2(i).

System potential effective shade occurs when:

1. <u>Near stream vegetation is appropriate for the site.</u>

   Indicators include:
   - Vegetation community is mature and undisturbed from anthropogenic sources
   - Vegetation height and density is at or near the potential expected for the given plant community and site conditions
   - Vegetation community is sufficiently wide to maximize solar attenuation
2. <u>Channel width is sufficiently narrow for the site</u>

   Indicators include:
   - Stream banks reflect appropriate ranges of stability
   - Sedimentation reflects appropriate levels of sediment input and transport
   - Substrate is appropriate to the channel type
   - High flow shear velocities are within appropriate ranges

In summary, system potential effective shade developed from potential site conditions is used as a surrogate measure of the load allocation for temperature. Specifically, system potential effective shade, developed from vegetation and stream channel conditions represents the best feasible or reasonable condition expected in the watershed. The load allocation described in terms of system potential shade is a much more useful parameter in pollutant evaluation and management than heat energy expressed in $j/m^2/s$. This information would help resource managers evaluate progress towards 'system potential effective shade' conditions.

SWQB Response: *SWQB agrees that $j/m^2/sec/day$ is not an easily translated parameter for groups working with non-point source issues. However, EPA has recently drafted numerous memos guiding the states to develop TMDLs that include a daily increment in response to the 2006 D.C. Circuit Court of Appeals decision Friends of the Earth, Inc. v. EPA, et al., No. 05-5015 in which the D.C. Circuit held that two TMDLs for the Anacostia River did not comply with the Clean Water Act because they were not expressed as daily loads. It is for this reason that SWQB will continue to use the $j/m^2/sec/day$ output from SSTEMP unless given different guidance by EPA. According to a June 22, 2007 draft memo from EPA on the subject, "EPA recognizes that it might continue to be appropriate and necessary to identify non-daily allocations in TMDL development despite the need to also identify daily loads." Estimates of percent shade reductions are given in the document to supplement the daily load requirements and make the load allocations more easily translated by watershed restoration groups. Ultimately, the goal is to meet WQS attainment and the temperature monitoring done by watershed groups and SWQB will be the measurement toward this goal.*

Thank you for considering our comments to the DRAFT Total Maximum Daily Load (TMDL) for the Rio Puerco Watershed – Part 2. If you have any questions related to our comments or would like clarification on any of our comments please contact Bryce Bohn at 505-346-3817, bbohn@fs.fed.us or Edward Huffman at 505-346-3908, elhuffman@fs.fed.us.

Sincerely,
NANCY ROSE
Forest Supervisor

cc: Edward L Huffman
Bryce Bohn
Chuck Hagerdon