FINAL APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

RIO HONDO WATERSHED (LINCOLN COUNTY)

PECOS RIVER TO HEADWATERS

FEBRUARY 10, 2006

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LIST OF ABBREVIATIONS

4Q3	4-Day, 3-year low-flow frequency
BLM	Bureau of Land Management
BMP	Best management practices
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CGP	Construction general storm water permit
cms	Cubic meters per second
CWA	Clean Water Act
CWF	Coldwater Fishery
^oC	Degrees Celcius
^oF	Degrees Farenheit
EPT	Ephemeroptera/Plecoptera/Tricoptera
FR	Forest Road
GIS	Geographic Information Systems
GPS	Global Positioning System
HBI	Hilsenhoff's Biotic Index
HQCWF	High quality cold water fishery
HUC	Hydrologic unit code
IOWDM	Input and Output for Watershed Data Management
$j/m^2/s$	Joules per square meter per second
LA	Load allocation
lb/day	Pounds per Day
mg/L	Milligrams per Liter
mi^2	Square miles
mL	Milliliters
mm	Millimeters
MOS	Margin of safety
MOU	Memoranda of Understanding
MS4	Municipal Separate Storm Sewer System
MSGP	Multi Sector Genral Storm Water Permit
NM	New Mexico
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint source
NTU	Nephelometric turbidity units
QAPP	Quality Assurance Project Plan
RBP	Rapid Bioassessment Protocol
RFP	Request for proposal
SBD	Stream bottom deposits
SSTEMP	Stream Segment Temperature Model
SWPPP	Storm Water Pollution Prevention Plan
SWQB	Surface Water Quality Bureau
SWSTAT	Surface Water Statistics

TMDL	Total maximum daily load
TSS	Total suspended solids
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
WQS	Water quality standards (NMAC 20.6.4 as amended through October 11, 2002)
WRAS	Watershed Restoration Action Strategy
WWTP	Waste water treatment plant
μmhos	Micromhos
μmhos/cm	Micromhos per centimeter

EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to develop Total Maximum Daily Load (TMDL) management plans for water bodies determined to be water quality limited. A TMDL documents the amount of a pollutant a water body 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 Part 130 as the sum of the individual Waste Load Allocations (WLAs) for point sources and Load Allocations (LAs) for nonpoint source and background conditions, and includes a Margin of Safety (MOS).

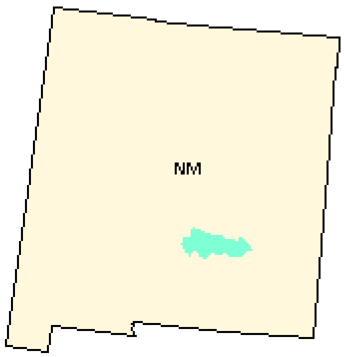
The Rio Hondo watershed is located in southcentral New Mexico. The Surface Water Quality Bureau (SWQB) conducted an intensive surface water quality survey of the Rio Hondo basin in 2003. Water quality monitoring stations were located throughout the upper Rio Hondo watershed during the intensive watershed survey to evaluate the impact of tributary streams and ambient water quality conditions. As a result of assessing data generated during this monitoring effort, combined with data from outside sources that met SWQB quality assurance requirements, impairment determinations of New Mexico water quality standards for fecal coliform were documented for Carrizo Creek (Rio Ruidoso to Headwaters), Rio Bonito (Angus Canyon to Headwaters), and Rio Hondo (Perennial Reaches to Rio Ruidoso). Impairment of the narrative plant nutrient standard was confirmed for the Rio Ruidoso (Rio Bonito to US Highway 70). Exceedences of the temperature criterion were documented on Rio Ruidoso (US Highway 70 to the Mescalero Apache Boundary). Impairment due to turbidity was verified on Rio Ruidoso (US Highway 70 to the Mescalero Apache Boundary). This TMDL document addresses the above noted impairments as summarized in the tables below.

A number of assessment units could not be assessed in this document due to insufficient data. These impairments will remain on the Clean Water Act Integrated §303(d)/§305(b) list of waters until additional data are available. Additionally, assessment units whose designated uses are not existing or attainable and those that will be de-listed are detailed in this document.

Additional water quality data will be collected by the SWQB 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 category on the Clean Water Act Integrated §303(d)/§305(b) list of waters.

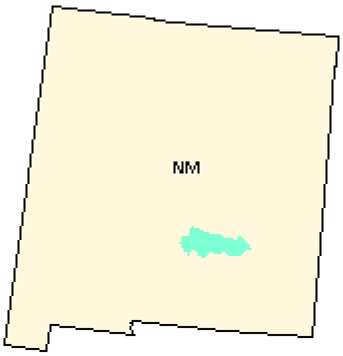
The SWQB's Watershed Protection Section has and will continue to work with the Upper Hondo Watershed Coalition to finalize the Watershed Restoration Action Strategies (WRAS) in order to develop and implement strategies to attempt to correct the water quality impairments detailed in this document. Implementation of items detailed in the WRAS will be done with participation of all interested and affected parties.

TOTAL MAXIMUM DAILY LOAD FOR
BACTERIA
CARRIZO CREEK (RIO RUIDOSO TO MESCALERO APACHE BOUNDARY)



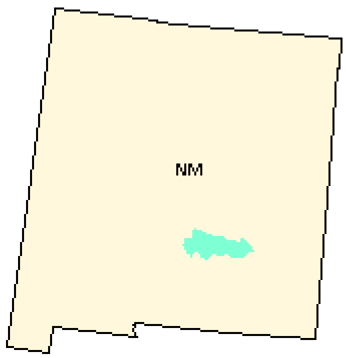
New Mexico Standards Segment	Pecos River Basin 20.6.4.209
Waterbody Identifier	Carrizo Creek (Rio Ruidoso to Mescalero Apache boundary) NM-2209.A_22 (formerly NM-PR8-50200)
Segment Length	3 miles
Parameters of Concern	Bacteria
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Hondo USGS Hydrologic Unit Code 13060008
Scope/size of Watershed	22.53 mi^2
Land Type	Arizona/New Mexico Mountains Ecoregion (23)
Land Use/Cover	Forest (97%), Grassland (1.7%), Shrubland (<1%), Water (<1%)
Identified Sources	Unknown Sources
Land Management	Mescalero Apache Reservation (86%), U.S. Forest Service (9%), Private (5%)
Priority Ranking	High
TMDL for: Fecal Coliform	**WLA (0) + LA (1.27x10^9) + MOS (6.70x10^7) = 1.34x10^9cfu/day**

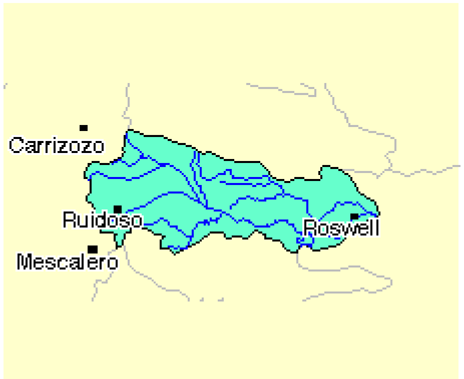
TOTAL MAXIMUM DAILY LOAD FOR
BACTERIA
RIO BONITO (ANGUS CANYON TO HEADWATERS)



New Mexico Standards Segment	Pecos River Basin 20.6.4.209
Waterbody Identifier	Rio Bonito (Angus Canyon to headwaters) NM-2209.A_10 (formerly NM-PR8-30000)
Segment Length	10.16 miles
Parameters of Concern	Bacteria
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Hondo USGS Hydrologic Unit Code 13060008
Scope/size of Watershed	45.96 mi^2
Land Type	Arizona/New Mexico Mountains Ecoregion (23)
Land Use/Cover	Forest (97%), Grassland (1.6%), Shrubland (1.3%), Water (<1%)
Identified Sources	Low flow alterations
Land Management	U.S. Forest Service (89%), Private (11%)
Priority Ranking	High
TMDL for: Fecal Coliform	**WLA (0) + LA ($2.30x10^9$) + MOS ($1.21x10^8$) = $2.42x10^9$cfu/day**

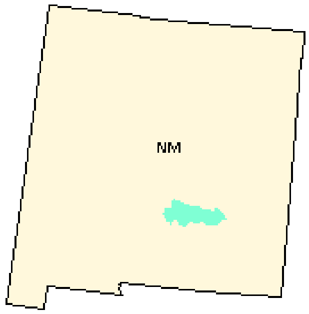
TOTAL MAXIMUM DAILY LOAD FOR
BACTERIA
RIO HONDO (PERENNIAL REACHES PECOS RIVER TO RIO RUIDOSO)





New Mexico Standards Segment	Pecos River Basin 20.6.4.208
Waterbody Identifier	Rio Hondo (Perennial reaches Pecos River to Rio Ruidoso) (formerly NM-2208_30)
Segment Length	8 miles
Parameters of Concern	Bacteria
Uses Affected	Coldwater Fishery
Geographic Location	Rio Hondo USGS Hydrologic Unit Code 13060008
Scope/size of Watershed	585.88 mi^2
Land Type	Arizona/New Mexico Mountains Ecoregion (23), Southwestern Tablelands (26)
Land Use/Cover	Forest (45%), Grassland (33%), Shrubland (20%), Agriculture (1.24%), Residential and commercial (<1%), Water (<1%)
Identified Sources	Unknown sources
Land Management	Private (45%), U.S. Forest Service (28%), Mescalero Apache Reservation (19%), BLM (5%), State (3%)
Priority Ranking	High
TMDL for: Fecal Coliform	**WLA (0) + LA (6.24×10^9) + MOS (3.29×10^8) = 6.57×10^9 cfu/day**

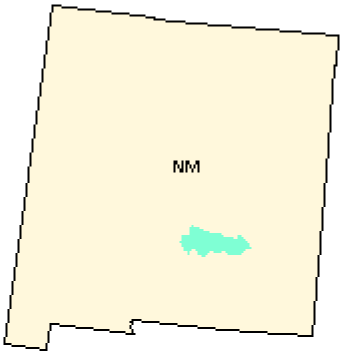
TOTAL MAXIMUM DAILY LOAD FOR
PLANT NUTRIENTS
RIO RUIDOSO (RIO BONITO TO US HIGHWAY 70)



New Mexico Standards Segment	Pecos River Basin 20.6.4.208
Waterbody Identifier	Rio Ruidoso (Rio Bonito to US Highway 70) NM-2208_20 (formerly NM-PR8-40000)
Segment Length	19.63 miles
Parameters of Concern	Plant Nutrients
Uses Affected	Coldwater Fishery
Geographic Location	Rio Hondo USGS Hydrologic Unit Code 13060008
Scope/size of Watershed	289.46 mi^2
Land Type	Arizona/New Mexico Mountains Ecoregion (23)
Land Use/Cover	Forest (77%), Grassland (13%), Shrubland (8%), Agriculture (1.2%), Residential and commercial (1%)
Identified Sources	Flow alterations from water diversions, highway/road/bridge runoff (non-construction related), loss of riparian habitat, municipal point source discharges, on-site treatment systems (septic systems and similar decentralized systems), rangeland grazing, streambank modifications/destabilization.
Land Management	U.S.Forest Service (38%), Mescalero Apache Reservation (33%), Private (26%), State (2.1%), BLM (1.3%)
Priority Ranking	High
TMDL for:	
Plant Nutrients:	
Total Phosphorus	**WLA(2.16) + LA(0.34) + BL(0.09)[a] + MOS(0.13) = 2.72 lbs/day**
Total Nitrogen	**WLA(18.9) + LA(5.28) + BL(1.66)[a] + MOS(1.36) = 27.2 lbs/day**

[a] BL = Background Load, or load attributable to natural sources (in lbs/day).

TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE and TURBIDITY RIO RUIDOSO (US HIGHWAY 70 TO MESCALERO APACHE BOUNDARY)



New Mexico Standards Segment	Pecos River Basin 20.6.4.209
Waterbody Identifier	Rio Ruidoso (US Highway 70 to Mescalero Apache bnd) NM-2209.A_20 (formerly NM-PR8-50000)
Segment Length	12.4 miles
Parameters of Concern	Temperature, Turbidity
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Hondo USGS Hydrologic Unit Code 13060008
Scope/size of Watershed	152.65 mi^2
Land Type	Arizona/New Mexico Mountains Ecoregion (23)
Land Use/Cover	Forest (93%), Grassland (3.5%), Shrubland (1.2%), Residental and commercial (1.6%), Agriculture (<1%), Water (<1%)
Identified Sources	Loss of riparian habitat, municipal point source discharges, on-site treatment systems (septic systems and similar decentralized systems), rangeland grazing, site clearance (land development or redevelopment), streambank modifications/destabilization.
Land Management	Mescalero Apache Reservation (61%), U.S. Forest Service (22%), Private (16%), State (<1%)
Priority Ranking	High
TMDL for: Temperature Turbidity	 **WLA (0) + LA (105.07) + MOS (11.67) =116.74 j/m^2/sec/day** **WLA (0) + LA (267) + MOS (89) = 356 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 the 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 standard 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 Rio Hondo watershed that have been determined to be 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 Rio Hondo watershed, provides applicable water quality standards for the assessment units addressed in this document, and briefly discusses the intensive water quality survey that was conducted in the Rio Hondo watershed in 2003. Section 3.0 provides detailed descriptions of the individual watersheds for which TMDLs were developed. Section 4.0 presents the TMDLs developed for bacteria in the Rio Hondo watershed. Section 5.0 provides nutrient TMDLs, Section 6.0 contains contains temperature TMDLs, and Section 7.0 contains a turbidity TMDL. Pursuant to Section 106(e)(1) of the Federal CWA, Section 8.0 provides a monitoring plan in which methods, systems, and procedures for data collection and analysis are discussed. Section 9.0 discusses implementation of TMDLs (phase two) and the relationship between TMDLs and Watershed Restoration Action Strategies (WRASs). Section 10.0 discusses assurance, Section 11.0 public participation in the TMDL process, and Section 12.0 provides references.

2.0 RIO HONDO BACKGROUND

The upper Rio Hondo Basin was intensively sampled by the Surface Water Quality Bureau (SWQB) from March to November 2003 and is addressed in this document. The Rio Hondo Basin includes perennial reaches of the Rio Hondo from the Pecos River to its headwaters, as well as tributaries that enter the Rio Hondo along those perennial reaches. 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 and those receiving de-list letters 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 Location Description

The upper Rio Hondo watershed (US Geological Survey [USGS] Hydrologic Unit Code [HUC] 13060008) is located in Lincoln and Otero Counties and the Mescalero Apache Indian Reservation in southcentral New Mexico (NM). The entire Rio Hondo watershed encompasses approximately 1680 square miles (mi^2) in Lincoln County. The Rio Hondo watershed consists of two smaller subwatersheds of about equal area: the Rio Bonito and the Rio Ruidoso. Both subwatersheds lie east and south of the Capitan and Sacramento Mountains. The Rio Hondo is formed at the confluence of the Rio Bonito and Rio Ruidoso. Landscapes range from forested mountains to desert grasslands to vegetated riparian zones. As presented in Figure 2.1, land use is 45% forest, 33% grassland, 20% shrubland, 1% agricultural, and 1% urban. Figure 2.2 shows land ownership as 45% private, 28% US Forest Service (USFS), 19% Tribal Land, 5% Bureau of Land Management (BLM), and 3% State.

Several species within this watershed are listed as either threatened or endangered by both State and Federal agencies. Federally listed endangered species include the kuenzler's cactus (*Echinocereus fendleri var kuenzleri*), Rio Grande silvery minnow (*Hybognathus amarus*), and Pecos gambusia (*Gambusia nobilis*). Federally listed threatened species include the Mexican spotted owl (*Strix occidentalis lucida*). Additional species listed by the State as endangered include the godding's onion (*Allium gooddingii*). Additional species listed by the State as threatened include the Mexican tetra (*Astyanax mexicanus*), gray redhorse (*Moxostoma congestum*), Pecos pupfish (*Cyprinodon pecosensis*), greenthroat darter (*Etheostoma lepiddum*), Sacramento mountain salamander (*Aneides hardii*), and the broad-billed hummingbird (*Cynanthus laitrostris*).

The vegetation of the Lincoln County area includes Chihuahuan Desert, Mexican Highlands, Great Plains, and Rocky Mountain floras (Barker *et al*. 1991). Tourism is a major component of the economy in the upper Rio Hondo Basin. The relatively cool summer climate and snowy winter conditions support activities such as hiking, mountain biking, camping, fishing, as well as skiing and other winter sports. Ranching and irrigated agriculture are additional contributors to the local economies.

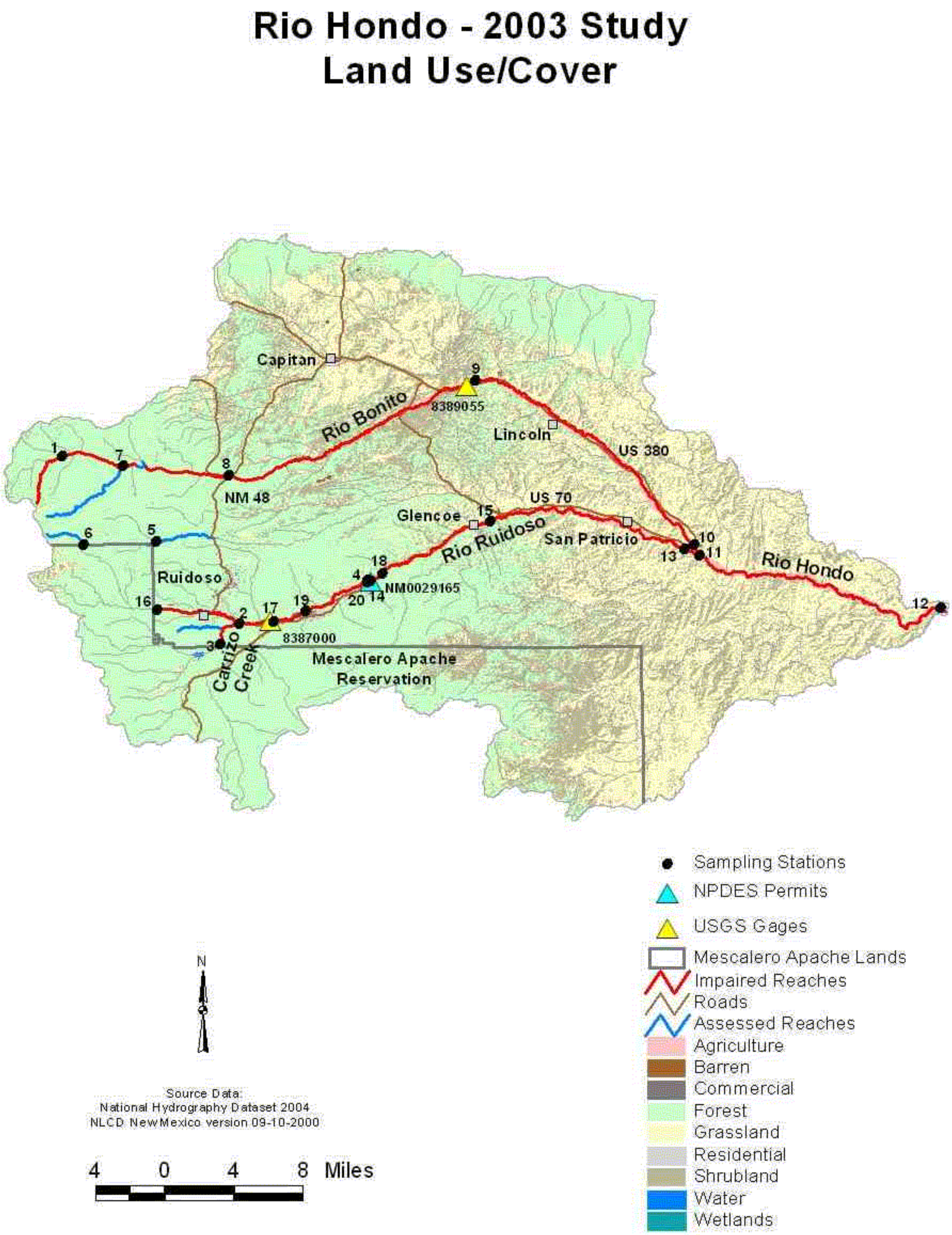


Figure 2.1 Rio HondoWatershed Land Use and 2003 Sampling Stations

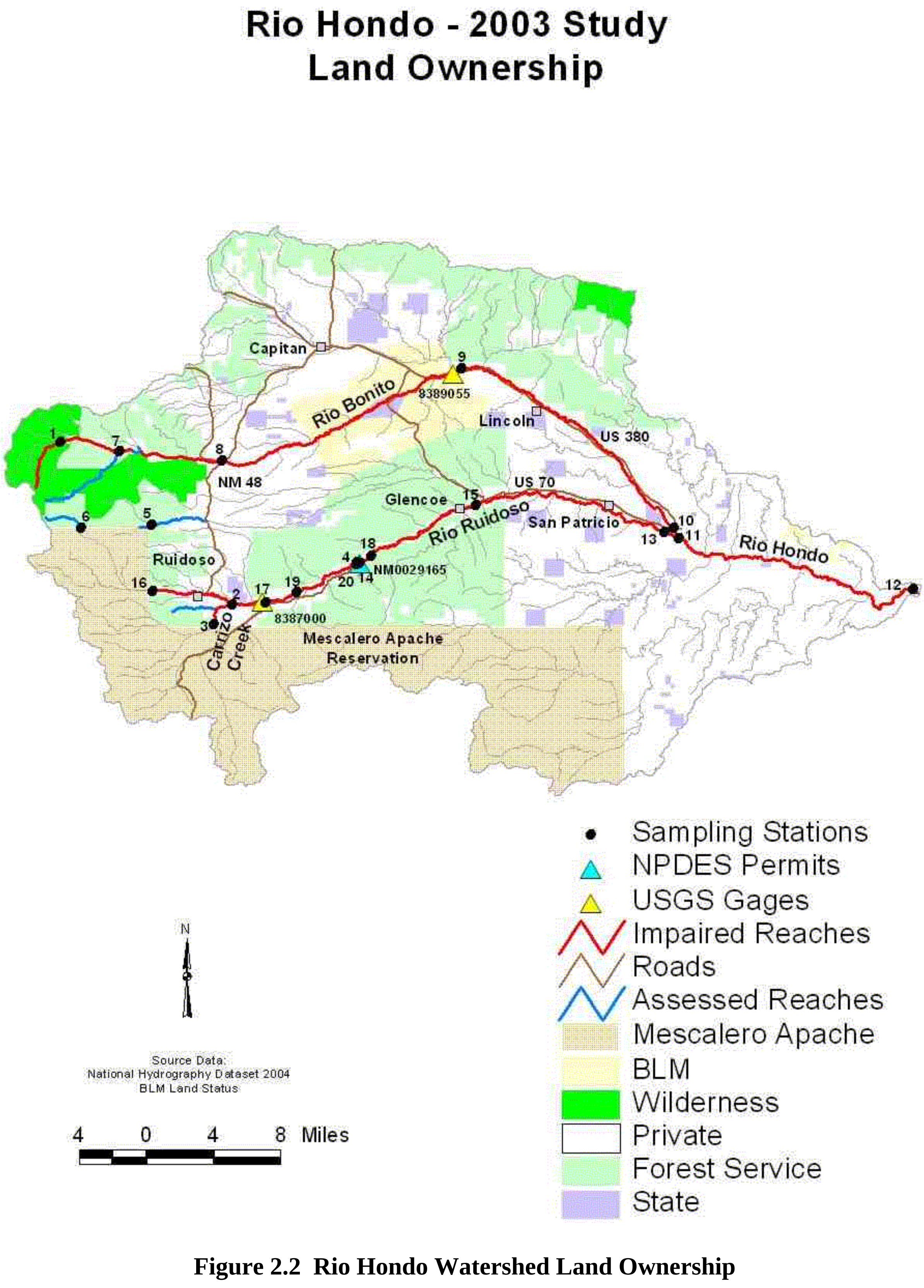


Figure 2.2 Rio Hondo Watershed Land Ownership

2.2 Geology and History

The geology of the Rio Hondo watershed consists of a complex distribution of Cretaceous intrusive rocks, Permian sedimentary rocks, and Cretaceous sedimentary rocks (Table 2.1, Figure 2.3). The high dome of Mt Sierra Blanca is an intrusion of Teriary igneous rocks associated with many nearby faults and dikes (Chronic 1987). Sierra Blanca is separated from the smaller Tertiary intrusions of the Carrizo and Capitan Mountains by the valley of soft, Cretaceous shale around its north end (*Ibid*). The Cenozoic igneous rocks of Sierra Blanca and the northwestern part of the Mescalero Apache Reservation include intrusive plugs, stocks, and dikes of the Sierra Blaca volcanic pile (Ahlen and Hanson 1986). Breccias and purplish-green porphyrys are commonly exposed on Sierra Blanca towards the Ski Area on Sierra Blanca Peak (*Ibid*). Cenozoic roks are also exposed on Sierra Blanca that include igneous intrusive, volcanic, and sedimentary rocks (*Ibid*). There are also glacial deposits in the cirque on the northeast slopes of the Peak at the head of the North Fork of the Rio Ruidoso (*Ibid*). San Andres Limestone formsthe surface between Tularosa and Ruidoso; the stream valleys in this watershed cut down into the red and yellow soil zone of the Yeso Formation (Chronic 1987). Cub Mountain Formation consists of white sandstone, multicolored siltstone, and light-colored igneous rocks (Ash and Davis 1964). The Yeso formation consists of beds of siltstone, sandstone, shale, limestone, anhydrite, gypsum, and salt and does not readily transmit water (Mourant 1963). The Yeso Formation was formed by the precipitation of gypsum and salt from an evaporating inland sea (Chronic 1987). The San Andres Limestone forms the aquifer for Roswell's water (*Ibid*). The upper part of the San Andres Limestone consists of dolomite and chert-limestone, as well as siltstone, sandstone, gypsum, anhydrite, and shale. The Artesia Formation consists of similar sedimentary rocks (Mourant 1963). The Cretaceous Dakota Sandstone consists of quartzose sandstone interbedded with grey shale and conglomerate (*Ibid*). Mancos Shale is black shale, limestone and sandstone while the Mesaverde Formation is grey, yellow, and buff quartzose sandstone, grey shale, and coal (*Ibid*).

Mining activity in Lincoln County has produced a number of minerals and metals including: gold, coal, iron, lead, copper, zinc, fluorite, gypsum, tungsten, and bastnaesite (Griswold 1959). Spaniards likely performed the earliest mining in Licoln County, but no evidence of their activity exists (*Ibid*). However, the first mining in Lincoln County by Americans appears to be a gold vein at the Helen Rae and American mines in 1868 (*Ibid*).

Three Rivers Petroglyphs (west of Sierra Blanca) is a mile-long display of pictures carved into the volcanic rock mostly made by prehistoric Native Americans and may be contemporary with the nearby Mimbres site dating from 900-1,000 A.D. (Ash and Davis 1964). Hale Springs (south of Ruidoso Downs) once fed a Native American irrigation ditch and the caliche formed in this ditch is used to line the driveways in the area (Ash and Davis 1964). One of the first battles of the Lincoln County War occurred at Blazer's Mill (southwest of Ruidoso) on April 5, 1878 when Billy the Kid and the McSween faction attempted to make an arrest (Ash and Davis 1964). The 116-mile Bontio pipeline built in 1908 supplied water for railroad and domestic use from Nogal Lake (Ash and Davis 1964). Bonito Lake was built in the 1930's to store the water from Nogal Lake when the first lake started leaking (Barker *et al.* 1991). As a cub, Smokey the Bear was rescued from a forest fire in Capitan Gap in 1950, nursed back to health, and flown to

Washington, D.C. to become the mascot for the U.S. Forest Service's fire prevention program (Ash and Davis 1964).

Table 2.1 Geologic Unit Definitions for the Rio Hondo

Geologic Unit Code	Definition
Kd	Dakota Sandstone; includes Oak Canyon, Cubero, and Paguate Tongues plus Clay Mesa Tongue of Mancos Shale; Cenomanian.
Km	Mancos Shale; divided into Upper and Lower parts by Gallup Sandstone
Kmv	Mesaverde Group includes the Gallup Sandstone, Crevasse Canyon Formation, Point Lookout Sandstone, Menelee Formation, and Cliff House Sandstone
Pal	Lower part of the Abo Formation
Pat	Artesia Group; shelf facies forming broad south-southeast trending outcrop from Glorieta to Artesia area; includes Grayburg, Queen, Seven Rivers, Yates, and Tansill Formations; Guadalupian. May locally include Moenkopi Formation (Triassic) on top.
Psa	San Andres Formation; limestone and dolomite with minor shale; Guadalupian in south, in part Leonardian to north.
Py	Yeso Formation; sandstones, siltstones, anhydrite, gypsum, halite, and dolomite; Leonardian.
QTp	Older piedmont alluvial deposits and shallow basin till; includes Quemado formation and in northeast, high level piedmont gravels.
Qal	Alluvium, middle and upper Quaternary.
TKi	Paleogene and Upper Cretaceous intrusive rocks; includes Hanover, Fierra, Tyrone, and Lordsburg granediorite-quartz manzonile perphries.
TR	Triassic rocks, general.
Tbc	Tertiary sediments, including Baca Formation and Cub Mountain Formation
Tvl	Tertiary volcanics
pC	Precambrian rocks, undifferentiated.

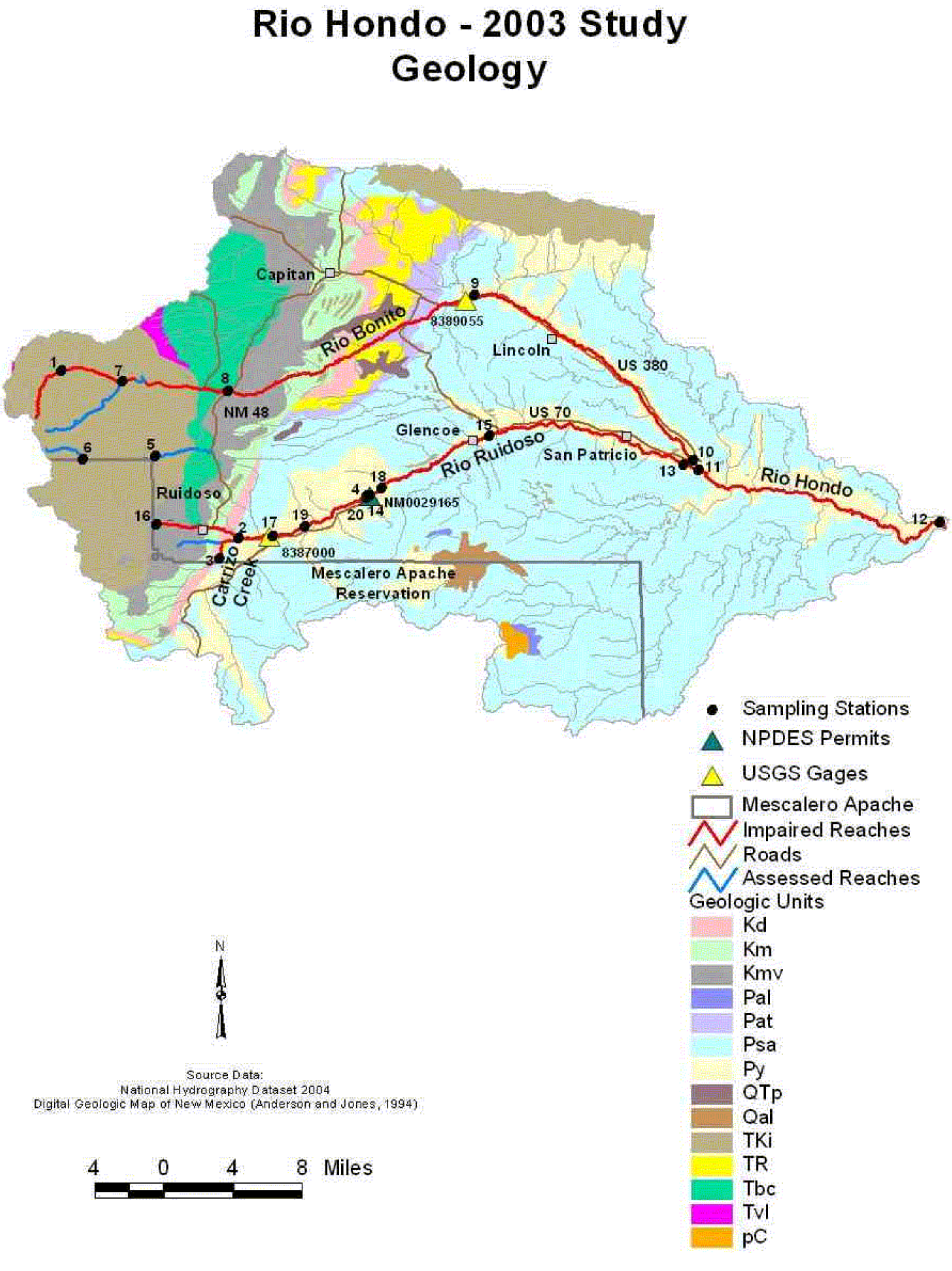


Figure 2.3 Rio Hondo Watershed Geology

2.3 Water Quality Standards

Water quality standards (WQS) for all assessment units in this document are set forth in sections, 20.6.4.208 and 20.6.4.209 of the *NM Standards for Interstate and Intrastate Surface Waters* (NM Administrative Code [NMAC] 20.6.4) (NMAC 2002).

20.6.4.208 **PECOS RIVER BASIN -** Perennial reaches of the Rio Peñasco and its tributaries above state highway 24 near Dunken, perennial reaches of the Rio Bonito downstream from state highway 48 (near Angus), the Rio Ruidoso downstream of the U.S. highway 70 bridge near Seeping Springs lakes, perennial reaches of the Rio Hondo, and Agua Chiquita.

A. Designated Uses: fish culture, irrigation, livestock watering, wildlife habitat, coldwater fishery, and secondary contact.

B. Criteria:

(1) In any single sample: pH within the range of 6.6 to 8.8, temperature shall not exceed 30°C (86°F) and total phosphorus (as P) less than 0.1 mg/L. The use-specific numeric 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 fecal coliform bacteria 200/100 mL or less; single sample 400/100 mL or less (see Subsection B of 20.6.4.13 NMAC).

20.6.4.209 **PECOS RIVER BASIN –**Eagle creek above Alto reservoir, the Rio Bonito upstream of state highway 48 (near Angus), and the Rio Ruidoso and its tributaries upstream of the U.S. highway 70 bridge near Seeping Springs lakes.

A. Designated Uses: domestic water supply, fish culture, high quality coldwater fishery, irrigation, livestock watering, wildlife habitat, municipal and industrial water supply and secondary contact.

B. Criteria:

(1) In any single sample: conductivity shall not exceed 600 µmhos/cm in Eagle creek, 1,100 µmhos in Bonito creek, and 1,500 µmhos in the Rio Ruidoso, pH shall be within the range of 6.6 to 8.8, temperature shall not exceed 20°C (68°F), and turbidity shall not exceed 10 NTU. The use-specific numeric 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 fecal coliform bacteria 100/100 mL or less; single sample shall exceed 200/100 mL or less (see Subsection B of 20.6.4.14 NMAC).

NMAC 20.6.4.900 provides standards applicable to attainable or designated uses unless otherwise specified in 20.6.4.101 through 20.6.4.899. NMAC 20.6.4.12 lists general standards that apply to all surface waters of the state at all times, unless a specified standard is provided elsewhere in NMAC (2002).

The New Mexico Environment Department (NMED) proposed several modifications to the New Mexico WQS during the February 2004 triennial review hearing. Changes that will potentially affect the Rio Hondo watershed are:

- Changing the criteria related to contact uses from fecal coliform to *E. coli* (monthly geometric mean of 126 colony forming units (cfu)/100 mL or less in 20.6.4.208 and 20.6.4.209, single sample 410 cfu/100 mL in 20.6.4.208, and single sample 235 cfu/100 mL in 20.6.4.209).

- The segment-specific turbidity criteria has been replaced with the following language applicable to all surface waters:

> **Turbidity**: Turbidity attributable to other than natural causes shall not reduce light transmission to the point that the normal growth, function or reproduction of aquatic life is impaired or that will cause substantial visible contrast with the natural appearance of the water. Turbidity shall not exceed 10 NTU over background turbidity when the background turbidity is 50 NTU or less, or increase more than 20 percent when the background turbidity is more than 50 NTU. Background turbidity shall be measured at a point immediately upstream of the turbidity-causing activity. However, limited-duration activities necessary to accommodate dredging, construction or other similar activities and that cause the criterion to be exceeded may be authorized provided all practicable turbidity control techniques have been applied and all appropriate permits and approvals have been obtained.

The State of New Mexico Water Quality Control Commission (WQCC) adopted the proposed WQS changes as of July 17, 2005. However, pending USEPA approval of these new proposed WQS, water quality data were assessed and TMDLs for the Rio Hondo watershed were prepared using the existing WQS (NMAC 2002). Adoption of the new WQS will not affect the turbidity TMDL in this document. Until there is an understanding as to the background levels of turbidity, the existing numeric criteria will be used for assessments. The fecal coliform TMDLs in this document will likewise not be affected, but future studies will incorporate the collection of *E. coli* samples in order to make assessments based on the new standards.

2.4 Intensive Water Quality Sampling

The Rio Hondo watershed was intensively sampled by the SWQB in 2003. A brief summary of the survey and the hydrologic conditions during the intensive sample period is provided in the following subsections.

2.4.1 Survey Design

Surface water quality samples were collected monthly between March and November for the 2003 intensive SWQB study. Temperature data also were collected in 2003. Surface water quality monitoring stations were selected to characterize water quality of various assessment units (i.e., stream reaches and reservoirs) throughout the basin (Table 2.2, Figures 2.1 through 2.3). The locations of 2003 thermograph deployment in the Rio Hondo watershed are described in Section 7.0 (Table 7.1 and Figure 7.1). Stations were located to evaluate the impact of tributary streams and to determine ambient water quality conditions. Data results from grab sampling are housed in the SWQB provisional water quality database and will be uploaded to USEPA's Storage and Retrieval (STORET) database. A water quality survey report is not yet available for this study.

All temperature and chemical/physical sampling and assessment techniques are detailed in the *Quality Assurance Project Plan* (QAPP, NMED/SWQB 2001) and the SWQB assessment protocols (NMED/SWQB 2004b). As a result of the 2003 monitoring effort and subsequent assessment of results, several surface water impairments were determined. Accordingly, these impairments were added to New Mexico's 2004-2006 CWA Integrated §303(d)/305(b) list (NMED/SWQB 2004a).

Table 2.2 SWQB 2003 Rio Hondo Sampling Stations

Station	Station Location
1	Bonito Creek @ White Mountain Wilderness Bounday
2	Carrizo Creek above the Rio Ruidoso
3	Carrizo Creek at Mescalero Boundary
4	City of Ruidoso New WWTP Outfall Pipe
5	Eagle Creek at USGS gage
6	N Fk Rio Ruidoso blw Ski Lodge
7	Rio Bonito abv Bonito Lk at FR 107 blw Bonito S.
8	Rio Bonito at Angus Bridge
9	Rio Bonito at BLM Orchard Site near Lincoln, NM
10	Rio Bonito at Hwy 70 bridge near Hwy 380 bridge
11	Rio Hondo 100 yds below confluence
12	Rio Hondo below Riverside on Rio Hondo Land and Cattle property
13	Rio Ruidoso 1 mi abv Rio Bonito at San Patricio
14	Rio Ruidoso 10 feet above WWTP outfall
15	Rio Ruidoso 7 miles below WWTP at Glencoe-FR 443
16	Rio Ruidoso at Mescalero Boundary at Gage
17	Rio Ruidoso at USGS Gaging Station at Hollywood
18	Rio Ruidoso below New WWTP
19	Rio Ruidoso below Ruidoso Downs Racetrack Property
20	Ruidoso 0.5 mile above WWTP at Hwy 70 Bridge above Seeping Springs

2.4.2 Hydrologic Conditions

There are two U.S. Geological Survey (USGS) gaging stations in the Rio Hondo watershed that are associated with reaches presented in this document. USGS gage locations are presented in Figures 2.1 through 2.3. Daily streamflow for the pertinent gages are presented graphically in Figures 2.4 and 2.5.

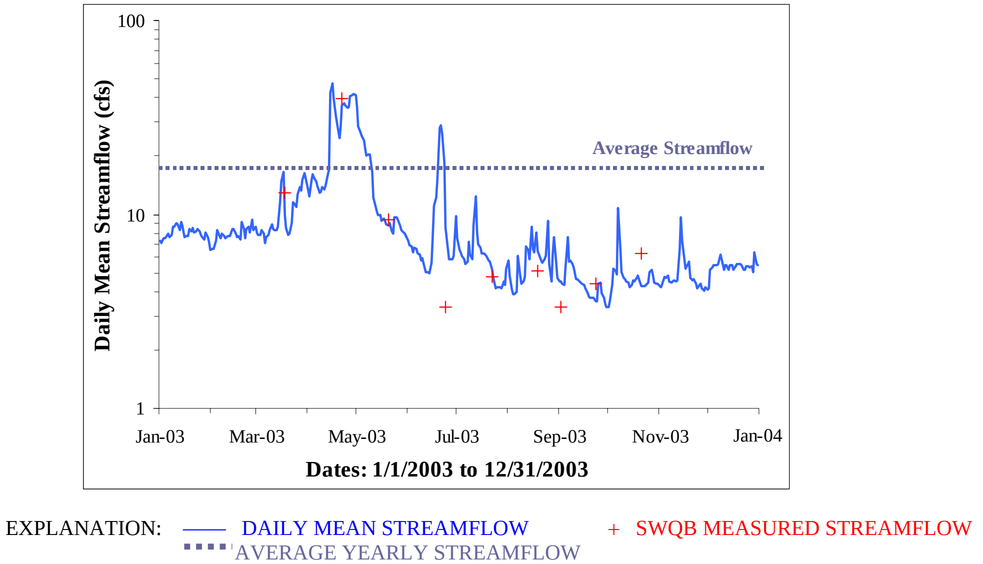


Figure 2.4 Daily Mean Streamflow: USGS 08387000 Rio Ruidoso at Hollywood, NM (2003)

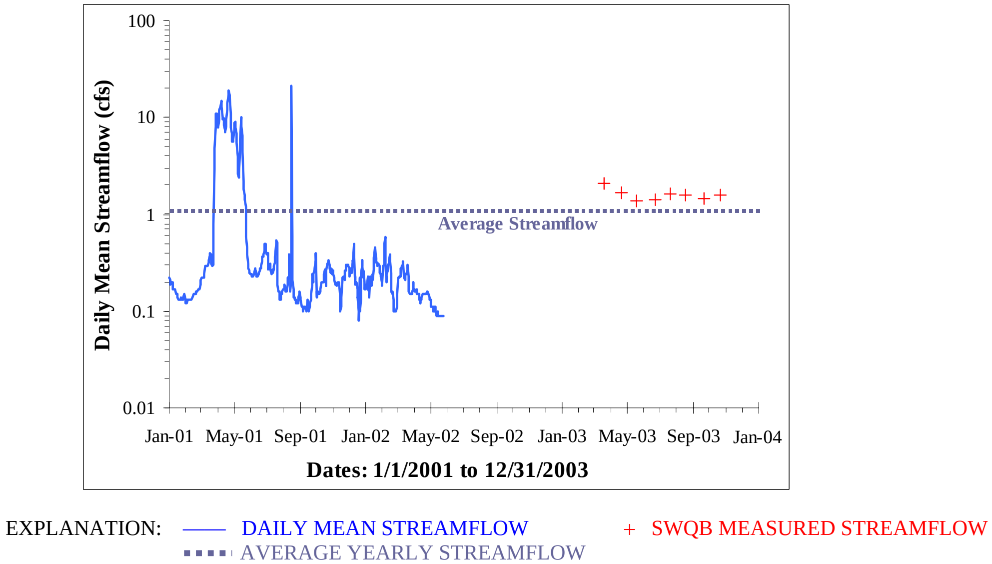


Figure 2.5 Daily Mean Streamflow: USGS 08389055 Rio Bonito near Lincoln, NM (01-02) and SWQB measured streamflow at Rio Bonito near Lincoln, NM (2003)

Flows in Rio Ruidoso (USGS Gage 08387000) during the 2003 survey year were below average based on the period of record, which spans from 1953 to present. Flows in Rio Bonito (USGS Gage 08389055) during the 2003 survey were about average based on the period of record, which spans from 1999-2002. For comparison, the instantaneous discharge measured by SWQB during the intensive survey is shown on Figures 2.4 and 2.5. Since the USGS Gage 08389055 (Rio Bonito near Lincoln, NM) was discontinued in 2002, the real-time, daily mean streamflow was not measured. As stated in the Assessment Protocol (NMED/SWQB 2004b), 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 designated use attainment status during the assessment process. In terms of assessing designated use attainment in ambient surface waters, WQS apply at all times under all flow conditions.

3.0 INDIVIDUAL WATERSHED DESCRIPTIONS

TMDLs were developed for assessment units for which constituent (or pollutant) concentrations measured during the 2003 water quality survey, as combined with quality outside data, 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 Hondo basin. In addition, the 2004-2006 Integrated §303(d)/§305(b) listings within the Rio Hondo basin are discussed (NMED/SWQB 2004a). Assessment units that will have delist letters prepared are discussed in their respective individual subwatershed sections.

3.1 Carrizo Creek Subwatershed

The headwaters of the 24.6 mi^2 Carrizo Creek subwatershed originate on the Mescalero Apache Indian Reservation. According to available Geographic Information System (GIS) coverages, the Carrizo Creek watershed has an average elevation of 7615 feet above sea level and receives approximately 22.7 inches of precipitation a year. As presented in Figure 2.1, land uses include 97% forest, 2% grassland, and less than 1% of the land use in this watershed is commercial, residential, or shrubland. Land ownership is 9% private, 79% Tribal Lands, and 12% Forest Service (Figure 2.2). The geology of the Carrizo Creek watershed is predominantly comprised of the Mesaverde Group and Mancos Shale with limited areas of Dakota Sandstone, San Andres Formation, Yeso Formation, and Quaternary Alluvium (Figure 2.3).

Carrizo Creek (Rio Ruidoso to Mescalero Apache Boundary) is approximately 3 miles in length. SWQB established two stations along this assessment unit and deployed one thermograph during the 2003 intensive survey. Carrizo Creek (Rio Ruidoso to Mescalero Apache Boundary) was included on the 2004-2006 Integrated CWA §303(d)/§305(b) list for bacteria. No TMDLs have previously been established for Carrizo Creek. Therefore, TMDLs were developed for inclusion in this document for the following assessment unit in the Carrizo Creek subwatershed:

- ***Bacteria*:** Carrizo Creek (Rio Ruidoso to Mescalero Apache Boundary)

Photo 3.1 Carrizo Creek at Two Rivers Park (June 10, 2003)

3.2 Rio Bonito Subwatershed

Rio Bonito originates in the Sacramento Mountains. The Rio Bonito watershed is approximately 296 mi^2 and is a tributary to Rio Hondo, which then joins the Pecos River. As presented in Figure 2.1, land use is 47% forest, 29% grassland, 22% shrubland, 1.4% agriculture, and less than 1% residential. Land ownership is 44% private, 39% U.S. Forest Service, 12% BLM, and 5% State (Figure 2.2). The Rio Bonito is usually perennial in the mountainous areas, but is dry much of the year in the reach beginning 10 miles upstream of the confluence with Rio Hondo (Mourant 1963).

The geology of the Rio Bonito watershed consists of Cretaceous intrusive rocks, Tertiary sediments, alluvium, and various Permian sedimentary rock formations. The Yeso Formation underlies most of this watershed (Mourant 1963). This subwatershed may mark the fault boundary with the Cub Mountain Formation to the north and Mesaverde Formation to the south (Ash and Davis 1964). The San Andres Limestone lies flat, but the Yeso Formation is folded into the Lincoln Folds, which are exposed for seven miles in bluffs north of Rio Bonito (Chronic 1987).

Rio Bonito (Rio Ruidoso to Angus Canyon) is approximately 34 miles in length. Two stations were established (Table 2.2, Figure 2.2) and one thermograph was deployed (Figure 7.1) in this assessment unit during the 2003 intensive survey. Rio Bonito (Rio Ruidoso to Angus Canyon) was listed on the 2004-2006 Integrated §303(d)/305(b) List of Impaired Waters (NMED/SWQB 2004a) for low flow alteration and sedimentation/siltation (stream bottom deposits) impairments. However, Rio Bonito at BLM Apple Orchard site was used as a sedimentation/siltation (stream bottom deposits) reference site during the assessment process and requires a de-list letter. No TMDLs have previously been prepared for this assessment unit.

Photo 3.2 Rio Bonito at Apple Orchard site (February 18, 2003)

Rio Bonito (Angus Canyon to headwaters) is approximately 10 miles in length. Three stations were established (Table 2.2, Figure 2.2) and two thermographs were deployed (Figure 7.1) in this assessment unit during the 2003 intensive survey. Rio Bonito (Angus Canyon to headwaters) was listed on the 2004-2006 Integrated CWA §303(d)/305(b) List of Impaired Waters (NMED/SWQB 2004a) for low flow alteration impairment. After assessing the 2003 water quality data, this reach was also found to be impaired by bacteria requires a TMDL. No TMDLs have previously been prepared for this assessment unit. The following TMDL was developed for this watershed:

- ***Bacteria* -** Rio Bonito (Angus Canyon to headwaters)

Photo 3.3 Rio Bonito above Bonito Lake at Forest Road 107 (March 4, 2003)

3.3 Rio Hondo Watershed

Rio Hondo orginates in the Sacramento Mountains. The Rio Hondo watershed is approximately 586 mi^2 and includes Rio Bonito and Rio Ruidoso before it joins the Pecos River near Roswell, New Mexico. As presented in Figure 2.1, land use is 45% forest, 33% grassland, 20% shrubland, 1% agriculture, and less than 1% residential and commercial. Land ownership is 45% private, 28% U.S. Forest Service, 19% Mescalero Apache Reservation, 5% BLM, and 3% State (Figure 2.2). The Rio Hondo is perennial in its upper reaches, gains in flow from Hondo to Picacho, then loses flow from Picacho to Roswell, but is again perennial from Roswell to the Pecos River (Mourant 1963). The Rio Hondo is dry most of the year from Riverside to Roswell (*Ibid*), so the SWQB 2003 intensive survey included a site near Riverside (site 12) as the most downstream site of the survey.

The geology of the Rio Hondo watershed consists of Cretaceous intrusive rocks, Tertiary sediments, alluvium, and various Permian sedimentary rock formations. The Rio Hondo Valley displays the San Andres Limestone and Permian Yeso Formation (Chronic 1987). The Yeso Formation is mostly pink sandstone and siltstone, but also contains limestone and gypsum (*Ibid*). Passages honeycomb the San Andres Limestone, sinks have formed as cavern roofs have collapsed, and fossil shellfish is abundant (*Ibid*).

Rio Hondo (Perennial reaches Pecos River to Rio Ruidoso) is approximately 8 miles in length. Two stations were established (Table 2.2, Figure 2.2) and two thermographs were deployed (Figure 7.1) in this assessment unit during the 2003 intensive survey. Rio Hondo (Perennial reaches Pecos River to Rio Ruidoso) was listed on the 2004-2006 Integrated §303(d)/305(b) List of Impaired Waters (NMED/SWQB 2004a) for unknown impairment. After assessing the water quality data, this reach was found to be impaired by bacteria and requires a TMDL. No TMDLs have previously been prepared for this assessment unit. The following TMDL was developed for this watershed:

- ***Bacteria*** **-** Rio Hondo (Perennial reaches Pecos River to Rio Ruidoso)

Photo 3.4 Rio Hondo at Rio Hondo Land and Cattle property (March 18, 2003)

3.4 Rio Ruidoso Subwatershed

The headwaters of the 290 mi^2 Rio Ruidoso watershed originate in the Sacramento Mountains. According to available GIS coverages, the Rio Ruidoso watershed has an average elevation of 7152 feet above sea level and receives approximately 20.2 inches of precipitation a year. As presented in Figure 2.1, land uses include 77% forest, 13% grassland, 8% shrubland, 1% agriculture, and less than 1% of the land use in this watershed is commercial or residential. Land ownership is 26% private, 33% Tribal Lands, 38% U.S. Forest Service, 2% State Lands, and 1% Bureau of Land Management (Figure 2.2). Rio Ruidoso is a perennial stream; the river is cut below the water table and will have some flow even during periods of low precipitation (Mourant 1963). The geology of the Rio Ruidoso watershed is predominantly comprised of Tertiary Igneous Rocks in the headwaters and the San Andres Formation, Yeso Formation, and Quaternary Alluvium in the lower regions with limited areas of Dakota Sandstone, Mancos Shale, Mesaverde Group, Triassic Rocks (general), Artesia Group, and Tertiary Sediments (Figure 2.3).

The Rio Ruidoso is divided into three assessment units (AUs). Rio Ruidoso (North Fork above Mescalero Apache Boundary) is approximately 2 miles in length. One station was established (Table 2.2, Figure 2.1) in this assessment unit during the 2003 intensive survey. Data from this station was combined with readily available data from other sources that met quality control objectives, and were assessed using established assessment protocols to determine whether or not designated uses were being met. As a result, the Rio Ruidoso (North Fork above Mescalero Apache Boundary) was found to be fully supporting of its designated uses and was NOT listed on the 2004-2006 Integrated §303(d)/305(b) List of Impaired Waters (NMED/SWQB 2004a). No TMDLs will be written for this assessment unit.

The Rio Ruidoso (US Highway 70 Bridge to Mescalero Apache Boundary) is approximately 12 miles in length. Four stations were established (Table 2.2, Figure 2.1) and three thermographs were deployed (Figure 7.1) in this assessment unit during the 2003 intensive survey. Rio Ruidoso (US Highway 70 Bridge to Mescalero Apache Boundary) was included on the 2004-2006 Integrated CWA §303(d)/§305(b) list for nutrient/eutrophication biological indicators, sedimentation/siltation, temperature, and turbidity. Nutrient/eutrophication biological data from these stations were combined with readily available data from other sources that met quality control objectives and were reassessed using a weight-of-evidence approach developed by SWQB and submitted to the USEPA in 2004. The weight-of-evidence approach includes analysis of a number of indicators of nutrient enrichment, such as total nitrogen (TN) concentration, total phosphorus (TP) concentration, dissolved oxygen concentration, dissolved oxygen saturation, pH, algal productivity (from algal bioassays), and benthic macroinvertebrate Index of Biotic Integrity (IBI) scores. As a result, the Rio Ruidoso (US Highway 70 Bridge to Mescalero Apache Boundary) will be de-listed for plant nutrients. The Rio Ruidoso at Mescalero Apache boundry site was used as a sedimentation/siltation (stream bottom deposits) reference site during the assessment process and requires a de-list letter. No TMDLs have previously been established for the Rio Ruidoso. Therefore, TMDLs were developed for inclusion in this document for the following assessment units in the Rio Ruidoso subwatershed:

- ***Temperature, Turbidity-*** Rio Ruidoso (US Hwy 70 Bridge to Mescalero Apache Bndy)

Photo 3.5 Rio Ruidoso at Mescalero Apache Boundary (June 10, 2003)

The Rio Ruidoso (Rio Bonito to US Highway 70 Bridge) is approximately 20 miles in length. Four stations were established (Table 2.2, Figure 2.1) and two thermographs were deployed (Figure 7.1) in this assessment unit during the 2003 intensive survey. Data from these stations were combined with readily available data from other sources that met quality control objectives, and were assessed using established assessment protocols to determine whether or not designated uses were being met. As a result, Rio Ruidoso (Rio Bonito to US Highway 70 Bridge) was included on the 2004-2006 Integrated CWA §303(d)/§305(b) list for nutrient/eutrophication biological indicators and sedimentation/siltation. However, as a result of the application of the data to the assessment protocol, this assessment unit will be de-listed for sedimentation/siltation. No TMDLs have previously been established for the Rio Ruidoso. Therefore, TMDLs were developed for inclusion in this document for the following assessment units in the Rio Ruidoso subwatershed:

- ***Nutrients* -** Rio Ruidoso (Rio Bonito to US Hwy 70 Bridge)

Photo 3.6 Rio Ruidoso at U.S. Highway 70 (September 24, 2003)

Photo 3.7 Rio Ruidoso at U.S. Highway 70 (June 11, 2003)

4.0 BACTERIA

During the 2003 SWQB sampling monitoring effort in the Rio Hondo watershed, fecal coliform data showed several exceedences of the New Mexico water quality secondary contact use standard for several assessment units. This data was combined with other sources of data to determine overall impairment for these assessment units. As a result, three assessment units in the Rio Hondo watershed are listed on the 2004-2006 Integrated CWA §303(d)/§305(b) list (NMED/SWQB 2004a) with fecal coliform as a pollutant of concern (see summary in Table 4.1 and data in Appendix A). Presence of fecal coliform bacteria is an indicator of the possible presence of other bacteria that may limit beneficial uses and present human health concerns. There are potential nonpoint and point sources of fecal coliform bacteria throughout the basin that could be contributing to the fecal coliform levels.

According to the New Mexico Water Quality Standards (WQS), the fecal coliform standard reads:

> *20.6.4.208 NMAC: The monthly geometric mean of fecal coliform bacteria shall not exceed 200/100mL; no single sample shall exceed 400/100mL.*
>
> *20.6.4.209 NMAC: The monthly geometric mean of fecal coliform bacteria shall not exceed 100/100mL; no single sample shall exceed 200/100mL.*

Per USEPA guidance, SWQB has proposed changes in the contact use criterion from fecal coliform to *E. coli*. This WQS change has not been approved by USEPA at the time these TMDLs were prepared and are therefore not discussed in this TMDL document. However, in the event that new data indicate that the targets used in this analysis are not appropriate and/or if these 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 category on the Clean Water Act Integrated §303(d)/§305(b) list of waters.

Table 4.1. Summary of Assessment Units Impaired for Bacteria in the Rio Hondo Basin

Assessment Unit	New Mexico Standards Segment	Fecal coliform: # Exceedences/ Total Samples	Fecal coliform[(a)] %Exceedence
Carrizo Creek (Rio Ruidoso to Mescalero Apache boundary)	20.6.4.209	2/8	25%
Rio Bonito (Angus Canyon to headwaters)	20.6.4.209	2/13	15%
Rio Bonito (Rio Ruidoso to Angus Canyon)	20.6.4.208	0/8	0%[(b)]
Rio Hondo (Pecos River to confluence of Rio Bonito and Rio Ruidoso)	20.6.4.208	6/13	46%
Rio Ruidoso (US Highway 70 to Mescalero Apache Boundary)	20.6.4.209	1/19	5%[(b)]
Rio Ruidoso (Rio Bonito to US Highway 70)	20.6.4.208	2/17	12%[(b)]

Notes:

[(a)] Exceedence rates $\geq$ 15% result in a determination of Non Support based on the assessment protocol (NMED/SWQB 2004b)

[(b)] There are no TMDL calculations for fecal coliform in the Rio Ruidoso or Rio Bonito (Rio Ruidoso to Angus Canyon) in this document because the exceedence rate was <15%. Thus, the determination would be Full Support.

4.1 Target Loading Capacity

Overall, the target values for bacteria 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 bacteria are based on the reduction in bacteria necessary to achieve numeric criteria. This TMDL is also consistent with New Mexico's antidegradation policy.

The segment-specific criteria leading to an assessment of use impairment for Carrizo Creek and Rio Bonito is the numeric criteria stating that "The monthly geometric mean of fecal coliform bacteria shall not exceed 100cfu /100 mL; no single sample shall exceed 200cfu /100 mL" for the designated contact use (20.6.4 NMAC). The segment-specific criteria leading to an assessment of use impairment for the Rio Hondo is the numeric criteria stating that "The monthly geometric mean of fecal coliform bacteria shall not exceed 200cfu /100 mL; no single sample shall exceed 400cfu /100 mL" for the designated contact use (20.6.4 NMAC).

4.2 Flow

Bacteria numbers can vary as a function of flow. Exceedences of the criterion occurred at both high and low flows in the impaired assessment units in the Rio Hondo basin. Therefore, the target flow was set at the critical low flow condition or 4Q3, defined as the minimum average four consecutive day flow which occurs with a frequency of once in three years (4Q3). Critical low flow was determined on an annual basis utilizing all available daily flow values rather than on a seasonal basis for these TMDLs because exceedences occurred during both low and high flow conditions.

When available, USGS gage data were used to determine 4Q3s (Table 4.2 and Appendix B). These 4Q3s were estimated through application of USGS gage data to 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). When necessary, 4Q3s calculated at USGS gaging stations are area weighted according to USGS (1970) to determine 4Q3 values for the ungaged portion (Appendix B).

It is important to remember that the TMDL itself is a value calculated at a defined critical condition, and is calculated as part of planning process designed to achieve water quality standards. Since flows vary throughout the year in these systems, the actual load at any given time will vary based on the changing flow. Management of the load to improve stream water quality should be a goal to be attained.

4.3 Calculations

Bacteria standards are expressed as colony forming units (cfu) per unit volume. The fecal coliform criteria are listed in Table 4.2.

Table 4.2. Criteria concentrations and flow values for allowable load calculations

Assessment Unit	Fecal coliform criterion used in target calculation (cfu/100ml)	Source of selected criterion	4Q3 [(a)]
Carrizo Creek (Rio Ruidoso to Mescalero Apache boundary)	200	NMAC 20.6.4.209 single sample criterion	0.547 cfs 0.354 mgd
Rio Bonito (Angus Canyon to headwaters)	200	NMAC 20.6.4.209 single sample criterion	0.990 cfs 0.640 mgd
Rio Hondo (Pecos River to confluence of Rio Bonito and Rio Ruidoso)	400	NMAC 20.6.4.208 single sample criterion	1.342 cfs 0.867 mgd

Notes:
[(a)] Determined by area-weighting the 4Q3 from USGS Gage 08387000 – Rio Ruidoso at Hollywood, NM (USGS 1970).
cfs = cubic feet per second; mgd = million gallons per day

Target loads for bacteria are calculated based on 4Q3 flow values, current and proposed WQS, and conversion factors (**Equation 1**). The more conservative geometric mean criteria are utilized in TMDL calculations to provide an implicit MOS. In addition, if the single sample criteria were used as targets, the geometric mean criteria may not be reached.

C as cfu/100 mL * 1,000 mL/1 L * 1 L/ 0.264 gallons * Q * 1,000,000 gallons = cfu/day **(Eq. 1)**

Where C = NM state water quality standard criterion for bacteria,
Q = stream flow in million gallons per day (mgd)

The target loads (TMDLs) predicted to attain current and proposed standards were calculated using **Equation 1** and are shown in Table 4.3.

Table 4.3. Calculation of Target Loads for Fecal Coliform

Assessment Unit	4Q3 Flow (mgd)	Fecal Coliform geometric mean criteria (cfu/100mL)	Conversion Factor[(a)]	Bacteria Target Load Capacity (cfu/day)
Carrizo Creek (Rio Ruidoso to Mescalero Apache boundary)	0.354	100	3.79×10^7	1.34×10^9
Rio Bonito (Angus Canyon to headwaters)	0.640	100	3.79×10^7	2.42×10^9
Rio Hondo (Pecos River to confluence of Rio Bonito and Rio Ruidoso)	0.867	200	3.79×10^7	6.57×10^9

Notes:
[(a)] Based on equation 1.

4.4 Waste Load Allocations and Load Allocations

4.4.1 Waste Load Allocation

There are no point source contributions associated with this TMDL. The WLA is therefore zero for all three of the impaired assessment units.

4.4.2 Load Allocation

In order to calculate the LA, the WLA and MOS were subtracted from the target capacity (TMDL), as shown below in **Equation 2**.

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

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 5% (see Section 4.7 for details) are presented in Table 4.4.

Table 4.4. Calculation of TMDLs for Fecal Coliform

Assessment Unit	WLA (cfu/day	LA (cfu/day)	MOS (5%) (cfu/day)	TMDL (cfu/day)
Carrizo Creek (Rio Ruidoso to Mescalero Apache boundary)	0	1.27×10^{9}	6.70×10^{7}	1.34×10^{9}
Rio Bonito (Angus Canyon to headwaters)	0	2.30×10^{9}	1.21×10^{8}	2.42×10^{9}
Rio Hondo (Pecos River to confluence of Rio Bonito and Rio Ruidoso)	0	6.24×10^{9}	3.29×10^{8}	6.57×10^{9}

The extensive data collection and analyses necessary to determine background fecal coliform loads for the Rio Hondo watershed were beyond the resources available for this study. It is therefore assumed that a portion of the load allocation is made up of natural background loads.

Measured loads were also calculated using **Equation 1**. In order to achieve comparability between the target capacity (i.e., TMDL values) and measured loads, the same flow rates were used for both calculations. Results are presented in Table 4.5.

Table 4.5. Calculation of Measured Loads for Fecal Coliform

Assessment Unit	4Q3 Flow (mgd)	Measured FC Concentrations[(b)] (cfu/100mL)	Conversion Factor[(a)]	Measured Load (cfu/day)
Carrizo Creek (Rio Ruidoso to Mescalero Apache boundary)	0.354	210	3.79×10^7	2.82×10^9
Rio Bonito (Angus Canyon to headwaters)	0.640	802	3.79×10^7	1.95×10^{10}
Rio Hondo (Pecos River to confluence of Rio Bonito and Rio Ruidoso)	0.867	1040	3.79×10^7	3.42×10^{10}

Notes:
[(a)] Based on equation 1.
[(b)] The measured concentration is the arithmetic mean of the measured values used to make the impairment determination (see Appendix A)

The nonpoint source and background load reductions necessary to meet the target loads were calculated to be the difference between the target load allocation and the measured load, and are shown in Table 4.6.

Table 4.6. Calculation of Load Reduction for Fecal Coliform

Assessment Unit	Target Load[(a)] (cfu/day)	Measured Load (cfu/day)	Load Reduction (cfu/day)	Percent Reduction[(b)]
Carrizo Creek (Rio Ruidoso to Mescalero Apache boundary)	1.27×10^9	2.82×10^9	1.55×10^9	55%
Rio Bonito (Angus Canyon to headwaters)	2.30×10^9	1.95×10^{10}	1.72×10^{10}	88%
Rio Hondo (Pecos River to confluence of Rio Bonito and Rio Ruidoso)	6.24×10^9	3.42×10^{10}	2.80×10^{10}	82%

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 = 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

It is important to note that load allocations are estimates based on a specific flow condition (i.e., low flow in this case). Under differing hydrologic conditions, the loads will change. For this reason the load allocations given here are less meaningful than are the relative percent reductions. Successful implementation of this TMDL will be determined based on achieving the fecal coliform water quality standards.

4.5 Identification and Description of Pollutant Sources

Based on measured loads and potential contributions from existing point sources, probable point and nonpoint pollutant sources that may be contributing to observed fecal coliform loads are displayed in Table 4.7. Probable source lists for *E. coli* would be similar.

Table 4.7. Pollutant Source Summary for Fecal Coliform

Pollutant Sources	Magnitude (cfu/day)	Assessment Unit	Potential Sources[a]
Point:			
Fecal coliform	None	Carrizo Creek (Rio Ruidoso to Mescalero Apache boundary)	0%
	None	Rio Bonito (Angus Canyon to headwaters)	0%
	None	Rio Hondo (Pecos River to confluence of Rio Bonito and Rio Ruidoso)	0%
Nonpoint:			
Fecal coliform	2.82×10^{9}	Carrizo Creek (Rio Ruidoso to Mescalero Apache boundary)	100% Drought-related Impacts, Flow Alterations from Water Diversions, Municipal (Urbanized High Density Area), On-site Treatment Systems (Septic Systems and Similar Decentralized Systems), Source Unknown, Loss of Riparian Habitat, Streambank Modifications/destabilization
	1.95×10^{10}	Rio Bonito (Angus Canyon to headwaters)	100% Drought-related Impacts, Flow Alterations from Water Diversions, Loss of Riparian Habitat, On-site Treatment Systems (Septic Systems and Similar Decentralized Systems), Rangeland Grazing, Streambank Modifications/ destabilization
	3.42×10^{10}	Rio Hondo (Pecos River to confluence of Rio Bonito and Rio Ruidoso)	100% Drought-related Impacts, Flow Alterations from Water Diversions, Loss of Riparian Habitat, On-site Treatment Systems (Septic Systems and Similar Decentralized Systems), Rangeland Grazing, Streambank Modifications/ destabilization

Notes:
[a] From the 2004-2006 Integrated 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.

4.6 Linkage Between Water Quality and Pollutant Sources

SWQB fieldwork includes an assessment of the potential sources of impairment (NMED/SWQB 1999). The Pollutant Source(s) Documentation Protocol form and Potential Sources Summary Table in Appendix C provides an approach for a visual analysis of a pollutant source 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 4.7 (Pollutant Source Summary) identifies and quantifies potential sources of nonpoint source impairments along the reach as determined by field reconnaissance and assessment.

Additional bacteria sampling would need to be conducted to more fully characterize probable sources of bacteria in the Rio Hondo watershed. However, sufficient data exist to support development of a fecal coliform TMDL to address the stream standards violations.

Among the potential sources of bacteria are poorly maintained or improperly installed (or missing) septic tanks, livestock grazing of valley pastures and riparian areas, upland livestock grazing, and wildlife. Very high fecal coliform concentrations have been measured in water sampled from both SWQB monitoring stations along the Rio Hondo. According to SWQB field discharge data, this reach seems to have a considerable ground water input with discharge increasing up to an order of magnitude along the river gradient depending on the season. In addition, the region along this river reach is sparsely vegetated with little permanent settlement and some livestock grazing. Howell et. al. (1996) found that fecal coliform concentrations in underlying sediment increase when cattle (*Bos taurus*) have direct access to streams, such as the Rio Hondo. Natural sources of bacteria are also present in the form of other wildlife such as elk, deer, and any other warm-blooded mammals. In addition to direct input from grazing operations and wildlife, fecal coliform concentrations may be subject to elevated levels as a result of re-suspension of bacteria laden sediment during storm events. Temperature can also play a role in fecal coliform concentrations. Howell et. al. (1996) observed that fecal coliform re-growth increases as water temperature increases, which is a concern along this assessment unit.

The bacteria loading from Carrizo Creek and Rio Bonito probably originate from a combination of drought-related impacts, increasing municipal demands on surface and ground water, septic systems and similar decentralized systems, and livestock and wildlife wastes that are transported downstream during runoff events. The Potential Sources Summary Table (Appendix C) also identifies recreational activities and road maintenance and runoff as potential sources of bacteria.

In order to determine exact sources and relative contributions, further study is needed. One method of characterizing sources of bacteria is a Bacterial, or Microbial, Source Tracking (BST) study. The extensive data collection and analyses necessary to determine bacterial sources were beyond the resources available for this study. However, sufficient data exist to support development of a fecal coliform TMDL to address the stream standards violations.

4.7 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. For these bacteria TMDLs, the MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors in flow calculations. Therefore, this MOS is the sum of the following two elements:

- *Conservative Assumptions*

  Treating fecal coliform as a conservative pollutant, that is a pollutant that does not readily degrade in the environment, was used as a conservative assumption in developing these loading limits.

  A more conservative limit of the geometric mean value, rather than the current and proposed standards which allow for higher concentrations in individual grab samples, was used to calculate loading values.

- *Errors in calculating flow*

  4Q3s low flow values were determined based on USGS gaging data. There is inherent error in all flow measurements. A conservative MOS for this element is therefore **5 percent**.

4.8 Consideration of Seasonal Variability

During the 2003 water quality survey, bacteria exceedences occurred during both summer and fall months. Data indicated no link between flow and exceedences. Therefore, although a target was chosen for the TMDL, it may not represent a true critical condition. Higher flows may flush more nonpoint source runoff containing fecal coliform. It is also possible the criterion may be exceeded under a low flow condition when there is insufficient dilution of a point source. Evaluation of seasonal variability for potential nonpoint sources is difficult due to limited available data. Because of the uncertainty involved, there will be no seasonal allocations for fecal coliform in these TMDLs.

4.9 Future Growth

According to the calculations, the overwhelming source of bacteria loading is from nonpoint sources. Estimates of future growth are not anticipated to lead to a significant increase in bacteria concentrations that cannot be controlled with BMP implementation in this watershed.

5.0 NUTRIENTS

The potential for excessive nutrients in the Rio Ruidoso were noted through visual observation during the 2003 SWQB study and the 2003-2005 Livingston Associates, P.C. study. Assessment of various water quality parameters did not indicate nutrient impairment in the upper Rio Ruidoso (US Highway 70 to the Mescalero Apache Boundary), but did indicate nutrient impairment in the lower Rio Ruidoso (Rio Bonito to US Highway 70). In the lower Rio Ruidoso, total phosphorus values were above the New Mexico State standard of 0.1 milligrams per liter (mg/L) in 66% of the samples; total nitrogen values were above the recommended criteria of 1.0 mg/L in 71% of the samples; and the dissolved oxygen saturation was greater than 120% in 15% of the samples. Since three or more indicators were exceeded along the Rio Ruidoso (Rio Bonito to US Highway 70), nutrients will be added as a cause of non support.

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).

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.

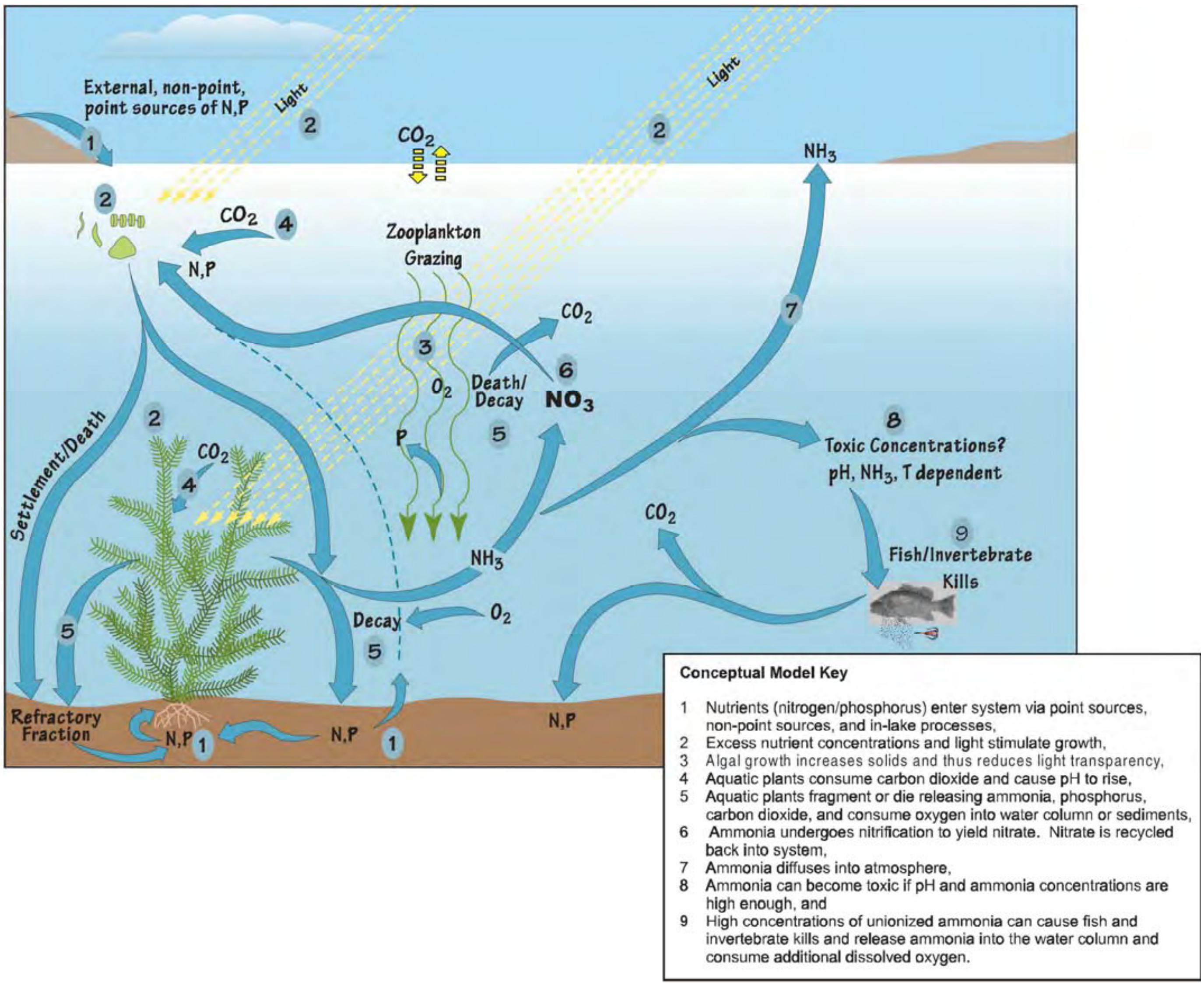


Figure 5.1. Nutrient Conceptual Model (USEPA 1999)

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 criteria. This TMDL is consistent with the New Mexico State antidegradation policy.

The New Mexico WQCC has adopted narrative water quality standards for plant nutrients to sustain and protect existing or attainable uses of the surface waters of the state. This general standard applies to surface waters of the state at all times unless a specified standard is provided elsewhere. These water quality standards have been set at a level to protect cold-water aquatic life. The general water quality standards 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 standard leading to an assessment of use impairment is as follows (NMAC 20.6.4.12.E):

> ***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.*

In addition to the narrative plant nutrient criteria, the segment-specific criteria leading to an assessment of use impairment for Rio Ruidoso is the numeric criteria stating that, "In any single sample, total phosphorus (as P) shall be less than 0.1 mg/L" (20.6.4 NMAC).

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 standards 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 standards 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 Rio Ruidoso.

The USEPA (2000) has published recommended nutrient criteria for causal (total nitrogen and total phosphorus) and response (chlorophyll *a* and turbidity) variables associated with the prevention and assessment of eutrophic conditions. The criteria are empirically derived from data in USEPA's STORET to represent conditions of surface waters that are minimally impacted by human activities and protective of aquatic life and recreational uses. Ideally, USEPA wanted to base these criteria on actual reference conditions. The criteria would have been based on the 75^{th} percentile of reference condition data. However, much of USEPA's data could not be considered to be reference conditions. Consequently, USEPA performed a statistical analysis of the entire body of non-reference data. The 25^{th} percentile of each season (winter, spring, summer, fall) was calculated, and then the median of these four values was calculated. This approach assumes that the lower 25^{th} percentile of all data overlaps with the 75^{th} percentile of reference condition data, so therefore the 25th percentile data can be used to represent reference conditions.

The Rio Hondo watershed is located in Level III Ecoregion 23 (the Arizona/New Mexico (AZ/NM) Mountains) contained within Aggregate Ecoregion II (Western Forested Mountains). The USEPA's recommended criteria for total phosphorus and total nitrogen in streams associated with these ecoregions are presented in Table 5.1 below.

Table 5.1. USEPA's Recommended Nutrient Criteria for Ecoregion II (Western Forested Mountains), Level III Ecoregion 23 (AZ/NM Mountains)

Nutrient Parameter	USEPA Recommended Criteria	
	Western Forested Mtns.	AZ/NM Mountains
Total Phosphorus	10.0 μg P/L	11.25 μg P/L
Total Nitrogen	0.12 mg N/L	0.28 mg N/L

The USEPA developed these criteria with the intention that they serve as a starting point for states to develop more refined nutrient criteria, as appropriate. There is a great deal of variability in nutrient levels and nutrient responses throughout the country due to differences in geology, climate and waterbody type. Rather than promulgate the proposed criteria, USEPA has allowed states and tribes to submit nutrient criteria development plans to document how nutrient criteria will be developed. SWQB has submitted a plan to USEPA that uses a weight-of-evidence approach, which includes a number of indicators of nutrient enrichment:

- Total Nitrogen concentration (TN)
- Total Phosphorus concentration (TP)
- Dissolved Oxygen Concentration
- Dissolved Oxygen Saturation
- pH
- Algal Productivity (from algal bioassays)
- Chlorophyll a concentration
- Hilsenhoff Biotic Index
- Benthic Macroinvertebrate IBI Score

The criteria for the other indicators are from USEPA guidance documents, peer reviewed literature, and NMED water quality standards.

A study concerning the effect of phosphorus and nitrogen additions on algal mass was conducted on appropriate river waters in the Rio Ruidoso (Appendix D). The water samples were designated as follows:

Designation	Site Collection
I	Rio Ruidoso @ Mescalero Boundary west of Ruidoso – Upper Canyon Road
II	Rio Ruidoso @ NM mile marker 267.5 (HWY 70), below Wastewater Treatment Plant (WWTP)
III	Rio Ruidoso abv. site on Susan Lattimer's property

In all three water samples, algal growth was increased by the addition of nitrogen indicating that nitrogen is the primary limiting nutrient in the Rio Ruidoso and is driving the productivity of algae and macrophytes in the stream. Phosphorus addition did not increase algal growth by itself but did increase growth when added along with nitrogen addition. Therefore, to ensure that the narrative WQS are met, management procedures should avoid any increase in both nitrogen and phosphorus inputs.

Based on chemical analysis of the Rio Ruidoso's waters, ratios above 10:1 were predictive of phosphorus limitation whereas ratios below 10:1 reflected nitrogen limitation. Table 5.2 reflects the usefulness of the N:P ratio in predicting algal productivity.

While colimitation of phosphorus and nitrogen may occur in waters, this is unusual. But if the limiting nutrient is increased, then a second nutrient becomes limiting. For example, if phosphorus is added to Carrizo Canyon Creek, productivity increases until nitrogen becomes limiting. A further increase of productivity occurs with nitrogen addition.

Table 5.2. N:P ratios for Rio Ruidoso water samples

Sample Sites	Total N / Total P	LIMITING NUTRIENT based on bioassay
Carrizo Canyon Creek below Canton Creek Lodge ½ mile below Mescalero sewage lagoon	19.3	Phosphorus
Rio Ruidoso above the site on Susan Lattimer's property (Algal Assay Site III)	6.2	Nitrogen
Rio Ruidoso @ HWY 70 bridge downstream of racetrack	14.7	Phosphorus
Rio Ruidoso west of Ruidoso @ Mescalero Boundary (Algal Assay Site I)	9.2	Nitrogen (slight)

The current, applicable New Mexico state standard states that TP shall be less than 0.1 mg/L in waters of the Rio Ruidoso (NMAC 20.6.4.208). In recommending a nitrogen standard, the SWQB bases its projection on the ratio of N:P required for algal biomass of 10:1. The chemical analysis of the Rio Ruidoso's waters supports the projection of a nitrogen standard that is 10 times greater than a phosphorus standard (Appendix D; Table 5.2). With a TP standard of 0.1 mg/L, the corresponding nitrogen standard would be 1.0 mg/L (Table 5.3). Total Nitrogen is defined as the sum of Nitrate-N, Nitrite-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 5.3. Numeric Targets

Constituent or Factor	TMDL Target Concentrations
Total Phosphorus	0.1 mg P/L
Total Nitrogen	1.0 mg N/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 Elemination System [NPDES]) permit WLA and in the development of TMDLs.

The critical flow conditions for this TMDL occur when the ratio of effluent to stream flow is the greatest and was obtained using a 4Q3 regression model (Appendix B). The 4Q3 is the minimum average four consecutive day flow that occurs with a frequency of at least once every 3 years. It is assumed that 4Q3 flows will be the critical periods for aquatic life.

It is often necessary to calculate a critical flow for a portion of a watershed where there is no stage gage. This can be accomplished by applying one of two formulas developed by the USGS. One formula (USGS 1993) is recommended when the ratio between the gaged and ungaged watershed areas is between 0.5 and 1.5. The other formula, to be used when the watershed ratio is outside this range, is a regression formula developed by James P. Borland (USGS 1970). These methods of estimating low flows are currently used by the NMED to establish TMDLs for watersheds and to administer water-quality standards through the NPDES program.

It is important to remember that the TMDL itself is a value calculated at a defined critical condition, and is calculated as part of planning process designed to achieve water quality standards. Since flows vary throughout the year in these systems, the actual load at any given time will vary based on the changing flow. Management of the load to improve stream water quality 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 the Rio Ruidoso 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 3**.

4Q3 (in mgd) x Numeric Target (in mg/L) x 8.34 = TMDL (pounds per day [lbs/day]) **(Eq. 3)**

USGS gage data were used to determine the 4Q3 for this calculation (Appendix B). The 4Q3 was estimated through application of USGS gage data to a log Pearson Type III distribution using IOWDM software, Version 4.1 (USGS 2002a) and SWSTAT software, Version 4.1 (USGS 2002b). A unit-less conversion factor of 8.34 is used to convert units to lbs/day (Appendix E). By applying **Equation 3**, it is determined that the lower Rio Ruidoso can transport approximately 2.72 lbs/day of total phosphorus and 27.2 lbs/day of total nitrogen during critical low-flow conditions and in-stream concentrations will not exceed 0.10 mg/L and 1.0 mg/L, respectively. The annual target loads for TP and TN are summarized in Table 5.4.

Table 5.4. Estimates of Annual Target Loads for TP and TN: Rio Ruidoso (Rio Bonito to US Highway 70)

Parameter	Combined Flow[(a)] (mgd)	Numeric Target (mg/L)	Conversion Factor	Estimate of Target Loading (lbs/day)
Total Phosphorus	3.265	0.10	8.34	2.72[(b)]
Total Nitrogen	3.265	1.0	8.34	27.2[(b)]

Notes:

(a) Combined Flow = 4Q3 low-flow (mgd) + WWTP design capacity (2.50 mgd)

(b) Values rounded to three significant figures.

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 standards (Table 5.5; Appendix F) was substituted for the standard in **Equation 3**. The same conversion factor of 8.34 was used. The results are presented in Table 5.6.

Table 5.5 SWQB data that *exceeded* the numeric criteria for TP and TN: Rio Ruidoso (Rio Hondo to US Hwy 70 Bridge)

Location	Sampling Date	TP (mg/L)	TN (mg/L)
Rio Ruidoso 10 ft	3/25/2004	0.24	1.32
above WWTP	2/17/2005	0.19	---
	3/24/2005	---	1.07
Rio Ruidoso	3/18/2003	0.478	2.505
Below WWTP	4/22/2003	0.306	1.277
	5/20/2003	0.681	4.526
	6/24/2003	0.982	4.775
	7/22/2003	1.100	3.385
	8/19/2003	1.260	3.308
	9/2/2003	1.195	4.670
	9/9/2003	1.140	6.120
	9/23/2003	1.000	4.922
	10/22/2003	0.920	6.376
Rio Ruidoso at	3/18/2003	0.183	1.156
Glencoe FR 443	4/22/2003	0.228	1.092
	5/20/2003	---	1.000
	6/24/2003	---	1.215
	7/22/2003	---	1.236
	8/19/2003	---	1.306
	9/23/2003	---	1.464
	10/22/2003	0.104	1.865
	4/24/2003	0.32	1.07
	5/22/2003	0.44	2.51
	6/26/2003	0.67	2.82
	7/24/2003	0.62	1.62
	8/14/2003	0.86	1.9
	8/29/2003	0.52	1.5
	9/25/2003	0.92	3.35
	10/23/2003	0.57	3.04
	11/20/2003	0.56	2.26
	12/18/2003	0.48	3.02
	1/22/2004	0.48	1.52
	2/12/2004	0.39	1.57
	2/26/2004	0.36	1.18
	3/25/2004	0.48	3.07
	4/22/2004	0.29	1.54
	5/19/2004	0.60	2.09
	6/23/2004	1.20	1.92
	7/22/2004	1.02	1.25
	8/25/2004	0.69	2.36
Rio Ruidoso at	9/22/2004	0.70	2.62
Glencoe FR 443	10/20/2004	0.44	1.39
	11/17/2004	0.47	1.66
	12/14/2004	0.33	1.74
	1/19/2005	0.33	1.74
	2/16/2005	0.33	1.74
	3/23/2005	0.33	1.74
R Ruidoso	4/24/2003	0.31	1.25
~1700 feet blw	5/22/2003	0.66	3.66
WWTP outfall	6/26/2003	1.21	4.93
	7/24/2003	1.28	3.27
	8/14/2003	1.41	3.69
	8/29/2003	1.15	3.42
	9/25/2003	1.49	5.42
	10/23/2003	1.08	5.98
	11/20/2003	1.03	4.39
	12/18/2003	0.57	3.01
	1/22/2004	0.38	2.63
	2/12/2004	0.70	2.48
	2/26/2004	0.61	1.96
	3/25/2004	0.47	2.70
	4/22/2004	0.26	1.59
	5/19/2004	0.53	2.25
	6/23/2004	1.19	2.79
	7/22/2004	0.81	1.67
	8/25/2004	0.94	3.62
	9/22/2004	1.23	5.37
	10/20/2004	0.68	2.32
	11/17/2004	0.63	1.86
	12/14/2004	0.46	2.37
	1/19/2005	0.46	2.37
	2/16/2005	0.46	2.37
	3/23/2005	0.46	2.37
R Ruidoso	4/24/2003	0.26	1.08
~3000 feet blw	5/22/2003	0.41	2.37
WWTP outfall	6/26/2003	1.08	4.41
	7/24/2003	1.41	3.34
	8/14/2003	1.98	2.89
	8/29/2003	1.05	3.10
	9/25/2003	1.18	3.49

Location	Sampling Date	TP (mg/L)	TN (mg/L)
R Ruidoso	10/23/2003	0.96	5.33
~3000 feet blw	11/20/2003	0.92	2.12
WWTP outfall	12/18/2003	0.78	4.25
	1/22/2004	0.65	2.05
	2/12/2004	0.48	1.78
	2/26/2004	0.63	1.77
	3/25/2004	0.48	2.69
	4/22/2004	0.28	1.35
	5/19/2004	0.52	2.15
	6/23/2004	1.15	2.64
	7/22/2004	1.23	1.99
	8/25/2004	0.93	3.45
	9/22/2004	1.17	4.77
	10/20/2004	0.71	2.01
	11/17/2004	0.60	1.67
	12/14/2004	0.45	2.08
	1/19/2005	0.45	2.08
	2/16/2005	0.45	2.08
	3/23/2005	0.45	2.08
R Ruidoso	4/24/2003	0.31	0.98
btwn Fox Cave	5/22/2003	0.44	2.55
and San Ysidro	6/26/2003	0.73	3.36
Church	7/24/2003	0.78	2.05
	8/14/2003	0.85	2.01
	8/29/2003	0.71	2.07

Location	Sampling Date	TP (mg/L)	TN (mg/L)
R Ruidoso	9/25/2003	1.07	4.60
btwn Fox Cave	10/23/2003	0.58	3.04
and San Ysidro	11/20/2003	0.45	1.42
Church	12/18/2003	0.37	1.83
	1/22/2004	0.49	1.56
	2/12/2004	0.47	1.97
	2/26/2004	0.47	1.49
	3/25/2004	0.22	1.19
	4/22/2004	0.30	1.55
	5/19/2004	0.41	1.78
	6/23/2004	0.76	1.80
	7/22/2004	1.01	0.67
	8/25/2004	0.52	1.95
	9/22/2004	0.72	2.50
	10/20/2004	0.49	1.54
	11/17/2004	0.47	1.47
	12/14/2004	0.26	1.53
	1/19/2005	0.26	1.53
	2/16/2005	0.26	1.53
	3/23/2005	0.26	1.53
GEOMETRIC MEAN		**0.578**	**2.205**

Table 5.6. Estimates of Annual Measured Loads for TP and TN: Rio Ruidoso (Rio Bonito to US Highway 70)

Parameter	Combined Flow[(a)] (mgd)	Geometric Mean Conc.[(b)] (mg/L)	Conversion Factor	Estimate of Measured Load (lbs/day)
Total Phosphorus	3.265	0.578	8.34	15.7[(c)]
Total Nitrogen	3.265	2.205	8.34	60.0[(c)]

Notes:

(a) Combined Flow = 4Q3 low-flow (mgd) + WWTP design capacity (2.50 mgd)

(b) Geometric mean of TP and TN exceedences (See Table 5.5 or Appendix F for data).

(c) Values rounded to three significant figures.

5.4 Waste Load Allocations and Load Allocations

5.4.1 Waste Load Allocation

The only existing point source along this assessment unit is the NPDES-permitted WWTP owned and operated by the Village of Ruidoso and the City of Ruidoso Downs (NM0029165). There are no individually permitted Municipal Separate Storm Sewer System (MS4) storm water permits in this assessment unit.

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 this assessment unit. However, because Ruidoso and Ruidoso Downs own and operate 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 NM0029165. Effluent limitations for TP and TN were calculated using the following equation:

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

where C_e = allowable WWTP effluent concentration (mg/L)
C_s = numeric criterion (mg/L)
C_a = average stream concentration upstream of assessment unit (mg/L)
Q_e = design capacity of WWTP (million gallons per day)
Q_a = critical 4Q3 low-flow of stream (million gallons per day)
BL = Background Load

The equation is based on a simple steady-state mass balance model. The stream standard and ambient upstream concentrations used to calculate the annual effluent limitation are 0.10 and 0.04 mg/L, respectively for TP and 1.0 and 0.46 mg/L, respectively for TN. The data that were used to calculate the average ambient upstream concentration are found in Appendix F. The results of this mixing calculation for TP are presented in Table 5.7 and in Table 5.8 for TN.

Table 5.7 Allowable TP effluent concentration and WLA to meet water quality standards in the Rio Ruidoso (Rio Bonito to US Highway 70)

	Discharge		Total Phosphorus		
Time Scale	Q_a (mgd)	Q_e (mgd)	C_a (mg/L)	C_e (mg/L)	WLA (lbs/day)
Annual	0.765	2.50	0.04	0.10	2.16

NOTES: Q_a = critical 4Q3 low-flow of stream (mgd)
Q_e = design capacity of WWTP (mgd)
C_a = average stream concentration upstream of assessment unit (mg/L)
C_e = allowable WWTP effluent concentration (mg/L)
WLA = Waste Load Allocation (lbs/day)

Table 5.8 Allowable TN effluent concentration and WLA to meet water quality standards in the Rio Ruidoso (Rio Bonito to US Highway 70)

	Discharge		Total Nitrogen		
Time Scale	Q_a (mgd)	Q_e (mgd)	C_a (mg/L)	C_e (mg/L)	WLA (lbs/day)
Annual	0.765	2.50	0.46	0.90	18.9

NOTES: Q_a = critical 4Q3 low-flow of stream (mgd)
Q_e = design capacity of WWTP (mgd)
C_a = average stream concentration upstream of assessment unit (mg/L)
C_e = allowable WWTP effluent concentration (mg/L)
WLA = Waste Load Allocation (lbs/day)

Current loading from the WWTP was estimated from nine grab samples collected by SWQB staff during the 2003 intensive survey. The TP and TN concentrations measured at the WWTP outfall pipe averaged 3.096 and 13.33 mg/L, respectively. Assuming that discharge was at plant capacity (2.50 mgd), the current phosphorus loading from the plant into the Rio Ruidoso is 64.6 lbs/day and the current nitrogen loading from the plant into the Rio Ruidoso is 278 lbs/day. The current phosphorus loading from the WWTP is approximately 30 times the level that it should be to maintain the chemical and biological integrity of the stream. Similarly, the nitrogen loading is approximately 15 times the appropriate level.

5.4.2 Background Load

Rock and soil erosion, leaf litter decay, and wild animal waste supply background phosphorus and nitrogen loads from undeveloped land to the Rio Ruidoso. Background concentrations were determined from USEPA ecoregional reference criteria and SWQB/Livingston Associates nutrient data from the Rio Ruidoso (US Hwy 70 Bridge to Mescalero Apache Boundary), Rio Ruidoso (North Fork), and Carrizo Creek (Rio Ruidoso to headwaters).

Reference sites are relatively undisturbed by human influences. The definition of a reference condition ranges from a pristine, undisturbed state of a stream, to merely the “best available” or “best attainable” conditions. In the case of the New Mexican streams used in this study, the seasonal concentrations from Level III Ecoregion 23 were weighted according to the number of samples collected and were used to help determine background water quality. SWQB and Livingston Associates nutrient data from upstream sampling sites and the USEPA seasonal concentrations from Level III Ecoregion 23 reference sites were averaged to calculate an annual background concentration (Appendix F).

The background load to the Rio Ruidoso is calculated by multiplying the representative 4Q3 flow volume (in mgd) by the background concentration (in mg/L). A unit-less conversion factor of 8.34 is used to convert units to lbs/day (Appendix E). The background loads for the assessment unit are summarized in Table 5.9.

Table 5.9. Calculated Annual TP and TN Background Loads to the Rio Ruidoso

Parameter	Representative 4Q3 Flow[(a)] Volume (mgd)	Background Concentration (mg P/L)	Unit-less Conversion Factor	Estimated Background Load (lbs/day)
Total Phosphorus	0.765	0.014	8.34	0.089[(b)]
Total Nitrogen	0.765	0.26	8.34	1.66[(b)]

Notes:
(a) See Appendix B.
(b) Values rounded to three significant figures.

5.4.3 Load Allocation

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

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

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 5% (see Section 5.7 for details) are presented in Table 5.10 and Figures 5.2 and 5.3.

Table 5.10. Calculation of Annual TMDL for TP and TN

Parameter	WLA (lbs/day)	LA (lbs/day)	BL (lbs/day)	MOS (5%) (lbs/day)	TMDL (lbs/day)
Total Phosphorus	2.16	0.34	0.09	0.13	2.72
Total Nitrogen	18.9	5.28	1.66	1.36	27.2

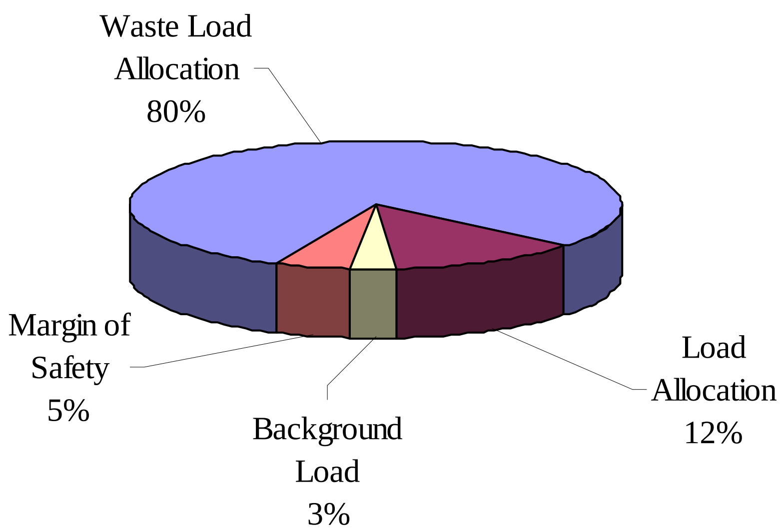


Figure 5.2. Annual TMDL for Total Phosphorus

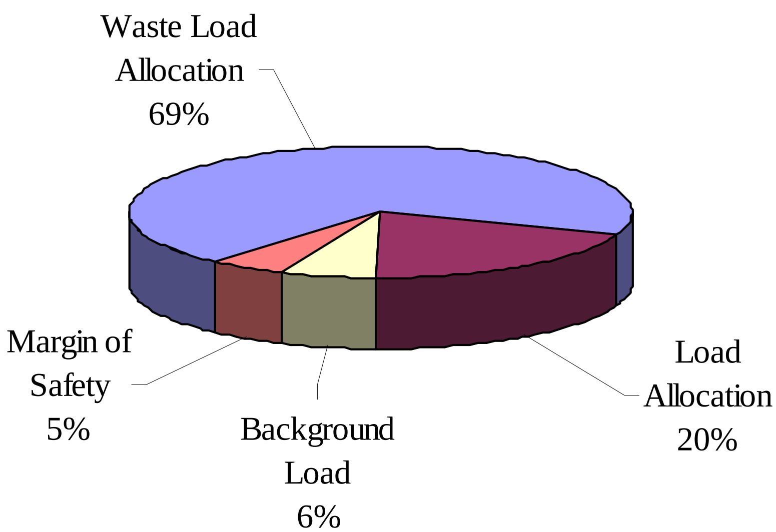


Figure 5.3. Annual TMDL for Total Nitrogen

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 5.11.

Table 5.11. Calculation of Load Reduction for TP and TN

Parameter	Target Load[(a)] (lbs/day)	Measured Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction [(b)]
Total Phosphorus	2.63	15.7	13.1	83%
Total Nitrogen	25.5	60.0	34.5	57%

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 = LA + WLA + BL
(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

Potential pollutant sources of TP that could contribute to this assessment unit are listed in Table 5.12. Potential sources of TN are listed in Table 5.13.

Table 5.12 Pollutant Source Summary for Total Phosphorus

Pollutant Sources	**Magnitude** (Measured Load [lbs/day])	**Location**	**Potential Sources** (% from each)
Point: NM0029165	12.0[a]	Ruidoso/Ruidoso Downs WWTP	77%
Nonpoint:	3.68[b]	Rio Ruidoso (Rio Hondo to US Hwy 70)	23% Drought-related Impacts Flow Alterations from Water Diversions Municipal (Urbanized High Density Area) On-site Treatment Systems (septic systems and similar decentralized systems) Range Grazing - Riparian or Upland Natural Sources

[a] The measured load for point sources was calculated by multiplying the total measured load calculated in Section 5.3 (Table 5.6) by the percent contribution to streamflow of the effluent discharge (77%).
[b] The measured load for nonpoint sources was calculated by multiplying the total measured load calculated in Section 5.3 (Table 5.6) by the percent contribution to streamflow of the 4Q3 low-flow (23%).

Table 5.13 Pollutant Source Summary for Total Nitrogen

Pollutant Sources	Magnitude (Measured Load [lbs/day])	Location	Potential Sources (% from each)
Point: NM0029165	46.2[a]	Ruidoso/Ruidoso Downs WWTP	77%
Nonpoint:	13.8[b]	Rio Ruidoso (Rio Hondo to US Hwy 70)	23% Drought-related Impacts Flow Alterations from Water Diversions Municipal (Urbanized High Density Area) On-site Treatment Systems (septic systems and similar decentralized systems) Range Grazing - Riparian or Upland Natural Sources

[a] The measured load for point sources was calculated by multiplying the total measured load calculated in Section 5.3 (Table 5.6) by the percent contribution to streamflow of the effluent discharge (77%).

[b] The measured load for nonpoint sources was calculated by multiplying the total measured load calculated in Section 5.3 (Table 5.6) by the percent contribution to streamflow of the 4Q3 low-flow (23%).

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.

SWQB fieldwork includes an assessment of the potential sources of impairment (NMED/SWQB 1999). The completed Pollutant Source(s) Documentation Protocol forms in Appendix C 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. Staff completing these forms identify and quantify potential sources of NPS 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, which is predominantly privately held, but also to consider upland and upstream areas in a more holistic watershed approach to implementing this TMDL. This nutrient TMDL was calculated using the best available methods that were known at the time of calculation and may be revised in the future.

The Rio Ruidoso has six main land uses that were identified as potential sources of phosphorus and nitrogen (Figure 2.1). They include commercial, residential, agriculture, forest, shrubland, and grasslands. 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 Rio Ruidoso 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. Industrial areas and urban development contribute 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. Background loads were estimated using SWQB and Livingston Associates water quality data as well as USEPA data from regional reference streams (Section 5.4.2).

Nutrients from anthropogenic and natural sources reach the Rio Ruidoso primarily by two routes: directly in overland flow (stormwater runoff and irrigation return flow) and indirectly in ground water. Nutrients applied directly to land (e.g. fertilizers, pet wastes) can be carried overland in storm water runoff and agricultural return flow or can dissolve and percolate through the soil to reach ground water. Septic tank disposal systems contribute nutrients primarily into ground water, which may eventually discharge into the stream. According to the public works departments in Ruidoso and Ruidoso Downs, about 20% of the total housing units have on-site wastewater systems (i.e. septic systems). Additionally, there are approximately 450 houses located within 100 meters of the Rio Ruidoso, an area that would be most affected by the use of septic systems because of the hydrologic connectivity between ground water and surface water in this near-stream zone. By multiplying the percent of houses on septic systems by the number of houses near the stream, it can be concluded that roughly 90 houses have on-site wastewater systems **<u>and</u>** are located within 100 m of the stream. Some of the phosphorus and nitrogen loads from these houses will be removed through plant uptake, but site-specific uptake rates are not known, therefore accurate groundwater loads could not be calculated.

This source-specific analysis accounts for the differences in magnitudes between sources and provides a basis for allocating loads. Analyses presented in these TMDLs demonstrate that defined loading capacities will ensure attainment of New Mexico water quality standards.

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 in flow calculations. 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.

  A more conservative limit of the geometric mean value, rather than the current and proposed standards which allow for higher concentrations in individual grab samples, was used to calculate measured loading values.

- *Errors in calculating flow*

  4Q3 low flow values were determined based on USGS gaging data. There is inherent error in all flow measurements. A conservative MOS for this element is therefore **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 this TMDL 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 and across multiple years, 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 and Appendix F. 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 Lincoln County project a 52% growth rate 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.

The Village of Ruidoso and City of Ruidoso Downs are currently investigating the potential for water quality trading of nutrients in the Rio Ruidoso. If water quality trading is determined to be a viable option for decreasing the amount of nutrient loading to the Rio Ruidoso then this TMDL will be revised to include trading options for the WWTP.

6.0 TEMPERATURE

Monitoring for temperature was conducted by SWQB in 2003. Based on available data, several exceedences of the New Mexico WQS for temperature were noted throughout the watershed (Figure 6.1). Thermographs were set to record once every hour for several months during the warmest time of the year (generally May through September). Thermograph data are assessed using Appendix C of the *State of New Mexico Procedures for Assessing Standards Attainment for the Integrated §303(d)/§305(b) Water Quality Monitoring and Assessment Report* (NMED/SWQB 2004b). Based on 2003 data, the temperature listing on the 2002-2004 CWA §303(d) for Rio Ruidoso (US Highway 70 to Mescalero Apache boundary) was confirmed. Temperature data from 2003 were used to develop 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 high quality coldwater fishery (HQCWF) (20.6.4.900.C NMAC). These WQS have been set at a level to protect cold-water aquatic life such as trout. The HQCWF 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 primary 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 2003 thermograph deployments. The following TMDL addresses a reach where temperatures exceeded the criterion (**Appendix G** of this document provides a graphical representation of thermograph data):

> Rio Ruidoso (US Highway 70 to Mescalero Apache boundary): Three thermographs were deployed on this reach in 2003. One thermograph was deployed at Rio Ruidoso at Hollywood USGS gage (site 8), recorded temperatures from May 20 (17:00) through September 15 (14:00) exceeded the HQCWF criterion 185 of 2,830 times (6.5%) with a maximum temperature of 23.71°C on July 8. A second thermograph was deployed at Rio Ruidoso at Hwy 70 above the WWTP (site 9), recorded temperatures from May 20 (17:00) through September 16 (12:00) exceeded the HQCWF criterion 362 of 2,852 times (13%) with a maximum temperature of 23.74°C on August 10. The third thermograph was deployed at Rio Ruidoso at Mescalero boundary (site 10), recorded temperatures from May 20 (17:00) through September 16 (14:00) exceeded the HQCWF criterion 289 of 2,854 times (10%) with a maximum temperature of 25.07°C on July 9.

Table 6.1 Rio Hondo Watershed Thermograph Sites

Site Number	Site Name	2003 Deployment Dates
1	Carrizo Creek at Two Rivers Park	5/20-9/15
2	Rio Bonito at Hwy 48 at Angus Canyon [1]	5/19-8/18 [a]
3	Rio Bonito at BLM Apple Orchard [1]	5/19-9/15
4	Rio Bonito above Bonito Lake at FR 107	5/19-9/17
5	Rio Hondo at Riverside [1]	5/19-9/16
6	Rio Hondo below Ruidoso-Bonito confluence [1]	5/19-9/16
7	Rio Ruidoso at Glencoe	5/20-9/15
8	Rio Ruidoso at Hollywood USGS gage	5/20-9/15
9	Rio Ruidoso at Hwy 70 above WWTP [1]	5/20-9/16
10	Rio Ruidoso at Mescalero boundary [1]	5/20-9/16
11	Rio Ruidoso above Rio Bonito	5/20-9/15

Note: [1]air thermograph simultaneously deployed
[a]air thermograph deployed through 9/17/2003

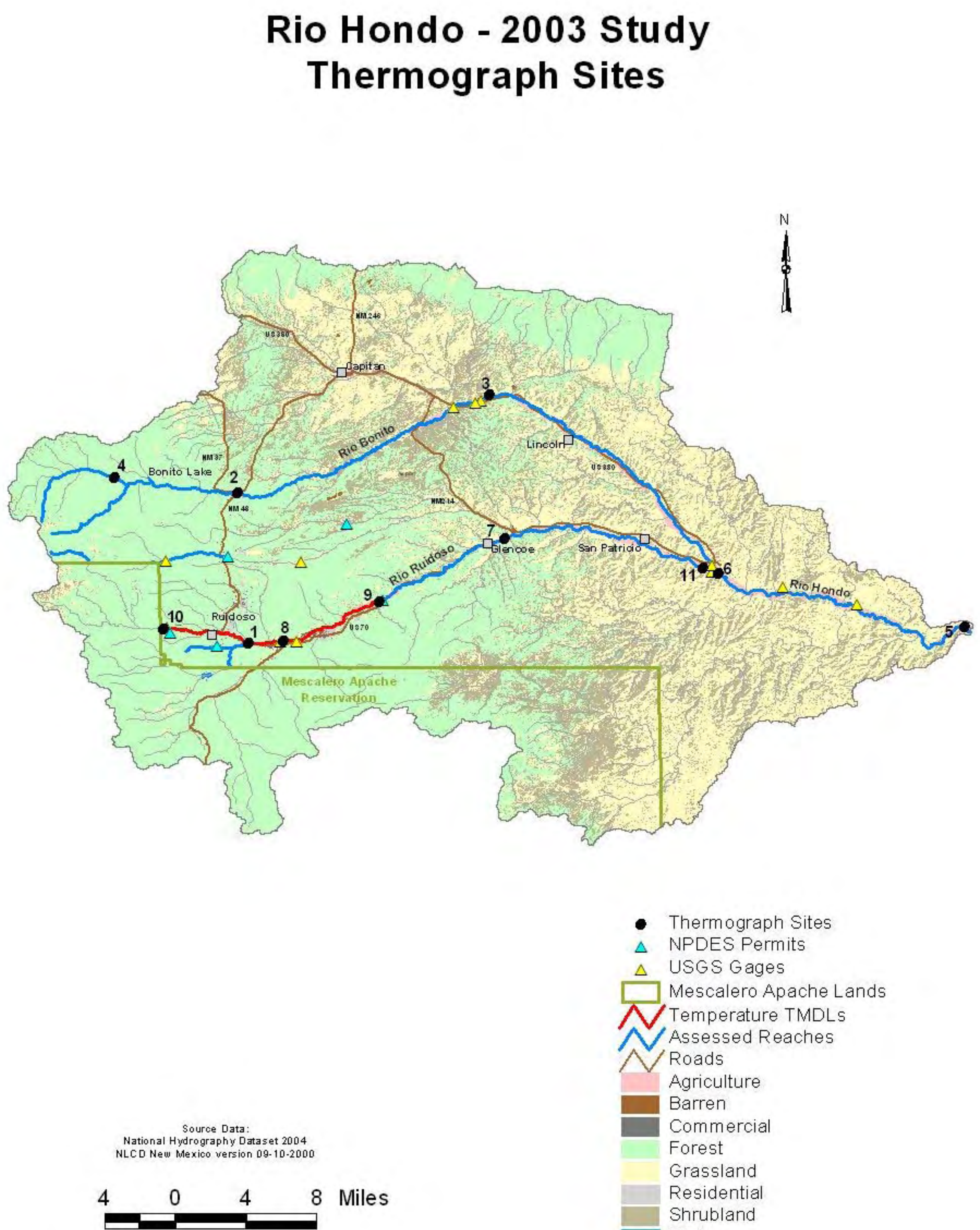


Figure 6.1 Rio Hondo Thermograph sites

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. This model was developed by the USGS Biological Resource Division (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 factors (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 active point source contributions associated with these TMDLs. The WLA is zero.

6.3.2 Load Allocation

Water temperature can be expressed as heat energy per unit volume. SSTEMP provides an estimate of heat energy expressed in joules per square meter per second ($j/m^2/s$) and Langley's per day. The following information relevant to the model runs used to determine temperature TMDLs is taken from the SSTEMP documentation (Bartholow 2002). Please refer to the SSTEMP User's Manual for complete text. Various notes have been added below in brackets to clarify local sources of input data.

> **<u>Description of Logic</u>**:
> In general terms, SSTEMP calculates the heat gained or lost from a parcel of water as it passes through a stream segment. This is accomplished by simulating the various heat flux processes that determine that temperature change. . . These physical processes include convection, conduction, evaporation, as well as heat to or from the air (long wave radiation), direct solar radiation (short wave), and radiation back from the water. SSTEMP first calculates the solar radiation and how much is intercepted by (optional) shading. This is followed by calculations of the remaining heat flux components for the stream segment. The details are just that: To calculate solar radiation, SSTEMP computes the radiation at the outer edge of the earth's atmosphere. This radiation is passed through the attenuating effects of the atmosphere and finally reflects off the water's surface depending on the angle of the sun. For shading, SSTEMP computes the day length for the level plain case, i.e., as if there were no local topographic influence. Next, sunrise and sunset times are computed by factoring in local east and west-side topography. Thus, the local topography results in a percentage decrease in the level plain daylight hours. From this local sunrise/sunset, the program computes the percentage of light that is filtered out by the riparian vegetation. This filtering is the result of the size, position and density of the shadow-casting vegetation on both sides of the stream. . .

HYDROLOGY VARIABLES

. . . 1. Segment Inflow (cfs or cms [cubic meters per second]) -- Enter the mean daily flow at the top of the stream segment. If the segment begins at an effective headwater, the flow may be entered as zero so that all accumulated flow will accrue from accretions, both surface water and groundwater. If the segment begins at a reservoir, the flow will be the outflow from that reservoir. Remember that this model assumes steady-state flow conditions.

If the inflow to the segment is the result of mixing two streams, you may use the mixing equation to compute the combined temperature:

$$T_j = \frac{(Q_1 \times T_1) + (Q_2 \times T_2)}{Q_1 + Q_2}$$

where

T_j = Temperature below the junction
Q_n = Discharge of source n
T_n = Temperature of source n

2. Inflow Temperature (°F or °C) -- Enter the mean daily water temperature at the top of the segment. If the segment begins at a true headwater, you may enter any water temperature, because zero flow has zero heat. If there is a reservoir at the inflow, use the reservoir release temperature. Otherwise, use the outflow from the next upstream segment.

3. Segment Outflow (cfs or cms) -- The program calculates the lateral discharge accretion rate by knowing the flow at the head and tail of the segment, subtracting to obtain the net difference, and dividing by segment length. The program assumes that lateral inflow (or outflow) is uniformly apportioned through the length of the segment. If any "major" tributaries enter the segment, you should divide the segment into two or more subsections. "Major" is defined as any stream contributing greater than 10% of the mainstem flow, particularly if there are major discontinuities in stream temperature.

[NOTE: To be conservative, 4Q3 low flow values were used as the segment outflow. These critical low flows were used to decrease assimilative capacity of the stream to adsorb and disperse solar energy. See **Appendix H** for calculations.]

4. Accretion Temperature (°F or °C) -- 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. You can verify this by checking United States Geological Survey (USGS) well log temperatures. Exceptions may arise in areas of geothermal activity. If irrigation return flow makes up most of the lateral flow, it may be warmer than mean annual air temperature. Return flow may be approximated by equilibrium temperatures.

GEOMETRY VARIABLES

. . . 1. Latitude (decimal degrees or radians) -- Latitude refers to the position of the stream segment on the earth's surface. It may be read off of any standard topographic map.

[NOTE: Latitude is generally determined in the field with a global positioning system (GPS) unit.]

2. Dam at Head of Segment (checked or unchecked) -- If there is a dam at the upstream end of the segment with a constant, or nearly constant diel release temperature, check the box, otherwise

leave it unchecked . . . Maximum daily water temperature is calculated by following a water parcel from solar noon to the end of the segment, allowing it to heat towards the maximum equilibrium temperature. If there is an upstream dam within a half-day's travel time from the end of the segment, a parcel of water should only be allowed to heat for a shorter time/distance. By telling SSTEMP that there is a dam at the top, it will know to heat the water only from the dam downstream. . . Just to confuse the issue, be aware that if there is no dam SSTEMP will assume that the stream segment's meterology and geometry also apply upstream from that point a half-day's travel time from the end of the segment. If conditions are vastly different upstream, this is one reason that the maximum temperature estimate can be inaccurate.

3. Segment Length (miles or kilometers) -- Enter the length of the segment for which you want to predict the outflowing temperature. Remember that all variables will be assumed to remain constant for the entire segment. Length may be estimated from a topographic map, but a true measurement is best.

[NOTE: Segment length is determined with National Hydrographic Dataset Reach Indexing Geographic Information System (GIS) tool.]

4. Upstream Elevation (feet or meters) -- Enter elevation as taken from a 7 ½ minute quadrangle map.

[NOTE: Upstream elevation is generally determined in the field with a GPS unit or GIS tool.]

5. Downstream Elevation (feet or meters) -- Enter elevation as taken from a 7 ½ minute quadrangle map. Do not enter a downstream elevation that is higher than the upstream elevation. . .

[NOTE: Downstream elevation is generally determined in the field with a GPS unit or GIS tool.]

6. Width's A Term (seconds/foot^2 or seconds/meter^2) -- This parameter may be derived by calculating the wetted width-discharge relationship. . . To conceptualize this, plot the width of the segment on the Y-axis and discharge on the X-axis of log-log paper. . . The relationship should approximate a straight line, the slope of which is the B term (the next variable). Theoretically, the A term is the untransformed Y-intercept. However, the width vs. discharge relationship tends to break down at very low flows. Thus, it is best to calculate B as the slope and then solve for A in the equation:

$$W = A * Q^B$$

where Q is a known discharge
W is a known width
B is the power relationship

Regression analysis also may be used to develop this relationship. First transform the flow to natural log (flow) and width to natural log (width). Log (width) will be the dependent variable. The resulting X coefficient will be the B term and the (non-zero) constant will be the A term when exponentiated. That is:

A = e^constant from regression

where ^ represents exponentiation

As you can see from the width equation, width equals A if B is zero. Thus, substitution of the stream's actual wetted width for the A term will result if the B term is equal to zero. This is satisfactory if you will not be varying the flow, and thus the stream width, very much in your simulations. If, however, you will be changing the flow by a factor of 10 or so, you should go to the trouble of calculating the A and B terms more precisely. Width can be a sensitive factor under many circumstances.

[NOTE: After Width's B Term is determined (see note below), Width's A Term is calculated as displayed above.]

7. Width's B Term (essentially dimensionless) -- From the above discussion, you can see how to calculate the B term from the log-log plot. This plot may be in either English or international units. The B term is calculated by linear measurements from this plot. Leopold et al. (1964, p.244) report a variety of B values from around the world. A good default in the absence of anything better is 0.20; you may then calculate A if you know the width at a particular flow.

[NOTE: Width's B Term is calculated at the slope of the regression of the natural log of width and the natural log of flow. Width vs. flow data sets are determined by entering cross-section field data into WINXSPRO (USDA 1998). See **Appendix H** for details.]

8. Manning's n or Travel Time (seconds/mile or seconds/kilometer) -- Manning's n is an empirical measure of the segment's "roughness. . ." A generally acceptable default value is 0.035. This parameter is necessary only if you are interested in predicting the minimum and maximum daily fluctuation in temperatures. It is not used in the prediction of the mean daily water temperature.

[NOTE: Rosgen stream type is also taken into account when estimating Manning's n (Rosgen 1996).]

TIME OF YEAR

Month/Day (mm/dd) -- Enter the number of the month and day to be modeled. January is month 1, etc. This program's output is for a single day. To compute an average value for a longer period (up to one month), simply use the middle day of that period, e.g., July 15. The error encountered in so doing will usually be minimal. Note that any month in SSTEMP can contain 31 days.

METEOROLOGICAL PARAMETERS

1. Air Temperature (°F or °C) -- Enter the mean daily air temperature. This information may of course be measured (in the shade), and should be for truly accurate results; however, this and the other (following) meteorological parameters may come from the Local Climatological Data (LCD) reports which can be obtained from the National Oceanic and Atmospheric Administration for a weather station near your site. The LCD Annual Summary contains monthly values, whereas the Monthly Summary contains daily values. The Internet is another obvious source of data today. If only scooping-level analyses are required, you may refer to sources of general meterology for the United States, such as USDA (1941) or USDC (1968).

Use the adiabatic lapse rate to correct for elevational differences from the met station:

$$Ta = To + Ct * (Z - Zo)$$

where Ta = air temperature at elevation E (°C)
To = air temperature at elevation Eo (°C)
Z = mean elevation of segment (m)
Zo = elevation of station (m)
Ct = moist-air adiabatic lapse rate (-0.00656 °C/m)

NOTE: Air temperature will usually be the single most important factor in determining mean daily water temperature. . .

[NOTE: Mean daily air temperature data were determined from air thermographs deployed in the shade near the instream thermograph locations or found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm). Regardless of the source, air temperatures are corrected for elevation using the above equation.]

2. Maximum Air Temperature (°F or °C) -- The maximum air temperature is a special case. Unlike the other variables where simply typing a value influences which variables "take effect", the maximum daily air temperature overrides only if the check box is checked. If the box is not checked, the program continues to estimate the maximum daily air temperature from a set of empirical coefficients (Theurer et al., 1984) and will print the result in the grayed data entry box. You cannot enter a value in that box unless the box is checked.

3. Relative Humidity (percent) -- Obtain the mean daily relative humidity for your area by measurement or from LCD reports by averaging the four daily values given in the report. Correct for elevational differences by:

$$Rh = Ro \times [1.0640 ** (To - Ta)] \times \left(\frac{Ta + 273.16}{To + 273.16} \right)$$

where Rh = relative humidity for temperature Ta (decimal)
Ro = relative humidity at station (decimal)
Ta = air temperature at segment (°C)
To = air temperature at station (°C)
** = exponentation
0 <= Rh <= 1.0

[NOTE: Relative humidity data are found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm). Regardless of the source, relative humidity data are corrected for elevation and temperature using the above equation.]

4. Wind Speed (miles per hour or meters/second) -- Obtainable from the LCD. Wind speed also may be useful in calibrating the program to known outflow temperatures by varying it within some reasonable range. In the best of all worlds, wind speed should be measured right above the water's surface.

[NOTE: Wind speed data are found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm).]

5. Ground Temperature (°F or °C) – In the absence of measured data, use mean annual air temperature from the LCD.

[NOTE: Mean annual air temperature is found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm).]

6. Thermal Gradient (Joules/Meter^2/Second/°C) -- This elusive quantity is a measure of rate of thermal input (or outgo) from the streambed to the water. It is not a particularly sensitive parameter within a narrow range. This variable may prove useful in calibration, particularly for the maximum temperature of small, shallow streams where it may be expected that surface waters interact with either the streambed or subsurface flows. In the absence of anything better, simply use the 1.65 default. **Note** that this parameter is measured in the same units regardless of the system of measurement used.

7. Possible Sun (percent) -- This parameter is an indirect and inverse measure of cloud cover. Measure with a pyrometer or use the LCD for historical data. Unfortunately, cloud cover is no longer routinely measured by NOAA weather stations. That means that one must "back calculate" this value or use it as a calibration parameter.

[NOTE: Percent possible sun is found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm).]

8. Dust Coefficient (dimensionless) -- This value represents the amount of dust in the air. If you enter a value for the dust coefficient, SSTEMP will calculate the solar radiation.

Representative values look like the following (TVA 1972):

Winter	6 to 13
Spring	5 to 13
Summer	3 to 10
Fall	4 to 11

If all other parameters are well known for a given event, the dust coefficient may be calibrated by using known ground-level solar radiation data.

9. Ground Reflectivity (percent) -- The ground reflectivity is a measure of the amount of short-wave radiation reflected back from the earth into the atmosphere. If you enter a value for the ground reflectivity, SSTEMP will calculate the solar radiation.

Representative values look like the following (TVA, 1972, and Gray, 1970):

Meadows and fields	14
Leaf and needle forest	5 to 20
Dark, extended mixed forest	4 to 5
Heath	10
Flat ground, grass covered	15 to 33
Flat ground, rock	12 to 15
Flat ground, tilled soil	15 to 30
Sand	10 to 20
Vegetation, early summer	19
Vegetation, late summer	29
Fresh snow	80 to 90
Old snow	60 to 80
Melting snow	40 to 60
Ice	40 to 50
Water	5 to 15

10. Solar Radiation (Langley's/day or Joules/meter^2/second) -- Measure with a pyrometer, or refer to Cinquemani et al. (1978) for reported values of solar radiation. If you do not calculate solar radiation within SSTEMP, but instead rely on an external source of ground level radiation, you should assume that about 90% of the ground-level solar radiation actually enters the water. Thus, multiply the recorded solar measurements by 0.90 to get the number to be entered. If you enter a value for solar radiation, SSTEMP will ignore the dust coefficient and ground reflectivity and "override' the internal calculation of solar radiation, graying out the unused input boxes.

[NOTE: Solar radiation data are found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm).]

SHADE PARAMETER

Total Shade (percent) -- This parameter refers to how much of the segment is shaded by vegetation, cliffs, etc. If 10% of the water surface is shaded through the day, enter 10. As a shortcut, you may think of the shade factor as being the percent of water surface shaded at noon on a sunny day. In actuality however, shade represents the percent of the incoming solar radiation that does not reach the water. If you enter a value for total shade, the optional shading parameters will be grayed out and ignored. You may find it to your advantage to use the Optional Shading Variables to more accurately calculate stream shading. . .

[NOTE: 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.]

OUTPUT

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. The mean daily equilibrium temperature is that temperature that the daily mean water temperature will approach, but never reach, if all conditions remain the same (forever) as you go downstream. (Of course, all conditions cannot remain the same, e.g., the elevation changes immediately.) The maximum daily equilibrium temperature is that temperature that the daily maximum water temperature will approach. . . Other output includes the intermediate parameters average width, and average depth and slope (all calculated from the input variables), and the mean daily heat flux components.

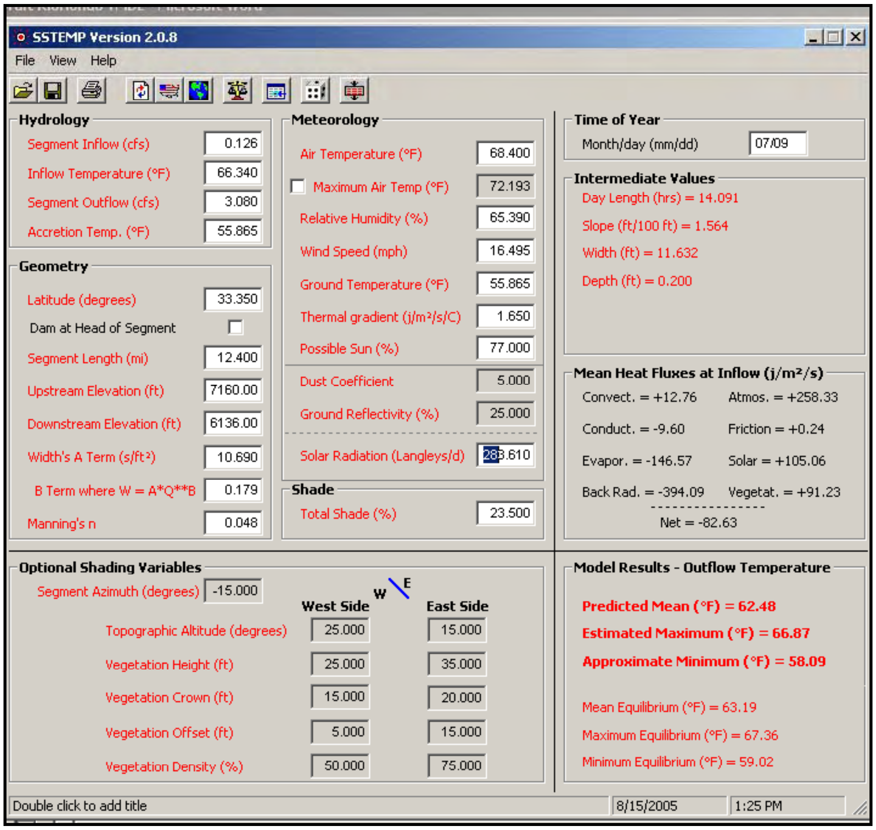


Figure 6.2 Example of SSTEMP input and output for Rio Ruidoso

. . . The mean heat flux components are abbreviated as follows:

Convect. = convection component
Conduct. = conduction component
Evapor. = evaporation component
Back Rad. = water's back radiation component
Atmos. = atmospheric radiation component
Friction = friction component
Solar = solar radiation component
Vegetat. = vegetative and topographic radiation component
Net = sum of all the above flux values

The sign of these flux components indicates whether or not heat is entering (+) or exiting (-) the water. The units are in joules/meter^2/second. In essence, these flux components are the best indicator of the relative importance of the driving forces in heating and cooling the water from inflow to outflow. SSTEMP produces two sets of values, one based on the inflow to the segment and one based on the outflow. You may toggle from one to the other by double clicking on the frame containing the values. In doing so, you will find that the first four flux values change as a function of water temperature which varies along the segment. In contrast, the last four flux values do not change because they are not a function of water temperature but of constant air temperature and channel attributes. For a more complete discussion of heat flux, please refer to Theurer et al. (1984). . .

The program will predict the total segment shading for the set of variables you provide. The program will also display how much of the total shade is a result of topography and how much is a result of vegetation. The topographic shade and vegetative shade are merely added to get the total shade. Use the knowledge that the two shade components are additive to improve your understanding about how SSTEMP deals with shade in toto.

SENSITIVITY ANALYSIS

SSTEMP may be used to compute a one-at-a-time sensitivity of a set of input values. Use **View|Sensitivity Analysis** or the scale toolbar button to initiate the computation. 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. This version does not compute any interactions between input values.

FLOW/DISTANCE MATRIX

The **View|Flow/DistanceMatrix** option allows you to look at a variety of flow and distance combinations from your stream segment. You may enter up to five flows and five distances for further examination. The program will supply a default set of each, with flows ranging from 33% to 166% of that given on the main screen, and distances regularly spaced along the segment. After making any changes you may need, you may choose to view the results in simple graphs either as a function of distance (X) or discharge (Q). The units for discharge, distance and temperature used on the matrix and the graph are a function of those from the main form. The graph is discrete, i.e., does not attempt to smooth between points, and does not currently scale the X-axis realistically.

Note that changing the flow only changes the flow through the segment. That is, the accretion rate per unit distance will remain the same. Flow does impact shading (if active) and all other dependent calculations. . .

Note that you may enter distances beyond your segment length, but if you do so you are assuming that everything remains homogeneous farther downstream, just as you have assumed for the segment itself. *If you try to look at distances very close to the top of the segment, you may get mathematical instability*. . .

UNCERTAINTY ANALYSIS

SNTEMP and previous versions of SSTEMP were deterministic; you supplied the “most likely” estimate of input variables and the model predicted the “most likely” thermal response. This approach was comforting and easy to understand. But choosing this “most likely” approach is like putting on blinders. We know there is variability in the natural system and inherent inaccuracy in the model. The previous model did not reflect variance in measured or estimated input variables (e.g., air temperature, streamflow, stream width) or parameter values (e.g., Bowen ratio, specific gravity of water); therefore they could not be used to estimate the uncertainty in the predicted temperatures. This version (2.0) adds an uncertainty feature that may be useful in estimating uncertainty in the water temperature estimates, given certain caveats.

The built-in uncertainty routine uses Monte Carlo analysis, a technique that gets its name from the seventeenth century study of the casino games of chance. The basic idea behind Monte Carlo analysis is that model input values are randomly selected from a distribution that describes the set of values composing the input. That is, instead of choosing one value for mean daily air temperature, the model is repeatedly run with several randomly selected estimates for air temperature in combination with random selections for all other relevant input values. The distribution of input values may be thought of as representing the variability in measurement and extrapolation error, estimation error, and a degree of spatial and temporal variability throughout the landscape. In other words, we may measure a single value for an input variable, but we know that our instruments are inaccurate to a degree. . . and we also know that the values we measure might have been different if we had measured in a different location along or across the stream, or on a different day. . .

SSTEMP is fairly crude in its method of creating a distribution for each input variable. There are two approaches in this software: a percentage deviation and an absolute deviation. The percentage deviation is useful for variables commonly considered to be reliable only within a percentage difference. For example, USGS commonly describes stream flow as being accurate plus or minus 10%. The absolute deviation, as the name implies, allows entry of deviation values in the same units as the variable (*and always in international units*). A common example would be water temperature where we estimate our ability to measure temperature plus or minus maybe 0.2 degrees. Do not be fooled with input variables whose units are themselves percent, like shade. In this case, if you are in the percentage mode and shade is 50% as an example, entering a value of 5% would impose a deviation of ±2.5 percent (47.5-52.5%), but if you were in the absolute mode, the same 5% value would impose a deviation of ±5 percent (45-55%). Ultimately, SSTEMP converts all of the deviation values you enter to the percent representation before it computes a sample value in the range. No attempt is made to allow for deviations of the date, but all others are fair game, with three exceptions. First, the deviation on stream width is applied only to the A-value, not the B-term. If you want to be thorough, set the width to a constant by setting the B-term to zero. Second, if after sampling, the upstream elevation is lower than the downstream elevation, the upstream elevation is adjusted to be slightly above the downstream elevation. Third, you may enter deviations only for the values being used on the main screen.

The sampled value is chosen from either 1) a uniform (rectangular) distribution plus or minus the percent deviation, or 2) a normal (bell-shaped) distribution with its mean equal to the original value and its standard deviation equal to 1.96 times the deviation so that it represents 95% of the samples drawn from that distribution. If in the process of sampling from either of these two distributions, a value is drawn that is either above or below the "legal" limits set in SSTEMP, a new value is drawn from the distribution. For example, lets assume that you had a relative humidity of 99% and a deviation of 5 percent. If you were using a uniform distribution, the sample range would be 94.05 to 103.95; but you cannot have a relative humidity greater than 100%. Rather than prune the distribution at 100%, SSTEMP resamples to avoid over-specifying 100% values. No attempt has been made to account for correlation among variables, even though we know there is some. I have found little difference in using the uniform versus normal distributions, except that the normal method produces somewhat tighter confidence intervals.

SSTEMP's random sampling is used to estimate the average temperature response, both for mean daily and maximum daily temperature, and to estimate the entire dispersion in predicted temperatures. You tell the program how many trials to run (minimum of 11) and how many samples per trial (minimum of two). Although it would be satisfactory to simply run many individual samples, the advantage to this trial-sample method is twofold. First, by computing the average of the trial means, it allows a better, tighter estimate of that mean value. This is analogous to performing numerous "experiments" each with the same number of data points used for calibration. Each "experiment" produces an estimate of the mean. Second, one can gain insight as to the narrowness of the confidence interval around the mean depending on how many samples there are per trial. This is analogous to knowing how many data points you have to calibrate the model with and the influence of that. For example, if you have only a few days' worth of measurements, your confidence interval will be far broader than if you had several months' worth of daily values. But this technique does little to reduce the overall spread of the resulting predicted temperatures. . .

ASSUMPTIONS

a. Water in the system is instantaneously and thoroughly mixed at all times. Thus there is no lateral temperature distribution across the stream channel, nor is there any vertical gradient in pools.

b. All stream geometry (e.g., slope, shade, friction coefficient) is characterized by mean conditions. This applies to the full travel distance upstream to solar noon, unless there is a dam at the upstream end.

c. Distribution of lateral inflow is uniformly apportioned throughout the segment length.

d. Solar radiation and the other meteorological and hydrological parameters are 24-hour means. You may lean away from them for an extreme case analysis, but you risk violating some of the principles involved. For example, you may alter the relative humidity to be more representative of the early morning hours. If you do, the mean water temperature may better approximate the early morning temperature, but the maximum and minimum temperatures would be meaningless.

e. Each variable has certain built-in upper and lower bounds to prevent outlandish input errors. These limits are not unreasonable; however, the user should look to see that what he or she types actually shows up on the screen. The screen image will always contain the values that the program is using.

f. This model does not allow either Manning's n or travel time to vary as a function of flow.

g. The program should be considered valid only for the Northern Hemisphere below the Arctic Circle. One could theoretically “fast forward” six months for the Southern Hemisphere’s shade calculations, but this has not been tested. The solar radiation calculations would likely be invalid due to the asymmetrical elliptical nature of the earth’s orbit around the sun.

h. The representative time period must be long enough for water to flow the full length of the segment. . . Remember that SSTEMP, like SNTEMP, is a model that simulates the mean (and maximum) water temperature for some period of days. (One day is the minimum time period, and theoretically, there is no maximum, although a month is likely the upper pragmatic limit.) SSTEMP looks at the world as if all the inputs represent an average day for the time period. For this reason, SSTEMP also assumes that a parcel of water entering the top of the study segment will have the opportunity to be exposed to a full day’s worth of heat flux by the time it exits the downstream end. If this is not true, the time period must be lengthened.

. . . suppose your stream has an average velocity of 0.5 meters per second and you want to simulate a 10 km segment. With 86,400 seconds in a day, that water would travel 43 km in a day’s time. As this far exceeds your 10 km segment length, you can simulate a single day if you wish. But if your stream’s velocity were only 0.05 mps, the water would only travel 4.3 km, so the averaging period for your simulation must be at least 3 days to allow that water to be fully influenced by the average conditions over that period. If, however, most conditions (flow, meteorology) are really relatively stable over the 3 days, you can get by with simulating a single day. Just be aware of the theoretical limitation.

i. Remember that SSTEMP does not and cannot deal with cumulative effects. For example, suppose you are gaming with the riparian vegetation shade’s effect on stream temperature. Mathematically adding or deleting vegetation is not the same as doing so in real life, where such vegetation may have subtle or not so subtle effects on channel width or length, air temperature, relative humidity, wind speed, and so on. . .

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 the Rio Ruidoso. 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 Rio Ruidoso (US Highway 70 to Mescalero boundary)

The two densitometer readings for this assessment unit varied widely and there has been noted urbanization and development in this watershed after the aerial photographs were taken, so the starting "% shade" value was estimated on the low end of the scale. For Rio Ruidoso (US Highway 70 to Mescalero boundary), the WQS for temperature is achieved when the percent total shade is increased to 15%. According to the SSTEMP model, the actual LA of 72.86 j/m^2/s is achieved when the shade is further increased to 23.5% (Table 6.2).

Table 6.2 SSTEMP Model Results for Rio Ruidoso (US Highway 70 to Mescalero boundary)

<table>
<tr><th>Rosgen Channel Type</th><th>WQS (HQCWF)</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>C5/B4C/ B3</td><td>20°C (68°F)</td><td>8/9/03</td><td>12.4</td><td>Current Field Condition
+127.72
joules/m^2/s</td><td>7</td><td>10.69</td><td>Minimum: 15.04
Mean: 17.64
Maximum: 20.24</td></tr>
<tr><td colspan="4" rowspan="3">TEMPERATURE ALLOCATIONS FOR
(US Highway 70 to Mescalero boundary)

[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:

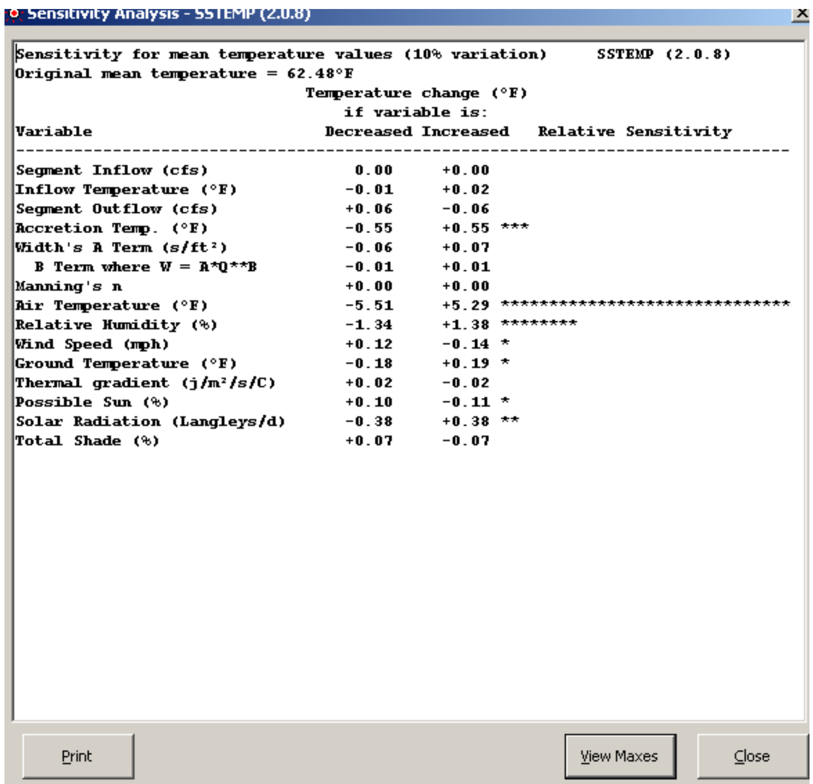
Current Condition – Load Allocation =

127.72 joules/m^2/s – 105.07 joules/m^2/s

=22.65 joules/m^2/s</td><td>Run 1
+123.60
joules/m^2/s</td><td>10</td><td>10.69</td><td>Minimum: 15.04
Mean: 17.58
Maximum: 20.13</td></tr>
<tr><td>Run 2
+116.74 [a]
joules/m^2/s</td><td>15</td><td>10.69</td><td>Minimum: 15.03
Mean: 17.49
Maximum: 19.96</td></tr>
<tr><td>Actual LA
105.07 [b]
joules/m^2/s</td><td>23.5</td><td>10.69</td><td>Minimum: 15.01
Mean: 17.33
Maximum: 19.64</td></tr>
</table>

According to the Sensitivity Analysis feature of the model runs, mean daily air temperature had the greatest influence on the predicted outflow temperatures and total shade values have the greatest influence on temperature reduction. 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 6.4 and 6.5. 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 6.4) and unimpaired assessment unit (Figure 6.5). The impaired reach experienced diurnal swings of 10ºC while the unimpaired reach reach only experienced a diurnal swing of 5ºC and both reaches experienced essentially the same air temperature.

The estimate of total shade used in the model calibration was based on densiometer readings and examination of aerial photographs (see **Appendix H**). Target loads as determined by the modeling runs are summarized in Tables 6.2 and 6.3. The MOS is estimated to be 10% of the target load calculated by the modeling runs. Results are summarized in Table 6.4. Additional details on the MOS chosen are presented in Section 6.7 below.



Sensitivity for mean temperature values (10% variation)   SSTEMP (2.0.8)
Original mean temperature = 62.48°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	0.00	+0.00	
Inflow Temperature (°F)	-0.01	+0.02	
Segment Outflow (cfs)	+0.06	-0.06	
Accretion Temp. (°F)	-0.55	+0.55	***
Width's A Term (s/ft²)	-0.06	+0.07	
B Term where W = A*Q**B	-0.01	+0.01	
Manning's n	+0.00	+0.00	
Air Temperature (°F)	-5.51	+5.29	******************************
Relative Humidity (%)	-1.34	+1.38	********
Wind Speed (mph)	+0.12	-0.14	*
Ground Temperature (°F)	-0.18	+0.19	*
Thermal gradient (j/m²/s/C)	+0.02	-0.02	
Possible Sun (%)	+0.10	-0.11	*
Solar Radiation (Langleys/d)	-0.38	+0.38	**
Total Shade (%)	+0.07	-0.07	

Figure 6.3 Example of SSTEMP sensitivity analysis for Rio Ruidoso

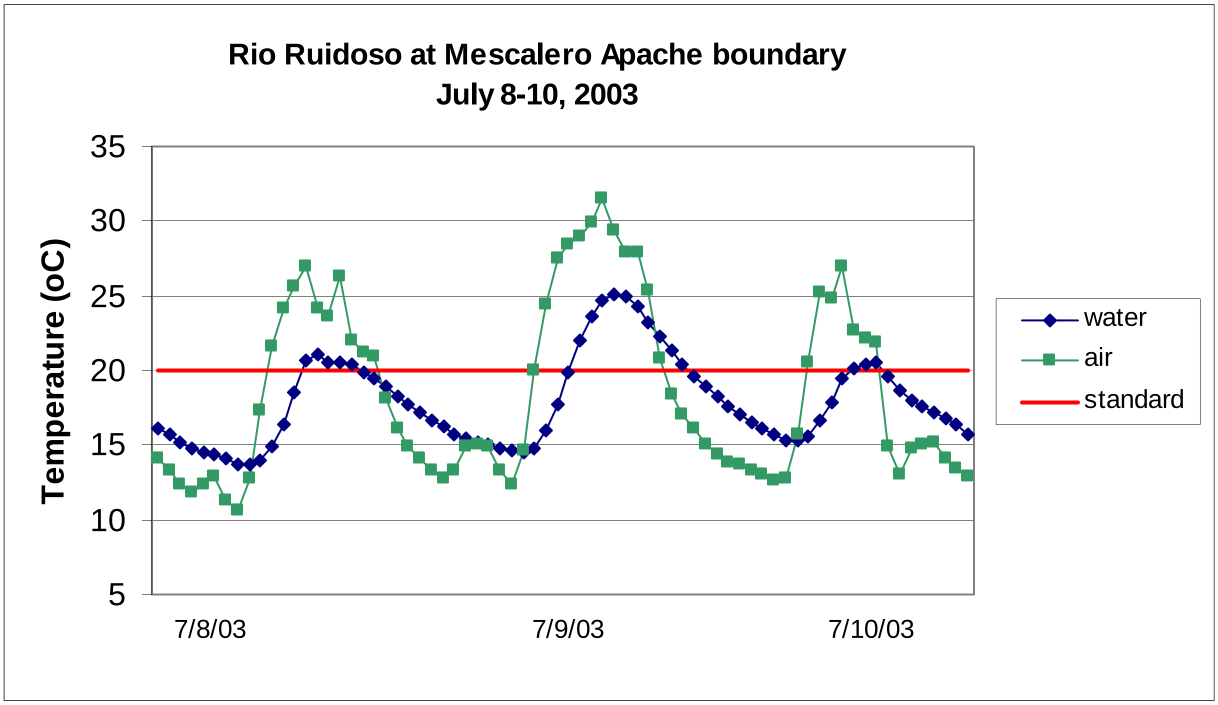


Figure 6.4 Air and water thermograph data for Rio Ruidoso

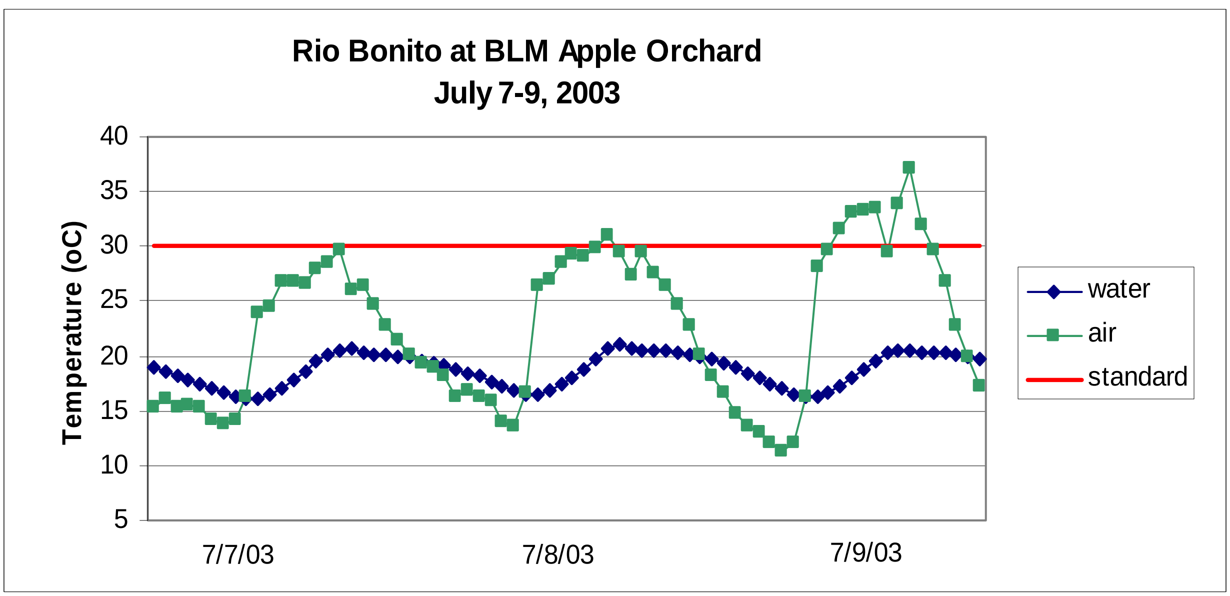


Figure 6.5 Air and water thermograph data for Rio Bonito

Table 6.3 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 ($j/m^2/s$)
Rio Ruidoso (US Highway 70 to Mescalero Apache boundary)	0	105*	11.7*	117*

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 and 6.3), and are shown in Table 6.4.

Table 6.4 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)]
Rio Ruidoso (US Highway 70 to Mescalero Apache boundary)	105*	128*	22.7*	18.0

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 = 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 6.5.

Table 6.5 Pollutant source summary for Temperature

Pollutant Sources	Magnitude[(a)]	Location	Potential Sources[(b)] (% from each)
Point:			
None	0	--------	0%
Nonpoint:			
	128	Rio Ruidoso	100% Loss of riparian habitat Municipal Point Source Discharges On-site treatment systems (septic systems and similar decentralized systems) Rangeland grazing Site clearance (land development and redevelopment) Streambank modifications/destabilization Agriculture pastureland, animal holding areas, channelization, flow regulation (fieldnotes)

Notes:

[(a)] Measured Load as j/m^2/s
[(b)] From the 2004-2006 Integrated CWA §303(d)/305(b) list unless otherwise noted.
[(c)] Expressed as solar radiation.

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, many either present or not present, 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 Standards for the protection of aquatic habitat, namely the HQCWF designed uses. Through monitoring, and pollutant source documentation, it has been observed that the most probable cause for these temperature exceedences are due to the alteration of the stream's hydrograph, removal of riparian vegetation, livestock grazing, and natural causes. Alterations can be historical or current in nature.

A variety of factors impact stream temperature (Figure 6.4). 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 the Rio Hondo watershed 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 C** 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 7.6 identifies and quantifies potential 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.

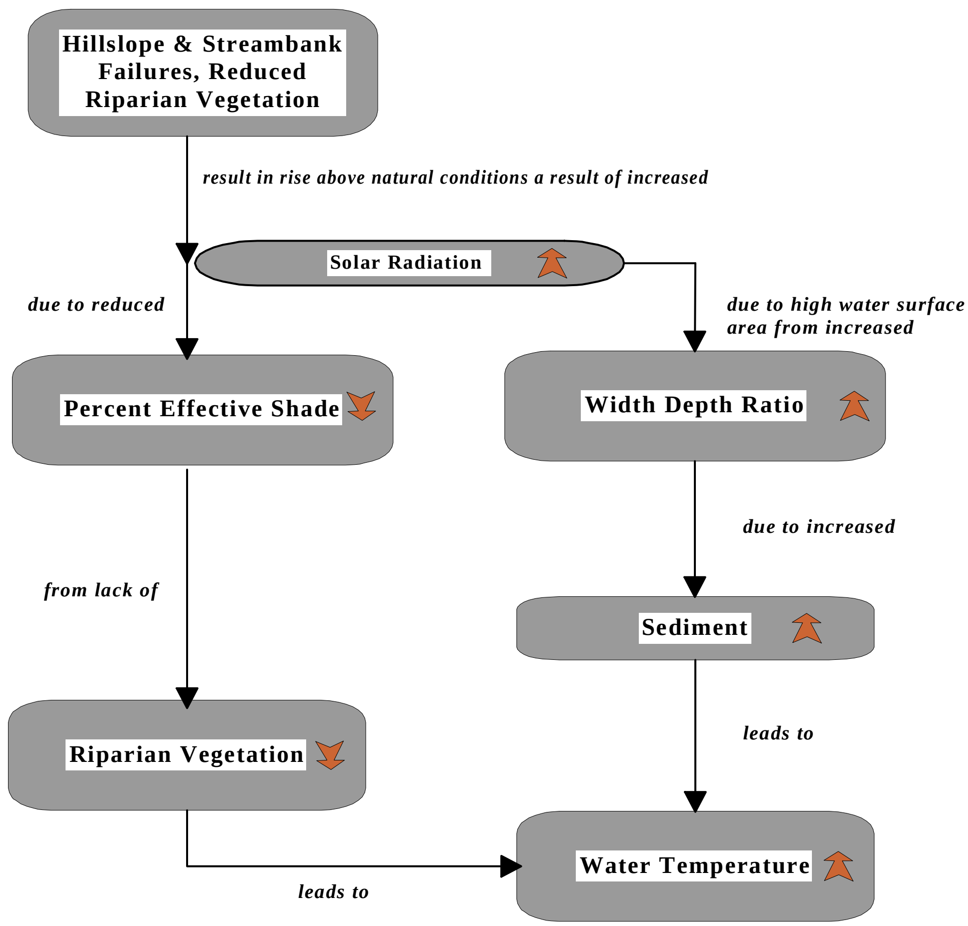


Figure 6.6 Factors That Impact Water Temperature

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 H** for details.

As detailed in **Appendix H,** 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

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 Lincoln County project a 52% growth rate through 2030. Since future projections indicate that Nonpoint sources 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 activities convered under general permits.

7.0 TURBIDITY

During the 2003 SWQB intensive water quality survey in the Rio Hondo watershed, an exceedence of the New Mexico water quality criteria for turbidity was documented in the Rio Ruidoso (US Highway 70 to Mesacalero Apache boundary) assessment unit. As a result, this assessment unit is listed on the 2004-2006 Integrated CWA §303(d)/§305(b) list (NMED/SWQB 2004a) with turbidity as a pollutant of concern (see summary in Table 7.1).

7.1 Target Loading Capacity

Target values for this turbidity TMDL 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 turbidity are based on numeric criteria. This TMDL is also consistent with New Mexico's antidegradation policy.

According to the New Mexico Water Quality Standards (20.6.4 NMAC), the general narrative standard for turbidity reads:

> *Turbidity: Turbidity attributable to other than natural causes shall not reduce light transmission to the point that the normal growth, function, or reproduction of aquatic life is impaired or that will cause substantial visible contrast with the natural appearance of the water.*

According to the 2002 New Mexico WQS, the turbidity standard for a high quality coldwater fishery reads:

> *20.6.4.900 NMAC: In any single sample: turbidity shall not exceed 10 NTU.*

The 2005 New Mexico WQS have transitioned from use specific turbidity standards to a general turbidity criterion that reads:

> *20.6.4.13(J) NMAC: Turbidity shall not exceed 10 NTU over background turbidity when the background turbidity is 50 NTU or less, or increase more than 20 percent when the background turbidity is more than 50 NTU. Background turbidity shall be measured at a point immediately upstream of the turbidity-causing activity…*

The SWQB is currently developing protocol to determine background turbidity in order to use the general turbidity criterion in future assessments. The 2002 New Mexico WQS use specific standards were used to assess the 2003 Rio Hondo water quality results and to prepare this TMDL.

The total suspended solids (TSS) analytical method is a commonly used measurement of suspended material in surface water. This method was originally developed for use on wastewater samples, but has widely been used as a measure of suspended materials in stream samples because it is acceptable for regulatory purposes and is an inexpensive laboratory procedure. This analytic method does not discern between solids produced from erosional activities versus biosolids when instream samples are collected and analyzed. Since there are no WWTPs discharging into this reach of the Rio Ruidoso, it is assumed that TSS measurements in these ambient stream samples are representative of erosional activities and thus comprised primarily of suspended sediment vs. any potential biosolids from WWTP effluent.

Turbidity levels can be inferred from studies that monitor suspended sediment concentrations. Extrapolation from these studies is possible when a site-specific relationship between concentrations of suspended sediments and turbidity is confirmed. Activities that generate varying amounts of suspended sediment will proportionally change or affect turbidity (USEPA 1991). The impacts of suspended sediment and turbidity are well documented in the literature. An increased sediment load is often the most important adverse effect of activities on streams, according to a monitoring guidelines report (USEPA 1991). This impact is largely a mechanical action that severely reduces the available habitat for macroinvertebrates and fish species that utilize the streambed in various life stages. An increase in suspended sediment concentration will reduce the penetration of light, decreases the ability of fish or fingerlings to capture prey, and reduce primary production (USEPA 1991). As stated in Relyea *et al* (2000) "increased turbidity by sediments can reduce stream primary production by reducing photosynthesis, physically abrading algae and other plants, and preventing attachment of autotrouphs to substrate surfaces."

TSS and turbidity were measured in the Rio Ruidoso during the 2003 survey (Table 7.1). The TSS target was derived using a regression equation developed using measured turbidity as the independent variable and measured TSS dependent variable. The equation and regression statistics are displayed below in Figure 7.1. A good correlation of $r^2 = 0.71$ was found between TSS and turbidity for the Rio Ruidoso.

Table 7.1 TSS, turbidity, and flow data for Rio Ruidoso (US Highway 70 to Mescalero Apache bnd)

Sample Date	TSS (mg/L)	Turbidity (NTU)	Discharge (cfs)
Rio Ruidoso 0.5 mile above WWTP at HWY 70 bridge above seeping springs (site #20)			
5/20/2002	5	6.1	n/a
3/18/2003	10	9.8	7.74
4/22/2003	27	33*	17.51
5/20/2003	9	12.2*	5.8
6/24/2003	3	3.8	3.09
7/22/2003	4	5.2	1.82
8/19/2003	13	12.8*	2.5
9/2/2003	18	17* [a]	2.41
9/9/2003	n/a	4	n/a
9/23/2003	3	4.8	2.35
10/22/2003	9	17.6*	2.8
Rio Ruidoso below Ruidoso Downs Racetrack Property (site #19)			
3/18/2003	4	7.6	8.89
4/22/2003	18	30*	17.72
5/20/2003	4	7	6
6/24/2003	4	5.1	3.96
7/22/2003	12	9.6	2.11
8/19/2003	16	43.4*	1.54
9/2/2003	11	23.4*	1.27
9/23/2003	3	3.4	0.51
10/22/2003	3	1.3	2.01
Rio Ruidoso at USGS gaging station at Hollywood (site#17)			
3/18/2003	8	7.4	13
4/22/2003	14	15.4*	39.5
5/20/2003	17	10.9*	9.4
6/24/2003	8	9.9	3.34
7/22/2003	14	26.4*	4.8
8/19/2003	22	43.2*	5.1
9/2/2003	11	15.5*	3.34
9/23/2003	3	4.7	4.4
10/22/2003	3	5.2	6.25

Sample Date	TSS (mg/L)	Turbidity (NTU)	Discharge (cfs)
Rio Ruidoso at Mescalero boundary at gage (site#16)			
5/20/2002	3	4.4	n/a
3/18/2003	6	4	11.5
4/22/2003	8	8	16.1
5/20/2003	12	16.5*	9.17
6/24/2003	6	6.8	1.8
7/22/2003	10	12*	1.62
8/19/2003	8	9.7	1.53
9/23/2003	3	3.2	1.31
10/22/2003	3	2.8	0.87
11/2/2004	n/a	4.9	n/a

Notes: *Exceedence of appropriate turbidity water quality criterion.
[a] Average of two samples taken 2 hours apart, 32.7 and 1.2 NTU
NTU = Nephelometric turbidity units

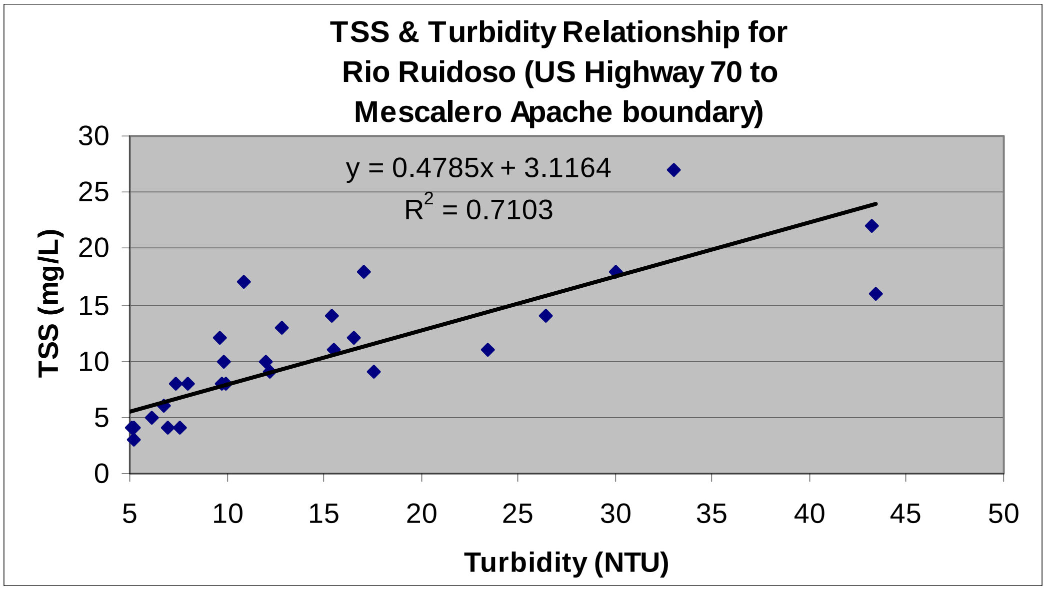


Figure 7.1 Relationship between TSS and Turbidity at Rio Ruidoso (US Highway 70 to Mescalero Apache boundary).

7.2 Flow

Sediment transport in a stream varies as a function of flow. As flow increases, the amount of sediment being transported increases. This TMDL is calculated at specific flows. For this reach, flow was measured by SWQB during the 2003 sampling runs using standard USGS procedures (NMED/SWQB 2001). Table 7.2 shows the dates of turbidity exceedences and the measured flow on those dates. Due to the fact that exceedences occurred in this reach in both low and high flows (Figure 7.2) and that flow measurements were available for all the sites and dates for which there were turbidity exceedences, the critical flow was determined to be the average of all measured flows associated with the exceedences. Therefore the critical flows for this TMDL was 8.30 cfs.

Table 7.2 Flow and turbidity exceedence data for Rio Ruidoso.

Rio Ruidoso site	Dates of exceedences	Flow (cfs)	Value of exceedence (NTU)
Rio Ruidoso 0.5 mile above WWTP at HWY 70 bridge above seeping spring	4/22/03	17.51	33
	5/20/03	5.8	12.2
	8/9/03	2.5	12.8
	9/2/03	2.41	17
	10/22/03	2.8	17.6
Rio Ruidoso below Ruidoso Downs Racetrack Property	4/22/03	17.72	30
	8/19/03	1.54	43.4
	9/2/03	1.27	24.4
Rio Ruidoso at USGS gaging station at Hollywood	4/22/03	39.5	15.4
	5/20/03	9.4	10.9
	7/22/03	4.8	26.4
	8/19/03	5.1	43.2
	9/2/03	3.34	15.5
Rio Ruidoso at Mescalero boundary at gage	5/20/03	9.17	16.5
	7/22/03	1.62	12

The flow value for Rio Ruidoso was converted from cfs to units of mgd as follows:

$$8.30\frac{ft^3}{\sec}\times 1{,}728\frac{in^3}{ft^3}\times 0.004329\frac{gal}{in^3}\times 86{,}400\frac{\sec}{day}\times 10^{-6} = 5.36\,mgd$$

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.

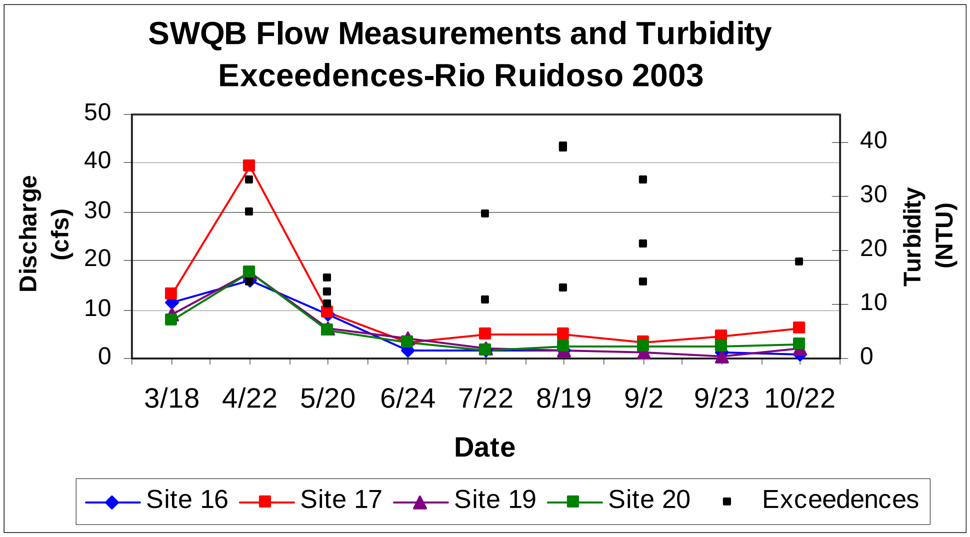


Figure 7.2 Relationship between flow and turbidity exceedences for Rio Ruidoso.

7.3 Calculations

Target loads for turbidity (expressed as TSS) are calculated based on a flow, the current water quality standards, and a conversion factor (8.34) that is a used to convert mg/L units to lbs/day (see **Appendix E** for Conversion Factor Derivation). The target loading capacity is calculated using **Equation 3**. The results are shown in Table 7.3.

Critical Flow (mgd) x Standard (mg/L) x 8.34 = Target Loading Capacity (Eq. 3)

Table 7.3 Calculation of target loads for turbidity (expressed as TSS)

Location	Flow (mgd)	TSS (mg/L)	Conversion Factor	Target Load Capacity (lbs/day)
Rio Ruidoso (US Highway 70 to Mescalero Apache boundary)	5.40⁺	7.90*⁺	8.34	356⁺

Notes:
*The TSS value was calculated using the relationship established between TSS and turbidity in Figure 4.2 (y=0.4785x + 3.1164, R^2=0.71) using the turbidity standard of 10 NTU for the X variable.
+ Values rounded to three significant figures.

The measured loads for turbidity (expressed as TSS) were similarly calculated. In order to achieve comparability between the target and measured loads, the flows used were the same for both calculations. The arithmetic mean of corresponding TSS values when turbidity exceeded the standard was substituted for the standard in **Equation 3**. The same conversion factor of 8.34 was used. Results are presented in Table 7.4.

Table 7.4 Calculation of measured loads for turbidity (expressed as TSS)

Location	Flow (mgd)	TSS Arithmetic Mean (mg/L)	Conversion Factor	Measured Load Capacity (lbs/day)
Rio Ruidoso (US Highway 70 to Mescalero Apache boundary)	5.40*	14.7*	8.34	663*

* Values rounded to three significant figures.

7.4 Waste Load Allocations and Load Allocations

7.4.1 Waste Load Allocation

There are no individually permitted point source facilities or MS4 storm water permits on Rio Ruidoso (US Highway 70 to Mescalero Apache boundary). Turbidity may be a component of some (primarily construction) storm water discharges that contribute to suspended sediment impacts, and 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 CGP requires preparation of a 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 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 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 WLAs for any 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 on the watershed load allocation.

7.4.2 Load Allocation

In order to calculate the LA, the WLA and MOS were subtracted from the target capacity (TMDL) following **Equation 2**.

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

The MOS is estimated to be 25% of the target load calculated in Table 7.3. Results are presented in Table 7.5. Additional details on the MOS chosen are presented in Section 7.7 below.

Table 7.5 Calculation of TMDL for turbidity

Location	WLA (lbs/day)	LA (lbs/day)	MOS (25%) (lbs/day)	TMDL (lbs/day)
Rio Ruidoso (US Highway 70 to Mescalero Apache boundary)	0	267*	89*	356*

* Values rounded to three significant figures.

The extensive data collection and analyses necessary to determine background turbidity load for the Rio Hondo watershed was beyond the resources available for this study. It is therefore assumed that a portion of the load allocation is made up of natural background loads.

The NPS and background load reductions that would be necessary to meet the target loads were calculated to be the difference between the target load allocation (Table 7.3) and the measured load (Table 7.4), and are shown in Table 7.6.

Table 7.6 Calculation of load reduction for turbidity (expressed as TSS)

Location	Target Load[(a)] (lbs/day)	Measured Load (lbs/day)	Load Reduction (lb/day)	Percent Reduction[(b)]
Rio Ruidoso (US Highway 70 to Mescalero Apache boundary)	267*	663*	396*	60%

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 = 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.

Table 7.7 Pollutant source summary for turbidity on Rio Ruidoso

Pollutant Sources	Magnitude (lbs/day)	Location	Potential Sources[(a)] (% from each)
Point: None	0	--------	0%
Nonpoint: Turbidity[(b)]	663*	Rio Ruidoso (US Highway 70 to Mescalero Apache boundary)	100% Loss of riparian habitat, municipal point source discharges, on-site treatment systems (septic systems and similar decentralized systems), rangeland grazing, site clearance (land development or redevelopment), streambank modifications/destabilization.

*Measured load

Notes:

(a) From the 2004-2006 Integrated 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.

(b) Expressed as TSS in lbs/day

7.6 Linkage of Water Quality and Pollutant Sources

Turbidity is an expression of the optical property in water that causes incident light to be scattered or absorbed rather than transmitted in straight lines. It is the condition resulting from suspended solids in the water, including silts, clays, and plankton. Such particles absorb heat in the sunlight, thus raising water temperature, which in turn lowers dissolved oxygen levels. It also prevents sunlight from reaching plants below the surface. This decreases the rate of photosynthesis, so less oxygen is produced by plants. Turbidity may harm fish and their larvae. Turbidity exceedences, historically, are generally attributable to soil erosion, excess nutrients, various wastes and pollutants, and the stirring of sediments up into the water column during high flow events. Turbidity increases, as observed in SWQB monitoring data, show turbidity values along these reaches that exceed the State Standards for the protection of aquatic habitat, HQCWF designed uses. Through monitoring, and pollutant source documentation, it has been observed that the most probable cause for these exceedences are due to the alteration of the stream's hydrograph and natural causes. Alterations can be historical or current in nature.

The components of a watershed continually change through natural ecological processes such as vegetation succession, erosion, and evolution of stream channels. Intrusive human activity often affects watershed function in ways that are inconsistent with the natural balance. These changes, often rapid and sometimes irreversible, occur when people:

- cut forests
- clear and cultivate land
- remove stream-side vegetation

- alter the drainage of the land
- channelize watercourses
- withdraw water for irrigation
- build towns and cities
- discharge pollutants into waterways.

Possible effects of these practices on aquatic ecosystems include:

1. Increased amount of sediment carried into water by soil erosion which may

    - increase turbidity of the water
    - reduce transmission of sunlight needed for photosynthesis
    - interfere with animal behaviors dependent on sight (foraging, mating, and escape from predators)
    - impede respiration (e.g., by gill abrasion in fish) and digestion
    - reduce oxygen in the water
    - cover bottom gravel and degrade spawning habitat
    - cover eggs, which may suffocate or develop abnormally; fry may be unable to emerge from the buried gravel bed

2. Clearing of trees and shrubs from shorelines which may

    - destabilize banks and promote erosion
    - increase sedimentation and turbidity
    - reduce shade and increase water temperature which could disrupt fish metabolism
    - cause channels to widen and become more shallow

3. Land clearing, constructing drainage ditches, straightening natural water channels which may

    - create an obstacle to upstream movement of fish and suspend more sediment in the water due to increased flow
    - strand fish upstream and dry out recently spawned eggs due to subsequent low flows
    - reduce baseflows

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.

SWQB fieldwork includes an assessment of the potential sources of impairment (NMED/SWQB 1999). The completed *Pollutant Source(s) Documentation Protocol* forms in **Appendix C** 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. Staff completing these forms identify and quantify potential sources of NPS 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.

The main sources of impairment along both reaches of Rio Ruidoso (US Highway 70 to Mescalero Apache boundary) appear to be from natural sources, streambank erosion, loss of riparian habitat, rangeland grazing, and site clearance for development.

7.7 Margin of Safety (MOS)

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and NPS load estimates, and the modeling analysis. For the Rio Ruidoso TMDLs, there will be no MOS for point sources since there are none in this assessment unit. However, for the NPS in all of the TMDLs, the MOS is estimated to be an addition of **25%** of the TMDL. This MOS incorporates several factors:

•Errors in calculating NPS loads

> A level of uncertainty does exist in the relationship between TSS and turbidity. In this case, the TSS measure does not include bedload and therefore does not account for a complete measure of sediment load. This does not influence the MOS because we need only be concerned with the turbidity portion of the sediment load, which is the basis for the standard. However, there is a potential to have errors in measurements of NPS loads due to equipment accuracy, time of sampling, etc. Accordingly, a conservative MOS increases the TMDL by **15%**.

•Errors in calculating flow

> Flow estimates were based on USGS gages and field measurements on thisreach. 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.

7.8 Consideration of Seasonal Variation

Data used in the calculation of this TMDL were collected during spring, summer, and fall in order to ensure coverage of any potential seasonal variation in the system. Critical condtions were estimated to be the average flow during exceedences and only data that exceeded the water quality criterion were used in determining the target capacities. Therefore, it is assumed that if critical conditions are met, coverage of any potential seasonal variation will also be met.

7.9 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 Lincoln County project a 52% growth rate through 2030. Since future projections indicate that Nonpoint sources of turbidity 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 activities convered under general permits.

8.0 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 the methods of 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 seven years. The next scheduled monitoring date for the Rio Hondo watershed is 2011. The SWQB maintains current quality assurance and quality control plans to cover all monitoring activities. This document, called the QAPP, is updated and certified annually by USEPA Region 6 (NMED/SWQB 2001). 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 will be directed toward those waters that are on the USEPA TMDL consent decree list (U.S. District Court for the District of New Mexico 1997).

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 2004b).

Long-term monitoring for assessments will be accomplished through the establishment of sampling sites that are representative of the waterbody and which can be revisited approximately every seven 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 recently developed a 10-year monitoring strategy submitted to USEPA on September 30, 2004. Once the 10-year monitoring plan is approved by the USEPA, it will be available at the SWQB website: http://www.nmenv.state.nm.us/swqb/swqb.html. The strategy will detail 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 draft proposed 8-year rotational cycle, which assumes the existing level of resources, the next time SWQB will intensively sample the Rio Hondo watershed during 2011.

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. 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 contribute to the State's Integrated §303(d)/§305(b) listing process for waters requiring TMDLs.

9.0 IMPLEMENTATION OF TMDLS

9.1 Coordination

In this watershed public awareness and involvement will be crucial to the successful implementation of these plans and improved water quality. Staff from SWQB have worked with stakeholders to develop a WRAS for the Upper Rio Hondo Watershed Coalition. The WRAS is a written plan intended to provide a long-range vision for various activities and management of resources in a watershed. It includes opportunities for private landowners and public agencies in reducing and preventing 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 any 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 other members of the Upper Rio Hondo Watershed Coalition.

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 discharge permits.

9.2 Time Line

The upper Rio Hondo watershed is atypical in that a watershed group was formed in 1998, 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 9.1).

9.3 Clean Water Act §319(h) Funding Opportunities

The Watershed Protection Section of the SWQB provides USEPA §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 §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: cities, counties, tribal entities, Federal agencies, or agencies of the State. Proposals are submitted by applicants two times 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 9.1 Proposed Implementation Timeline

Implementation Actions	Year 1 (1998)	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Public Outreach and Involvement	X	X	X	X	X	X	X	X
Form watershed groups	X	X						
TMDL Development					X	X	X	X
WRAS Development				X	X	X		
Revise any NPDES permits as necessary (currently EPA Region 6)			X					X
Establish Performance Targets				X				
Secure Funding			X	X				
Implement Management Measures (BMPs)			X	X	X	X	X	X
Monitor BMPs			X	X	X			
Determine BMP Effectiveness					X	X	X	X
Re-evaluate Performance Targets						X	X	X

9.4 Other Funding Opportunities and Restoration Efforts in the Rio Hondo 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). They can also provide matching funds for appropriate CWA §319(h) projects using state revolving fund monies. The USDA Environmental Quality Incentive Program (EQIP) program can provide assistance to private land owners in the basin. The USDA Forest Service aligns their mission to protect lands they manage with the TMDL process, and are another source of assistance. The BLM has several programs in place to provide assistance to improve unpaved roads and grazing allotments.

10.0 ASSURANCES

New Mexico's Water Quality Act (Act) does authorize 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. Several statutory provisions on nuisance law could also be applied to NPS 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 NMAC 20.6.4.10.C) (NMAC 2002) states:

> *These water quality standards do not grant the Commission or any other entity the power to create, 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 NPS. The NMED NPS water quality management program has historically strived for and will continue to promote voluntary compliance to NPS water pollution concerns by utilizing a voluntary, cooperative approach. The State provides technical support and grant monies for implementation of BMPs and other NPS prevention mechanisms through §319 of the Clean Water Act. Since portions of this TMDL will be implemented through NPS control mechanisms, the New Mexico Watershed Protection Program will target efforts to this and other watersheds with TMDLs. The Red River Watershed

Group applied for and was awarded a §319 grant to begin development of projects to address impairments noted in this TMDL document.

In order to obtain reasonable assurances for implementation in watersheds with multiple landowners, including Federal, State and private land, NMED has established Memoranda of Understanding (MOUs) with various Federal agencies, in particular the Forest Service and the Bureau of Land Management. MOUs 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 NPS issues.

The time required to attain standards for all reaches is estimated to be approximately 10-20 years. This estimate is based on a five-year time frame implementing several watershed projects that may not be starting immediately or may be in response to earlier projects. Stakeholders in this process will include SWQB, and other members of the WRAS. The cooperation of watershed stakeholders will be pivotal in the implementation of these TMDLs as well.

11.0 PUBLIC PARTICIPATION

Public participation was solicited in development of this TMDL (see **Appendix I**). The draft TMDL was made available for a 30-day comment period October 12, 2005. Response to comments are attached as **Appendix J** 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.

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APPENDIX A

FECAL COLIFORM DATA

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Sample site	Collection date/time	Analytical suite	Result	Units
CARRIZO CREEK ABOVE THE RIO RUIDOSO	3/20/2003 8:30	Bacteria (fecal coliforms)	4	/100ml
CARRIZO CREEK ABOVE THE RIO RUIDOSO	4/23/2003 10:15	Bacteria (fecal coliforms)	7	/100ml
CARRIZO CREEK ABOVE THE RIO RUIDOSO	5/21/2003 8:50	Bacteria (fecal coliforms)	140	/100ml
CARRIZO CREEK ABOVE THE RIO RUIDOSO	6/25/2003 8:35	Bacteria (fecal coliforms)	40	/100ml
CARRIZO CREEK ABOVE THE RIO RUIDOSO	7/23/2003 8:30	Bacteria (fecal coliforms)	90	/100ml
CARRIZO CREEK ABOVE THE RIO RUIDOSO	8/20/2003 8:10	Bacteria (fecal coliforms)	210	/100ml
CARRIZO CREEK ABOVE THE RIO RUIDOSO	9/24/2003 8:35	Bacteria (fecal coliforms)	210	/100ml
CARRIZO CREEK ABOVE THE RIO RUIDOSO	10/23/2003 8:25	Bacteria (fecal coliforms)	20	/100ml
MEASURED LOAD =	**2.82E+09**	**Geometric Mean**	**210**	
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	3/20/2003 7:40	Bacteria (fecal coliforms)	1	/100ml
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	4/23/2003 10:10	Bacteria (fecal coliforms)	1	/100ml
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	5/21/2003 8:00	Bacteria (fecal coliforms)	5	/100ml
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	6/25/2003 7:45	Bacteria (fecal coliforms)	780	/100ml
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	7/9/2003 7:20	Bacteria (fecal coliforms)	890	/100ml
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	7/9/2003 7:30	Bacteria (fecal coliforms)	760	/100ml
	7/9/2003	**Average**	**825**	**/100ml**
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	7/23/2003 7:45	Bacteria (fecal coliforms)	65	/100ml
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	8/20/2003 7:20	Bacteria (fecal coliforms)	190	/100ml
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	9/24/2003 8:00	Bacteria (fecal coliforms)	200	/100ml
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	10/23/2003 7:35	Bacteria (fecal coliforms)	5	/100ml
RIO BONITO AT ANGUS BRIDGE	3/20/2003 7:55	Bacteria (fecal coliforms)	1	/100ml
RIO BONITO AT ANGUS BRIDGE	4/23/2003 9:30	Bacteria (fecal coliforms)	1	/100ml
RIO BONITO AT ANGUS BRIDGE	5/21/2003 8:15	Bacteria (fecal coliforms)	24	/100ml
RIO BONITO AT ANGUS BRIDGE	6/25/2003 8:00	Bacteria (fecal coliforms)	49	/100ml
MEASURED LOAD =	**1.95E+10**	**Geometric Mean**	**802**	
Rio Bonito at BLM Apple Orchard Site	3/20/2003 10:15	Bacteria (fecal coliforms)	16	/100ml
Rio Bonito at BLM Apple Orchard Site	4/23/2003 11:55	Bacteria (fecal coliforms)	14	/100ml
Rio Bonito at BLM Apple Orchard Site	5/21/2003 10:35	Bacteria (fecal coliforms)	53	/100ml
Rio Bonito at BLM Apple Orchard Site	6/25/2003 10:15	Bacteria (fecal coliforms)	200	/100ml
Rio Bonito at BLM Apple Orchard Site	6/25/2003 10:16	Bacteria (fecal coliforms)	210	/100ml
Rio Bonito at BLM Apple Orchard Site	7/23/2003 10:15	Bacteria (fecal coliforms)	290	/100ml
Rio Bonito at BLM Apple Orchard Site	8/20/2003 10:00	Bacteria (fecal coliforms)	100	/100ml
Rio Bonito at BLM Apple Orchard Site	9/24/2003 10:15	Bacteria (fecal coliforms)	35	/100ml
Rio Bonito at BLM Apple Orchard Site	10/23/2003 10:00	Bacteria (fecal coliforms)	14	/100ml
RIO HONDO 100 YDS BELOW CONFLUENCE	3/20/2003 9:20	Bacteria (fecal coliforms)	210	/100ml
RIO HONDO 100 YDS BELOW CONFLUENCE	4/23/2003 11:15	Bacteria (fecal coliforms)	72	/100ml
RIO HONDO 100 YDS BELOW CONFLUENCE	5/21/2003 9:45	Bacteria (fecal coliforms)	48	/100ml
RIO HONDO 100 YDS BELOW CONFLUENCE	6/25/2003 8:30	Bacteria (fecal coliforms)	250	/100ml
RIO HONDO 100 YDS BELOW CONFLUENCE	7/23/2003 9:30	Bacteria (fecal coliforms)	1100	/100ml
RIO HONDO 100 YDS BELOW CONFLUENCE	8/20/2003 9:10	Bacteria (fecal coliforms)	2400	/100ml
RIO HONDO 100 YDS BELOW CONFLUENCE	9/24/2003 9:45	Bacteria (fecal coliforms)	930	/100ml
RIO HONDO 100 YDS BELOW CONFLUENCE	10/23/2003 9:30	Bacteria (fecal coliforms)	660	/100ml
Rio Hondo below Riverside on Rio Hondo Land and Cattle property	3/20/2003 8:30	Bacteria (fecal coliforms)	120	/100ml
Rio Hondo below Riverside on Rio Hondo Land and Cattle property	4/23/2003 11:50	Bacteria (fecal coliforms)	290	/100ml
Rio Hondo below Riverside on Rio Hondo Land and Cattle property	5/21/2003 8:30	Bacteria (fecal coliforms)	230	/100ml
Rio Hondo below Riverside on Rio Hondo Land and Cattle property	7/23/2003 8:00	Bacteria (fecal coliforms)	1100	/100ml
Rio Hondo below Riverside on Rio Hondo Land and Cattle property	8/20/2003 8:00	Bacteria (fecal coliforms)	710	/100ml
MEASURED LOAD =	**3.42E+10**	**Geometric Mean**	**1040**	
Rio Ruidoso at Mescalero boundary at gauge	3/20/2003 8:15	Bacteria (fecal coliforms)	1	/100ml
Rio Ruidoso at Mescalero boundary at gauge	4/23/2003 10:00	Bacteria (fecal coliforms)	1	/100ml
Rio Ruidoso at Mescalero boundary at gauge	5/21/2003 8:40	Bacteria (fecal coliforms)	1	/100ml
Rio Ruidoso at Mescalero boundary at gauge	6/25/2003 8:20	Bacteria (fecal coliforms)	44	/100ml
Rio Ruidoso at Mescalero boundary at gauge	7/23/2003 8:20	Bacteria (fecal coliforms)	39	/100ml
Rio Ruidoso at Mescalero boundary at gauge	8/20/2003 7:55	Bacteria (fecal coliforms)	22	/100ml
Rio Ruidoso at Mescalero boundary at gauge	9/24/2003 7:15	Bacteria (fecal coliforms)	10	/100ml
Rio Ruidoso at Mescalero boundary at gauge	10/23/2003 8:10	Bacteria (fecal coliforms)	4	/100ml
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	9/24/2003 8:40	Bacteria (fecal coliforms)	86	/100ml
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	10/23/2003 8:35	Bacteria (fecal coliforms)	26	/100ml
Rio Ruidoso .5 mile above WWTP at HWY 70 bridge above seeping springs	3/20/2003 8:40	Bacteria (fecal coliforms)	10	/100ml
Rio Ruidoso .5 mile above WWTP at HWY 70 bridge above seeping springs	4/23/2003 10:45	Bacteria (fecal coliforms)	19	/100ml
Rio Ruidoso .5 mile above WWTP at HWY 70 bridge above seeping springs	5/21/2003 9:05	Bacteria (fecal coliforms)	54	/100ml
Rio Ruidoso .5 mile above WWTP at HWY 70 bridge above seeping springs	6/25/2003 8:50	Bacteria (fecal coliforms)	23	/100ml
Rio Ruidoso .5 mile above WWTP at HWY 70 bridge above seeping springs	7/23/2003 8:45	Bacteria (fecal coliforms)	59	/100ml
Rio Ruidoso .5 mile above WWTP at HWY 70 bridge above seeping springs	8/20/2003 8:25	Bacteria (fecal coliforms)	1100	/100ml

Sample site	Collection date/time	Analytical suite	Result	Units
Rio Ruidoso .5 mile above WWTP at HWY 70 bridge above seeping springs	9/2/2003 10:20	Bacteria (fecal coliforms)	120	/100ml
Rio Ruidoso .5 mile above WWTP at HWY 70 bridge above seeping springs	9/24/2003 8:50	Bacteria (fecal coliforms)	45	/100ml
Rio Ruidoso .5 mile above WWTP at HWY 70 bridge above seeping springs	10/23/2003 8:40	Bacteria (fecal coliforms)	67	/100ml
RIO RUIDOSO BELOW NEW WWTP	3/20/2003 8:45	Bacteria (fecal coliforms)	43	/100ml
RIO RUIDOSO BELOW NEW WWTP	4/23/2003 11:00	Bacteria (fecal coliforms)	29	/100ml
RIO RUIDOSO BELOW NEW WWTP	5/21/2003 9:10	Bacteria (fecal coliforms)	39	/100ml
RIO RUIDOSO BELOW NEW WWTP	6/25/2003 8:55	Bacteria (fecal coliforms)	200	/100ml
RIO RUIDOSO BELOW NEW WWTP	7/23/2003 8:55	Bacteria (fecal coliforms)	82	/100ml
RIO RUIDOSO BELOW NEW WWTP	8/20/2003 8:35	Bacteria (fecal coliforms)	270	/100ml
RIO RUIDOSO BELOW NEW WWTP	9/2/2003 11:00	Bacteria (fecal coliforms)	530	/100ml
RIO RUIDOSO BELOW NEW WWTP	9/24/2003 9:00	Bacteria (fecal coliforms)	57	/100ml
RIO RUIDOSO BELOW NEW WWTP	10/23/2003 8:55	Bacteria (fecal coliforms)	49	/100ml
RIO RUIDOSO 1 MI ABV RIO BONITO AT SAN PATRICIO	3/20/2003 9:05	Bacteria (fecal coliforms)	87	/100ml
RIO RUIDOSO 1 MI ABV RIO BONITO AT SAN PATRICIO	4/23/2003 11:25	Bacteria (fecal coliforms)	3	/100ml
RIO RUIDOSO 1 MI ABV RIO BONITO AT SAN PATRICIO	5/21/2003 9:30	Bacteria (fecal coliforms)	10	/100ml
RIO RUIDOSO 1 MI ABV RIO BONITO AT SAN PATRICIO	6/25/2003 9:20	Bacteria (fecal coliforms)	95	/100ml
RIO RUIDOSO 1 MI ABV RIO BONITO AT SAN PATRICIO	7/23/2003 9:15	Bacteria (fecal coliforms)	13	/100ml
RIO RUIDOSO 1 MI ABV RIO BONITO AT SAN PATRICIO	8/20/2003 9:00	Bacteria (fecal coliforms)	1200	/100ml
RIO RUIDOSO 1 MI ABV RIO BONITO AT SAN PATRICIO	9/24/2003 9:30	Bacteria (fecal coliforms)	48	/100ml
RIO RUIDOSO 1 MI ABV RIO BONITO AT SAN PATRICIO	10/23/2003 9:15	Bacteria (fecal coliforms)	16	/100ml
50M FROM DAM BETWEEN CENTER AND NORTHWEST SHORE	6/25/2003 9:30	Bacteria (fecal coliforms)	1	/100ml
GRINDSTONE CANYON RESERVOIR DAM	6/25/2003 13:00	Bacteria (fecal coliforms)	1	/100ml
CITY OF RUIDOSO NEW WWTP OUTFALL PIPE	8/20/2003 8:30	Bacteria (fecal coliforms)	36	/100ml
CITY OF RUIDOSO NEW WWTP OUTFALL PIPE	9/2/2003 10:45	Bacteria (fecal coliforms)	570	/100ml
CITY OF RUIDOSO NEW WWTP OUTFALL PIPE	9/24/2003 8:55	Bacteria (fecal coliforms)	30	/100ml
CITY OF RUIDOSO NEW WWTP OUTFALL PIPE	10/23/2003 8:45	Bacteria (fecal coliforms)	34	/100ml

NOTE: HIGLIGHTED samples are above the NM State fecal coliform criteria for that assessment unit.

APPENDIX B

4Q3 LOW-FLOW

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It is often necessary to calculate a critical flow for a portion of a watershed where there is no stage gage. This can be accomplished by applying one of two formulas developed by the USGS. One formula (Thomas, 1993) is recommended when the ratio between the two watershed areas is between 0.5 and 1.5. The other formula, to be used when the watershed ratio is outside this range, is a regression formula also developed by the USGS (Borland, 1970).

1. 4Q3 flow at USGS Streamflow Gage 08387000 (Rio Ruidoso at Hollywood, NM) in cubic feet per second

a) ***Annual*** 4Q3 Flow Using Log-Pearson Type III Statistics (SWSTAT 4.1)

(based on USGS Program A193)

April 1 - start of season
March 31 - end of season
1955 - 2005 - time period
4-day low - parameter

0.725	1.175	1.150	1.100	1.750	0.775	1.000	1.400	2.775
1.225	0.550	3.800	3.275	1.155	4.950	3.325	1.750	1.400
3.950	3.800	2.450	5.775	6.375	6.075	8.300	7.625	6.150
5.975	2.850	6.825	8.350	5.775	9.600	8.575	11.000	7.100
7.725	10.500	7.450	8.850	1.950	6.850	5.400	10.000	7.725
4.825	5.275	4.525	2.675	3.425	3.550			

The following 7 statistics are based on non-zero values:

Mean (logs)	0.558
Variance (logs)	0.125
Standard Deviation (logs)	0.354
Skewness (logs)	-0.623
Standard Error of Skewness (logs)	0.333
Serial Correlation Coefficient (logs)	0.687
Coefficient of Variation (logs)	0.634

Non-exceedance Probability	Recurrence Interval	Parameter Value
0.0100	100.00	0.378
0.0200	50.00	0.524
0.0500	20.00	0.833
0.1000	10.00	1.224
0.2000	5.00	1.888
0.3333	3.00	**2.731**
0.5000	2.00	3.931
0.8000	1.25	7.262
0.9000	1.11	9.573
0.9600	1.04	12.450
0.9800	1.02	14.510
0.9900	1.01	16.476

4Q3 Low-Flow

2. 4Q3 flow at UNGAGED locations

a) The nearest gage to the points of interest is the Rio Ruidoso at Hollywood, NM (USGS Gage 08387000). The drainage area above this gage (A_g) is 120 mi^2. Using the guidelines recommended by the USGS, when the ratio between the ungaged and gaged watersheds is outside the 0.5-1.5 range we apply **Equation 1**. (*Latitude and longitude of the point of interest were input into GIS Weasel to determine the basin and climatic characteristics necessary for these computations.*)

Equation 1

$$7Q2_{(u)} = 1.36\times10^{-4} * (A_u)^{0.566} * (P_a)^{3.32}$$ **(Reference: USGS, 1970)**

Where:

$7Q2_{(u)}$ = weighted 7Q2 flow estimate at ungaged site, in cubic feet per second (cfs)
A_u = drainage area above the ungaged site, in square miles
P_a = mean precipitation (October through April), in inches

b) Using the ratio between 4Q3 and 7Q2 at the gaged site and applying **Equation 2**, the annual 4Q3 flow at the ungaged site can be calculated.

Equation 2

$$4Q3_{(u)} = 7Q2_{(u)} * (4Q3_{(g)}/7Q2_{(g)})$$ **(Reference: USGS, 1970)**

Where:

$4Q3_{(u)}$ = weighted annual 4Q3 flow estimate at ungaged site, in cfs
$7Q2_{(u)}$ = calculated annual 7Q2 flow at ungaged site (from **Equation 1**), in cfs
$4Q3_{(g)}$ = Log-Pearson Type III annual 4Q3 flow at gaged site, in cfs
$7Q2_{(g)}$ = Log-Pearson Type III annual 7Q2 flow at gaged site, in cfs

parameter	Ruidoso @ Hollywood (gage location)	Upper Bonito (ungaged portion)	Carrizo (ungaged portion)	Rio Hondo (ungaged portion)
Ag	120.00	-	-	-
Au	-	45.96	24.62	878.41
Au/Ag	**-**	**0.38**	**0.21**	**7.32**
P*annual*	22.22	25.00	22.70	18.10
P*winter*	7.61	8.60	8.00	5.70
7Q2 (cfs)	**4.147**	1.503	0.830	2.038
4Q3(g)/7Q2(g)	**0.659**	-	-	-
4Q3 (cfs)	**2.731**	**0.990**	**0.547**	**1.342**
4Q3 (mgd)	**1.765**	**0.640**	**0.353**	**0.867**

APPENDIX C
POLLUTANT SOURCE(S) DOCUMENTATION PROTOCOL

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This protocol was designed to support federal regulations and guidance requiring states to document and include probable source(s) of pollutant(s) in their §303(d) Lists as well as the States §305(b) Report to Congress.

The following procedure should be used when sampling crews are in the field conducting water quality surveys or at any other time field staff are collecting data.

Pollutant Source Documentation Steps:

1). Obtain a copy of the most current §303(d) List.

2). Obtain copies of the ***Field Sheet for Assessing Designated Uses and Nonpoint Sources of Pollution***.

3). Obtain 35mm camera that has time/date photo stamp on it. **DO NOT USE A DIGITAL CAMERA FOR THIS PHOTODOCUMENTATION**

4). Identify the reach(s) and probable source(s) of pollutant in the §303(d) List associated with the project that you will be working on.

5). Verify if current source(s) listed in the §303(d) List are accurate.

6). Check the appropriate box(s) on the field sheet for source(s) of nonsupport and estimate percent contribution of each source.

7). Photodocument probable source(s) of pollutant.

8). Create a folder for the TMDL files, insert field sheet and photodocumentation into the file.

This information will be used to update §303(d) Lists and the States §305(b) Report to Congress.

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FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

:ODES FOR USES NOT FULLY SUPPORTED

☐	HQCWF =	HIGH QUALITY COLDWATER FISHERY	☐	DWS	=	DOMESTIC WATER SUPPLY
☐	CWF =	COLDWATER FISHERY	☐	PC	=	PRIMARY CONTACT
☐	MCWF =	MARGINAL COLDWATER FISHERY	☐	IRR	=	IRRIGATION
☐	WWF =	WARMWATER FISHERY	☐	LW	=	LIVESTOCK WATERING
☐	LWWF =	LIMITED WARMWATER FISHERY	☐	WH	=	WILDLIFE HABITAT

'ish culture, secondary contact and municipal and industrial water supply and storage are also designated in particular stream reaches where these ises are actually being realized. However, no numeric standards apply uniquely to these uses.

REACH NAME: Carrizo Creek (Rio Ruidoso to headwaters)
SEGMENT NUMBER:
BASIN: Rio Hondo
PARAMETER:

STAFF MAKING ASSESSMENT: Eib
DATE: 08/05

:ODES FOR SOURCES OF NONSUPPORT (CHECK ALL THAT APPLY)

☐ 0100 INDUSTRIAL POINT SOURCES

☐ 0200 MUNICIPAL POINT SOURCES
☐ 0201 DOMESTIC POINT SOURCES

☐ 0400 COMBINED SEWER OVERFLOWS

☐ 1000 AGRICULTURE
☐ 1100 NONIRRIGATED CROP PRODUCTION
☐ 1200 IRRIGATED CROP PRODUCTION
☐ 1201 IRRIGATED RETURN FLOWS
☐ 1300 SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
☐ 1400 PASTURELAND
☐ 1500 RANGELAND
☐ 1600 FEEDLOTS - ALL TYPES
☐ 1700 AQUACULTURE
☐ 1800 ANIMAL HOLDING/MANAGEMENT AREAS
☐ 1900 MANURE LAGOONS

☐ 2000 SILVICULTURE
☐ 2100 HARVESTING, RESTORATION, RESIDUE MANAGEMENT
☐ 2200 FOREST MANAGEMENT
☐ 2300 ROAD CONSTRUCTION or MAINTENANCE

☐ 3000 CONSTRUCTION
☐ 3100 HIGHWAY/ROAD/BRIDGE
☐ 3200 LAND DEVELOPMENT
☒ 3201 RESORT DEVELOPMENT
☐ 3300 HYDROELECTRIC

☒ 4000 URBAN RUNOFF/STORM SEWERS

☐ 5000 RESOURCES EXTRACTION
☐ 5100 SURFACE MINING
☐ 5200 SUBSURFACE MINING
☐ 5300 PLACER MINING
☐ 5400 DREDGE MINING
☐ 5500 PETROLEUM ACTIVITIES
☐ 5501 PIPELINES
☐ 5600 MILL TAILINGS
☐ 5700 MINE TAILINGS
☐ 5800 ROAD CONSTRUCTION/MAINTENANCE
☐ 5900 SPILLS

☐ 6000 LAND DISPOSAL
☐ 6100 SLUDGE
☐ 6200 WASTEWATER
☐ 6300 LANDFILLS
☐ 6400 INDUSTRIAL LAND TREATMENT
☐ 6500 ONSITE WASTEWATER SYSTEMS (septic tanks, etc.)
☐ 6600 HAZARDOUS WASTE
☐ 6700 SEPTAGE DISPOSAL
☐ 6800 UST LEAKS

☐ 7000 HYDROMODIFICATION
☒ 7100 CHANNELIZATION
☐ 7200 DREDGING
☒ 7300 DAM CONSTRUCTION/REPAIR
☒ 7400 FLOW REGULATION/MODIFICATION
☐ 7500 BRIDGE CONSTRUCTION
☒ 7600 REMOVAL OF RIPARIAN VEGETATION
☐ 7700 STREAMBANK MODIFICATION OI DESTABILIZATION
☐ 7800 DRAINING/FILLING OF WETLANDS

☐ 8000 OTHER
☐ 8010 VECTOR CONTROL ACTIVITIES
☐ 8100 ATMOSPHERIC DEPOSITION
☐ 8200 WASTE STORAGE/STORAGE TANK LEAKS
☐ 8300 ROAD MAINTENANCE or RUNOFF
☐ 8400 SPILLS
☐ 8500 IN-PLACE CONTAMINANTS
☐ 8600 NATURAL
☒ 8700 RECREATIONAL ACTIVITIES
☒ 8701 ROAD/PARKING LOT RUNOFF
☐ 8702 OFF-ROAD VEHICLES
☐ 8703 REFUSE DISPOSAL
☐ 8704 WILDLIFE IMPACTS
☐ 8705 SKI SLOPE RUNOFF
☒ 8800 UPSTREAM IMPOUNDMENT
☐ 8900 SALT STORAGE SITES

☐ 9000 SOURCE UNKNOWN

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

:ODES FOR USES NOT FULLY SUPPORTED

☐	HQCWF =	HIGH QUALITY COLDWATER FISHERY	☐	DWS	=	DOMESTIC WATER SUPPLY
☐	CWF =	COLDWATER FISHERY	☐	PC	=	PRIMARY CONTACT
☐	MCWF =	MARGINAL COLDWATER FISHERY	☐	IRR	=	IRRIGATION
☐	WWF =	WARMWATER FISHERY	☐	LW	=	LIVESTOCK WATERING
☐	LWWF =	LIMITED WARMWATER FISHERY	☐	WH	=	WILDLIFE HABITAT

'ish culture, secondary contact and municipal and industrial water supply and storage are also designated in particular stream reaches where these ıses are actually being realized. However, no numeric standards apply uniquely to these uses.

REACH NAME: Rio Bonito (Rio Ruidoso to NM 48 near Angus)
SEGMENT NUMBER:
BASIN:
PARAMETER:

STAFF MAKING ASSESSMENT: Eib
DATE: 08/05

:ODES FOR SOURCES OF NONSUPPORT (CHECK ALL THAT APPLY)

☐	0100	INDUSTRIAL POINT SOURCES
☐	0200	MUNICIPAL POINT SOURCES
☐	0201	DOMESTIC POINT SOURCES
☐	0400	COMBINED SEWER OVERFLOWS
☐	1000	AGRICULTURE
☐	1100	NONIRRIGATED CROP PRODUCTION
☒	1200	IRRIGATED CROP PRODUCTION
☐	1201	IRRIGATED RETURN FLOWS
☐	1300	SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
☒	1400	PASTURELAND
☒	1500	RANGELAND
☐	1600	FEEDLOTS - ALL TYPES
☐	1700	AQUACULTURE
☒	1800	ANIMAL HOLDING/MANAGEMENT AREAS
☐	1900	MANURE LAGOONS
☐	2000	SILVICULTURE
☐	2100	HARVESTING, RESTORATION, RESIDUE MANAGEMENT
☐	2200	FOREST MANAGEMENT
☐	2300	ROAD CONSTRUCTION or MAINTENANCE
☐	3000	CONSTRUCTION
☐	3100	HIGHWAY/ROAD/BRIDGE
☐	3200	LAND DEVELOPMENT
☐	3201	RESORT DEVELOPMENT
☐	3300	HYDROELECTRIC
☐	4000	URBAN RUNOFF/STORM SEWERS
☐	5000	RESOURCES EXTRACTION
☐	5100	SURFACE MINING
☐	5200	SUBSURFACE MINING
☐	5300	PLACER MINING
☐	5400	DREDGE MINING
☐	5500	PETROLEUM ACTIVITIES
☐	5501	PIPELINES
☐	5600	MILL TAILINGS
☐	5700	MINE TAILINGS
☐	5800	ROAD CONSTRUCTION/MAINTENANCE
☐	5900	SPILLS
☐	6000	LAND DISPOSAL
☐	6100	SLUDGE
☐	6200	WASTEWATER
☐	6300	LANDFILLS
☐	6400	INDUSTRIAL LAND TREATMENT
☐	6500	ONSITE WASTEWATER SYSTEMS (septic tanks, etc.)
☐	6600	HAZARDOUS WASTE
☐	6700	SEPTAGE DISPOSAL
☐	6800	UST LEAKS
☐	7000	HYDROMODIFICATION
☐	7100	CHANNELIZATION
☐	7200	DREDGING
☐	7300	DAM CONSTRUCTION/REPAIR
☒	7400	FLOW REGULATION/MODIFICATION
☐	7500	BRIDGE CONSTRUCTION
☒	7600	REMOVAL OF RIPARIAN VEGETATION
☐	7700	STREAMBANK MODIFICATION OI DESTABILIZATION
☐	7800	DRAINING/FILLING OF WETLANDS
☐	8000	OTHER
☐	8010	VECTOR CONTROL ACTIVITIES
☐	8100	ATMOSPHERIC DEPOSITION
☐	8200	WASTE STORAGE/STORAGE TANK LEAKS
☐	8300	ROAD MAINTENANCE or RUNOFF
☐	8400	SPILLS
☐	8500	IN-PLACE CONTAMINANTS
☐	8600	NATURAL
☐	8700	RECREATIONAL ACTIVITIES
☐	8701	ROAD/PARKING LOT RUNOFF
☐	8702	OFF-ROAD VEHICLES
☐	8703	REFUSE DISPOSAL
☐	8704	WILDLIFE IMPACTS
☐	8705	SKI SLOPE RUNOFF
☒	8800	UPSTREAM IMPOUNDMENT
☐	8900	SALT STORAGE SITES
☐	9000	SOURCE UNKNOWN

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

REACH NAME: Rio Bonito (NM 48 near Angus to headwaters)

SEGMENT NUMBER:
BASIN: Rio Hondo
PARAMETER:

STAFF MAKING ASSESSMENT: Eib
DATE: 08/05

:ODES FOR USES NOT FULLY SUPPORTED

☐	HQCWF	=	HIGH QUALITY COLDWATER FISHERY	☐	DWS	=	DOMESTIC WATER SUPPLY
☐	CWF	=	COLDWATER FISHERY	☐	PC	=	PRIMARY CONTACT
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☐	LWWF	=	LIMITED WARMWATER FISHERY	☐	WH	=	WILDLIFE HABITAT

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☐	0400	COMBINED SEWER OVERFLOWS
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☐	1201	IRRIGATED RETURN FLOWS
☐	1300	SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
☐	1400	PASTURELAND
☐	1500	RANGELAND
☐	1600	FEEDLOTS - ALL TYPES
☐	1700	AQUACULTURE
☒	1800	ANIMAL HOLDING/MANAGEMENT AREAS
☐	1900	MANURE LAGOONS
☐	2000	SILVICULTURE
☐	2100	HARVESTING, RESTORATION, RESIDUE MANAGEMENT
☐	2200	FOREST MANAGEMENT
☐	2300	ROAD CONSTRUCTION or MAINTENANCE
☐	3000	CONSTRUCTION
☐	3100	HIGHWAY/ROAD/BRIDGE
☐	3200	LAND DEVELOPMENT
☐	3201	RESORT DEVELOPMENT
☐	3300	HYDROELECTRIC
☐	4000	URBAN RUNOFF/STORM SEWERS
☐	5000	RESOURCES EXTRACTION
☐	5100	SURFACE MINING
☐	5200	SUBSURFACE MINING
☐	5300	PLACER MINING
☐	5400	DREDGE MINING
☐	5500	PETROLEUM ACTIVITIES
☐	5501	PIPELINES
☐	5600	MILL TAILINGS
☒	5700	MINE TAILINGS
☐	5800	ROAD CONSTRUCTION/MAINTENANCE
☐	5900	SPILLS
☐	6000	LAND DISPOSAL
☐	6100	SLUDGE
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☐	8010	VECTOR CONTROL ACTIVITIES
☐	8100	ATMOSPHERIC DEPOSITION
☐	8200	WASTE STORAGE/STORAGE TANK LEAKS
☒	8300	ROAD MAINTENANCE or RUNOFF
☐	8400	SPILLS
☐	8500	IN-PLACE CONTAMINANTS
☐	8600	NATURAL
☒	8700	RECREATIONAL ACTIVITIES
☒	8701	ROAD/PARKING LOT RUNOFF
☐	8702	OFF-ROAD VEHICLES
☐	8703	REFUSE DISPOSAL
☐	8704	WILDLIFE IMPACTS
☐	8705	SKI SLOPE RUNOFF
☒	8800	UPSTREAM IMPOUNDMENT
☐	8900	SALT STORAGE SITES
☐	9000	SOURCE UNKNOWN

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

REACH NAME: Rio Hondo (Pecos R to Rio Ruidoso)

SEGMENT NUMBER:
BASIN: Rio Hondo
PARAMETER:

STAFF MAKING ASSESSMENT: Eib
DATE: 08/05

CODES FOR USES NOT FULLY SUPPORTED

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☐	CWF	=	COLDWATER FISHERY
☐	MCWF	=	MARGINAL COLDWATER FISHERY
☐	WWF	=	WARMWATER FISHERY
☐	LWWF	=	LIMITED WARMWATER FISHERY
☐	DWS	=	DOMESTIC WATER SUPPLY
☐	PC	=	PRIMARY CONTACT
☐	IRR	=	IRRIGATION
☐	LW	=	LIVESTOCK WATERING
☐	WH	=	WILDLIFE HABITAT

Fish culture, secondary contact and municipal and industrial water supply and storage are also designated in particular stream reaches where these uses are actually being realized. However, no numeric standards apply uniquely to these uses.

CODES FOR SOURCES OF NONSUPPORT (CHECK ALL THAT APPLY)

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☐	0400	COMBINED SEWER OVERFLOWS
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☒	1201	IRRIGATED RETURN FLOWS
☐	1300	SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
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☒	1500	RANGELAND
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☐	1700	AQUACULTURE
☒	1800	ANIMAL HOLDING/MANAGEMENT AREAS
☐	1900	MANURE LAGOONS
☐	2000	SILVICULTURE
☐	2100	HARVESTING, RESTORATION, RESIDUE MANAGEMENT
☐	2200	FOREST MANAGEMENT
☐	2300	ROAD CONSTRUCTION or MAINTENANCE
☐	3000	CONSTRUCTION
☒	3100	HIGHWAY/ROAD/BRIDGE
☐	3200	LAND DEVELOPMENT
☐	3201	RESORT DEVELOPMENT
☐	3300	HYDROELECTRIC
☐	4000	URBAN RUNOFF/STORM SEWERS
☐	5000	RESOURCES EXTRACTION
☐	5100	SURFACE MINING
☐	5200	SUBSURFACE MINING
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☐	5400	DREDGE MINING
☐	5500	PETROLEUM ACTIVITIES
☐	5501	PIPELINES
☐	5600	MILL TAILINGS
☐	5700	MINE TAILINGS
☐	5800	ROAD CONSTRUCTION/MAINTENANCE
☐	5900	SPILLS
☐	6000	LAND DISPOSAL
☐	6100	SLUDGE
☐	6200	WASTEWATER
☐	6300	LANDFILLS
☐	6400	INDUSTRIAL LAND TREATMENT
☐	6500	ONSITE WASTEWATER SYSTEMS (septic tanks, etc.)
☐	6600	HAZARDOUS WASTE
☐	6700	SEPTAGE DISPOSAL
☐	6800	UST LEAKS
☐	7000	HYDROMODIFICATION
☐	7100	CHANNELIZATION
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☐	7300	DAM CONSTRUCTION/REPAIR
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☐	8705	SKI SLOPE RUNOFF
☒	8800	UPSTREAM IMPOUNDMENT
☐	8900	SALT STORAGE SITES
☐	9000	SOURCE UNKNOWN

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

REACH NAME: Rio Ruidoso (Rio Bonito to US Hwy 70)

SEGMENT NUMBER:
BASIN: Rio Hondo
PARAMETER:

STAFF MAKING ASSESSMENT: Eib
DATE: 08/05

CODES FOR USES NOT FULLY SUPPORTED

☐	HQCWF	=	HIGH QUALITY COLDWATER FISHERY	☐	DWS	=	DOMESTIC WATER SUPPLY
☐	CWF	=	COLDWATER FISHERY	☐	PC	=	PRIMARY CONTACT
☐	MCWF	=	MARGINAL COLDWATER FISHERY	☐	IRR	=	IRRIGATION
☐	WWF	=	WARMWATER FISHERY	☐	LW	=	LIVESTOCK WATERING
☐	LWWF	=	LIMITED WARMWATER FISHERY	☐	WH	=	WILDLIFE HABITAT

Fish culture, secondary contact and municipal and industrial water supply and storage are also designated in particular stream reaches where these uses are actually being realized. However, no numeric standards apply uniquely to these uses.

CODES FOR SOURCES OF NONSUPPORT (CHECK ALL THAT APPLY)

- ☐ 0100 INDUSTRIAL POINT SOURCES
- ☐ 0200 MUNICIPAL POINT SOURCES
- ☐ 0201 DOMESTIC POINT SOURCES
- ☐ 0400 COMBINED SEWER OVERFLOWS
- ☒ 1000 AGRICULTURE
- ☐ 1100 NONIRRIGATED CROP PRODUCTION
- ☒ 1200 IRRIGATED CROP PRODUCTION
- ☒ 1201 IRRIGATED RETURN FLOWS
- ☐ 1300 SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
- ☒ 1400 PASTURELAND
- ☒ 1500 RANGELAND
- ☐ 1600 FEEDLOTS - ALL TYPES
- ☐ 1700 AQUACULTURE
- ☒ 1800 ANIMAL HOLDING/MANAGEMENT AREAS
- ☐ 1900 MANURE LAGOONS
- ☐ 2000 SILVICULTURE
- ☐ 2100 HARVESTING, RESTORATION, RESIDUE MANAGEMENT
- ☐ 2200 FOREST MANAGEMENT
- ☐ 2300 ROAD CONSTRUCTION or MAINTENANCE
- ☐ 3000 CONSTRUCTION
- ☒ 3100 HIGHWAY/ROAD/BRIDGE
- ☒ 3200 LAND DEVELOPMENT
- ☐ 3201 RESORT DEVELOPMENT
- ☐ 3300 HYDROELECTRIC

- ☐ 4000 URBAN RUNOFF/STORM SEWERS
- ☐ 5000 RESOURCES EXTRACTION
- ☐ 5100 SURFACE MINING
- ☐ 5200 SUBSURFACE MINING
- ☐ 5300 PLACER MINING
- ☐ 5400 DREDGE MINING
- ☐ 5500 PETROLEUM ACTIVITIES
- ☐ 5501 PIPELINES
- ☐ 5600 MILL TAILINGS
- ☐ 5700 MINE TAILINGS
- ☐ 5800 ROAD CONSTRUCTION/MAINTENANCE
- ☐ 5900 SPILLS
- ☐ 6000 LAND DISPOSAL
- ☐ 6100 SLUDGE
- ☒ 6200 WASTEWATER
- ☐ 6300 LANDFILLS
- ☐ 6400 INDUSTRIAL LAND TREATMENT
- ☒ 6500 ONSITE WASTEWATER SYSTEMS (septic tanks, etc.)
- ☐ 6600 HAZARDOUS WASTE
- ☐ 6700 SEPTAGE DISPOSAL
- ☐ 6800 UST LEAKS
- ☐ 7000 HYDROMODIFICATION
- ☒ 7100 CHANNELIZATION
- ☐ 7200 DREDGING
- ☐ 7300 DAM CONSTRUCTION/REPAIR

- ☐ 7400 FLOW REGULATION/MODIFICATION
- ☐ 7500 BRIDGE CONSTRUCTION
- ☐ 7600 REMOVAL OF RIPARIAN VEGETATION
- ☐ 7700 STREAMBANK MODIFICATION OR DESTABILIZATION
- ☐ 7800 DRAINING/FILLING OF WETLANDS
- ☐ 8000 OTHER
- ☐ 8010 VECTOR CONTROL ACTIVITIES
- ☐ 8100 ATMOSPHERIC DEPOSITION
- ☐ 8200 WASTE STORAGE/STORAGE TANK LEAKS
- ☐ 8300 ROAD MAINTENANCE or RUNOFF
- ☐ 8400 SPILLS
- ☐ 8500 IN-PLACE CONTAMINANTS
- ☐ 8600 NATURAL
- ☒ 8700 RECREATIONAL ACTIVITIES
- ☒ 8701 ROAD/PARKING LOT RUNOFF
- ☐ 8702 OFF-ROAD VEHICLES
- ☐ 8703 REFUSE DISPOSAL
- ☐ 8704 WILDLIFE IMPACTS
- ☐ 8705 SKI SLOPE RUNOFF
- ☐ 8800 UPSTREAM IMPOUNDMENT
- ☐ 8900 SALT STORAGE SITES
- ☐ 9000 SOURCE UNKNOWN

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

REACH NAME: Rio Ruidoso (US Hwy 70 to Mescalero Apache bnd)
SEGMENT NUMBER:
BASIN: Rio Hondo
PARAMETER:
STAFF MAKING ASSESSMENT: Eib
DATE: 08/05

:ODES FOR USES NOT FULLY SUPPORTED

☐	HQCWF	=	HIGH QUALITY COLDWATER FISHERY	☐	DWS	=	DOMESTIC WATER SUPPLY
☐	CWF	=	COLDWATER FISHERY	☐	PC	=	PRIMARY CONTACT
☐	MCWF	=	MARGINAL COLDWATER FISHERY	☐	IRR	=	IRRIGATION
☐	WWF	=	WARMWATER FISHERY	☐	LW	=	LIVESTOCK WATERING
☐	LWWF	=	LIMITED WARMWATER FISHERY	☐	WH	=	WILDLIFE HABITAT

'ish culture, secondary contact and municipal and industrial water supply and storage are also designated in particular stream reaches where these ıses are actually being realized. However, no numeric standards apply uniquely to these uses.

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- ☐ 1300 SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
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- ☐ 1900 MANURE LAGOONS
- ☐ 2000 SILVICULTURE
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- ☐ 5400 DREDGE MINING
- ☐ 5500 PETROLEUM ACTIVITIES
- ☐ 5501 PIPELINES
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- ☐ 8900 SALT STORAGE SITES
- ☐ 9000 SOURCE UNKNOWN

APPENDIX D

ALGAL GROWTH POTENIAL ASSAY (AGP)

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Algal Growth Potential (AGP) Assays

on

Water from the Rio Ruidoso

to

State Of New Mexico
Environment Department
1190 St. Francis Drive
P.O. Box 26110
Santa Fe, New Mexico 87502

submitted to

Julie Tsatsaros

August 7, 2002

by

Larry L. Barton and Gordon V. Johnson

Department of Biology, University of New Mexico
Albuquerque, NM 87131
Tel: 505-2772537
Fax: 505-277-4078
Email: lbarton@unm.edu

Background:

The water was collected on 5-20-02 and transported on ice to our laboratory. Water from each site was autoclaved and filtered, and used immediately. The initial tests for growth potential were initiated two days later and were terminated after 7 days of incubation under continuous illumination.

The procedures used for determining limiting nutrients and toxicity to algae was as established in the EPA-600/9-78-018 publication entitled "The *Selenastrum Capricornutum* Prinz Algal Assay Bottle Test" and EPA-660/3-75-034 publication entitled "Proceedings: Biostimulation/and/ Nutrient Assessment Workshop" The design is as follows:

Water from the creeks/rivers was autoclaved and passed through filters which had a pore diameter of 0.4 micrometers. The filtered water, 25 ml, was placed in 125 ml Erlenmeyer flasks which were cotton plugged. Each assay was conducted in triplicate.

The design of the test for algal growth potential are as listed below:

1. Control (filtered river water with no additions)
2. Control + 0.05 mg P/liter
3. Control + 1.00 mg N/liter
4. Control + 1.00 mg N + 0.05 mg P /liter
5. Control + 1.00 mg Na_2 EDTA/liter
6. Control + 1.00 mg Na_2 EDTA + 0.05 mg P/liter
7. Control + 1.00 mg Na_2 EDTA + 1.00 mg N/liter
8. Control + 1.00 mg Na_2 EDTA + 1.00 mg N + 0.05 mg P/liter
9. Control + 1.00 mg Na_2 EDTA + 1.00 mg N + 0.05 mg P + 4.5 μg Fe/liter

At the end of 7 days of incubation, the amount of chlorophyll was determined using fluoresence measurements. The fluorescence values were converted to dry weight values using a standard that we had constructed under these conditions of growth. The results are given in dry weight measurements as is accordance with the EPA procedure.

The water samples were designated as follows:

Designation	Site of collection
I	Rio Ruidoso @ Mescalero Boundary west of Ruidoso - upper canyon Road
II	Rio Ruidoso @ NM 267 ½ HWY 70
III	Rio Ruidoso above site on Susan Lattimer's property

Results:

The values for algal growth potential are given below as mg dry weight of algae/L.

Algal assays	Sites of water collection I	II	III
1. Control (filtered river water with no additions)	0.108	0.695	0.086
2. Control + 0.05 mg P/liter	0.157	1.061	0.077
3. Control + 1.00 mg N/liter	0.528	1.856	0.274
4. Control + 1.00 mg N + 0.05 mg P /liter	0.742	1.268	0.421
5. Control + 1.00 mg Na_2 EDTA/liter	0.125	0.757	0.096
6. Control + 1.00 mg Na_2 EDTA + 0.05 mg P/liter	0.102	0.787	0.045
7. Control + 1.00 mg Na_2 EDTA + 1.00 mg N/liter	0.497	1.783	0.212
8. Control + 1.00 mg Na_2 EDTA + 1.00 mg N + 0.05 mg P/liter	0.718	1.380	0.421
9. Control + 1.00 mg Na_2 EDTA + 1.00 mg N + 0.05 mg P + 4.5 µg Fe/liter	0.853	1.554	0.779

A study concerning the effect of N and P additions on algal growth was conducted on appropriate creek/river waters. The growth values are presented below and as graphs for various additions of P and N alone.

Nutrients were added to the sterilized water and the amount of algal mass was determined after 7 days of incubation.

Productivity of algae as influenced by Nitrogen addition. Growth as mg dry weight/L.

Nitrogen added (Mg N/L)	Sites of water collection I	II	III
0	0.108	0.695	0.085
0.25	0.356	1.043	0.211
0.5	0.485	1.339	0.225
0.75	0.628	1.493	0.268
1.0	0.528	1.857	0.274
2.0	0.656	1.736	0.309

Productivity of algae as influenced by Phosphorus addition. Growth as mg dry weight/L.

Phosphorus added (Mg N/L)	Sites of water collection I	II	III
0	0.108	0.695	0.085
0.01	0.129	0.736	0.049
0.025	0.094	0.797	0.043
0.0375	0.092	0.849	0.053
0.05	0.157	1.061	0.262
.1	0.090	0.791	0.049

NOTE: Graphs of the N and P additions are in the attachment entitled graphs.

The following summary statements can be made concerning the individual waters:

Rio Ruidoso @ Mescalero Boundary west of Ruidoso - upper canyon Road

Site I has low algal productivity. Growth is increased by addition of nitrogen indicating that nitrogen is the primary limiting nutrient. When both nitrogen and phosphorus are added, a small increase in productivity occurs.

Rio Ruidoso @ NM 267 ½ HWY 70

Site II has a high level of algal productivity without nutrient additions. Growth was increased by nitrogen addition indicating that nitrogen is the limiting nutrient. The high phosphorous availability results in large increases in algal growth when the nitrogen levels are increased. Management procedures should not increase the amount of nitrogen entering the water at this site and if possible, the inputs of both phosphorus and nitrogen should be decreased.

Rio Ruidoso above site on Susan Lattimer's property

Site III has low algal productivity. Growth is increased by the addition of nitrogen and this indicates that nitrogen is the primary limiting nutrient. With added nitrogen, an increase in productivity occurs with additions of phosphorus. With addition of both nitrogen and phosphorus, a further increase in productivity occurs when iron is added.

Addition of the metal chelating agent, EDTA, to water from Sites I, II, and III did not increase algal productivity indicating that no toxic metals were inhibiting algal growth.

Comparison of Algal Growth Bioassay to Chemical Analysis of Water Samples

Results of the algal growth responses to nutrient additions are in agreement with the chemical analysis of water samples provided by the NM Environment Department. Sites I and II had very low algal growth potential without addition of nitrogen or phosphorus to the water samples as suggested by the very low dissolved nitrogen and total phosphorus present in the water samples. Nitrogen was the limiting nutrient for algal growth at both Site I and from Site II.

Chemical analysis of water samples from Site II showed nearly 10X as much dissolved nitrogen and nearly 20X as much total phosphorus as samples from Sites I and III. Without nutrient addition, algal growth was 7X greater in samples from Site II than from Sites I and III. Addition of nitrogen to samples from Site II resulted in further increases in algal growth; indicating that nitrogen is the limiting nutrient at Site II.

Aquatic plants identified from Rio Ruidoso

Site II	*Clasospora*, a green alga, was present. This organism is common throughout the state. It will grow as a dense mat in the water.
Site III	*Potamogeton foliosus* was present. This plant is commonly found in many of the water ways thorough out New Mexico.

Productivity

The basis for productivity classification of river water using standards established for lakes using the laboratory assay technique to assess biomass. (Reference: EPA-600/9-78-018 publication entitled "The *Selenastrum Capricornutum* Prinz Algal Assay Bottle Test" and EPA-660/3-75-034 publication entitled "Proceedings: Biostimulation/and/ Nutrient Assessment Workshop")

Classification	Algal cell density (algal dry weight)
Low productivity	0.00 - 0.10 mg/L
Moderate productivity	0.11 - 0.80 mg/L
Moderately high productivity	0.81 - 6.00 mg/L
High Productivity	6.10 - 20.00 mg/L

1. Status of water in Rio Ruidoso water at the three sites equivalent.

Site I (@ Mescalero Boundary)	Site II (Below the WWTP @ MM 267 ½)	Site III (@ Susan Lattimer's property)
Low productivity	Moderate productivity	Low productivity

2. Effect of N addition to the sites:

Site I (Mescalero boundary): Addition of 0.25 mg/L and 0.5 mg/L result in moving the trophic status up to the lower portion of the MODERATE level. The addition of 0.75mg/L and higher levels result in raising the productivity to the MODERATE level.

Site II (Below the WWTP): The addition of 0.25 mg N/L produces a MODERATELY HIGH level and addition of up to 2.0 mg/L of N produces a MODERATELY HIGH level.

Site III (Susan Lattimer's property): The addition of 0.25 - 2.0 mg/L of N gives MODERATE productivity.

3. Effect of P addition to the three sites:

Site I (Mescalero Boundary): Increase of P up to 0.1 mg/L does not increase cell yield and beyond 0.1 mg/L P the water is at the high end of LOW PRODUCTIVITY.

Site II (Below the WWTP) : Increase of P from 0.025 to 0.1 mg/L will trend toward MODERATELY HIGH productivity.

Site III (Susan Lattimer's property) : Addition of up to 0.1 mg/L of P will not exceed low productivity.

4. General comments:

- If limiting nutrient (typically nitrogen) is added then phosphorus addition will increase algal productivity.
- If phosphorus level is adequate to support algal growth but nitrogen is limiting, this creates a condition favorable for N_2 - fixing cyanobacterial growth.
- If phosphorus and nitrogen level is high enough to support algal growth, then green algae will be abundant. This is the case at Site II.

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APPENDIX E
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:

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

APPENDIX F

NUTRIENT DATA
from
SWQB and Livingston Associates, P.C.

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Sample site		Collection date/time	TKN	NO2+NO3	TN	TP	Units
Site #1		4/24/2003	0.1	0.63	0.73	0.02	mg/L
N Fork Ruidoso -		5/22/2003	0.1	0.83	0.93	0.02	mg/L
Ski Apache		6/26/2003	0.2	0.64	0.84	0.02	mg/L
		7/24/2003	0.2	0.76	0.96	0.02	mg/L
		8/14/2003	0.1	0.71	0.81	0.01	mg/L
		8/29/2003	0.3	0.76	1.06	0.27	mg/L
		9/25/2003	0.1	0.61	0.71	0.005	mg/L
		10/23/2003	0.1	0.52	0.62	0.02	mg/L
		11/20/2003	0.3	0.54	0.84	0.005	mg/L
		12/18/2003	-	-	-	-	mg/L
		1/22/2004	-	-	-	-	mg/L
		2/12/2004	-	-	-	-	mg/L
		2/26/2004	0.2	0.025	0.23	0.005	mg/L
		3/25/2004	0.2	0.93	1.13	0.05	mg/L
		4/22/2004	0.2	0.64	0.84	0.02	mg/L
		5/19/2004	0.3	0.025	0.33	0.01	mg/L
		6/23/2004	0.2	0.61	0.81	0.01	mg/L
		7/22/2004	0.1	0.51	0.61	0.01	mg/L
		8/25/2004	0.3	0.69	0.99	0.01	mg/L
		9/22/2004	0.1	0.025	0.13	0.01	mg/L
		10/20/2004	0.1	0.025	0.13	0.01	mg/L
		11/17/2004	0.1	0.54	0.64	0.04	mg/L
		12/14/2004	0.1	0.025	0.13	0.02	mg/L
		1/19/2005	0.1	0.025	0.13	0.08	mg/L
		2/16/2005	0.1	0.025	0.13	0.11	mg/L
		3/23/2005	0.1	1.33	1.43	0.005	mg/L
	AVERAGE	**ANNUAL**	***0.16***	***0.50***	***0.66***	***0.03***	**mg/L**
	SD	**ANNUAL**	***0.08***	***0.36***	***0.38***	***0.06***	**mg/L**
	SE	**ANNUAL**	***0.02***	***0.08***	***0.08***	***0.01***	**mg/L**
Rio Ruidoso at Mescalero boundary at gauge		5/20/2002 17:30	0.21	0.05	0.260	0.042	mg/L
Rio Ruidoso at Mescalero boundary at gauge		3/18/2003 8:20	0.05	1	1.05	0.015	mg/L
Rio Ruidoso at Mescalero boundary at gauge		4/22/2003 8:15	0.05	1.2	1.25	0.015	mg/L
Rio Ruidoso at Mescalero boundary at gauge		5/20/2003 10:00	0.38	0.46	0.84	0.034	mg/L
Rio Ruidoso at Mescalero boundary at gauge		6/24/2003 7:08	0.437	0.3	0.737	0.041	mg/L
Rio Ruidoso at Mescalero boundary at gauge		7/22/2003 9:00	0.435	0.16	0.595	0.040	mg/L
Rio Ruidoso at Mescalero boundary at gauge		8/19/2003 7:10	0.406	0.05	0.456	0.048	mg/L
Rio Ruidoso at Mescalero boundary at gauge		9/23/2003 7:40	0.215	0.05	0.265	0.050	mg/L
Rio Ruidoso at Mescalero boundary at gauge		10/22/2003 7:30	0.168	0.05	0.218	0.015	mg/L
Rio Ruidoso at Mescalero boundary at gauge		11/2/2004 9:30	0.2	0.34	0.540	0.010	mg/L
	AVERAGE	**ANNUAL**	**0.26**	**0.37**	**0.62**	**0.03**	**mg/L**
	SD	**ANNUAL**	**0.15**	**0.42**	**0.35**	**0.02**	**mg/L**
	SE	**ANNUAL**	**0.05**	**0.13**	**0.11**	**0.005**	**mg/L**
		4/24/2003	0.1	0.95	1.05	0.09	mg/L
Site #2		5/22/2003	0.1	0.83	0.93	0.03	mg/L
R Ruidoso		6/26/2003	0.2	0.56	0.76	0.02	mg/L
at Mescalero		7/24/2003	0.2	0.25	0.45	0.02	mg/L
Boundary		8/14/2003	0.1	0.025	0.13	0.03	mg/L
		8/29/2003	0.1	0.025	0.13	0.09	mg/L
		9/25/2003	0.1	0.025	0.13	0.02	mg/L
		10/23/2003	0.3	0.025	0.33	0.02	mg/L
		11/20/2003	0.2	0.025	0.23	0.02	mg/L
		12/18/2003	0.1	0.025	0.13	0.04	mg/L
		1/22/2004	0.1	0.025	0.13	0.005	mg/L
		2/12/2004	0.1	0.025	0.13	0.005	mg/L
		2/26/2004	0.1	0.8	0.90	0.03	mg/L
		3/25/2004	0.2	1.31	1.51	0.11	mg/L
		4/22/2004	0.2	1.15	1.35	0.02	mg/L
		5/19/2004	0.2	0.025	0.23	0.02	mg/L
		6/23/2004	0.4	0.025	0.43	0.04	mg/L
		7/22/2004	0.1	0.025	0.13	0.04	mg/L
		8/25/2004	0.3	0.025	0.33	0.03	mg/L
		9/22/2004	0.1	0.025	0.13	0.01	mg/L
		10/20/2004	0.1	0.025	0.13	0.01	mg/L
		11/17/2004	0.1	0.025	0.13	0.01	mg/L
		12/14/2004	0.2	0.74	0.94	0.06	mg/L
		1/19/2005	0.1	0.56	0.66	0.005	mg/L
		2/16/2005	0.1	0.025	0.13	0.02	mg/L
		3/23/2005	0.1	1.47	1.57	0.005	mg/L
	AVERAGE	**ANNUAL**	***0.15***	***0.35***	***0.50***	***0.03***	**mg/L**
	SD	**ANNUAL**	***0.08***	***0.47***	***0.47***	***0.03***	**mg/L**
	SE	**ANNUAL**	***0.02***	***0.09***	***0.09***	***0.01***	**mg/L**

Highlighted samples exceed TN or TP criteria

Sample site		Collection date/time	TKN	NO2+NO3	TN	TP	Units
Site #4		4/24/2003	0.1	0.19	0.29	0.005	mg/L
Carrizo @		5/22/2003	0.1	0.74	0.84	0.005	mg/L
Mescalero		6/26/2003	0.1	0.025	0.13	0.005	mg/L
Boundary		7/24/2003	0.2	0.25	0.45	0.005	mg/L
		8/14/2003	0.1	0.025	0.13	0.005	mg/L
		8/29/2003	0.3	0.025	0.33	0.02	mg/L
		9/25/2003	0.1	0.025	0.13	0.01	mg/L
		10/23/2003	0.1	0.025	0.13	0.01	mg/L
		11/20/2003	0.1	0.025	0.13	0.02	mg/L
		12/18/2003	0.1	0.025	0.13	0.005	mg/L
		1/22/2004	0.1	0.025	0.13	0.005	mg/L
		2/12/2004	0.1	0.025	0.13	0.005	mg/L
		2/26/2004	0.1	0.025	0.13	0.005	mg/L
		3/25/2004	0.1	0.025	0.13	0.005	mg/L
		4/22/2004	0.2	0.025	0.23	0.02	mg/L
		5/19/2004	0.1	0.025	0.13	0.01	mg/L
		6/23/2004	0.5	0.025	0.53	0.01	mg/L
		7/22/2004	0.1	0.025	0.13	0.01	mg/L
		8/25/2004	0.2	0.025	0.23	0.01	mg/L
		9/22/2004	0.1	0.025	0.13	0.01	mg/L
		10/20/2004	0.1	0.025	0.13	0.01	mg/L
		11/17/2004	0.1	0.025	0.13	0.01	mg/L
		12/14/2004	0.1	0.025	0.13	0.005	mg/L
		1/19/2005	0.1	0.025	0.13	0.005	mg/L
		2/16/2005	0.1	0.025	0.13	0.12	mg/L
		3/23/2005	0.1	0.91	1.01	0.005	mg/L
	AVERAGE	**ANNUAL**	***0.13***	***0.10***	***0.24***	***0.01***	**mg/L**
	SD	**ANNUAL**	***0.09***	***0.22***	***0.23***	***0.02***	**mg/L**
	SE	**ANNUAL**	***0.02***	***0.04***	***0.05***	***0.00***	**mg/L**
CARRIZO CREEK ABOVE THE RIO RUIDOSO		3/18/2003 9:30	0.23	0.25	0.480	0.015	mg/L
CARRIZO CREEK ABOVE THE RIO RUIDOSO		4/22/2003 9:30	0.05	0.15	0.200	0.015	mg/L
CARRIZO CREEK ABOVE THE RIO RUIDOSO		5/20/2003 11:30	0.127	0.05	0.177	0.015	mg/L
CARRIZO CREEK ABOVE THE RIO RUIDOSO		6/24/2003 8:45	0.246	0.22	0.466	0.015	mg/L
CARRIZO CREEK ABOVE THE RIO RUIDOSO		7/22/2003 10:00	0.33	0.285	0.615	0.015	mg/L
CARRIZO CREEK ABOVE THE RIO RUIDOSO		8/19/2003 8:00	0.3485	0.27	0.619	0.049	mg/L
CARRIZO CREEK ABOVE THE RIO RUIDOSO		9/23/2003 8:20	0.253	0.22	0.473	0.050	mg/L
CARRIZO CREEK ABOVE THE RIO RUIDOSO		10/22/2003 8:30	0.195	0.265	0.460	0.030	mg/L
	AVERAGE	**ANNUAL**	**0.22**	**0.21**	**0.44**	**0.03**	**mg/L**
	SD	**ANNUAL**	**0.10**	**0.08**	**0.17**	**0.02**	**mg/L**
	SE	**ANNUAL**	**0.04**	**0.03**	**0.06**	**0.01**	**mg/L**
Site #5		4/24/2003	0.1	0.68	0.78	0.005	mg/L
Carrizo abv		5/22/2003	0.1	0.67	0.77	0.005	mg/L
R Ruidoso		6/26/2003	0.1	0.025	0.125	0.03	mg/L
		7/24/2003	0.1	0.25	0.35	0.005	mg/L
		8/14/2003	0.3	0.55	0.85	0.03	mg/L
		8/29/2003	0.1	0.025	0.125	0.005	mg/L
		9/25/2003	0.1	0.025	0.125	0.01	mg/L
		10/23/2003	0.1	0.025	0.125	0.01	mg/L
		11/20/2003	0.2	0.025	0.225	0.005	mg/L
		12/18/2003	0.1	0.025	0.125	0.005	mg/L
		1/22/2004	0.2	0.025	0.225	0.005	mg/L
		2/12/2004	0.1	0.025	0.125	0.005	mg/L
		2/26/2004	0.1	0.025	0.125	0.005	mg/L
		3/25/2004	0.3	1.08	1.38	0.08	mg/L
		4/22/2004	0.2	0.94	1.14	0.06	mg/L
		5/19/2004	0.3	0.025	0.33	0.01	mg/L
		6/23/2004	0.3	0.025	0.33	0.05	mg/L
		7/22/2004	0.1	0.025	0.13	0.01	mg/L
		8/25/2004	0.3	0.025	0.33	0.01	mg/L
		9/22/2004	0.1	0.025	0.13	0.01	mg/L
		10/20/2004	0.1	0.025	0.13	0.01	mg/L
		11/17/2004	0.1	0.58	0.68	0.01	mg/L
		12/14/2004	0.1	0.025	0.13	0.005	mg/L
		1/19/2005	0.1	0.025	0.13	0.005	mg/L
		2/16/2005	0.5	0.025	0.53	0.15	mg/L
		3/23/2005	0.1	1.17	1.27	0.005	mg/L
	AVERAGE	**ANNUAL**	***0.17***	***0.25***	***0.41***	***0.02***	**mg/L**
	SD	**ANNUAL**	***0.11***	***0.37***	***0.39***	***0.03***	**mg/L**
	SE	**ANNUAL**	***0.02***	***0.07***	***0.08***	***0.01***	**mg/L**

Highlighted samples exceed TN or TP criteria

Sample site	Collection date/time	TKN	NO2+NO3	TN	TP	Units
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	3/18/2003 10:00	0.215	0.46	0.675	0.015	mg/L
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	4/22/2003 9:50	0.165	0.78	0.945	0.045	mg/L
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	5/20/2003 12:30	0.272	0.16	0.432	0.015	mg/L
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	6/24/2003 9:15	0.55	0.05	0.600	0.015	mg/L
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	7/22/2003 11:00	0.05	0.13	0.180	0.032	mg/L
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	8/19/2003 9:15	0.332	0.05	0.382	0.045	mg/L
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	9/2/2003 9:40	0.175	0.05	0.225	0.058	mg/L
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	9/23/2003 9:10	0.175	0.05	0.225	0.050	mg/L
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	10/22/2003 9:40	0.16	0.05	0.210	0.015	mg/L
AVERAGE	**ANNUAL**	**0.23**	**0.20**	**0.43**	**0.03**	**mg/L**
SD	**ANNUAL**	**0.14**	**0.26**	**0.26**	**0.02**	**mg/L**
SE	**ANNUAL**	**0.05**	**0.09**	**0.09**	**0.01**	**mg/L**
Site #10	4/24/2003	0.1	0.58	0.68	0.005	mg/L
R Ruidoso	5/22/2003	0.1	0.65	0.75	0.005	mg/L
at Hollywood	6/26/2003	0.2	0.025	0.23	0.01	mg/L
	7/24/2003	0.2	0.25	0.45	0.09	mg/L
	8/14/2003	0.4	0.025	0.43	0.18	mg/L
	8/29/2003	0.2	0.025	0.23	0.03	mg/L
	9/25/2003	0.1	0.025	0.13	0.005	mg/L
	10/23/2003	0.1	0.025	0.13	0.09	mg/L
	11/20/2003	0.1	0.025	0.13	0.02	mg/L
	12/18/2003	0.1	0.025	0.13	0.005	mg/L
	1/22/2004	0.1	0.025	0.13	0.005	mg/L
	2/12/2004	0.1	0.025	0.13	0.005	mg/L
	2/26/2004	0.1	0.025	0.13	0.005	mg/L
	3/25/2004	0.1	0.89	0.99	0.12	mg/L
	4/22/2004	0.4	0.85	1.25	0.06	mg/L
	5/19/2004	0.3	0.025	0.33	0.01	mg/L
	6/23/2004	0.2	0.025	0.23	0.01	mg/L
	7/22/2004	0.1	0.025	0.13	0.01	mg/L
	8/25/2004	0.1	0.025	0.13	0.01	mg/L
	9/22/2004	0.1	0.025	0.13	0.01	mg/L
	10/20/2004	0.1	0.025	0.13	0.01	mg/L
	11/17/2004	0.1	0.025	0.13	0.01	mg/L
	12/14/2004	0.4	0.025	0.43	0.04	mg/L
	1/19/2005	0.1	0.025	0.13	0.005	mg/L
	2/16/2005	0.4	0.025	0.43	0.11	mg/L
	3/23/2005	0.1	1.02	1.12	0.005	mg/L
AVERAGE	**ANNUAL**	***0.17***	***0.18***	***0.35***	***0.03***	**mg/L**
SD	**ANNUAL**	***0.11***	***0.32***	***0.34***	***0.05***	**mg/L**
SE	**ANNUAL**	***0.02***	***0.06***	***0.07***	***0.01***	**mg/L**
Site #9	4/24/2003	0.1	0.59	0.69	0.010	mg/L
R Ruidoso	5/22/2003	0.2	0.69	0.89	0.005	mg/L
abv Racetrack	6/26/2003	0.1	0.025	0.13	0.005	mg/L
near Walmart	7/24/2003	0.2	0.25	0.45	0.02	mg/L
(Susan Lattimer)	8/14/2003	0.2	0.025	0.23	0.07	mg/L
	8/29/2003	0.4	0.025	0.43	0.28	mg/L
	9/25/2003	0.1	0.025	0.13	0.005	mg/L
	10/23/2003	0.1	0.025	0.13	0.005	mg/L
	11/20/2003	0.1	0.025	0.13	0.005	mg/L
	12/18/2003	0.1	0.025	0.13	0.005	mg/L
	1/22/2004	0.1	0.025	0.13	0.005	mg/L
	2/12/2004	0.1	0.025	0.13	0.03	mg/L
	2/26/2004	0.1	0.025	0.13	0.005	mg/L
	3/25/2004	0.1	1	1.10	0.17	mg/L
	4/22/2004	0.5	0.82	1.32	0.08	mg/L
	5/19/2004	0.3	1.37	1.67	0.01	mg/L
	6/23/2004	0.1	0.025	0.13	0.01	mg/L
	7/22/2004	0.1	0.025	0.13	0.01	mg/L
	8/25/2004	0.1	0.025	0.13	0.03	mg/L
	9/22/2004	0.1	0.025	0.13	0.01	mg/L
	10/20/2004	0.1	0.025	0.13	0.01	mg/L
	11/17/2004	0.1	0.025	0.13	0.01	mg/L
	12/14/2004	2.1	0.025	2.13	0.04	mg/L
	1/19/2005	0.1	0.025	0.13	0.005	mg/L
	2/16/2005	0.5	0.025	0.53	0.11	mg/L
	3/23/2005	0.1	1.03	1.13	0.005	mg/L
AVERAGE	**ANNUAL**	***0.24***	***0.24***	***0.48***	***0.04***	**mg/L**
SD	**ANNUAL**	***0.40***	***0.40***	***0.56***	***0.06***	**mg/L**
SE	**ANNUAL**	***0.08***	***0.08***	***0.11***	***0.01***	**mg/L**

Highlighted samples exceed TN or TP criteria

Sample site		Collection date/time	TKN	NO2+NO3	TN	TP	Units
Rio Ruidoso below Ruidoso Downs Racetrack Property		3/18/2003 11:00	0.198	0.44	0.638	0.032	mg/L
Rio Ruidoso below Ruidoso Downs Racetrack Property		4/22/2003 10:15	0.05	0.74	0.790	0.015	mg/L
Rio Ruidoso below Ruidoso Downs Racetrack Property		5/20/2003 13:12	0.112	0.13	0.242	0.015	mg/L
Rio Ruidoso below Ruidoso Downs Racetrack Property		6/24/2003 9:40	0.423	0.05	0.473	0.015	mg/L
Rio Ruidoso below Ruidoso Downs Racetrack Property		7/22/2003 11:30	0.59	0.13	0.72	0.039	mg/L
Rio Ruidoso below Ruidoso Downs Racetrack Property		9/2/2003 9:55	0.05	0.05	0.100	0.024	mg/L
Rio Ruidoso below Ruidoso Downs Racetrack Property		9/23/2003 9:40	0.326	0.05	0.376	0.050	mg/L
Rio Ruidoso below Ruidoso Downs Racetrack Property		10/22/2003 10:10	0.203	0.05	0.253	0.015	mg/L
	AVERAGE	**ANNUAL**	**0.24**	**0.21**	**0.45**	**0.03**	**mg/L**
	SD	**ANNUAL**	**0.19**	**0.25**	**0.25**	**0.01**	**mg/L**
	SE	**ANNUAL**	**0.07**	**0.09**	**0.09**	**0.005**	**mg/L**
Site #11		4/24/2003	0.1	0.57	0.67	0.01	mg/L
R Ruidoso		5/22/2003	0.2	0.64	0.84	0.005	mg/L
blw Racetrack		6/26/2003	0.2	0.025	0.23	0.02	mg/L
		7/24/2003	0.2	0.25	0.45	0.01	mg/L
		8/14/2003	0.3	0.025	0.33	0.04	mg/L
		8/29/2003	0.2	0.025	0.23	0.02	mg/L
		9/25/2003	0.1	0.025	0.13	0.01	mg/L
		10/23/2003	0.1	0.025	0.13	0.005	mg/L
		11/20/2003	0.1	0.025	0.13	0.005	mg/L
		12/18/2003	0.1	0.025	0.13	0.01	mg/L
		1/22/2004	0.1	0.025	0.13	0.005	mg/L
		2/12/2004	0.1	0.025	0.13	0.005	mg/L
		2/26/2004	0.2	0.025	0.23	0.005	mg/L
		3/25/2004	0.3	0.89	1.19	0.09	mg/L
		4/22/2004	0.3	0.89	1.19	0.04	mg/L
		5/19/2004	0.4	0.51	0.91	0.01	mg/L
		6/23/2004	0.2	0.025	0.23	0.01	mg/L
		7/22/2004	0.4	0.025	0.43	0.07	mg/L
		8/25/2004	0.1	0.025	0.13	0.04	mg/L
		9/22/2004	0.1	0.025	0.13	0.01	mg/L
		10/20/2004	0.1	0.025	0.13	0.01	mg/L
		11/17/2004	0.1	0.025	0.13	0.01	mg/L
		12/14/2004	0.1	0.025	0.13	0.04	mg/L
		1/19/2005	0.1	0.025	0.13	0.005	mg/L
		2/16/2005	0.5	0.025	0.53	0.17	mg/L
		3/23/2005	0.1	1.02	1.12	0.005	mg/L
	AVERAGE	**ANNUAL**	***0.18***	***0.20***	***0.39***	***0.02***	**mg/L**
	SD	**ANNUAL**	***0.12***	***0.32***	***0.37***	***0.04***	**mg/L**
	SE	**ANNUAL**	***0.02***	***0.06***	***0.07***	***0.01***	**mg/L**
Rio Ruidoso 0.5 miles above WWTP at HWY 70 bridge above seeping springs		5/20/2002 16:20	0.222	0.05	0.272	0.015	mg/L
		3/18/2003 11:40	0.184	0.44	0.624	0.032	mg/L
		4/22/2003 10:45	0.167	0.6	0.767	0.043	mg/L
		5/20/2003 14:00	0.139	0.27	0.409	0.015	mg/L
		6/24/2003 10:40	0.33	0.17	0.500	0.015	mg/L
		7/22/2003 12:10	0.221	0.25	0.471	0.015	mg/L
		8/19/2003 10:40	0.299	0.22	0.519	0.036	mg/L
		9/2/2003 10:20	2.39	10.58	12.97	2.78	mg/L
		9/9/2003 12:40	0.05	0.15	0.200	0.015	mg/L
		9/23/2003 10:15	0.189	0.2	0.389	0.500	mg/L
		10/22/2003 10:40	0.245	0.17	0.415	0.077	mg/L
	AVERAGE	**ANNUAL**	**0.40**	**1.19**	**1.59**	**0.32**	**mg/L**
	SD	**ANNUAL**	**0.66**	**3.12**	**3.78**	**0.83**	**mg/L**
	SE	**ANNUAL**	**0.20**	**0.94**	**1.14**	**0.25**	**mg/L**
Site #13		4/24/2003	0.1	0.51	0.61	0.02	mg/L
R Ruidoso		5/22/2003	0.2	0.78	0.98	0.01	mg/L
0.5 miles abv		6/26/2003	0.1	0.025	0.13	0.07	mg/L
WWTP		7/24/2003	0.3	0.25	0.55	0.01	mg/L
		8/14/2003	0.6	0.025	0.63	0.72	mg/L
		8/29/2003	0.4	0.025	0.43	0.13	mg/L
		9/25/2003	0.1	0.025	0.13	0.03	mg/L
		10/23/2003	0.1	0.025	0.13	0.10	mg/L
		11/20/2003	0.2	0.025	0.23	0.02	mg/L
		12/18/2003	0.1	0.025	0.13	0.02	mg/L
		1/22/2004	0.1	0.025	0.13	0.005	mg/L
		2/12/2004	0.1	0.025	0.13	0.05	mg/L
		2/26/2004	0.1	0.025	0.13	0.005	mg/L
		3/25/2004	0.5	0.96	1.46	0.27	mg/L
		4/22/2004	0.4	0.7	1.10	0.09	mg/L

Highlighted samples exceed TN or TP criteria

Sample site		Collection date/time	TKN	NO2+NO3	TN	TP	Units
		5/19/2004	0.3	0.025	0.33	0.01	mg/L
		6/23/2004	0.1	0.025	0.13	0.01	mg/L
		7/22/2004	0.2	0.025	0.23	0.01	mg/L
		8/25/2004	0.2	0.025	0.23	0.02	mg/L
		9/22/2004	0.1	0.025	0.13	0.01	mg/L
		10/20/2004	0.1	0.025	0.13	0.01	mg/L
		11/17/2004	0.1	0.025	0.13	0.01	mg/L
		12/14/2004	0.1	0.025	0.13	0.02	mg/L
		1/19/2005	0.1	0.025	0.13	0.005	mg/L
		2/16/2005	0.7	0.025	0.73	0.24	mg/L
		3/23/2005	0.1	0.99	1.09	0.005	mg/L
	AVERAGE	**ANNUAL**	***0.21***	***0.18***	***0.39***	***0.07***	**mg/L**
	SD	**ANNUAL**	***0.17***	***0.32***	***0.39***	***0.15***	**mg/L**
	SE	**ANNUAL**	***0.03***	***0.06***	***0.08***	***0.03***	**mg/L**
Site #6		4/24/2003	0.1	0.65	0.75	0.02	mg/L
R Ruidoso		5/22/2003	0.1	0.68	0.78	0.005	mg/L
blw Cedar Cr.		6/26/2003	0.2	0.025	0.23	0.005	mg/L
		7/24/2003	0.2	0.25	0.45	0.02	mg/L
		8/14/2003	0.2	0.025	0.23	0.04	mg/L
		8/29/2003	0.5	0.025	0.53	0.03	mg/L
		9/25/2003	0.1	0.025	0.13	0.01	mg/L
		10/23/2003	0.1	0.025	0.13	0.01	mg/L
		11/20/2003	0.2	0.025	0.23	0.005	mg/L
		12/18/2003	0.1	0.025	0.13	0.06	mg/L
		1/22/2004	0.1	0.025	0.13	0.005	mg/L
		2/12/2004	0.1	0.025	0.13	0.005	mg/L
		2/26/2004	0.1	0.025	0.13	0.005	mg/L
		3/25/2004	0.8	0.99	1.79	0.18	mg/L
		4/22/2004	0.2	0.98	1.18	0.03	mg/L
		5/19/2004	0.4	0.025	0.43	0.01	mg/L
		6/23/2004	0.5	0.025	0.53	0.05	mg/L
		7/22/2004	0.1	0.025	0.13	0.01	mg/L
		8/25/2004	0.3	0.025	0.33	0.03	mg/L
		9/22/2004	0.1	0.025	0.13	0.02	mg/L
		10/20/2004	0.1	0.025	0.13	0.02	mg/L
		11/17/2004	0.1	0.025	0.13	0.01	mg/L
		12/14/2004	0.1	0.025	0.13	0.005	mg/L
		1/19/2005	0.1	0.025	0.13	0.005	mg/L
		2/16/2005	0.4	0.025	0.43	0.10	mg/L
		3/23/2005	0.1	1.1	1.20	0.005	mg/L
	AVERAGE	**ANNUAL**	***0.21***	***0.19***	***0.40***	***0.02***	**mg/L**
	SD	**ANNUAL**	***0.15***	***0.40***	***0.40***	***0.03***	**mg/L**
	SE	**ANNUAL**	***0.04***	***0.11***	***0.11***	***0.01***	**mg/L**
Site #8		4/24/2003	0.1	0.63	0.73	0.005	mg/L
R Ruidoso		5/22/2003	0.1	0.68	0.78	0.005	mg/L
blw Gavilan		6/26/2003	0.1	0.025	0.13	0.01	mg/L
Canyon		7/24/2003	0.2	0.25	0.45	0.01	mg/L
		8/14/2003	0.1	0.025	0.13	0.07	mg/L
		8/29/2003	0.3	0.025	0.33	0.05	mg/L
		9/25/2003	0.1	0.025	0.13	0.005	mg/L
		10/23/2003	0.1	0.025	0.13	0.02	mg/L
		11/20/2003	0.1	0.025	0.13	0.01	mg/L
		12/18/2003	0.1	0.025	0.13	0.005	mg/L
		1/22/2004	0.2	0.025	0.23	0.005	mg/L
		2/12/2004	0.1	0.025	0.13	0.005	mg/L
		2/26/2004	0.2	0.025	0.23	0.005	mg/L
		3/25/2004	0.5	1.01	1.51	0.05	mg/L
		4/22/2004	0.3	0.91	1.21	0.03	mg/L
		5/19/2004	0.3	0.025	0.33	0.01	mg/L
		6/23/2004	0.4	0.025	0.43	0.03	mg/L
		7/22/2004	0.1	0.025	0.13	0.01	mg/L
		8/25/2004	0.1	0.025	0.13	0.01	mg/L
		9/22/2004	0.2	0.025	0.23	0.01	mg/L
		10/20/2004	0.1	0.025	0.13	0.01	mg/L
		11/17/2004	0.1	0.025	0.13	0.01	mg/L
		12/14/2004	0.1	0.025	0.13	0.005	mg/L
		1/19/2005	0.1	0.025	0.13	0.005	mg/L
		2/16/2005	0.7	0.025	0.73	0.26	mg/L

Highlighted samples exceed TN or TP criteria

Sample site		Collection date/time	TKN	NO2+NO3	TN	TP	Units
		3/23/2005	0.1	1.05	1.15	0.005	mg/L
	AVERAGE	**ANNUAL**	***0.19***	***0.19***	***0.38***	***0.02***	**mg/L**
	SD	**ANNUAL**	***0.15***	***0.34***	***0.39***	***0.05***	**mg/L**
	SE	**ANNUAL**	***0.03***	***0.07***	***0.08***	***0.01***	**mg/L**
Site #12		4/24/2003	0.1	0.63	0.73	0.02	mg/L
R Ruidoso at		5/22/2003	0.1	0.66	0.76	0.005	mg/L
Parker Rd bridge		6/26/2003	0.2	0.025	0.23	0.02	mg/L
		7/24/2003	0.3	0.25	0.55	0.01	mg/L
		8/14/2003	0.4	0.025	0.43	0.22	mg/L
		8/29/2003	0.4	0.025	0.43	0.24	mg/L
		9/25/2003	0.1	0.025	0.13	0.03	mg/L
		10/23/2003	0.1	0.025	0.13	0.01	mg/L
		11/20/2003	0.1	0.025	0.13	0.98	mg/L
		12/18/2003	0.1	0.025	0.13	0.005	mg/L
		1/22/2004	0.2	0.025	0.23	0.005	mg/L
		2/12/2004	0.1	0.025	0.13	0.02	mg/L
		2/26/2004	0.1	0.025	0.13	0.005	mg/L
		3/25/2004	0.1	0.85	0.95	0.03	mg/L
		4/22/2004	0.3	0.84	1.14	0.07	mg/L
		5/19/2004	0.4	0.025	0.43	0.01	mg/L
		6/23/2004	0.3	0.025	0.33	0.01	mg/L
		7/22/2004	0.2	0.025	0.23	0.01	mg/L
		8/25/2004	0.1	0.025	0.13	0.01	mg/L
		9/22/2004	0.1	0.025	0.13	0.01	mg/L
		10/20/2004	0.1	0.025	0.13	0.01	mg/L
		11/17/2004	0.1	0.025	0.13	0.01	mg/L
		12/14/2004	0.1	0.025	0.13	0.03	mg/L
		1/19/2005	0.1	0.025	0.13	0.03	mg/L
		2/16/2005	0.1	0.025	0.13	0.03	mg/L
		3/23/2005	0.1	0.025	0.13	0.03	mg/L
	AVERAGE	**ANNUAL**	***0.17***	***0.14***	***0.31***	***0.07***	**mg/L**
	SD	**ANNUAL**	***0.11***	***0.27***	***0.29***	***0.19***	**mg/L**
	SE	**ANNUAL**	***0.02***	***0.05***	***0.06***	***0.04***	**mg/L**
	AVERAGE Upstream TOTAL	**ANNUAL**	**0.19**	**0.26**	**0.46**	**0.04**	**mg/L**

Highlighted samples exceed TN or TP criteria

		TN	TP		
Aggregate Ecoregion II		**TN**	**TP**		
Level III Ecoregion 23	**fall**	**0.27**	**0.013**	**mg/L**	**n = 25 & 53**
(25th percentiles)	**spring**	**0.20**	**0.010**	**mg/L**	**n = 25 & 53**
	summer	**0.29**	**0.020**	**mg/L**	**n = 34 & 63**
(USEPA 2000)	**winter**	**0.30**	**0.010**	**mg/L**	**n = 10 & 40**
	AVERAGE	**0.262**	**0.014**	**mg/L**	**n = 94 & 209**

		TN	TP	
AVERAGE Ambient Concentration (C_a)	**ANNUAL**	**0.41**	**0.032**	**mg/L**

APPENDIX G
THERMOGRAPH SUMMARY DATA AND GRAPHICS

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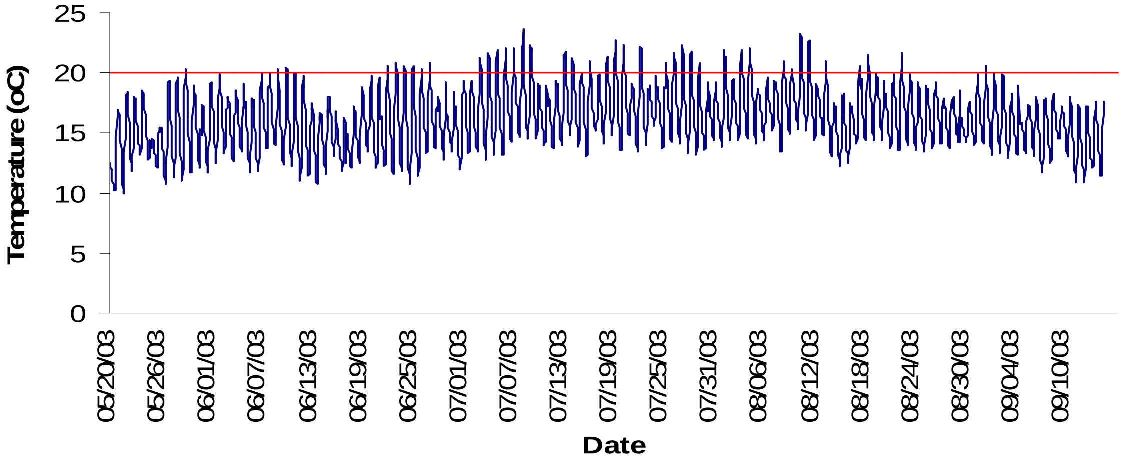
G1.0 Rio Ruidoso (Seeping Springs Lake to Mescalero Apache boundary)

Rio Ruidoso at Hollywood USGS gage
May 20 (17:00) through September 15 (14:00):

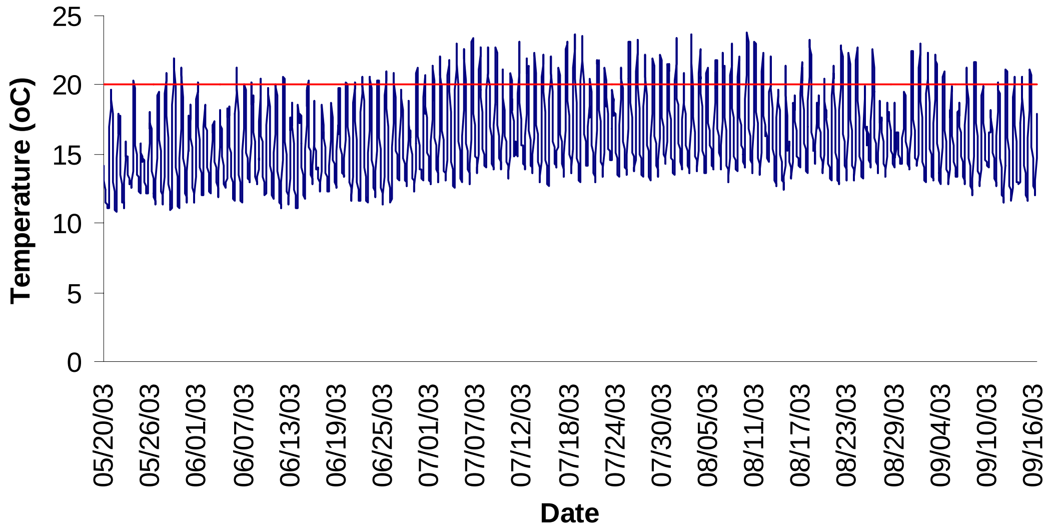
Number of Data Points:	8,254
Number of Measurements >20^{o}C:	1,044
Percentage Data Points >20^{o}C:	13%
Minimum Temperature (^{o}C):	10.0
Maximum Temperature (^{o}C):	23.71



Rio Ruidoso at Hollywood USGS gage
March 3, 2003

Rio Ruidoso at Hwy 70 above WWTP
May 20 (17:00) through September 16 (12:00):

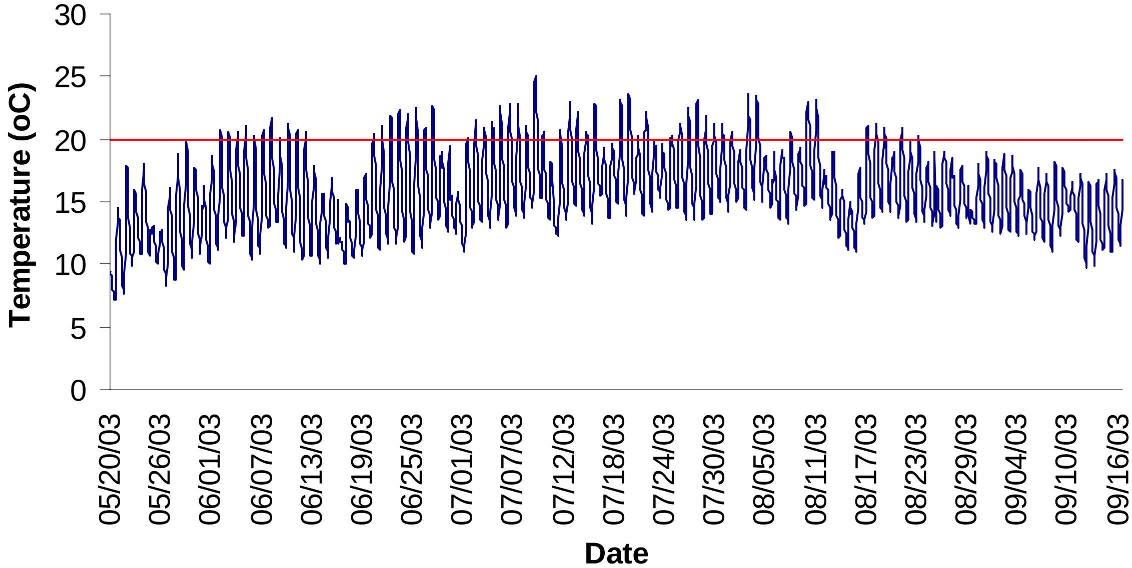
Number of Data Points:	2,852
Number of Measurements >20^{o}C:	362
Percentage Data Points >20^{o}C:	13%
Minimum Temperature (^{o}C):	10.79
Maximum Temperature (^{o}C):	23.74



Rio Ruidoso at Hwy 70
March 24, 2003

Rio Ruidoso at Mescalero boundary
May 20 (17:00) through September 16 (14:00):

Number of Data Points:	2,854
Number of Measurements >20°C:	289
Percentage Data Points >20°C:	10%
Minimum Temperature (°C):	7.22
Maximum Temperature (°C):	25.07



See Photo 3.5 in text

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

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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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H 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 H.1 Assessment Units and Modeled Dates

Assessment Unit ID	Assessment Unit Description	Modeled Date
NM-2209.A_10	Rio Bonito (Angus Canyon to headwaters)	8/9/2003
NM-2209.A_20	Rio Ruidoso (Seeping Springs Lake to Mescalero Apache boundary)	7/9/2003

H 2.0 HYDROLOGY

H 2.1 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 was 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 H.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-2209.A_10	—[(a)]	—	—[(b)]	45.962	—	—
NM-2209.A_20	08387000	120	18.236	152.65	15%[(c)]	127%

Notes:
[(a)]Regression method developed by Waltemeyer (2002) was used to estimate flows since this is an ungaged stream.
[(b)]Assessment unit begins at headwaters.
[(c)] The method developed by Thomas et al. (1997) is not applicable because the drainage area of the ungaged site is greater than 150 percent of the drainage area of the gaged site. Therefore, the method developed by Waltemeyer (2002) was used to estimate flows for the inflow of this assessment unit.

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):

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

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):

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

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 H.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-2209.A_10	Mountainous	8,330	8.6	0.404
NM-2209.A_20	Mountainous	7,552	7.61	0.254

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

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

Table H.4 Inflow

Assessment Unit	Ref.	4Q3[(1)] (cfs)	DAt (mi^2)	DAg (mi^2)	Pw (in)	S unitless	Inflow (cfs)
NM-2209.A_10	N/A	—	—	—	8.6	0.404	0.000[(2)]
NM-2209.A_20	(a)	2.731	18.236	120	7.61	0.254	0.126

Notes:
N/A = Not applicable, assessment unit begins at headwaters.
Ref. = Reference
(a) 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.
[(2)] Inflow is zero because assessment unit begins at headwaters.

H 2.2 Inflow Temperature

This parameter represents the *mean daily* water temperature at the top of the segment. 2003 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 H.5 Mean Daily Water Temperature

Assessment Unit	Upstream Thermograph Location	Inflow Temp. (°C)	Inflow Temp. (°F)
NM-2209.A_10	None (headwaters)	0	32.0
NM-2209.A_20	Rio Ruidoso at Mescalero boundary	19.08	66.34

Notes:
ºC = Degrees Celcius
ºF = Degrees Farenheit

H 2.3 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:

Table H.6 Segment Outflow

Assessment Unit	Ref.	4Q3[(1)] (cfs)	DAb (mi^2)	DAg (mi^2)	Pw (in)	S unitless	Outflow (cfs)
NM-2209.A_10	(a)	2.731[(c)]	45.962	120	8.6	0.404	0.696
NM-2209.A_20	(b)	2.731	152.65	120	7.61	0.254	3.08

Notes:
Ref. = Reference
(a) Waltemeyer 2002, mountainous
(b) Thomas 1997
(c) No long-term USGS data available for Rio Bonito, used Rio Ruidoso gage data.
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
(1) Based on period of record for USGS gage.

The period of record for the USGS gage on the Rio Bonito near Lincoln, NM (08389055) only extended from 1999-2002 and is not a long enough time period to calculate a 4Q3 value. The upper assessment units for Rio Ruidoso and Rio Bonito were assumed to be comparable, so the calculated 4Q3 value for the Rio Ruidoso was also used for the Rio Bonito. Table H.7 shows the 2003 flow as measured by SWQB in the two assessment units. All other geomorphologic and climatic data unique to each watershed were used in the calculations for each respective watershed.

Table H.7 SWQB 2003 Measured Discharge-Rio Bonito and Rio Ruidoso

Assessment Unit						
Rio Bonito (Angus Canyon to headwaters)			Rio Ruidoso (Hwy 70 to Mescalero Apache boundary)			
Site			**Site**			
	Rio Bonito above Bonito Lake at FR 107	Rio Ruidoso at Mescalero boundary		Rio Ruidoso at Mescalero boundary	Rio Ruidoso at Hollywood gage	Rio Ruidoso below Ruidoso Downs racetrack
Date	**Discharge (cfs)**	**Discharge (cfs)**	**Date**	**Discharge (cfs)**	**Discharge (cfs)**	**Discharge (cfs)**
3/19	0.74	0.5	3/18	11.5	13	8.89
4/21	5.77	0.25	4/22	16.1	39.5	17.72
5/19	3.0	1.0	5/20	9.17	9.4	6.0
6/23	0.25	0.1	6/24	1.8	3.34	3.96
7/22	0.25	0	7/22	1.62	4.8	2.11
8/18	0.25	0	8/19	1.53	5.1	1.54
9/22	0.25	0	9/23	1.31	4.4	0.51
10/21	0.25	0	10/22	0.87	6.25	2.01

H 2.4 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 2003 was used in the absence of measured data. The following table presents the mean annual air temperature for each assessment unit:

Table H.8 Mean Annual Air Temperature as an Estimate for Accretion Temperature

Assessment Unit	Ref.	Mean Annual Air Temperature (°C)	Mean Annual Air Temperature (°F)
NM-2209.A_10	(a)	13.258	55.865
NM-2209.A_20	(a)	13.258	55.865

Notes:
Ref. = References for Weather Station Data are as follows:
(a) *New Mexico State University Climate Network (Ruidoso METAR, Elevation 2,076 meters; Latitude 33° 28' N, Longitude 105° 32' W),* ***2003***
°F = Degrees Farenheit
°C = Degrees Celcius

H 3.0 GEOMETRY

H 3.1 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 H.9 Assessment Unit Latitude

Assessment Unit	Latitude (decimal degrees)
NM-2209.A_10	33.44
NM-2209.A_20	33.35

H 3.2 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 H.10 Presence of Dam at Head of Segment

Assessment Unit	Dam?
NM-2209.A_10	No
NM-2209.A_20	No

D3.3 Segment Length

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

Table H.11 Segment Length

Assessment Unit	Length (miles)
NM-2209.A_10	10.16
NM-2209.A_20	12.4

H 3.4 Upstream Elevation

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

Table H.12 Upstream Elevations

Assessment Unit	Upstream Elevation (feet)
NM-2209.A_10	10,100
NM-2209.A_20	7,160

H 3.5 Downstream Elevation

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

Table H.13 Downstream Elevations

Assessment Unit	Downstream Elevation (feet)
NM-2209.A_10	6,875
NM-2209.A_20	6,136

H 3.6 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) Program (U.S. Department of Agriculture [USDA] 1998). 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 H.14 Width's A and Width's B Terms

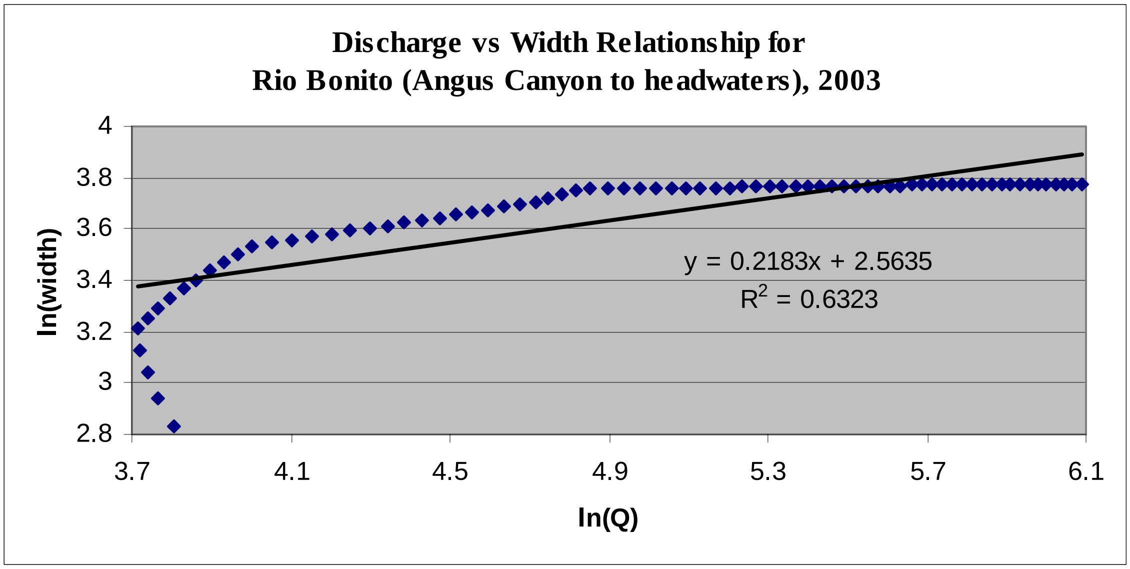
Assessment Unit	Width's B-Term	Width's A-Term[(1)]
NM-2209.A_10[(a)]	0.218	6.30
NM-2209.A_20[(b)]	0.179	10.69

[(a)] *14.3 ft width and 42.9 cfs discharge measured on March 4, 2003*
[(b)] *25.1 ft width and 117.5 cfs discharge measured on June 10, 2003*

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

Measurements were collected at one site within these assessment units. The regression of natural log of width and natural log of flow for each location is as follows:

Figure H.1 Wetted Width versus Flow for Assessment Unit NM-2209.A_10



SUMMARY OUTPUT

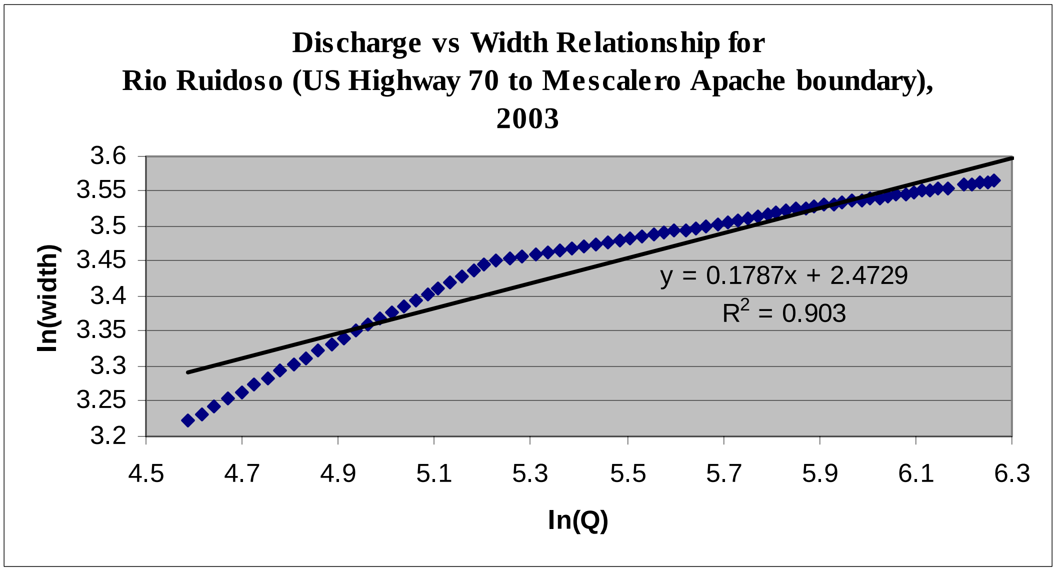
Regression Statistics	
Multiple R	0.795170244
R Square	0.632295716
Adjusted R Square	0.627326739
Standard Error	0.128532079
Observations	76

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2.102211133	2.102211	127.2487	9.67353E-18
Residual	74	1.222516647	0.01652		
Total	75	3.32472778			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.563476422	0.097007164	26.42564	2E-39	2.370185405	2.756767439	2.370185405	2.756767439
X Variable 1	0.218284388	0.019350671	11.28046	9.67E-18	0.179727329	0.256841447	0.179727329	0.256841447

Figure H.2 Wetted Width versus Flow for Assessment Unit NM-2209.A_20



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.950250218
R Square	0.902975477
Adjusted R Square	0.901664335
Standard Error	0.030122792
Observations	76

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.624908761	0.624909	688.6938	3.17704E-39
Residual	74	0.067146313	0.000907		
Total	75	0.692055074			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.472945038	0.0376513	65.6802	2.33E-67	2.397923176	2.547967	2.397923176	2.547966899
X Variable 1	0.178730582	0.006810607	26.24298	3.18E-39	0.165160151	0.192301	0.165160151	0.192301014

Geomorphology data were available for three sites in the Rio Ruidoso (US Highway 70 to Mescalero Apache boundary) assessment unit: Rio Ruidoso at Mescalero boundary, Rio Ruidoso at Hollywood gage, and Rio Ruidoso above Highway 70. However, the data for the most upstream site (Rio Ruidoso at Mescalero boundary) was used for the modeling and calculating of the width A and B terms.

H3.7 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 H.15 Manning’s n Values

Assessment Unit	Manning’s n
NM-2209.A_10	0.050 [(a)]
NM-2209.A_20	0.048 [(b)]

[(a)] average of Rio Bonito thermograph sites 2 and 4.
[(b)] average of Rio Ruidoso sites 8,9, and 10

H 4.0 METEOROLOGICAL PARAMETERS

H 4.1 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 temperature was 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 H.16 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-2209.A_10[a]	2,093	21.48[a]	2,539	18.55	66.34
NM-2209.A_20[b]	2,013	22.12[b]	2,302	20.22	68.40

Notes:
[a] Values for **August 9, 2003** from the air thermograph deployed at thermograph site 2.
[b] Average values for **July 9, 2003** from air thermographs deployed at thermograph sites 9 and 10.

ºF = Degrees Farenheit
ºC = Degrees Celcius

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)

H 4.2 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.

H 4.3 Relative Humidity

Relative humidity data were obtained from the Western Regional Climate Center web site (www.wrcc.dri.edu) or 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 H.17 Mean Daily Relative Humidity

Assessment Unit	Ref.	Mean Daily Air Temp. at Weather Station (ºC)	Mean Daily Air Temperature at AU (ºC)	Mean Daily Relative Humidity at Weather Station (percent)	Mean Daily Relative Humidity for AU (percent)
NM-2209.A_10	(a)	23.17	18.55	47.995	62.93
NM-2209.A_20	(b)	17.67	20.22	75.927	65.39

Notes:
Ref. = References for Weather Station Data are as follows:
(a) *New Mexico State University Climate Network (Ruidoso METAR, Elevation 2,076 meters; Latitude 33° 28' N, Longitude 105° 32' W)* ***August 9, 2003***
(b) *New Mexico State University Climate Network (Ruidoso METAR, Elevation 2,076 meters;*
(c) *Latitude 33° 28' N, Longitude 105° 32' W)* ***July 9, 2003***

AU = Assessment Unit
ºC = Degrees Celcius

H 4.4 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 H.18 Mean Daily Wind Speed

Assessment Unit	Ref.	Mean Daily Wind Speed (miles per hour)
NM-2209.A_10	(a)	12.323
NM-2209.A_20	(b)	16.495

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

(a) *New Mexico State University Climate Network (Ruidoso METAR, Elevation 2,076 meters; Latitude 33° 28' N, Longitude 105° 32' W)* ***August 9, 2003***

(b) *New Mexico State University Climate Network (Ruidoso METAR, Elevation 2,076 meters; Latitude 33° 28' N, Longitude 105° 32' W)* ***July 9, 2003***

H 4.5 Ground Temperature

Mean annual air temperature data for 2003 were used in the absence of measured data. The following table presents the mean annual air temperature for each assessment unit:

Table H.19 Mean Annual Air Temperature as an Estimate for Ground Temperature

Assessment Unit	Ref.	Mean Annual Air Temperature (°C)	Mean Annual Air Temperature (°F)
NM-2209.A_10	(a)	13.258	55.865
NM-2209.A_20	(a)	13.258	55.865

Ref. = References for Weather Station Data are as follows:
(a) New Mexico State University Climate Network (Ruidoso METAR, Elevation 2,076 meters; Latitude 33° 28' N, Longitude 105° 32' W), ***2003***

°F = Degrees Farenheit
°C = Degrees Celcius

H 4.6 Thermal Gradient

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

H 4.7 Possible Sun

Percent possible sun for Roswell 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 77 percent for July and 73 percent for August.

H 4.8 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).

H 4.9 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).

H 4.10 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. Solar radiation data were not available for either the Pecos RAWS or Las Vegas METAR stations, so the nearest station with solar radiation was used. The following table presents the measured solar radiation at Smoky Bear RAWS station for 2001:

Table H.20 Mean Daily Solar Radiation

Assessment Unit	Ref.	Date	Mean Solar Radiation (L/day)	Mean Solar Radiation x 0.90 (L/day)
NM-2209.A_10	(a)	8-9-2003	196.66	176.99
NM-2209.A_20	(a)	7-9-2003	315.12	283.61

Ref. = References for Weather Station Data are as follows:
(a) New Mexico State University Climate Network (Smoky Bear RAWS, Elevation 2,103 meters; Latitude 33° 21' N, Longitude 105° 40' W)

H 5.0 SHADE

Percent shade was estimated for the assessment units using densiometer readings taken in 2003. The measurements were 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. The following table summarizes percent shade for each assessment unit:

Table H.21 Percent Shade

Assessment Unit	Percent Shade
NM-2209.A_10	65%[(a)]
NM-2209.A_20	7%[(b)]

(a) Densiometer readings only taken at thermograph site 4 (88%) during 2003 study.
(b) Densiometer readings at site 8(45%) and site 9 (1.2%).

H 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/.

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APPENDIX I
PUBLIC PARTICIPATION PROCESS FLOWCHART

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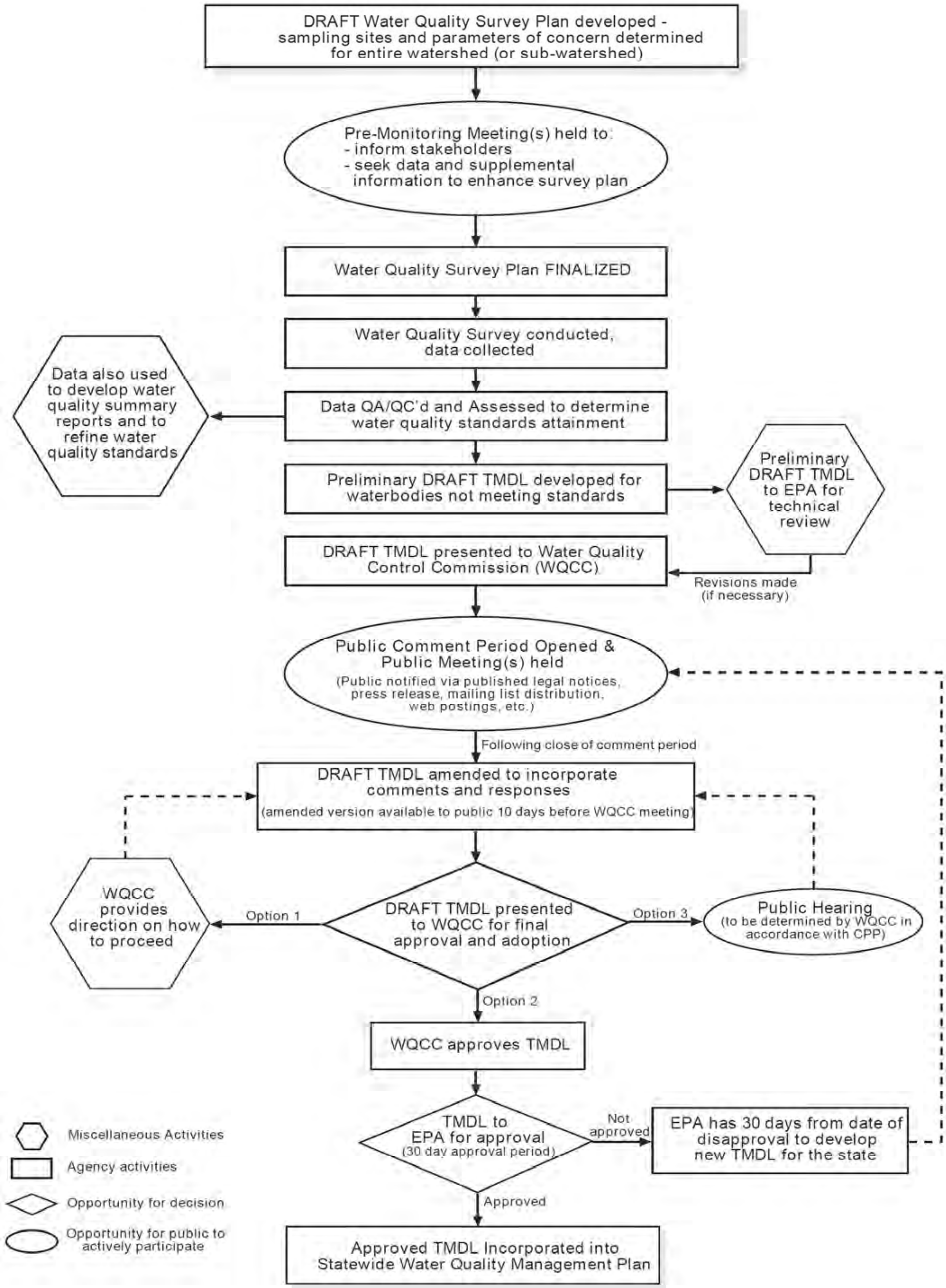
DRAFT Water Quality Survey Plan developed - sampling sites and parameters of concern determined for entire watershed (or sub-watershed)
Pre-Monitoring Meeting(s) held to:
- inform stakeholders
- seek data and supplemental information to enhance survey plan
Water Quality Survey Plan FINALIZED
Water Quality Survey conducted, data collected
Data QA/QC'd and Assessed to determine water quality standards attainment
Data also used to develop water quality summary reports and to refine water quality standards
Preliminary DRAFT TMDL developed for waterbodies not meeting standards
Preliminary DRAFT TMDL to EPA for technical review
DRAFT TMDL presented to Water Quality Control Commission (WQCC)
Revisions made (if necessary)
Public Comment Period Opened & Public Meeting(s) held
(Public notified via published legal notices, press release, mailing list distribution, web postings, etc.)
Following close of comment period
DRAFT TMDL amended to incorporate comments and responses
(amended version available to public 10 days before WQCC meeting)
DRAFT TMDL presented to WQCC for final approval and adoption
Option 1
WQCC provides direction on how to proceed
Option 3
Public Hearing
(to be determined by WQCC in accordance with CPP)
Option 2
WQCC approves TMDL
TMDL to EPA for approval
(30 day approval period)
Not approved
EPA has 30 days from date of disapproval to develop new TMDL for the state
Approved
Approved TMDL Incorporated into Statewide Water Quality Management Plan
Miscellaneous Activities
Agency activities
Opportunity for decision
Opportunity for public to actively participate

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APPENDIX J
RESPONSE TO COMMENTS

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Comment Set A:

Residents of the Rio Ruidoso/Rio Hondo Valley

(PDF of letter received inserted)

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November 3, 2005

We, the undersigned of the Rio Ruidoso/Rio Hondo Valley, are concerned for our health, safety and welfare due to high pollutant levels found in these waters by the New Mexico Environment Department (NMED). According to test results recently released by the NMED, waters downstream of the Village of Ruidoso sewage treatment plant have nutrient and bacteria levels that are in violation of the State of New Mexico Water Quality Standards. The poor water quality in the Rio Ruidoso resulting from water released by the sewage treatment plant creates unacceptable odors and has contributed to algae blooms that adversely affect the diversion dams and gates of the acequia system serving the residents of the Valley. Moreover, we fear for the health of our children who play near the river and the effects on our livestock and domestic animals that drink from the river and acequia system.

The residents of the Valley have expressed concern over the issue for at least 15 years. We are extremely concerned that the current problems will be exacerbated by the increased amount of sewage being treated at this plant from additional sources such as the Inn of the Mountain Gods, the Travel Center, and the pipeline from the Palmer Loop Subdivision. We are concerned that the additional effluent will further stress the sewage treatment plant that has not operated correctly from its initial start-up and, according to NMED test results, was in violation of water quality standards 66% of the time in 2002-2003. The level and frequency of violations is very likely to increase with the current additions from the Village of Ruidoso and the City of Ruidoso Downs and the Mescalero Reservation. We respectively request that the Village of Ruidoso take immediate action to correct this problem before the already significant threat to the health of Valley residents gets even worse. Since the Village of Ruidoso has been releasing such polluted water we also believe they should not receive credit from the Office of the State Engineer for the effluent from that sewer plant. It is ludicrous for them to receive credit for destroying a stream and put valley residents at risk.

Please sign and write address legibly or your name won't be counted.

Name	Printed Name	Address	City	State	Zip	Email

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Water meeting 6:00 6:30
Hondo School 11-10

November 3, 2005

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NMED/SWQB Response: The Surface Water Quality Bureau (SWQB) understands your concern and appreciates your commitment to improving the health of the watershed in your community. The SWQB believes that the monitoring, assessment, TMDL development, and watershed protection activities should be in the best interest of the target watershed. SWQB works collaboratively with stakeholders, such as federal, tribal, state, and local governments, local businesses, and point source dischargers in the watershed, as well as local citizen and interest groups to help protect and improve the biological, chemical, and physical integrity of surface waters in the State of New Mexico.

The current designated uses for the perennial reaches of the Rio Ruidoso downstream of U.S. Highway 70 include fish culture, coldwater aquatic life, irrigation, livestock watering, wildlife habitat, and secondary contact (NMAC 20.6.4.208). The SWQB is not the ultimate decision-making authority with regards to whether or not the wastewater treatment plant (WWTP) will expand or how the Village of Ruidoso, Ruidoso Downs, or private landowners choose to develop their land. However, taking the design capacity of the WWTP into consideration, the SWQB can provide maximum allowable effluent concentrations that will be protective of the river and that ensure the river's designated uses will be supported.

The SWQB will be conducting another intensive survey of the Rio Hondo watershed in 2011 to monitor and assess multiple biological, chemical, and physical water quality parameters of the perennial surface waters in this watershed. If the data from this survey indicate impairments then new TMDLs will be written accordingly.

The National Pollutant Discharge Elimination System (NPDES) permit program is responsible for the protection of surface water quality throughout the State by regulating point source discharges, such as WWTPs, to surface watercourses. Since the program's inception, EPA Region 6 based in Dallas, TX has administered the program in New Mexico with assistance and oversight by the SWQB Point Source Regulation Section. New Mexico is currently pursuing state authorization for the program. Federal laws provide EPA with various methods of taking enforcement actions against violators of permit requirements. Equally important is how the general public can enforce permit conditions. The facility monitoring reports are public documents, and the general public can review them. If any member of the general public finds that a facility is violating its NPDES permit, that member can independently start a legal action.

Comments regarding water rights and water credits need to be directed to Office of the State Engineer (OSE) and the Interstate Stream Commission (ISC). The OSE and the ISC are separate but companion agencies charged with administering the state's water resources. The agencies have jurisdiction over the supervision, measurement, appropriation and distribution of essentially all surface and ground water in New Mexico, including streams and rivers that cross state boundaries.

Comment Set B:
Robert L. Trimble
COE Ranch
Glencoe, NM

(PDF of letter received inserted)

ROBERT L. TRIMBLE
COE RANCH
P.O. Box 5
Glencoe, NM 88324

(505) 653-4312

October 20, 2005

NMED SWQB
Attn: Heidi Henderson
Room N2163
P.O. Box 26110
Santa Fe, NM 87502

Re: Ruidoso's Sewage Treatment Plant

Dear Ms. Henderson:

Our ranch is located approximately 15 miles northeast of the Ruidoso sewage treatment plant. We have cattle, horses and domestic animals on our ranch and approximately 1 mile of the Ruidoso River runs through there. I can testify personally that the water quality in the river is horrible. Sometimes, particularly in the dryer seasons, it is unuseable. It smells and is so polluted that we use well water to water our livestock. We have 83 acres of senior water rights which we paid dearly for and because of the actions of the Village of Ruidoso, we are often times unable to use them without going to the expense of operating electric pumps for subsurface water. I find it incredulous that the Village of Ruidoso can knowingly violate the law and continue to do so with impunity. I urge you to keep the state standards as they are and not make an exception. I also urge you to enforce the current standards and get Ruidoso in compliance with state law.

I paid a lot of money for my ranch and one of the main factors in my purchasing it and paying the price I did was having access to water. I resent being denied that access by pollution from the Village of Ruidoso. The Village of Ruidoso has been totally irresponsible in their development planning by allowing more and more development when they knew that their sewage treatment plant did not have the capacity to handle it. It is unfair for me to pay for their stupidity.

Sincerely,

Robert L. Trimble

/lh

NMED/SWQB Response: The Surface Water Quality Bureau (SWQB) understands your concern and appreciates your commitment to improving the health of the watershed in your community. Under Section 303(d)(1) of the Clean Water Act (CWA), states are required to develop a list of waters within a state that are not in compliance with water quality standards and establish a total maximum daily load (TMDL) for each pollutant. Once implemented, the nutrient TMDLs are designed to protect the stream by maintaining water quality standards and fully supporting the designated uses, such as coldwater aquatic life, irrigation, livestock watering, and wildlife habitat, throughout the stream reach.

In regards to your comment about the state standards, target nutrient loads for the Rio Ruidoso were calculated based on the critical 4Q3 low-flow values, a segment-specific numeric criterion for total phosphorus (NMAC 20.6.4.208), and a numeric translator for total nitrogen based on the algal growth potential assay and appropriate nitrogen to phosphorus ratios (see Section 5.1 for details). The maximum allowable effluent concentrations and waste load allocations calculated in the TMDL will be used to design a revised National Pollutant Discharge Elimination System (NPDES) permit for the Ruidoso/Ruidoso Downs wastewater treatment plant (WWTP).

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