FINAL APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

JEMEZ RIVER WATERSHED
VALLES CALDERA NATIONAL PRESERVE
BOUNDARIES TO HEADWATERS

OCTOBER 11, 2006

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COVER PHOTO: EAST FORK JEMEZ BELOW JARAMILLO

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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
^oC	Degrees Celcius
^oF	Degrees Farenheit
GIS	Geographic Information Systems
GPS	Global Positioning System
HQCW	High quality cold water
HUC	Hydrologic unit code
$j/m^2/s$	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
MOS	Margin of safety
MOU	Memoranda of Understanding
MS4	Municipal Separate Storm Sewer System
MSGP	Multi Sector General Storm Water Permit
NM	New Mexico
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric turbidity units
QAPP	Quality Assurance Project Plan
RFP	Request for proposal
SSTEMP	Stream Segment Temperature Model
STORET	USEPA's Storage and Retrieval Database
SWPPP	Storm Water Pollution Prevention Plan
SWQB	Surface Water Quality Bureau
TMDL	Total maximum daily load
TSS	Total suspended solids
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VCNP	Valles Caldera National Preserve
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/cm	Micromhos per centimeter

EXECUTIVE SUMMARY

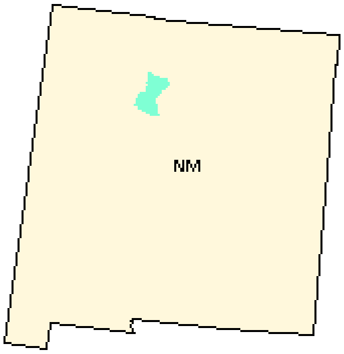
Section 303(d) of the Federal Clean Water Act requires states to develop Total Maximum Daily Load (TMDL) management plans for water bodies determined to be water quality limited. A TMDL documents the amount of a pollutant a water body can assimilate without violating a state's water quality standards. 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 Jemez River watershed is located in north central New Mexico. The Surface Water Quality Bureau (SWQB) conducted an intensive surface water quality survey of the Valles Caldera basin in 2001-2002. Water quality monitoring stations were located throughout the Valles Caldera 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 temperature were documented for East Fork Jemez (Valles Caldera National Preserve [VCNP] boundary to headwaters) and Jaramillo Creek (East Fork Jemez to headwaters). Jaramillo Creek (East Fork Jemez to headwaters) was also determined to be impaired due to turbidity. This TMDL document addresses the above noted impairments as summarized in the tables below. Several of the assessment units were found to be impaired due to pH and dissolved oxygen. The completion of a nutrient TMDL for these assessment units, if necessary, is pending until a full nutrient assessment is completed and area-specific criteria are developed. Additionally, all seven assessment units in this survey are impaired due to dissolved aluminum, but they are listed on the Integrated Clean Water Act (CWA) §303(d)/§305(b) List as 5B because aluminum is naturally high in this watershed.

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 in the Integrated CWA §303(d)/§305(b)Report (NMED/SWQB 2004).

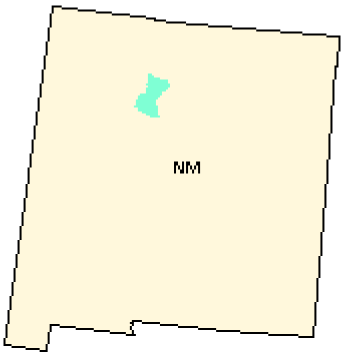
The SWQB's Watershed Protection Section has and will continue to work with watershed groups to develop Watershed Restoration Action Strategies to develop and implement strategies to attempt to correct the water quality impairments detailed in this document. Implementation of items detailed in Watershed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

TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE EAST FORK JEMEZ RIVER (VCNP BOUNDARY TO HEADWATERS)



New Mexico Standards Segment	Jemez River Basin 20.6.4.108
Waterbody Identifier	East Fork Jemez River (VCNP boundary to headwaters) NM-2106.A_10 (formerly NM-MRG2-30000)
Segment Length	8.66 miles
Parameters of Concern	Temperature
Uses Affected	High Quality Coldwater Aquatic Life
Geographic Location	Jemez USGS Hydrologic Unit Code 13020202
Scope/size of Watershed	67 mi^2
Land Type	Southern Rockies Ecoregion (21)
Land Use/Cover	Evergreen forest (50%), Grassland (40%), Shrubland (9%), Deciduous and Mixed forest (<1%)
Identified Sources	Natural sources, other recreational pollution sources, rangeland grazing, silviculture harvesting, streambank modifications/destabilization, upstream impoundments (e.g., PI-566 NRCS structures), wildlife other than waterfowl.
Land Management	Valles Caldera National Preserve (98%), U.S. Forest Service (1.3%), Private (<1%), National Park Service (<1%)
Priority Ranking	High
TMDL for: Temperature	**WLA (0) + LA (113) + MOS (13.0) =126 j/m^2/sec/day**

TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE AND TURBIDITY JARAMILLO CREEK (VCNP BOUNDARY TO HEADWATERS)



New Mexico Standards Segment	Jemez River Basin 20.6.4.108
Waterbody Identifier	Jaramillo Creek (VCNP boundary to headwaters) NM-2106.A_12 (formerly NM-MRG2-30200)
Segment Length	10 miles
Parameters of Concern	Temperature, turbidity
Uses Affected	High Quality Coldwater Aquatic Life
Geographic Location	Jemez USGS Hydrologic Unit Code 13020202
Scope/size of Watershed	15 mi^2
Land Type	Southern Rockies Ecoregion (21)
Land Use/Cover	Evergreen forest (51%), Grassland (35%), Shrubland (13%), Deciduous forest (<1%)
Identified Sources	Highway/road/bridge runoff (non-construction related), natural sources, rangeland grazing, streambank modifications/destabilization, wildlife other than waterfowl.
Land Management	Valles Caldera National Preserve (100%)
Priority Ranking	High
TMDL for:	
Temperature	**WLA (0) + LA (94.7) + MOS (10.3) =105 j/m^2/sec/day**
Turbidity	**WLA (0) + LA (69.7) + MOS (23.2) =92.9 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 standards including consideration of existing pollutant loads and reasonably foreseeable increases in pollutant loads*" (USEPA 1999). A TMDL documents the amount of a pollutant a waterbody can assimilate without violating a state's water quality standards. It also allocates that load capacity to known point sources and nonpoint sources at a given flow. TMDLs are defined in 40 Code of Federal Regulations (CFR) Part 130 as the sum of the individual Waste Load Allocations (WLAs) for point sources and Load Allocations (LAs) for nonpoint sources and natural background conditions, and includes a margin of safety (MOS). This document provides TMDLs for assessment units within the Valles Caldera National Preserve (VCNP) 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 VCNP basin, 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 VCNP basin in 2001 - 2002. Section 3.0 provides detailed descriptions of the individual watersheds for which TMDLs were developed. Section 4.0 presents the TMDLs developed for temperature in the VCNP basin. Section 5.0 provides turbidity TMDLs. Pursuant to Section 106(e)(1) of the Federal CWA, Section 6.0 provides a monitoring plan in which methods, systems, and procedures for data collection and analysis are discussed. Section 7.0 discusses implementation of TMDLs (phase two) and the relationship between TMDLs and Watershed Restoration Action Strategies (WRASs). Section 8.0 discusses assurance, section 9.0 describes public participation in the TMDL process, and Section 10.0 provides references.

2.0 VALLES CALDERA BACKGROUND

The VCNP basin was intensively sampled by the Surface Water Quality Bureau (SWQB) from May 2001 through April 2002 and is addressed in this document. The Valles Caldera Basin includes portions of seven streams from the VCNP boundary to their respective headwaters. Surface water quality monitoring stations were selected to characterize water quality of the stream reaches. Assessment units that will have a TMDL prepared in this document are discussed in their respective individual watershed sections. The dissolved oxygen and pH impairments will remain on the Integrated CWA §303(d)/§305(b) List of Assessed Surface Waters (NMED/SWQB 2004) until additional data are available

2.1 Location Description

The Jemez watershed (US Geological Survey [USGS] Hydrologic Unit Code [HUC] 130020202) is located in northern New Mexico (NM). The entire Valles Caldera basin encompasses approximately 138 square miles (mi^2) in Sandoval County. The VCNP bain consists of seven assessment units on the following streams: East Fork Jemez, Jaramillo Creek, La Jara Creek, Redondo Creek, Rito de los Indios, San Antonio Creek, and Sulphur Creek. As presented in Figure 2.1, land use is 60% evergreen forest, 29% grassland, 9% shrubland, and 1% deciduous/mixed forest. Figure 2.2 shows ownership as 98% VCNP, 1% Forest Service, and less than 1% National Park Service and private.

The Natural Heritage New Mexico Program website (http://nhnm.unm.edu/query_bcd/bcd_watershed_query.php) places 37 plant and animal species within the Jemez watershed. However, none of these species are listed as either threatened or endangered by either State or Federal agencies. These plant species are found within varying terrain, including high elevation sub-alpine forests, mixed conifer, open foothill pine woodlands, high montane grasslands, and wetlands (Muldavin and Tonne 2003). VCNP is one of the most diverse areas in the Southern Rocky Mountains Ecoregion (Muldavin and Tonne 2003). Virgin forests are located in the upper East Fork Jemez and San Antonio Creek watersheds (Muldavin and Tonne 2003). Although the VCNP basin is in relatively good condition, the long-term grazing of both cattle and sheep have impacted the streams within VCNP in terms of a decline in native bunchgrasses and increases in exotic species (Muldavin and Tonne 2003).

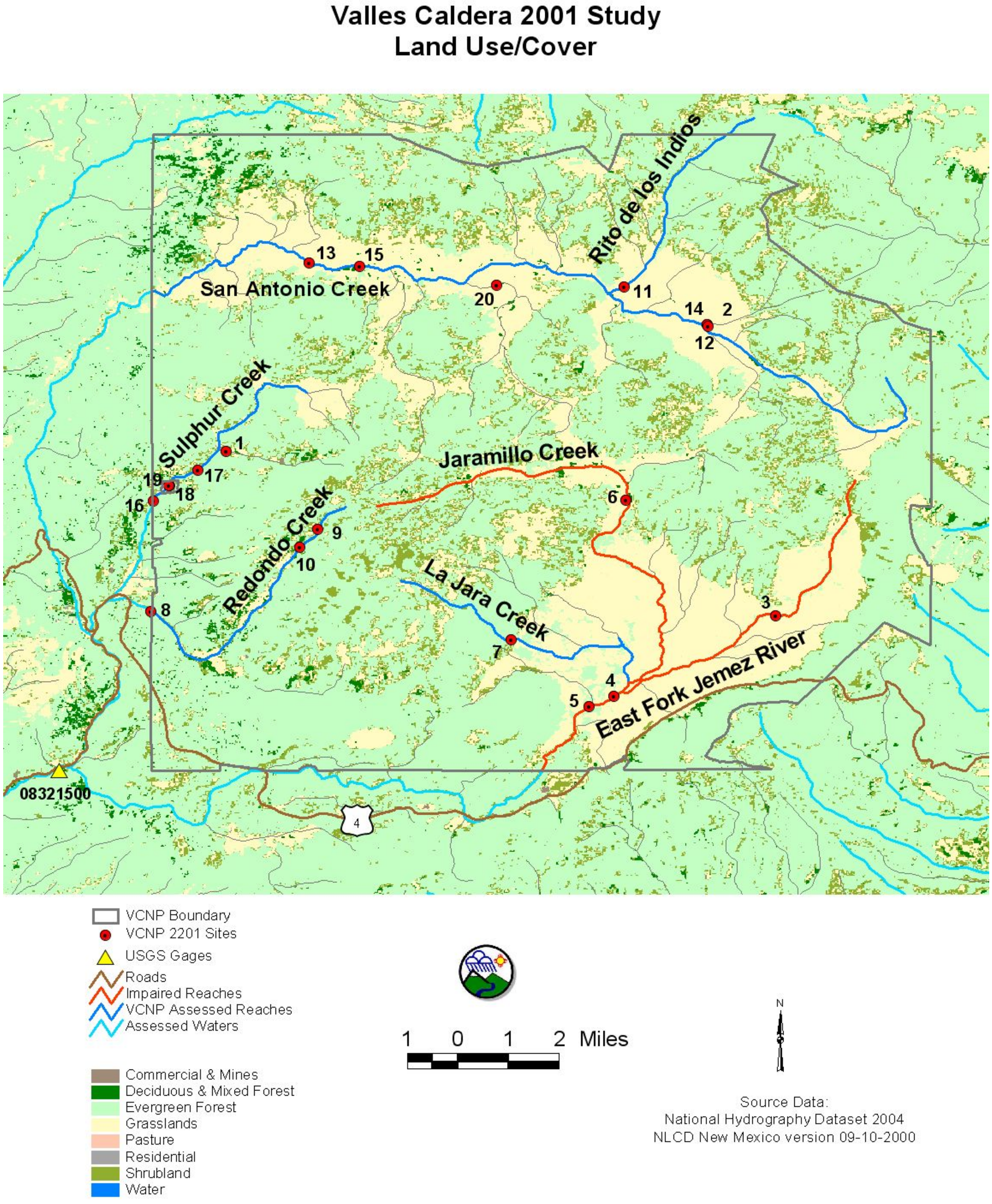


Figure 2.1 Valles Caldera Land Use and 2001 Sampling Stations.

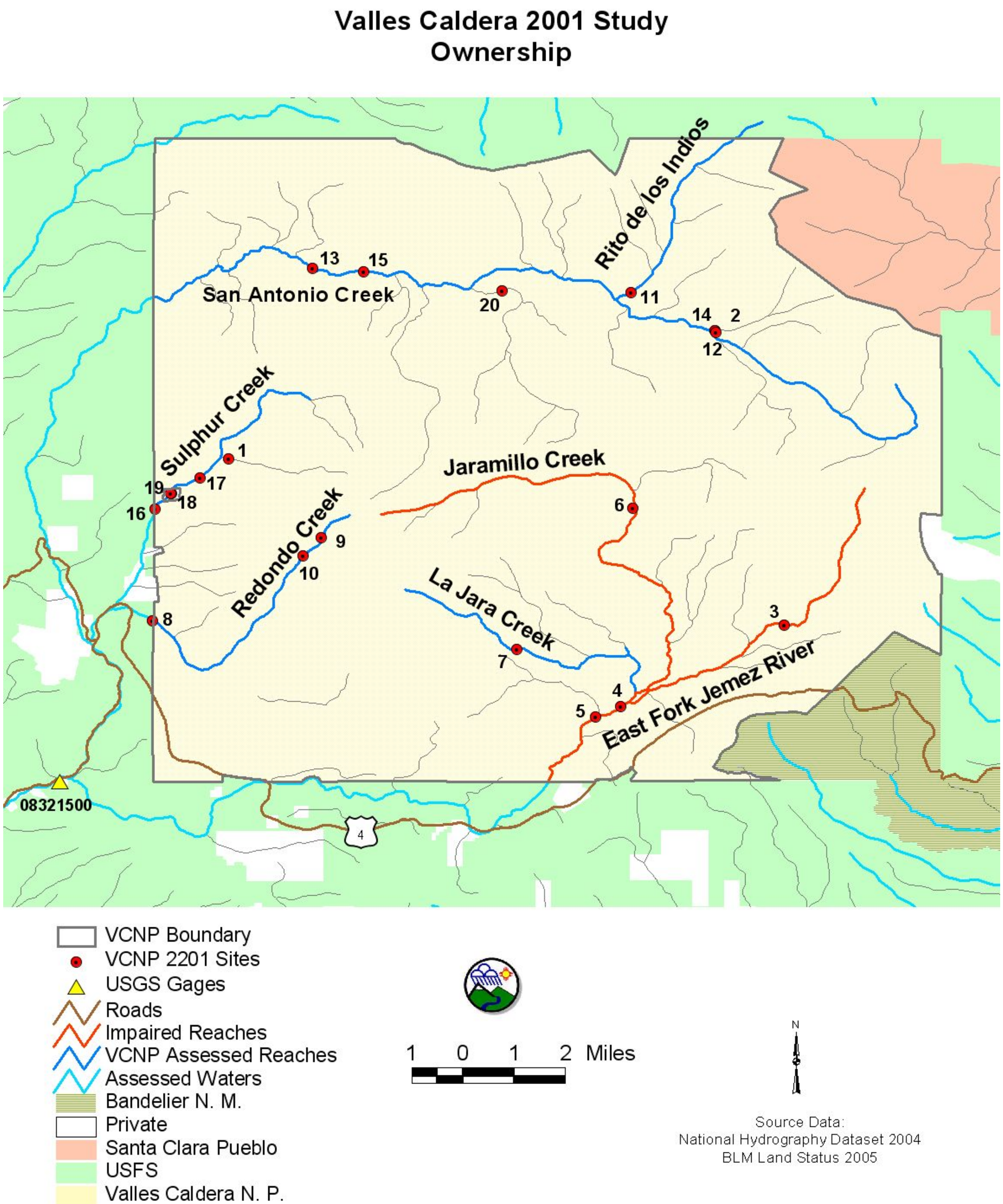


Figure 2.2 Valles Caldera Land Ownership.

2.2 Geology and History

The geology of the VCNP basin consists of a unique and complex distribution of Paleozoic limestone, Quaternary alluvium, and significant Quaternary volcanic deposits (Table 2.1, Figure 2.3). The VCNP is in the Jemez Mountains- a volcanic field overlying the western edge of the Rio Grande Rift. The Jemez Volcano, a composite volcano, had alternating layers of thick lava and ash, resulting from alternating fairly quiet and quite explosive eruptions. It rose above a base of older volcanic rock, which can be seen in the lower gorge of the Frijoles River and reached its maximum height a little more than a million years ago. At its peak, the volcano was likely the shape and size of Mt. St. Helens before its 1980 eruption (Chronic 1987). The 15-mile diameter caldera was formed one million years ago when an eruption of ash caused the volcanic pile to collapse (NMED/SWQB 2006a). The great dome of Redondo Peak, which formed by resurgence of the floor of the caldera soon after the great collapse, is at the center of the caldera (Chronic 1987). The rhyolites were vented from a series of temporally and spatially separated magma chambers (Spell *et al*. 1993). Magma continued to rise and form domes along the caldera ring fracture. The caldera was formerly a closed basin that formed a high altitude lake. The walls of this lake eventually were breached and the drained lake exposed the long accumulated sediments (NMED/SWQB 2006a). The Bandelier Tuff exists in three layers east and west of Jemez Springs; the thick layers of ash were deposited on an irregular surface full of valleys and ridges (Chronic 1987). The red Abo Formation differs from most other Paleozoic formations in New Mexico- the Abo is continental and was deposited on land rather than in the sea (Chronic 1987). Its red color comes from oxidized iron. The Jemez Mountains contain a number of active hot springs resulting from groundwater flow above a subsurface body of partially molten igneous rock. The entire area of geothermal activity in the VCNP is estimated to be 12-15 square miles. The geothermal reservoir is recharged by rainwater that moves down through the aquifers to a depth of 6,500 feet at temperatures reaching 330ºC (USGS 2000).

Redondo Peak is sacred to the native people of the area (Muldavin and Tonne 2003). Throughout the 1700’s and 1800’s, Basque colonists in New Mexico supported a thriving sheep grazing industry, including areas within the VCNP. Under the Land Grant Treaty of Guadalupe Hidalgo of 1821, the Luis Maria Cabeza de Baca family was awarded much of what is now the VCNP (NMED/SWQB 2006a). Sheep grazing was phased out in the early 1900’s in favor of Anglo cattle grazing and logging. The Dunigan family of Abilene, Texas bought the Baca Grant. The Dunigans on the Baca Ranch leased grazing, drilled wells to explore the geothermal potential, and clashed with the New Mexico Timer Company over timber issues (NMED/SWQB 2006a).

After two years of negotiations, the White House reached an agreement in 1999 to buy the 89,000-acre Baca Ranch to permanently protect the area as Valles Caldera National Preserve per the Valles Caldera Preservation Act. A nine member Board of Trustees is responsible for the protection and development of this unique experiment in land management (NMED/SWQB 2006a).

Table 2.1 Geologic Unit Definitions for the Valles Caldera

Geologic Unit Code	Definition
&m	Madera Formation (Limestone or Group)
Pa	Permian Abo Formation; red beds, arkosic at base, finer and more mature above.
Qa	Upper and middle Quaternary alluvium.
Qbt	Bandelier Tuff; Jemez Mountains area only.
Qp	Basalt and andesite flows and locally vent deposits.
Qr	Silicic volcanic rocks.
Qvr	Valles Rhyolite; Jemez Mountains area only.
TKi	Paleogene and Upper Cretaceous intrusive rocks.
Tnr	Silicic to intermediate volcanic rocks; mainly quartz latite and rhyolite Neogene.
Tnv	Neogene volcanic rocks; primarily in Jemez Mountains.
Tsf	Lower and Middle Santa Fe Group.

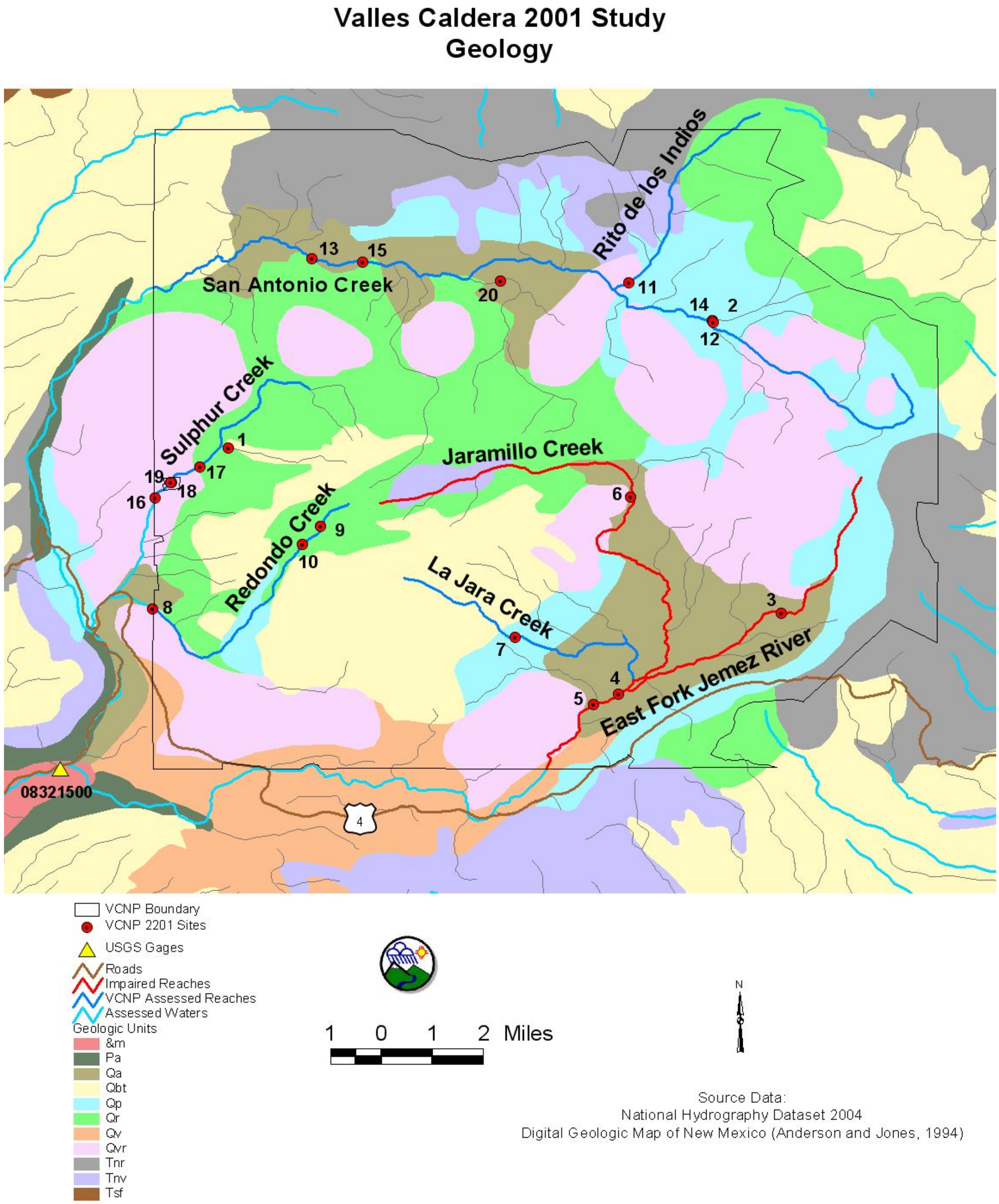


Figure 2.3 Valles Caldera Geology

2.3 Water Quality Standards

Water quality standards (WQS) for all assessment units in this document are set forth in sections 20.6.4.108 and 20.6.4.124 of the *NM Standards for Interstate and Intrastate Surface Waters* (NM Administrative Code [NMAC] 20.6.4) (NMAC 2005).

20.6.4.108 **RIO GRANDE BASIN -** Perennial reaches of the Jemez river and all its tributaries above Soda dam near the town of Jemez Springs, except Sulphur creek about its confluence with Redondo creek, and perennial reaches of the Guadalupe river and all its tributaries.

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

B. Criteria:

(1) In any single sample: specific conductance 400 µmhos/cm or less, pH within the range of 6.6 to 8.8 and temperature 20°C (68°F) or less. 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 E. coli bacteria 126/100 mL or less; single sample 235/100 mL or less (see Subsection B of 20.6.4.14 NMAC).

20.6.4.124 **RIO GRANDE BASIN -** Perennial reaches of Sulphur creek from its headwaters to its confluence with Redondo creek.

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

B. Criteria:

(1) In any single sample: pH within the range of 2.0 to 9.0 and temperature 30°C (86°F) or less. 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 E. coli bacteria 548/100 mL or less; single sample 2507/100 mL or less (see Subsection B of 20.6.4.14 NMAC).

(3) The chronic aquatic life criteria of Subsections I and J of 20.6.4.900 NMAC shall also apply.

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 20.6.4.13 lists general standards that apply to all surface waters of the state at all times, unless a specified standard is provided elsewhere in NMAC (2005).

2.4 Intensive Water Quality Sampling

The VCNP basin was intensively sampled by the SWQB in 2001-2002. 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 May-October 2001 and March-April 2002 for the intensive SWQB study. Temperature data also were collected in 2001. 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 2001 thermograph deployment in the VCNP basin are described in Section 4.0 (Table 4.1 and Figure 4.1). 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 has been prepared for this study (NMED/SWQB 2006a). VCNP also staff deployed sondes and collected grab samples April-November 2005.

Table 2.2 SWQB 2001 Valles Caldera Sampling Stations

Station	Station Location
1	Alamo Canyon above Sulphur Creek
2	Artesian well on San Antonio Creek
3	East Fork Jemez above Jaramillo Creek
4	East Fork Jemez below La Jara Creek
5	East Fork Jemez blw unnamed drainage sw of hq
6	Jaramillo above Cerro Pinon @ Rd B
7	La Jara above headquarters. VCNP #15
8	Redondo Creek above VCNP boundary
9	Redondo Creek above steam wells
10	Redondo Creek below steam wells
11	Rito de los Indios above San Antonio Creek
12	San Antonio Creek above artesian well
13	San Antonio Creek below warm springs
14	San Antonio below Artisian Well
15	San Antonio warm springs
16	Sulphur Creek above VCNP boundary
17	Sulphur Creek below Alamo Canyon
18	Sulphur Springs
19	Sulphur pond
20	Valle Santa Rosa above San Antonio Creek

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 2006b). As a result of the 2001-2002 and 2005 monitoring efforts and subsequent assessment of results, several surface water impairments were determined.

Accordingly, these impairments were added to New Mexico's 2004-2006 Integrated CWA §303(d)/305(b) Report (NMED/SWQB 2004).

2.4.2 Hydrologic Conditions

There are no USGS gaging stations within the VCNP. The nearest USGS gaging station, Jemez River below East Fork near Jemez Springs (08321500), has a period of record from 1951-1990 and a daily mean streamflow of 33 cubic feet per second (cfs). Since USGS Gage 08321500 has been discontinued, the real-time, daily mean streamflow was not measured. The mean daily streamflow for the nearest, active gage is displayed in Figure 2.4.

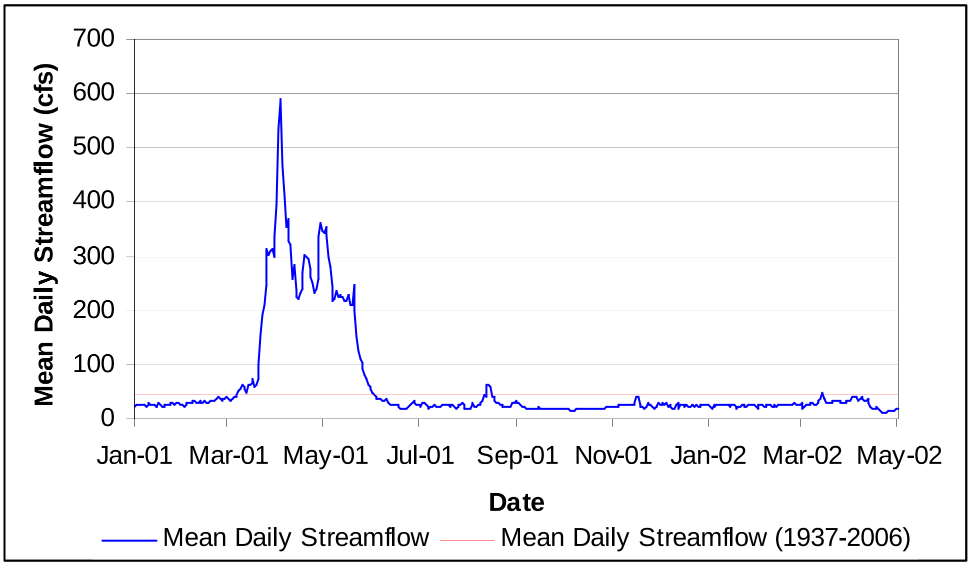


Figure 2.4 Daily Mean Streamflow: USGS 08324000 Jemez River near Jemez, NM

Flows in the Jemez River (USGS Gage 08324000) during the 2001-2002 survey years were below average based on the period of record that spans from 1937 to present. Instantaneous discharge was measured by SWQB during the intensive survey in all of the assessment units except for Sulphur Creek. Values ranged from 17 cfs on East Fork Jemez in May 2001 to less than one cfs on all assessment units at least once during the intensive survey. As stated in the Assessment Protocol (NMED/SWQB 2006b), data collected during all flow conditions, including low flow conditions (i.e., flows below the 4-day, 3-year low-flow frequency [4Q3]), will be used to determine 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 2001-2002 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 VCNP. In addition, the 2004-2006 Integrated CWA §303(d)/§305(b) listings within the VCNP are discussed (NMED/SWQB 2004).

There are seven assessment units included in the 2001 survey of the VCNP. Based on land management changes at the VCNP boundary the SWQB decided the assessment units should be broken at the VCNP boundary. This change affected three of the assessment units: East Fork Jemez, Redondo Creek, and San Antonio Creek. This document includes the updated assessment unit names. Also, TMDLs were written in 2003 (based on data collected in 1998-1999) for a number of reaches included in the 2001 VCNP survey, including: East Fork Jemez (turbidity), Redondo Creek (temperature and turbidity), San Antonio Creek (temperature and turbidity), and Sulphur Creek (pH and conductivity). Many of these same reaches were found to be impaired based on the 2001 survey by the parameters for which TMDLs were written in prior to the survey. In these cases, new TMDLs were not included in this document. Additionally, a few assessment units are impaired by pH and dissolved oxygen. The completion of a nutrient TMDL for these reaches, if necessary, is pending until a full nutrient assessment is completed and area-specific criteria are developed.

3.1 East Fork Jemez Subwatershed

The headwaters of the 44 mi^2 East Fork Jemez subwatershed originates in the Jemez Mountains. According to available Geographic Information System (GIS) coverages, the East Fork Jemez watershed (within VCNP boundary) has an average elevation of 8911 feet above sea level and receives an average of 12.58 inches of winter precipitation a year. As presented in Figure 2.1, land uses include 50% evergreen forest, 41% grassland, 9% shrubland, and less than 1% of the land use in this watershed is deciduous forest. Land ownership is 98% VCNP, 1.3% Forest Service, and less than 1% is National Park Service and private (Figure 2.2). The geology of the East Fork Jemez watershed is predominantly comprised of Quaternary alluvium and Madera Limestone along with various volcanics, including Valles Rhyolite, silicic volcanics, basalt, and andesite (Figure 2.3).

East Fork Jemez (VCNP boundary to headwaters) is approximately 9 miles in length. SWQB established three stations along this assessment unit and deployed one thermograph (Figure 4.1) during the 2001-2002 intensive survey. Jemez River (East Fork) was included on the 2004-2006 Integrated CWA §303(d)/§305(b) list for aluminum, dissolved oxygen, pH, temperature, and turbidity. TMDLs have previously been written for turbidity. Aluminum is naturally occurring in this watershed and will not receive a TMDL. Dissolved oxygen and pH were found to be impairments for this assessment unit based on the 2001-2002 survey, but a TMDL will not be written until a full nutrient assessment is completed. The designated use of high quality coldwater aquatic life is not supported, but the designated uses of domestic water supply, fish culture, irrigation, livestock watering, secondary contact, and wildlife habitat are supported. Due to a significant management change as well as the constraints of the existing TMDLs, the East

Fork Jemez has been divided into two discrete assessment units that break at the VCNP boundary. TMDLs were developed for inclusion in this document for the following assessment unit in the East Fork Jemez subwatershed:

- ***Temperature*:** East Fork Jemez (VCNP boundary to headwaters)

Photo 3.1 East Fork Jemez below unnamed drainage (2001)

3.2 Jaramillo Creek Subwatershed

Jaramillo Creek originates in the Jemez Mountains. The Jaramillo Creek watershed is approximately 15 mi^2 and is a tributary to East Fork Jemez, which then joins the Jemez River. As presented in Figure 2.1, land use is 51% evergreen forest, 35% grassland, 13% shrubland, and less than 1% deciduous forest. Land ownership is 100% VCNP (Figure 2.2). The geology of the Jaramillo Creek watershed consists of Quaternary allumvium and numerous volcanics, including Valles Rhyloite and Neogene volcanics (Figure 2.3).

Jaramillo Creek (East Fork Jemez to headwaters) is approximately 10 miles in length. One station was established (Table 2.2, Figure 2.2) and one thermograph was deployed (Figure 4.1) in this assessment unit during the 2001-2002 intensive survey. Jaramillo Creek (East Fork Jemez to headwaters) was listed on the 2004-2006 Integrated CWA §303(d)/305(b) List of Assessed Surface Waters (NMED/SWQB 2004) for aluminum, temperature, and turbidity. No TMDLs have previously been prepared for this assessment unit. Aluminum is naturally occurring in this watershed and will not receive a TMDL. Dissolved oxygen was found to be an impairment for this assessment unit based on the 2001-2002 survey, but a TMDL will not be written until a full nutrient assessment is completed. The designated use of high quality coldwater aquatic life is not supported, but the designated uses of domestic water supply, fish culture, irrigation, livestock watering, secondary contact, and wildlife habitat are supported. The following TMDLs were developed for this watershed:

- ***Temperature and Turbidity-*** Jaramillo Creek (East Fork Jemez to headwaters)

Photo 3.2 Jaramillo Creek geomorphological survey (June 2001)

4.0 TEMPERATURE

Monitoring for temperature was conducted by SWQB in 2001. Based on available data, several exceedences of the New Mexico WQS for temperature were noted throughout the watershed (Figure 4.1). Thermographs were set to record once every hour for several months during the warmest time of the year (generally May through October). Thermograph data are assessed using Appendix C of the *State of New Mexico Procedures for Assessing Standards Attainment for the Integrated CWA §303(d)/§305(b) Water Quality Monitoring and Assessment Report* (NMED/SWQB 2006b). Based on 2001 data, temperature listings were added to the *2002-2004 State of NM §303(d) List for Impaired Waters* (NMED/SWQB 2002) for Jaramillo Creek (East Fork Jemez to headwaters) and East Fork Jemez (VCNP boundary to headwaters). These impairments listings have remained on subsequent §303(d) lists awaiting TMDL development. Temperature data from 2001-2002 were used to develop these TMDLs.

4.1 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 (HQCW) aquatic life (20.6.4.900.C NMAC). These WQS have been set at a level to protect coldwater aquatic life such as trout. The HQCW aquatic life 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 4.1 and Figure 4.1 highlight the 2001 thermograph deployments. VCNP staff deployed sondes that are also highlighted in Table 4.1 and Figure 4.1. The following TMDL addresses two reaches where temperatures exceeded the criterion (**Appendix C** of this document provides a graphical representation of thermograph data):

> *East Fork Jemez:* One thermograph was deployed on this reach in 2001 at East Fork Jemez below La Jara (site 1). Recorded temperatures from May 8 (16:26) through October 30 (13:26) exceeded the HQCW aquatic life use criterion 730 of 4,198 times (17%) with a maximum temperature of 28.27°C on July 6. One thermograph was deployed by the U.S. Forest Service (USFS) from June 14-October 2, 2001 at the VCNP boundary that recorded temperatures every four hours with a maximum daily temperature of 24.51ºC (July 4).
>
> *Jaramillo Creek (East Fork Jemez to headwaters):* One thermograph was deployed on this reach in 2001 at Jaramillo Creek above Cerro Piñon (site 2). Recorded temperatures from May 30 (16:00) through October 29 (13:40) exceeded the HQCW aquatic life use criterion 297 of 3,647 times (8%) with a maximum temperature of 26.09°C on July 7.

Table 4.1 Valles Caldera Thermograph (SWQB) and Sonde (VCNP) Sites

Site Number	Site Name	Deployment Dates
	SWQB sites[1]	**2001**
1	East Fork Jemez below La Jara	5/8-10/30
2	Jaramillo Creek above Cerro Pinon	5/30-10/29
3	Redondo Creek above VCNP boundary	5/9-10-30
4	Rito de los Indios above San Antonio Creek	5/8-10/30
5	San Antonio Creek below warm springs	5/8-10/30
	VCNP sites [2]	**2005**
a	East Fork Jemez in Valle Grande	4/29-11/16
b	Redondo Creek above VCNP boundary	Dates pending
c	Rito de los Indios above San Antonio Creek	6/11-11/16
d	San Antonio Creek leaving Valle Toledo	6/1-11/16
e	San Antonio Creek above VCNP boundary	5/18-11/16

[1] *SWQB deployed thermographs in 2001*
[2] *VCNP deployed sondes in 2005*

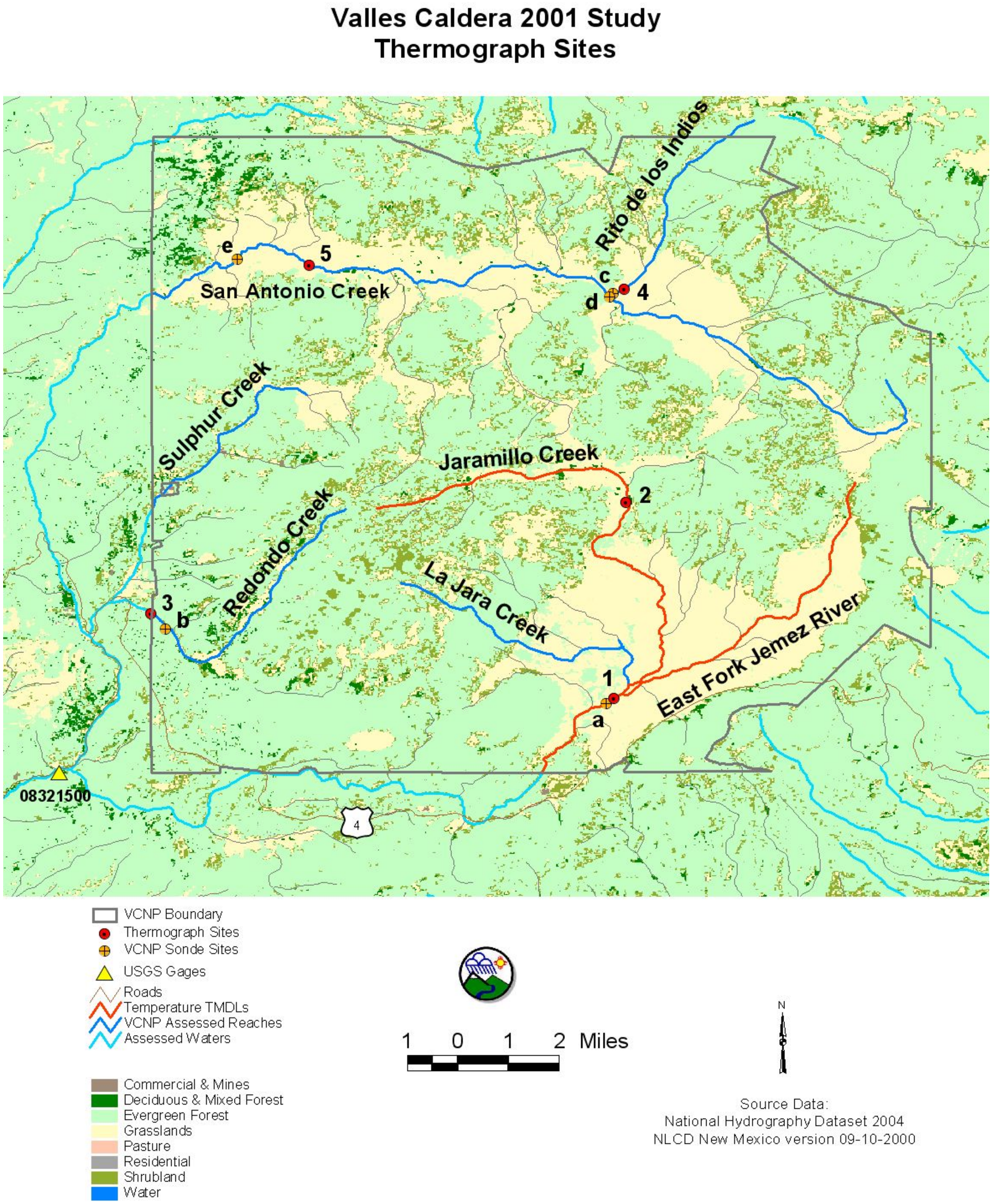


Figure 4.1 Valles Caldera thermograph sites

4.2 Calculations

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

4.3 Waste Load Allocations and Load Allocations

4.3.1 Waste Load Allocation

There are no active point source contributions associated with these TMDLs. The WLA is zero.

4.3.2 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.

Description of Logic:
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 D** 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 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 2005). See **Appendix D** 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:

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

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.

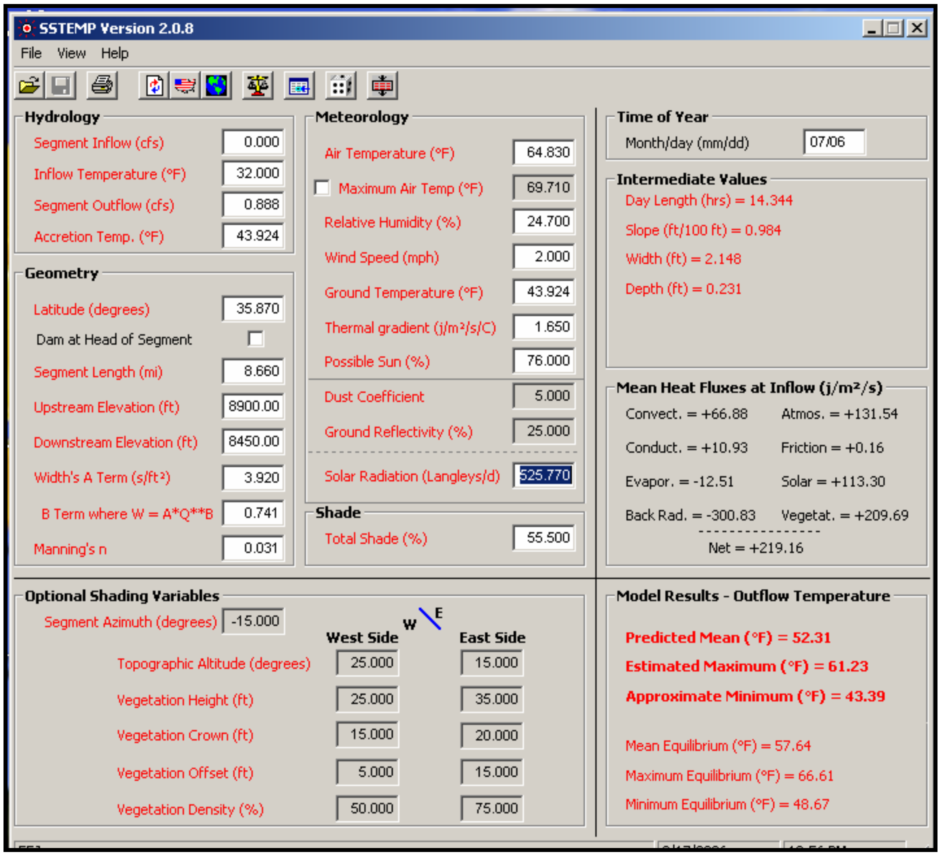


Figure 4.2 Example of SSTEMP input and output for East Fork Jemez

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.

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

Table 4.2 details model run outputs for segments on East Fork Jemez and Jaramillo Creek. 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 East Fork Jemez (VCNP boundary to headwaters)

For East Fork Jemez (VCNP boundary to headwaters), the WQS for temperature is achieved when the percent total shade is increased to 50.5%. According to the SSTEMP model, the actual LA of 113.43 j/m^2/s is achieved when the shade is further increased to 55.5% (Table 4.2).

Table 4.2 SSTEMP Model Results for East Fork Jemez (VCNP boundary to headwaters)

<table>
<tr><th>Rosgen Channel Type</th><th>WQS (HQCW Aquatic Life)</th><th>Model Run Dates</th><th>Segment Length (miles)</th><th>Solar Radiation Component per 24-Hours (+/-)</th><th>% Total Shade</th><th>Width's A Term</th><th>Modeled Temperature °C (24 hour)</th></tr>
<tr><td>E4</td><td>20°C (68°F)</td><td>7/6/01</td><td>8.66</td><td>Current Field Condition
+254.60
j/m^2/s</td><td>0</td><td>3.92</td><td>Minimum: 11.27
Mean: 19.05
Maximum: 26.83</td></tr>
<tr><td colspan="4" rowspan="3">TEMPERATURE ALLOCATIONS FOR East Fork Jemez
(VCNP boundary to headwaters)

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

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

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

Current Condition – Load Allocation =

254.60 j/m^2/s – 113.43 j/m^2/s

=141.17 j/m^2/s</td><td>Run 1
+229.14
j/m^2/s</td><td>10</td><td>3.92</td><td>Minimum: 10.86
Mean: 18.23
Maximum: 25.61</td></tr>
<tr><td>Run 2
+126.03 [(a)]
j/m^2/s</td><td>50.5</td><td>3.92</td><td>Minimum: 9.41
Mean: 14.71
Maximum: 20.00</td></tr>
<tr><td>Actual LA
113.43 [(b)]
j/m^2/s</td><td>55.5</td><td>3.92</td><td>Minimum: 9.26
Mean: 14.24
Maximum: 19.23</td></tr>
</table>

Temperature Load Allocation for Jaramillo Creek (East Fork Jemez to headwaters)

For Jaramillo Creek (East Fork Jemez to headwaters), the WQS for temperature is achieved when the percent total shade is increased to 60%. According to the SSTEMP model, the actual LA of 94.67 j/m^2/s is achieved when the shade is further increased to 64% (Table 4.3).

Table 4.3 SSTEMP Model Results for Jaramillo Creek (East Fork Jemez to headwaters)

<table>
<tr><th>Rosgen Channel Type</th><th>WQS (HQCW Aquatic Life)</th><th>Model Run Dates</th><th>Segment Length (miles)</th><th>Solar Radiation Component per 24-Hours (+/-)</th><th>% Total Shade</th><th>Width's A Term</th><th>Modeled Temperature °C (24 hour)</th></tr>
<tr><td>E4</td><td>20°C (68°F)</td><td>7/7/01</td><td>10.01</td><td>Current Field Condition
+262.97 j/m^2/s</td><td>0</td><td>3.26</td><td>Minimum: 12.59
Mean: 20.77
Maximum: 28.95</td></tr>
<tr><td colspan="4" rowspan="3">TEMPERATURE ALLOCATIONS FOR Jaramillo Creek
(East Fork Jemez to headwaters)

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

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

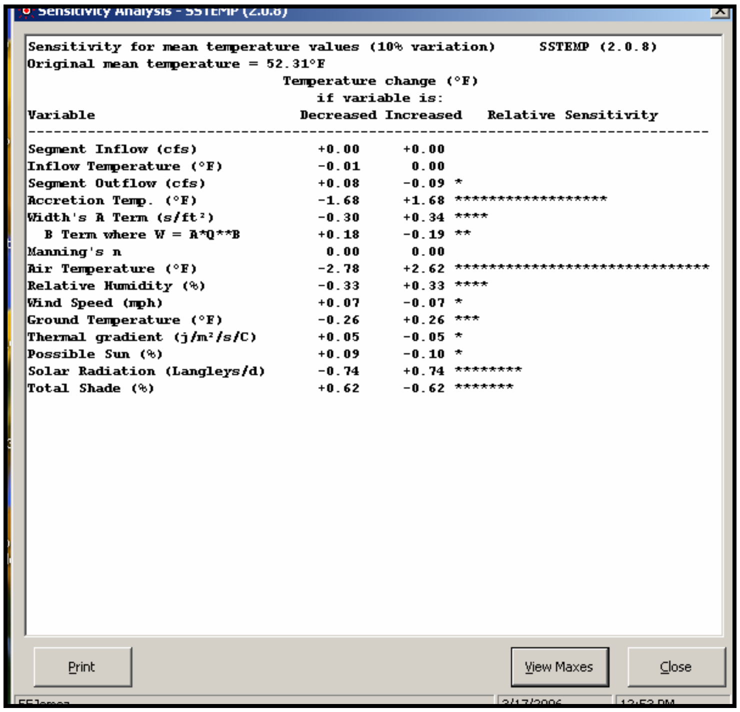
Actual reduction in solar radiation necessary to meet surface WQS for temperature:

Current Condition – Load Allocation =

262.97 j/m^2/s – 94.67 j/m^2/s

=168.30 j/m^2/s</td><td>Run 1
+236.67 j/m^2/s</td><td>10</td><td>3.26</td><td>Minimum: 12.11
Mean: 19.87
Maximum: 27.64</td></tr>
<tr><td>Run 2
+105.19 (a)
j/m^2/s</td><td>60</td><td>3.26</td><td>Minimum: 9.98
Mean: 14.95
Maximum: 19.92</td></tr>
<tr><td>Actual LA
94.67 (b)
j/m^2/s</td><td>64</td><td>3.26</td><td>Minimum: 9.84
Mean: 14.52
Maximum: 19.2</td></tr>
</table>

According to the Sensitivity Analysis feature of the model runs (Figure 4.3), 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. There were no air thermograph data available from the VCNP 2001-2002 survey in order to display the relationship between air and water temperatures. Ordinarily, the figures would show a greater diurnal swing in impaired reaches as compared to those in an unimpaired reach.



Sensitivity Analysis - SSTEMP (2.0.8)

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)
Original mean temperature = 52.31°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	+0.00	+0.00	
Inflow Temperature (°F)	-0.01	0.00	
Segment Outflow (cfs)	+0.08	-0.09	*
Accretion Temp. (°F)	-1.68	+1.68	******************
Width's A Term (s/ft²)	-0.30	+0.34	****
B Term where W = A*Q**B	+0.18	-0.19	**
Manning's n	0.00	0.00	
Air Temperature (°F)	-2.78	+2.62	******************************
Relative Humidity (%)	-0.33	+0.33	****
Wind Speed (mph)	+0.07	-0.07	*
Ground Temperature (°F)	-0.26	+0.26	***
Thermal gradient (j/m²/s/C)	+0.05	-0.05	*
Possible Sun (%)	+0.09	-0.10	*
Solar Radiation (Langleys/d)	-0.74	+0.74	********
Total Shade (%)	+0.62	-0.62	*******

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Figure 4.3 Example of SSTEMP sensitivity analysis for East Fork Jemez

The estimate of total shade used in the model calibration was based on densiometer readings (field notes) and examination of aerial photographs (see **Appendix D**). Target loads as determined by the modeling runs are summarized in Tables 4.2 and 4.3. The MOS is estimated to be 10% of the target load calculated by the modeling runs. Results are summarized in Table 4.4. Additional details on the MOS are presented in Section 4.7 below.

Table 4.4 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 ($j/m^2/s$)
East Fork Jemez (VCNP boundary to headwaters)	0	113*	13.0*	126*
Jaramillo Creek (East Fork Jemez to headwaters)	0	94.7*	10.3*	105*

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 4.2 and 4.3), and are shown in Table 4.5.

Table 4.5 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)
East Fork Jemez (VCNP boundary to headwaters)	113*	255*	142*	56
Jaramillo Creek (East Fork Jemez to headwaters)	94.7*	263*	168*	64

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

4.4 Identification and Description of pollutant source(s)

Pollutant sources that could contribute to each segment are listed in Table 4.6.

Table 4.6 Pollutant source summary for Temperature

Pollutant Sources	Magnitude[(a)]	Location	Potential Sources[(b)] (% from each)
Point:			
None	0	--------	0%
Nonpoint:			
	255	East Fork Jemez	100% Natural Sources, other recreational pollution sources, rangeland grazing, silviculture harvesting, streambank modifications/destabilization, upstream impoundments (e.g. PI-566 NRCS structures), wildlife other than waterfowl.
	263	Jaramillo Creek	100% Highway/road/bridge runoff (non-construction related), natural sources, rangeland grazing, streambank modifications/destabilization, wildlife other than waterfowl.

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

4.5 Linkage of Water Quality and Pollutant Sources

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

Temperature increases, as observed in SWQB thermograph data, show temperatures that exceed the State Standards for the protection of aquatic habitat, namely the HQCW aquatic life designated 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 4.4). 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 VCNP bain 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 B** 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 4.6 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.

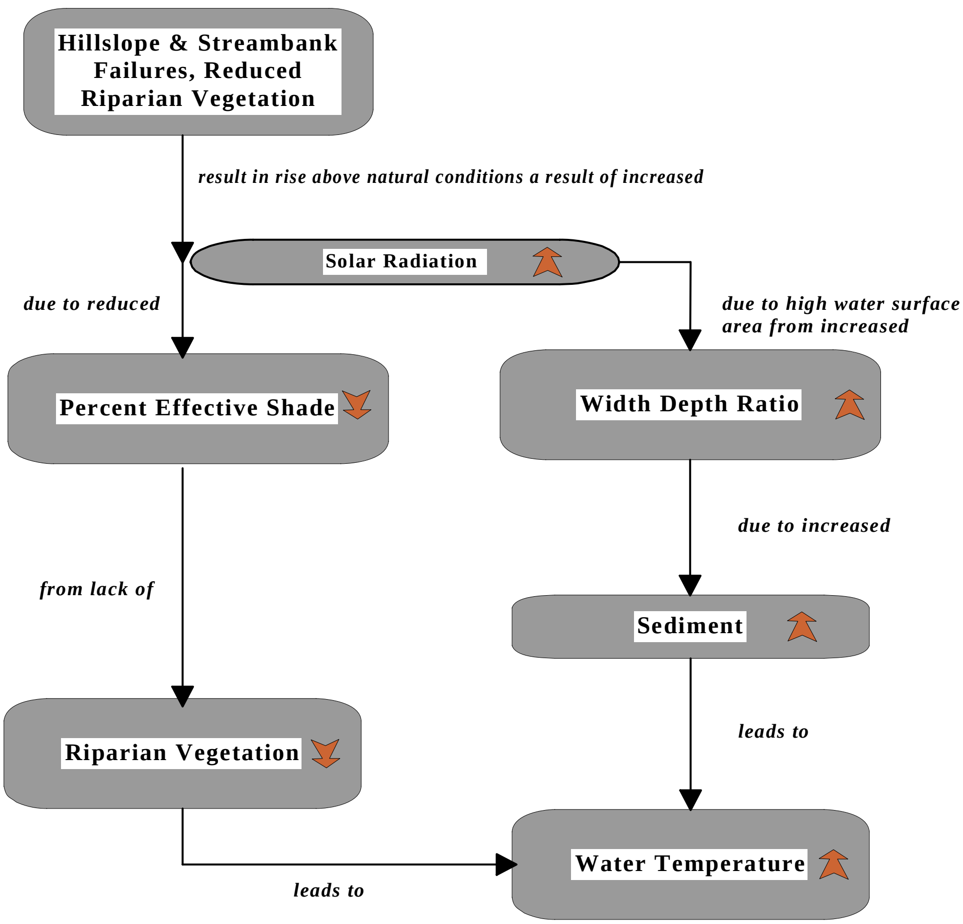

Figure 4.4 Factors That Impact Water Temperature

4.6 Margin of Safety (MOS)

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

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

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

- Data from the warmest time of the year were used in order to capture the seasonality of temperature exceedences.
- Critical upstream and downstream low flows were used because assimilative capacity of the stream to absorb and disperse solar heat is decreased during these flow conditions.
- Low flow was modeled using formulas developed by the USGS. One formula (Thomas et al. 1997) is recommended when the ratio between the gaged watershed area and the ungaged watershed area is between 0.5 and 1.5. When the ratio is outside of this range, a different regression formula is used (Waltemeyer 2002). See **Appendix D** for details.

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

4.7 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.

4.8 Future Growth

Estimations of future growth are not anticipated to lead to a significant increase for temperature that cannot be controlled with BMP implementation in this watershed. As noted in Sections 3.1 and 3.2 as well as displayed in Figure 2.1, a significant portion (41% East Fork Jemez and 35% Jaramillo) of the assessment units impaired by temperature are grasslands. VCNP staff are experimenting with elk exclosures as well as investigating the extent to which historic riparian shade existed in the VCNP.

5.0 TURBIDITY

During the 2001 - 2002 SWQB intensive water quality survey in the VCNP basin, an exceedence of the New Mexico water quality criteria for turbidity was documented in Jaramillo Creek (East Fork Jemez to headwaters) assessment unit. Based on 2001 data, the turbidity listing was added to the *2002-2004 State of NM §303(d) List of Impaired Waters* (NMED/SWQB 2002) for Jaramillo Creek (East Fork Jemez to headwaters) (see summary in Table 5.1).

5.1 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 WQS (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 segment specific criteria reads:

> *20.6.4.108 NMAC: In any single sample: turbidity shall not exceed 25 NTU.*

The 2005 New Mexico WQS have transitioned from segment 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 2001-2002 VCNP 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 Wastewater Treatment Plants (WWTPs) discharging into Jaramillo Creek, it is assumed that TSS measurements in these ambient stream samples are representative of erosional activities and thus comprised primarily of suspended sediment versus 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 autotroughs to substrate surfaces."

TSS and turbidity were measured in Jaramillo Creek during the 2001-2002 survey (Table 5.1). The TSS target was derived using a regression equation developed using measured turbidity as the independent variable and measured TSS as the dependent variable. The equation and regression statistics are displayed below in Figure 5.1. A correlation of $r^2 = 0.32$ was found between TSS and turbidity for Jaramillo Creek.

Table 5.1 TSS, turbidity, and flow data for Jaramillo Creek (East Fork Jemez to headwaters).

Sample Date	TSS (mg/L)	Turbidity (NTU)	Discharge (cfs) [(a)]
Jaramillo Creek above Cerro Piñon @ Rd B (site #6)			
5/9/01	4	15.6	7.993
5/15/01	4	11.8	n/a
5/23/01	8	13.6	n/a
5/30/01	3	13.2	n/a
6/14/01	3	18	0.87
6/26/01	16	44.2*	n/a
7/18/01	4	37.1*	0.717
8/8/01	3.5	13.8	n/a
8/27/01	8	28.3*	n/a
9/4/01	3	13.4	1.44
10/10/01	12	13.2	n/a
10/30/01	3	7.8	0.51
3/20/02	25	32.2*	n/a
3/26/02	5	21.8	n/a
4/10/02	9	14.7	n/a
4/24/02	3	13.5	0.1

Notes:
*Exceedence of appropriate turbidity water quality criterion.
(a) discharge measurements taken within a day of water quality samples
NTU = Nephelometric turbidity units

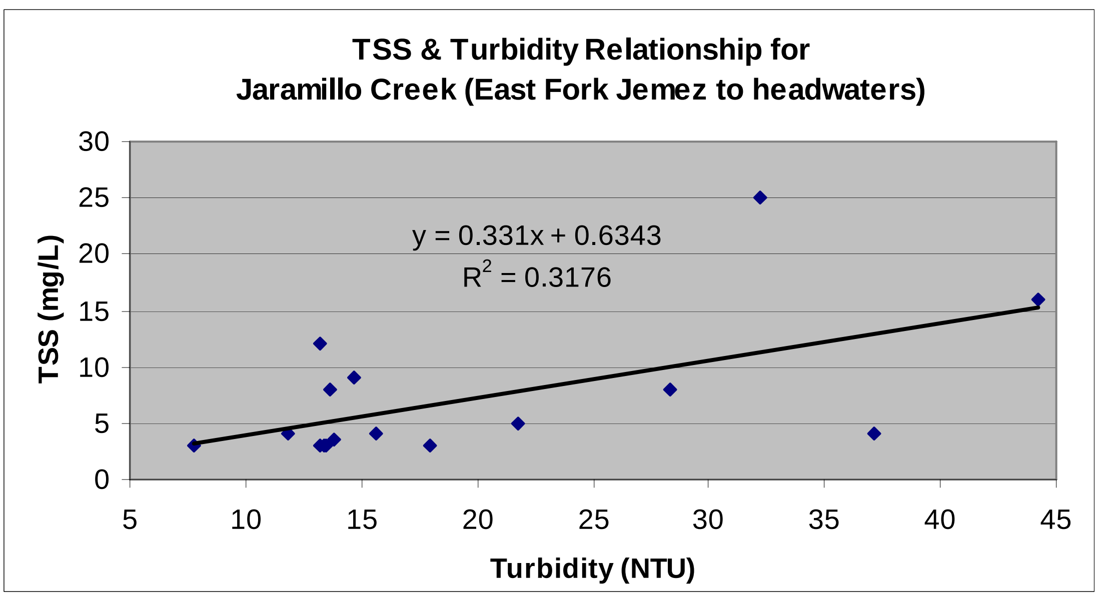

Figure 5.1 Relationship between TSS and Turbidity at Jaramillo Creek (East Fork Jemez to headwaters).

5.2 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 2001-2002 sampling runs using standard USGS procedures (NMED/SWQB 2001). Table 5.1 shows the dates of turbidity exceedences and the measured flow on those dates. WQS exceedences occurred frequently throughout this entire range of sampling dates. Due to the fact that there are no gages on Jaramillo Creek and only limited flow measurements were taken, the critical flow was determined to be the average of all measured flows during the 2001-2002 sampling year. Therefore, the critical flow for Jaramillo Creek was determined to be 1.94 cfs.

The flow value for Jaramillo Creek was converted from cfs to units of million gallons per day (mgd) as follows:

$$1.94\,\frac{ft^3}{\sec} \times 7.48\,\frac{gal}{ft^3} \times 86{,}400\,\frac{\sec}{day} \times 10^{-6} = 1.25\,mgd$$

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.

5.3 Calculations

Target loads for turbidity (expressed as TSS) are calculated based on the critical flow, the water quality criterion, and a conversion factor (8.34) that is a used to convert milligram per liter (mg/L) units to pounds per day (lbs/day) (see **Appendix A** for Conversion Factor Derivation). The target loading capacity is calculated using **Equation 3**. The results are shown in Table 5.2.

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

Table 5.2 Calculation of target loads for turbidity (expressed as TSS).

Location	Flow (mgd)	TSS (mg/L)	Conversion Factor	Target Load Capacity (lbs/day)
Jaramillo Creek (East Fork Jemez to headwaters)	1.25+	8.91*+	8.34	92.9+

Notes:
*The TSS value was calculated using the relationship established between TSS and turbidity in Figure 4.2 (y=0.331x + 0.6343, R^2=0.32) using the turbidity standard of 25 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 5.3.

Table 5.3 Calculation of measured loads for turbidity (expressed as TSS).

Location	Flow (mgd)	TSS Arithmetic Mean[+] (mg/L)	Conversion Factor	Measured Load Capacity (lbs/day)
Jaramillo Creek (East Fork Jemez to headwaters)	1.25[*]	13.3[*]	8.34	139[*]

Values rounded to three significant figures.
+ Arithmetic mean of TSS values when measured turbidity exceeded the standard (see Table 5.1).

5.4 Waste Load Allocations and Load Allocations

5.4.1 Waste Load Allocation

There are no individually permitted point source facilities or MS4 storm water permits on Jaramillo Creek (East Fork Jemez to headwaters). 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 National Pollutant Discharge Elimination System (NPDES) Construction general storm water permit (CGP) for construction sites greater than one acre requires preparation of a Storm Water Pollution Prevention Plan (SWPPP) that includes identification and control of all pollutants associated with the construction activities to minimize impacts to water quality. In addition, the current CGP also includes state specific requirements to implement Best Management Practices (BMPs) that are designed to prevent to the maximum extent practicable, an increase in sediment, or a parameter that addresses sediment (e.g., 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 Multi Sector General Storm Water Permit (MSGP). This permit also requires preparation of an SWPPP that includes identification and control of all pollutants associated with the industrial activities to minimize impacts to water quality. In addition, the current MSGP also includes state specific requirements to further limit (or eliminate) pollutant loading to water quality impaired/water quality limited waters from facilities where there is a reasonable potential to contain pollutants for which the receiving water is impaired. In this case, compliance with a SWPPP that meets the requirements of the MSGP is generally assumed to be consistent with this TMDL.

Individual 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.

5.4.2 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 5.2. Results are presented in Table 5.4. Additional details on the MOS are presented in Section 5.7 below.

Table 5.4 Calculation of TMDL for turbidity.

Location	WLA (lbs/day)	LA (lbs/day)	MOS (25%) (lbs/day)	TMDL (lbs/day)
Jaramillo Creek (East Fork Jemez to headwaters)	0	69.7*	23.2*	92.9*

* Values rounded to three significant figures.

The extensive data collection and analyses necessary to determine background turbidity load for the VCNP basin 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 nonpoint source and background load reductions that would be necessary to meet the target loads were calculated to be the difference between the target (Table 5.4) and the measured load (Table 5.3), and are shown in Table 5.5.

Table 5.5 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)]
Jaramillo Creek (East Fork Jemez to headwaters)	92.9*	139*	46.1*	33%

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.

5.5 Identification and Description of pollutant source(s)

Pollutant sources that could contribute to this segment are listed in Table 5.6.

Table 5.6 Pollutant source summary for turbidity on Jaramillo Creek.

Pollutant Sources	Magnitude (lbs/day)	Location	Potential Sources[(a)] (% from each)
Point: None	0	--------	0%
Nonpoint: Turbidity[(b)]	139[(b)]	Jaramillo Creek (East Fork Jemez to headwaters)	100% Highway/road/bridge runoff (non-construction related), natural sources, rangeland grazing, streambank modifications/destabilization, wildlife other than waterfowl.

Notes:
[(a)] From the 2004-2006 Integrated CWA §303(d)/§305(b) Report. 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)] Measured load expressed as TSS in lbs/day

5.6 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, thus reducing the amount of oxygen produced by plants. 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 this reach that exceed the State Standards for the protection of aquatic habitat, HQCW aquatic life designated 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 B** 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 nonpoint sourceimpairments 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 Jaramillo Creek appear to be from highway/road/bridge runoff (non-construction related), natural sources, rangeland grazing, streambank modifications/destabilization, and wildlife other than waterfowl.

5.7 Margin of Safety (MOS)

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

•Errors in calculating nonpoint sourceloads

> 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 nonpoint sourceloads due to equipment accuracy, time of sampling, etc. Accordingly, a conservative MOS of **15%** will be assigned to account for uncertainties in calculating nonpoint sourceloads.

•Errors in calculating flow

Flow estimates were based on USGS gages and field measurements on this reach. 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.

5.8 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 conditions 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.

5.9 Future Growth

Estimations of future growth are not anticipated to lead to a significant increase for turbidity that cannot be controlled with BMP implementation in this watershed. In fact, VCNP staff have already started the process of implementing BMPs on the Preserve.

6.0 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 VCNP basin is 2013 because the VCNP is scheduled for sampling as part of the Jemez Watershed. In addition the VCNP will continue to be monitored by VCNP staff for various water quality parameters.. 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 2006b).

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/index.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 rotational cycle, which assumes the existing level of resources, the next time SWQB will intensively sample the entire Jemez watershed is in 2013.

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 CWA §303(d)/§305(b) listing process for waters requiring TMDLs.

7.0 IMPLEMENTATION OF TMDLS

7.1 Coordination

Watershed public awareness and involvement will be crucial to the successful implementation of these plans to improve water quality. Staff from SWQB have worked with stakeholders to develop a WRAS for the Jemez Watershed (Jemez Watershed Group 2005). 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, VCNP, and members of the Jemez Watershed Group.

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.

7.2 Time Line

The Jemez Watershed Group was established in 2003 after the first set of Jemez Watershed TMDLs were prepared in 2002. As a result, the Jemez Watershed WRAS was developed and finalized before preparation of these TMDLs. The general implementation timeline is detailed below (Table 7.1).

Table 7.1 Proposed Implementation Timeline

Implementation Actions	Year 1	Year 2	Year 3	Year 4	Year 5
Public Outreach and Involvement	X	X	X	X	X
Form watershed groups	X	X			
WRAS Development		X	X	X	
Establish Performance Targets		X			
Secure Funding		X	X		

Implement Management Measures (BMPs)		X	X	X	
Monitor BMPs		X	X	X	
Determine BMP Effectiveness				X	X
Re-evaluate Performance Targets				X	X

7.3 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 CWA §303(d)/ §305(b) list. These monies are available to all private, for profit, and nonprofit organizations that are authenticated legal entities, or governmental jurisdictions including: 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/.

7.4 Other Funding Opportunities and Restoration Efforts in the VCNP 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 U.S. Department of Agriculture (USDA) Environmental Quality Incentive Program (EQIP) program can provide assistance to private land owners in the basin. The USDA Forest Service aligns their mission to protect lands they manage with the TMDL process, and are another source of assistance. The Bureau of Land Management (BLM) has several programs in place to provide assistance to improve unpaved roads and grazing allotments.

8.0 ASSURANCES

New Mexico's Water Quality Act authorizes the Water Quality Control Commission (WQCC) to "promulgate and publish regulation to prevent or abate water pollution in the state" and to require permits. The Act also 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 nonpoint sourcewater pollution. In addition, the Act 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.*

Furthermore, the State of New Mexico Surface WQS (see NMAC 20.6.4.11.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 CWA §101(g):

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

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

As a constituent agency, NMED has the authority under Chapter 74, Article 6-10 NMSA 1978 to issue a compliance order or commence civil action in district court for appropriate relief if NMED determines that actions of a "person" (as defined in the Act) have resulted in a violation of a water quality standard including a violation caused by a nonpoint source. The NMED nonpoint sourcewater quality management program has historically strived for and will continue to promote voluntary compliance to nonpoint sourcewater pollution concerns by utilizing a voluntary, cooperative approach. The State provides technical support and grant monies for implementation of BMPs and other nonpoint sourceprevention mechanisms through §319 of the CWA. Since portions of this TMDL will be implemented through nonpoint sourcecontrol mechanisms, the New Mexico Watershed Protection Program will target efforts to this and other watersheds with TMDLs. The Jemez Watershed Group applied for and was awarded 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 previously established Memoranda of Understanding (MOUs) with various Federal agencies, in particular the Forest Service and the BLM. MOUs in the past have also been developed with other State agencies, such as the New Mexico State Highway and Transportation Department. These MOUs provide for coordination and consistency in dealing with nonpoint source issues.

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

9.0 PUBLIC PARTICIPATION

Public participation was solicited in development of this TMDL (see **Appendix E**). The draft TMDL will be made available for a 30-day public comment period on May 15, 2006. Response to comments will be attached as **Appendix F** of this document. The draft document notice of availability was extensively advertised via newsletters, email distribution lists, webpage postings (http://www.nmenv.state.nm.us), and press releases to area newspapers. A public meeting in the Jemez Watershed will be held on May 25, 2006 from 6-7 pm in Jemez Springs, New Mexico.

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APPENDIX A
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:

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

Conversion Factor Derivation:

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

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APPENDIX B
FIELD SHEETS FOR ASSESSING DESIGNATED USES AND NON-POINT SOURCE OF POLLUTION

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FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

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.

REACH NAME: Jaramillo Crk above Cerro pinyon

SEGMENT NUMBER: 2106

BASIN: Rio Grande

PARAMETER:

STAFF MAKING ASSESSMENT: Joseph

DATE:

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 8400
☐ 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 OF 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

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.

REACH NAME: ~~Sutter Creek~~ ~~@ VCNP boundary~~ E. FK. Jemez abv Jaramillo
SEGMENT NUMBER: 2106
BASIN: Rio Grande
PARAMETER: ~~Turbidity~~ pH Conductivity
STAFF MAKING ASSESSMENT: Joseph
DATE:

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 8400
☐	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 OF 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

APPENDIX C
THERMOGRAPH SUMMARY DATA AND GRAPHICS

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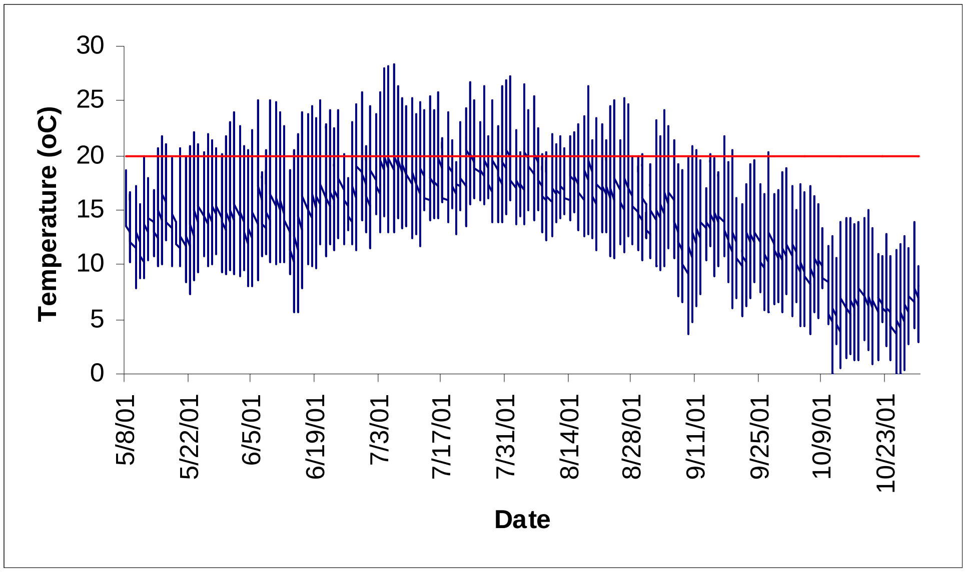
C1.0 East Fork Jemez (VCNP boundary to headwaters)

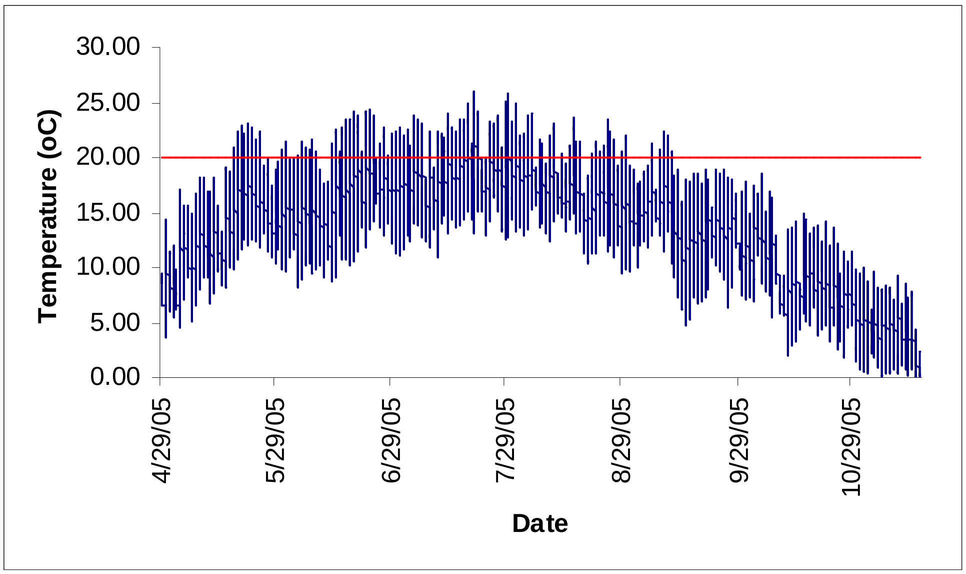
May 8, 2001 through October 30, 2001:	
Number of Data Points:	4,198
Number of Measurements >20°C:	730
Percentage Data Points >20°C:	17%
Minimum Temperature (°C):	-0.8
Maximum Temperature (°C):	28.27



See Photo 3.1 in text.

East Fork Jemez in Valle Grande (VCNP staff)

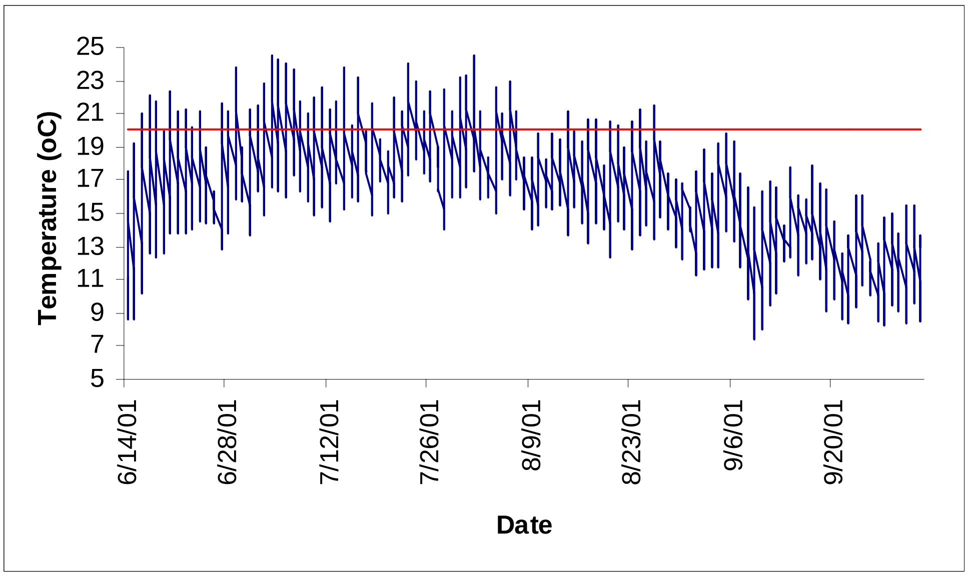
April 29, 2005 (15:45) through November 16, 2005:	
Number of Data Points:	19,278
Number of Measurements >20^{o}C:	2,276
Percentage Data Points >20^{o}C:	12%
Minimum Temperature (^{o}C):	-0.11
Maximum Temperature (^{o}C):	25.96



No photo.

East Fork Jemez at VCNP boundary (USFS staff)

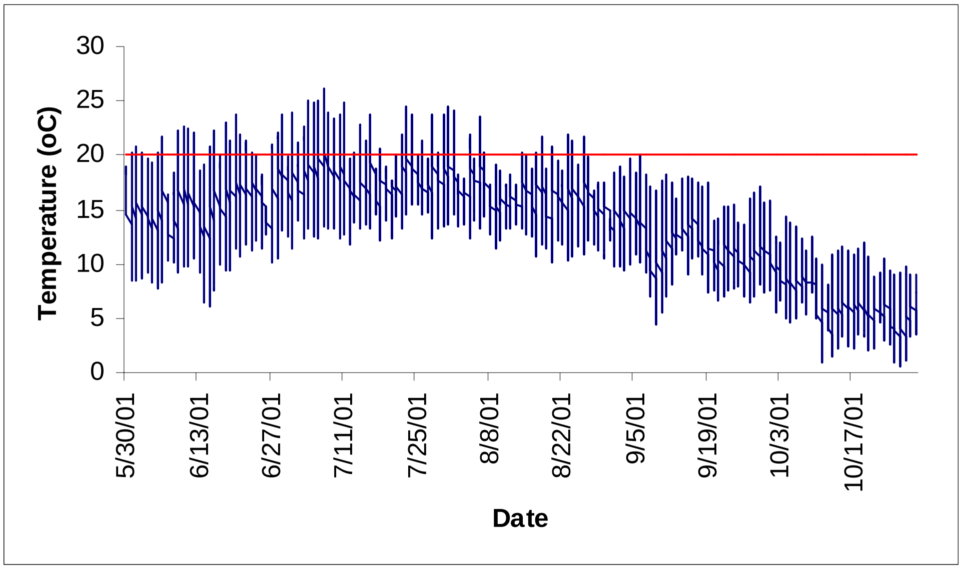
June 14, 2001 (3:11) through October 2, 2001:	
Number of Data Points:	666
Number of Measurements >20°C:	112
Percentage Data Points >20°C:	17%
Minimum Temperature (°C):	7.43
Maximum Temperature (°C):	24.51



No photo.

C2.0 Jaramillo Creek (East Fork Jemez to headwaters)

May 30, 2001 through October 29, 2001:	
Number of Data Points:	3,647
Number of Measurements >20°C:	297
Percentage Data Points >20°C:	8%
Minimum Temperature (°C):	0.53
Maximum Temperature (°C):	26.09



See Photo 3.2 in text.

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

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LIST OF ACRONYMS

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

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D 1.0 INTRODUCTION

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

Table D.1 Assessment Units and Modeled Dates

Assessment Unit ID	Assessment Unit Description	Modeled Date
NM-2106.A_10	East Fork Jemez (VCNP boundary to headwaters)	7/6/2001
NM-2106.A_12	Jaramillo Creek (East Fork Jemez to headwaters)	7/7/2001

D 2.0 HYDROLOGY

D2.1 Segment Inflow

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

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

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

where,

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

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

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

Assessment Unit	USGS Gage	Drainage Area from Gage (mi^2)	Drainage Area from Top of AU (mi^2)	Drainage Area from Bottom of AU (mi^2)	Ratio of DA of Ungaged (upstream) to Gaged Site	Ratio of DA of Ungaged (downstream) to Gaged Site
NM-2106.A_10	— (a)	—	— (b)	43.727	—	—
NM-2106.A_12	— a)	—	— (b)	14.997	—	—

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.

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):

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

where,

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

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

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

Assessment Unit	Regression Model[(a)]	Average Elevation for Assessment Unit (feet)	Mean Basin Winter Precipitation (inches)	Average Basin Slope (unitless)
NM-2106.A_10	Mountainous	8,911	12.58	0.181
NM-2106.A_12	Mountainous	9,035	12.63	0.182

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

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

Table D.4 Inflow

Assessment Unit	Ref.	4Q3 (cfs)	DAt (mi^2)	DAg (mi^2)	Pw (in)	S unitless	Inflow (cfs)
NM-2106.A_10	N/A	–	0.215	–	12.58	0.181	0.00[(1)]
NM-2106.A_12	N/A	–	0.04	–	12.63	0.182	0.00[(1)]

Notes:
N/A = Not applicable, assessment unit begins at headwaters.
Ref. = Reference

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)] Inflow is zero because assessment unit begins at headwaters.

D2.2 Inflow Temperature

This parameter represents the *mean daily* water temperature at the top of the segment. 2001 data from thermographs positioned at the top of the assessment unit were used when possible. If the segment began at a true headwater, the temperature entered was zero degrees Celcius (^oC) (zero flow has zero heat). The following inflow temperatures for impaired assessment units were modeled in SSTEMP:

Table D.5 Mean Daily Water Temperature

Assessment Unit	Upstream Thermograph Location	Inflow Temp. (ºC)	Inflow Temp. (ºF)
NM-2106.A_10	East Fork Jemez below La Jara	0	32.0
NM-2106.A_12	Jaramillo Creek above Cerro Piñon	0	32.0

Notes:
ºC = Degrees Celcius
ºF = Degrees Farenheit

D2.3 Segment Outflow

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

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

Table D.6 Segment Outflow

Assessment Unit	Ref.	4Q3[(1)] (cfs)	DAb (mi^2)	DAg (mi^2)	Pw (in)	S unitless	Outflow (cfs)
NM-2106.A_10	(a)	–	43.727	–	12.58	0.181	0.888
NM-2106.A_12	(a)	–	14.997	–	12.63	0.182	0.429

Notes:
Ref. = Reference
(a) Waltemeyer 2002

cfs = cubic feet per second
mi^2 = Square miles
in = Inches
Pw = Mean winter precipitation
(1) xxx

DAb = Drainage area from bottom of segment
DAg = Drainage area from USGS gage
S = Average basin slope

D2.4 Accretion Temperature

The temperature of the lateral inflow, barring tributaries, generally should be the same as groundwater temperature. In turn, groundwater temperature may be approximated by the mean annual air temperature. Mean annual air temperature for 2001 was used in the absence of measured data. The following table presents the mean annual air temperature for each assessment unit:

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

Assessment Unit	Ref.	Mean Annual Air Temperature (°C)	Mean Annual Air Temperature (°F)
NM-2106.A_10	(a)	6.62	43.924
NM-2106.A_12	(a)	6.62	43.924

Notes:
Ref. = References for Weather Station Data are as follows:
(a) New Mexico State University Climate Network (Jemez METAR, Elevation 2,438 meters; Latitude 35° 50' 28" N, Longitude 106° 37' 8" W), ***2001***
ºF = Degrees Farenheit
ºC = Degrees Celcius

D 3.0 GEOMETRY

D3.1 Latitude

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

Table D.8 Assessment Unit Latitude

Assessment Unit	Latitude (decimal degrees)
NM-2106.A_10	35.87
NM-2106.A_12	35.88

D3.2 Dam at Head of Segment

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

Table D.9 Presence of Dam at Head of Segment

Assessment Unit	Dam?
NM-2106.A_10	No
NM-2106.A_12	No

D3.3 Segment Length

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

Table D.10 Segment Length

Assessment Unit	Length (miles)
NM-2106.A_10	8.66
NM-2106.A_12	10.01

D3.4 Upstream Elevation

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

Table D.11 Upstream Elevations

Assessment Unit	Upstream Elevation (feet)
NM-2106.A_10	8,900
NM-2106.A_12	9,380

D3.5 Downstream Elevation

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

Table D.12 Downstream Elevations

Assessment Unit	Downstream Elevation (feet)
NM-2106.A_10	8,450
NM-2106.A_12	8,480

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

Width's B Term was calculated as the slope of the regression of the natural log of width and the natural log of flow. Width-versus-flow regression analyses were prepared by entering cross-section field data into a Windows-Based Stream Channel Cross-Section Analysis (WINXSPRO) 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:

$$W \quad = \quad A \times Q^{B}$$

where,

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

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

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

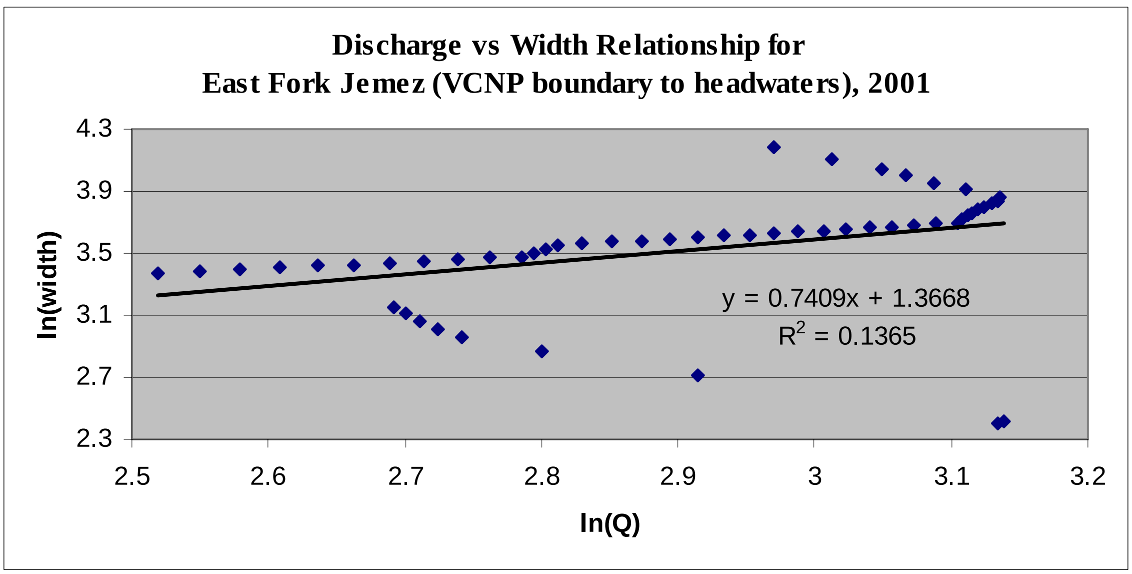
Assessment Unit	Width's B-Term	Width's A-Term (1)
NM-2106.A_10	0.741	3.92
NM-2106.A_12	0.935	3.26

(1) A=e^constant from regression

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

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

Figure D.1 Wetted Width versus Flow for Assessment Unit NM-2106.A_10



SUMMARY OUTPUT

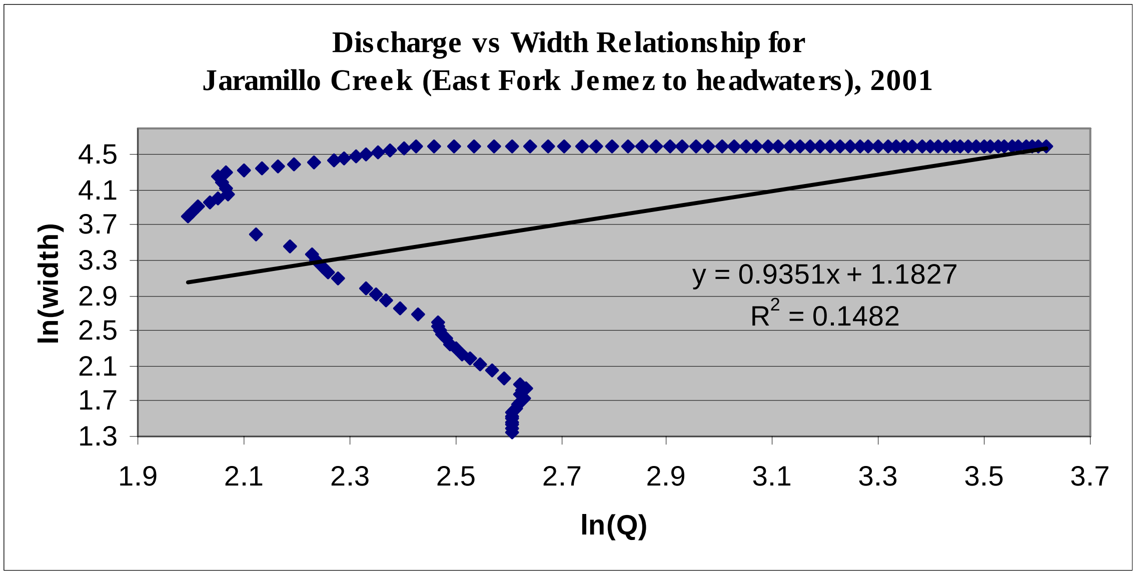
Regression Statistics	
Multiple R	0.369488671
R Square	0.136521878
Adjusted R	0.119590935
Standard E	0.348929007
Observatio	53

ANOVA

	df	SS	MS	F	Significance F
Regressior	1	0.981737183	0.981737	8.063454	0.006471864
Residual	51	6.209324031	0.121751		
Total	52	7.191061214			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	1.366762126	0.760006876	1.798355	0.07804	-0.15901417	2.892538422	-0.15901417	2.892538422
X Variable	0.740870119	0.260904478	2.839622	0.006472	0.217082927	1.264657311	0.217082927	1.264657311

Figure D.2 Wetted Width versus Flow for Assessment Unit NM-2106.A_12



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.384906671
R Square	0.148153145
Adjusted R	0.140934104
Standard E	1.066021269
Observatio	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	23.32185542	23.32186	20.52255	1.41991E-05
Residual	118	134.0953589	1.136401		
Total	119	157.4172144			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.182691194	0.573004028	2.064019	0.041208	0.047988452	2.317394	0.047988452	2.317393936
X Variable	0.935075939	0.206410223	4.530182	1.42E-05	0.526327946	1.343824	0.526327946	1.343823931

D3.7 Manning's n or Travel Time

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

Table D.14 Manning's n Values

Table D.14 Manning's n Values

Assessment Unit	Manning's n
NM-2106.A_10	0.031
NM-2106.A_12	0.033

D 4.0 METEOROLOGICAL PARAMETERS

D4.1 Air Temperature

This parameter is the mean daily air temperature for the assessment unit (or average daily temperature at the mean elevation of the assessment unit). Air temperature will usually be the single most important factor in determining mean daily water temperature. Although air temperatures are usually measured directly (in the shade) using air thermographs and adjusted to what the temperature would be at the mean elevation of the assessment unit, no air thermographs were deployed during the VCNP intensive survey. The following table summarizes mean daily air temperatures for each assessment unit (for its modeled date) requiring a temperature Total Maximum Daily Load (TMDL):

Table D.15 Mean Daily Air Temperature

Assessment Unit	Elevation at Air Thermograph Location (meters)	Measured Mean Daily Air Temperature (°C) [(a)]	Mean Elevation for Assessment Unit (meters)	Adjusted Mean Daily Air Temperature (°C)	Adjusted Mean Daily Air Temperature (°F)
NM-2106.A_10	2,438	20.06	2,716	18.24	64.83
NM-2106.A_12	2,438	20.24	2,754	18.17	64.71

Notes:
(a) *New Mexico State University Climate Network (Jemez METAR, Elevation 2,438 meters; Latitude 35° 50' 28" N, Longitude 106° 37' 8" W)*

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)

D4.2 Maximum Air Temperature

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

D4.3 Relative Humidity

Relative humidity data were obtained from the 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 D.16 Mean Daily Relative Humidity

Assessment Unit	Ref.	Mean Daily Air Temp. at Weather Station (°C)	Mean Daily Air Temperature at AU (°C)	Mean Daily Relative Humidity at Weather Station (percent)	Mean Daily Relative Humidity for AU (percent)
NM-2106.A_10	(a)	20.06	18.24	22.198	24.70
NM-2106.A_12	(b)	20.24	18.17	24.521	27.68

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

(a) *New Mexico State University Climate Network (Jemez METAR, Elevation 2,438 meters; Latitude 35° 50' 28" N, Longitude 106° 37' 8" W)* ***July 6, 2003***
(b) *New Mexico State University Climate Network (Jemez METAR, Elevation 2,438 meters; Latitude 35° 50' 28" N, Longitude 106° 37' 8" W)* ***July 7, 2003***

AU = Assessment Unit
ºC = Degrees Celcius

D4.4 Wind Speed

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

Table D.17 Mean Daily Wind Speed

Assessment Unit	Ref.	Mean Daily Wind Speed (miles per hour)	Date
NM-2106.A_10	(a)	2.0	7/6/2001
NM-2106.A_12	(a)	0.958	7/7/2001

Notes:
Ref. = References for Weather Station Data are as follows:
(a) *New Mexico State University Climate Network (Coyote RAWS, Elevation 2,682 meters; Latitude 36° 4' N, Longitude 106° 38' 50" W)*

D4.5 Ground Temperature

Mean annual air temperature data for 2001 were used in the absence of measured data. The following table presents the mean annual air temperature for each assessment unit:

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

Assessment Unit	Ref.	Mean Annual Air Temperature (°C)	Mean Annual Air Temperature (°F)
NM-2106.A_10	(a)	6.62	43.924
NM-2106.A_12	(a)	6.62	43.924

Ref. = References for Weather Station Data are as follows:
(a) *New Mexico State University Climate Network (Jemez METAR, Elevation 2,438 meters; Latitude 35° 50' 28" N, Longitude 106° 37' 8" W), **2001***

ºF = Degrees Farenheit
ºC = Degrees Celcius

D4.6 Thermal Gradient

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

D4.7 Possible Sun

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

D4.8 Dust Coefficient

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

D4.9 Ground Reflectivity

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

D4.10 Solar Radiation

Because solar radiation data were obtained from an external source of ground level radiation, it was assumed that about 90% of the ground-level solar radiation actually enters the water. Thus, the recorded solar measurements were multiplied by 0.90 to get the number to be entered into the SSTEMP Model. Solar radiation data were not available for either the Jemez METAR or Coyote RAWS stations, so the nearest station with solar radiation was used. The following table presents the measured solar radiation at Tower RAWS station for 2001:

Table E.19 Mean Daily Solar Radiation

Assessment Unit	Ref.	Date	Mean Solar Radiation (L/day)	Mean Solar Radiation x 0.90 (L/day)
NM-2106.A_10	(a)	7-6-2001	584.184	525.77
NM-2106.A_12	(a)	7-7-2001	603.384	543.05

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

(a) New Mexico State University Climate Network (Tower RAWS, Elevation 1,981 meters; Latitude 35° 46' 45" N, Longitude 107° 37' 36" W)

D 5.0 SHADE

Percent shade was estimated for the assessment units using field estimations per geomorphological survey field notes from June 2001. 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 D.20 Percent Shade

Assessment Unit	Percent Shade
NM-2106.A_10	0%
NM-2106.A_12	0%

D 6.0 REFERENCES

Bartholow, J.M. 2002. SSTEMP for Windows: The Stream Segment Temperature Model (Version 2.0). U.S. Geological Survey computer model and documentation. Available on the internet at http://www.fort.usgs.gov. Revised August 2002.

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Theurer, Fred D., Kenneth A. Voos, and William J. Miller. 1984. Instream Water Temperature Model. Instream Flow Inf. Pap. 16 Coop. Instream Flow and Aquatic System Group. U.S. Fish & Wildlife Service, Fort Collins, CO.

Thomas, Blakemore E., H.W. Hjalmarson, and S.D. Waltemeyer. 1997. Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States. USGS Water-Supply Paper 2433.

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

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

APPENDIX E
PUBLIC PARTICIPATION PROCESS FLOWCHART

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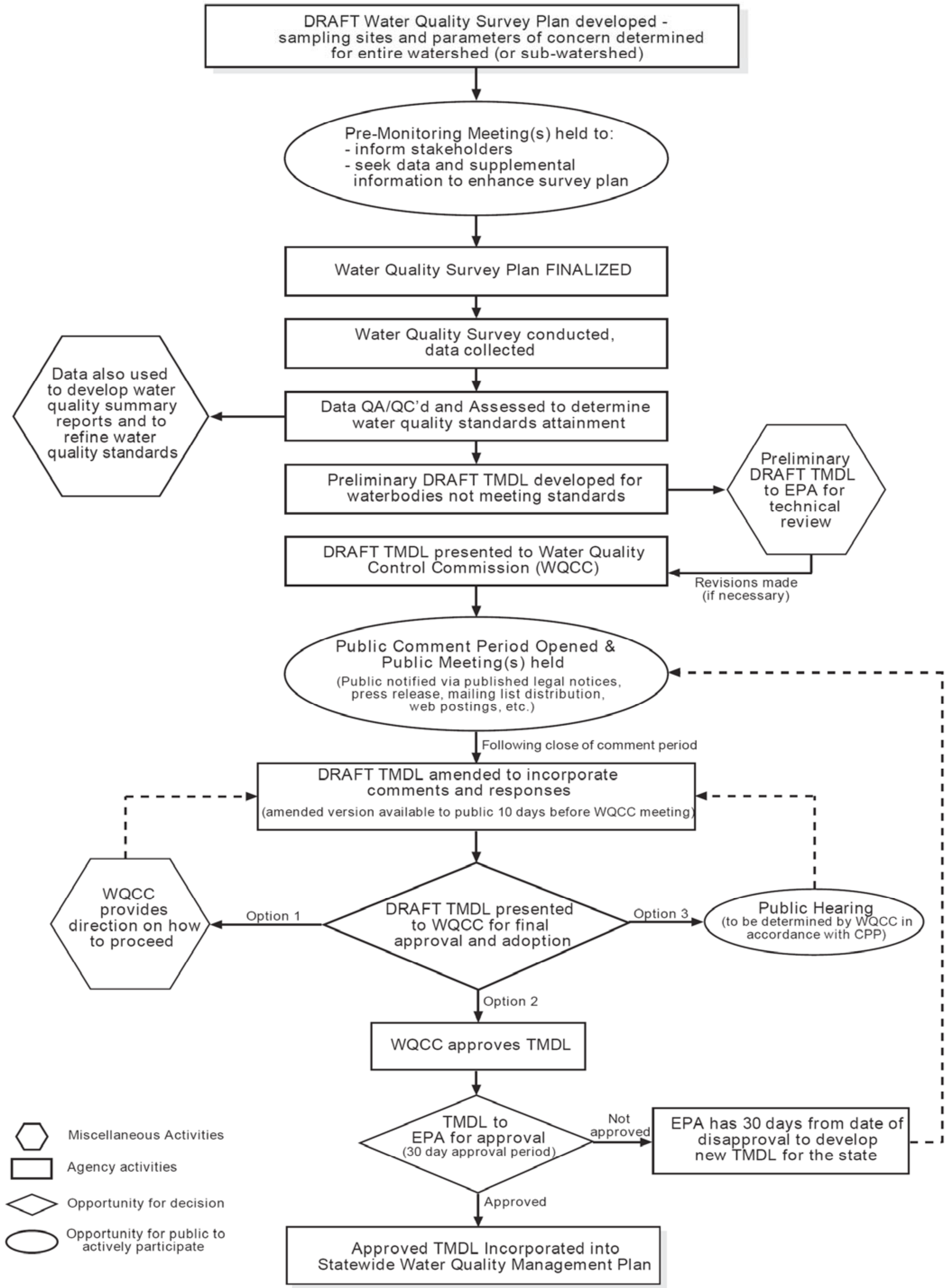

DRAFT Water Quality Survey Plan developed - sampling sites and parameters of concern determined for entire watershed (or sub-watershed)
Pre-Monitoring Meeting(s) held to:
- inform stakeholders
- seek data and supplemental information to enhance survey plan
Water Quality Survey Plan FINALIZED
Water Quality Survey conducted, data collected
Data also used to develop water quality summary reports and to refine water quality standards
Data QA/QC'd and Assessed to determine water quality standards attainment
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)
WQCC provides direction on how to proceed
Option 1
DRAFT TMDL presented to WQCC for final approval and adoption
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

APPENDIX F
RESPONSES TO COMMENTS

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Comments on VCNP Watershed TMDL

Comment Set A:

From: Foster, Dean, NMENV

Sent: Wednesday, May 17, 2006 9:31 AM

To: Henderson, Heidi, NMENV

Subject: Jemez River TMDL's – public comment

Attachments: *ms-15_Ager.pdf*

I am in favor of the proposed TMDL's. The TMDL's can probably be acheived through land management practices which exclude livestock grazing. This statement wasn't in the the draft document but it was understood. And so the public comments will probably focus on cattle grazing - pro and con.

Perhaps the draft document could investigate the economics of removing domestic livestock grazing from the Caldera.

For example: Lost Revenue Gained Revenues
grazing fees saved personnel salaries
saved fencing and cattlegaurd costs
saved water development, seeding, and brush control costs
increased elk herd size - increased Game and Fish Revenues
via tag sales

A good place to start a cattle/elk energetics investigation is with the attached document or by contacting the Game and Fish wildlife specialist for the region.

As for me I enjoy elk hunting, elk on my table, and walking through a forest without stepping into cowpatties or arriving at a spring for a drink without finding the water fouled by cattle; so I would be in favor of permanently removing cattle grazing from the Caldera as was done temporarily this spring/summer (2006) in response to poor forage due to prolonged drought.

Dean

Dean Foster
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WIPP site - 505-234-6012

Note: the following 21 page attachment was included along with this correspondence:
Ager, A.A., B.K. Johnson, P.K. Coe, and M.J. Wisdom. 2005. Land Simulation of Foraging by Elk, Mule Deer, and Cattle on Summer Range. Pages 170-184 in Wisdom, J.J., technical editor, The Starkey Project: a synthesis of long-term studies of elk and mule deer. Reprinted from the 2004 Transactions of the North American Wildlife and Natural Resouces Conference, Alliance Communications Group, Lawrence, Kansas, USA.

Landscape Simulation of Foraging by Elk, Mule Deer, and Cattle on Summer Range

Alan A. Ager[1], Bruce K. Johnson, Priscilla K. Coe, and Michael J. Wisdom

Introduction

Cattle, mule deer (Odocoileus hemionus), and elk (Cervus elaphus) share more area of spring, summer, and fall range than any other combination of wild and domestic ungulates in western North America (Wisdom and Thomas 1996). Not surprisingly, conflicts over perceived competition for forage have a long history, yet knowledge about actual competition is limited (Van Dyne et al. 1984b, Hobbs et al. 1996, Johnson et al. 1996). One of the first studies of the Starkey Project (Rowland et al. 1997) was designed to address the issue of whether mule deer and elk compete with cattle for available forage on summer range. A component of this study was to build a forage allocation model that could be used to analyze forage allocation problems on summer range in the Blue Mountains. This model would use data on animal spatial distributions, resource selection patterns, behavioral interactions, and diet selection of cattle, elk, and deer collected as part of the Starkey Project at the Starkey Experimental Forest and Range (Johnson et al. 2000; Coe et al. 2001, 2004; Findholt et al. 2004).

Modeling the forage removal and animal performance for multiple species of ungulates across large landscapes is a complex problem (Weisberg et al. 2002). The high degree of temporal and spatial variability in ungulate distributions, forage production, and nutritional value of forage contribute to the problem (Wisdom and Thomas 1996). Several early forage allocation models built for western rangelands were never widely used, owing to insufficient data, model complexity, and institutional barriers (Van Dyne et al. 1984a, McInnis et al. 1990). A prototype forage allocation model built from Starkey data (Johnson et al. 1996) suffered from similar problems, but did provide a framework for further discussions and model development (Vavra et al. 2004). This model used linear programming with a weighted objective function that contained terms for forage production, forage energy content, and resource selection coefficients. Animal foraging behavior could be optimized with respect to each of these three variables or some weighted combination. The Johnson et al. (1996) model generated reasonable predictions of species distributions and forage consumption patterns at monthly time steps. However, the linear programming framework was cumbersome and had limited capability to analyze the temporal dynamics of ungulate foraging behavior.

Using many of the parameters from the earlier work, we built a more detailed, spatially-explicit individual animal foraging model (heretofore Starkey Foraging Model, SFM). Initial testing of this model was described in Vavra et al. (2004). In this paper we describe additional developments and testing, and demonstrate the model's capability to predict forage removal and animal performance at Starkey. Ultimately, the model or subsequent outgrowths are intended for use in allotment management planning on summer ranges shared by cattle, mule deer, and elk.

Methods

The Starkey Foraging Model uses empirical data on habitat preferences, forage production, forage quality, and energy dynamics of cattle, mule deer, and elk. These data are coupled with information on foraging behavior to simulate forage consumption by the three ungulates on the Starkey landscape. The SFM was developed in Object Pascal using the Delphi 6 (Borland Inc., Scotts Valley CA) integrated

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[1] Suggested citation: Ager, A. A., B. K. Johnson, P. K. Coe, and M. J. Wisdom. 2005. Land Simulation of Foraging by Elk, Mule Deer, and Cattle on Summer Range. Pages 170-184 in Wisdom, M. J., technical editor, The Starkey Project: a synthesis of long-term studies of elk and mule deer. Reprinted from the 2004 Transactions of the North American Wildlife and Natural Resources Conference, Alliance Communications Group, Lawrence, Kansas, USA.

development environment. Data sources used for the SFM are described in detail by Vavra et al. (2004) and summarized here.

Habitat preferences for each species were incorporated using resource selection functions developed at Starkey (Johnson et al. 2000, Coe et al. 2001). These resource selection functions (RSFs) were estimated from Starkey telemetry data collected between 1993 and 1996, and were estimated for monthly time steps, from April through October (Tables 1, 2). The RSF's represent the probability of an animal visiting a particular pixel over the monthly interval, as described by Johnson et al. (1996, 2000).

Forage production was estimated using several empirical models built from Starkey data (clipped plots from 1993-2000) and other sources (Vavra et al. 2004). We built functions to predict herbage production as a function of calendar day for grasslands, ponderosa pine (Pinus ponderosa) and riparian ecotypes. The equations for these ecotypes were extrapolated to the seven plant association groups in the model (moist meadows, dry meadows, bunch grass and shrub lands, warm dry forests with grass understory, warm dry forests with shrub understory, cool moist forest with grass understory, cool moist forest with shrub understory). The forage production was partitioned into forbs, grass, and shrubs using scaling factors developed by Hall (1973) and Johnson and Hall (1990). The growth functions were also adjusted for canopy closure on a pixel basis using relationships developed at four grazing exclosures at Starkey and the data of Pyke and Zamora (1982). Forage growth was represented in the model on a daily time step, and we used the same growth functions for forage re-growth as those used for initial forage growth.

Forage quality, as measured by in-vitro digestible energy (IVDDM) of forage was obtained from the literature (Holechek et al. 1981, Svejcar and Vavra 1985, Sheehy 1987, Westenskow 1991) and data from Starkey. Digestible energy (DE) was calculated from IVDDM using methods of McGinnis et al. (1990), with estimates made on a monthly time step.

The spatial dynamics of animal foraging were modeled as a multi-scale process that involved the selection of foraging patches and subsequent selection of forage within the patch. We used concepts and data from a variety of sources for the foraging component of the model (Spalinger and Hobbs 1992; Gross et al. 1993, 1995; Shipley and Spalinger 1995; Bailey 1996) as well as observations on elk and deer movements at Starkey (Ager et al. 2003). Foraging patches were defined at the same scale as the Starkey spatial database, that is, each 30 by 30 m pixel. Selection of foraging patches was modeled by using a neighborhood search algorithm that searched a 10 by 10 pixel neighborhood, and that subsequently chose the pixel that maximized an index of preference according to:

$$PREF_p = (RSF_{spm} * W_{rsf}) + (DE_{pm} * W_{qual}) + (F_{pm} * W_{mass}) \qquad (1)$$

where
$PREF_p$ = pixel preference score for pixel p
RSF_{spm} = resource selection function score ($0 < RSF < 1$) for pixel p, species s, and month m;
DE_{pm} = digestible energy in mcal/kg forage for pixel p and month m;
F_{pm} = forage (kg/ha) present on pixel p and month m.

Here, W_{rsf}, W_{qual}, W_{mass} are weighting coefficients that control the relative importance of habitat selection, forage quality (DE) and standing forage biomass in the foraging process. The formulation recognized that both resource selection functions and forage characteristics need to be considered in the selection of foraging areas. Initially we used a product of $RSF_{spm,}$ $DE_{pm,}$ and F_{pm} to calculate the preference score and included the weighting coefficients W_{qual}, W_{rsf}, W_{mass} as exponents. This method created some scaling issues that led to the current formulation. Although the weighting coefficients could be species-specific, we used the same values for each species in the present simulations. Pixels were selected for foraging by randomly sampling the pixels and respective preference scores in each 10 by 10 pixel neighborhood 90 times (90 percent of the total number of pixels) to reflect the fact that animals have a less than perfect knowledge of the surrounding forage conditions. The pixel with the highest preference score was selected and foraging initiated. A range of values were used for the weighting coefficients in equation (1) as well as the spatial search parameters as part of the model building process. Values used in the simulations for equation (1) are described later. To prevent animals from foraging on high RSF pixels with very low or non-existent forage biomass, we added a constraint that required a selected pixel to contain 80 percent of the forage biomass of the previously selected pixel. Although areas still could be selected based primarily on their RSFs, this constraint also had the effect of moderating the rate of forage depletion of the pixels with the highest RSF scores, and allowed the simulation of RSF-driven foraging without resulting in infinite pixel searches.

To allow for selection of foraging areas outside the animal's sensory detection range, we nested the neighborhood search within a low-frequency meta-neighborhood search that allowed simulated animals to move (i.e. Levy flight, Marell et al.2002) to another neighborhood if larger values for equation (1) were found. We experimented with a range of values for the search neighborhood size, the meta-neighborhood size, the "jump" frequency and "jump" distance, and found that these variables would strongly influence animal movement measurements. In the current simulations we set values for the meta-neighborhood at 100 by 100 pixels, the "jump" frequency at 0.1, and the "jump" distance at 1,000 meters.

Once a foraging pixel was selected, consumption of forage (grass, forbs, and shrubs) was modeled with simulated individual bites. Bite size was estimated using data from foraging trials conducted at Starkey (Findholt et al. 2004) and elsewhere (J. Cook, personal communication), and was 1.1 g for cows, 0.20 g for mule deer, and 0.55 g for elk. It should be noted that we did not constrain intake rate by bite size or other bite-dependent variable (Gross et al. 1993) and hence the bite process served primarily as a mechanism to sample the three types of vegetation data in the pixel over successive bites. Bite selection in the pool of simulated forage at each pixel was modeled as a Monte Carlo process that simulated successive bites that removed forage types in proportion to the sum of total forage available multiplied by simulated forage DE at the pixel, quantified as:

$$P_{ts} = \frac{(F_{pdt} * WB_{mass}) + (DE_{pmt} * WB_{qual})}{\sum_{1}^{t} [(F_{pdt} * WB_{mass}) + (DE_{pmt} * WB_{qual})]} \qquad (2)$$

where

P_{ts} = probability of removing forage type t for species s ($0 < P_{ts} < 1$);
F_{pdt} = forage (kg/ha) of type t on pixel p at day d;
DE_{pmt} = digestible energy (Mcal/kg) for forage type t, pixel p, and month m;
WB_{mass} = weighting factor for forage biomass; and
WB_{qual} = weighting factor for forage quality.

This foraging process simulated removal of vegetation in proportion to biomass and energy content, and/or some weighted combination, and recognized that while animals can focus their foraging on specific forage types, other non-preferred types are also depleted at some lesser rate. Initially we used WB_{mass} of 1.0 and WB_{qual} = (body weight)$^{-0.75}$, with the idea that mule deer would select for high forage DE and cattle would select for forage bulk (Findholt et al. 2004). Elk, with their intermediate body weight, were simulated as having a foraging behavior intermediate to that of deer and cattle (Findholt et al. 2004). Initial simulations showed that stronger weighting of the energy component was needed to significantly influence the forage composition.

Using the foraging rules described above, simulated animals were allowed to forage until they consumed 135 g of forage dry weight per kg of metabolic body weight (Cook et al 2004), or until the total foraging time per day exceeded 12 hours (Cook 2002), whichever condition came first. The foraging time was calculated using relationships between standing biomass and intake rate from Wickstrom et al (1984:1291) for elk and deer, and from data from Starkey for cattle (Figure 1). For elk, we used the relationship for mixed forest conditions presented by Wickstrom et al. (1984), and combined the grass and mixed forest data to develop a relationship for deer. Intake rates could also have been predicted using relationships between bite size and plant size (Spallinger and Hobbs 1993), but the latter data were not available for conditions at Starkey.

Energy balance and weight change was updated daily using pro-rated monthly energy requirements (Table 3) obtained from a number of sources (Leege 1982; Hudson and White 1985a, b; Cook 2002). Daily energy generated by consumed forage was calculated using the energy conversion equation as:

$$Me = 1000 \times (F \times (0.038 \times \%DE + 0.18)/1.22) \quad (3)$$

Where,
DE = digestible energy (mcal/kg forage), and
F = forage biomass (dry matter kg/ha) consumed on a given day of forage.

Negative energy balances were translated into a weight loss by using a conversion of 6 mcal/kg. Positive daily energy balances were translated into a weight gain by using the conversion of 12 mcal/kg.

Most simulations used herd sizes of 500 cows, 450 elk, and 250 mule deer under a summer deferred-rotation grazing system (April 15 to November 15, 210 days). These are the approximate stocking rates and summer range foraging season at Starkey. In other simulations, the stocking rates varied depending on the objective of the simulation. On each day, cattle foraging was simulated first, followed by elk and then mule deer, which gave cattle preference over elk and mule deer and elk preference over mule deer for the available forage (Coe et al. 2004). Initial weights were set at 992 pounds (450 kg), 507 pounds (230 kg), and 132 pounds (60 kg) per animal for cows, elk and mule deer, respectively, based on data from Starkey. Typical execution times for the model were about one minute. We first ran simulations to examine the effects of different weights in equation (1) on animal performance, foraging patterns and movements. This involved 125 simulations where each weight was varied by a factor of 10 between 1 and 100,000. We selected a set of weights where the model outputs appeared to be not overly influenced by the values and replicated observed animal performance at Starkey. The effects of different weights in equation (2) were then tested in a similar process in an additional 25 simulations and selected weights for equation (2). We then ran additional simulations to test how incremental changes in the number of cattle, mule deer and elk (2-2,500), and forage production (10-100 percent of normal) affected animal performance. The latter simulations were intended to represent varying drought intensities. Reductions in forage quality from drought (Vavra and Phillips 1980, Weisberg et al. 2002) were not modeled due to limited data.

Results

Simulations using a range of values (1-100,000) for the W_{rsf}, W_{mass}, and W_{qual} coefficients in equation (1) were found to produce reasonable outputs in terms of predicted weight gains for cattle, elk, and mule deer (Figures 2-4). For instance, mule deer, which generally gain around 11-22 pounds (5-10 kg) per animal at Starkey, showed simulated weight gains of 15.4-19.8 pounds (7-9 kg) for the range of coefficients tested. Cattle and elk showed more pronounced changes in animal weights (Figures 2, 4), although a wide range of coefficients replicated the weight changes observed for cattle 0-22 pounds (0-10 kg) and elk 22-44 pounds (10-20 kg) at Starkey. For all species, increasing W_{rsf} relative to W_{mass} forced simulated animals to forage in areas of high RSF values (Figure 5) and generally resulted in decreased animal weights. The effect of increasing W_{rsf} on weight reductions was dampened as the forage biomass (F_{mass}) coefficient was increased to values above 1000.

Changes in average cattle weights ranged from -72.6 to 26.4 pounds (-33 to 12 kg) (Figure 2), the negative weight changes being associated with a high values of W_{rsf} and low values of W_{mass}. Cattle showed an intermediate optimal weight gain of 22 pounds (10 kg) when the W_{rsf} was increased by a factor of 10 over the W_{mass}. This trend was not found for elk or mule deer (Figures 3, 4). The most plausible explanation for this is that a higher forage quality is realized at this combination of W_{mass} and W_{rsf}, although this was not tested.

Results of simulations for elk showed weight changes between -44 pounds (-20 kg) and 77 pounds (35 kg), with weight gains over a wide range of W_{rsf} and W_{mass}. However, when the W_{rsf} became 1,000 times the W_{mass}, negative weight changes were observed. Unlike cattle, weight changes with different combinations of W_{rsf} and W_{mass} were asymptotic with the maximum values at about 77 pounds (35 kg). Compared to the W_{mass} and W_{rsf} coefficients, changing the forage quality (W_{qual}) coefficient had a very minor effect, producing weight differences less than 2.2 pounds (1 kg) over the entire range (1-10,000) of values simulated.

Simulated animal distributions were compared with the maps of the RSF scores to examine how well the model replicated observed animal distributions at Starkey (Figure 5). For space reasons we limit the comparison to elk and note that the findings for elk are typical for the cattle and mule deer. The comparison is made difficult by the fact that the RSF maps represent a long-run probability of animal use during presumed periods of peak foraging based on six years of telemetry data, whereas the outputs from a simulation run represent animal use for one season, and represent only foraging activities. We did not perform statistical testing of the differences in simulated versus observed distributions, although this would have provided more definitive comparison. The maps show that simulations with high values of W_{rsf} generated animal distributions that were compatible with the RSF maps (Figure 5). In contrast, simulations with a relatively high weighting for W_{mass} generated markedly different animal distributions that reflected high levels of foraging on productive grassland meadows (Figure 6a).

The effect of changing W_{rsf} and W_{mass} weights on the relative use of pixels with different RSF scores was examined by assigning the RSF probabilities to integer classes from 1 to 40 and then measuring the forage removal for each class. The integer classes were generated by re-scaling the RSF scores by 100x. Values above 0.4 were assigned the integer class 40. Simulations were run with W_{rsf} of 10,000 and W_{mass} of 1, and W_{rsf} and W_{mass} both equal 1. The results (Figure 7) showed that a significant amount of forage was removed from higher RSF class pixels when W_{rsf} was weighted at 10,000 versus 1. The difference is somewhat magnified however by the overall higher total forage removal in the simulations where both the W_{rsf} and W_{mass} coefficients are set at one.

To choose a set of coefficients for further simulations we looked for values that resulted in weight changes that approximated those observed at Starkey using the highest possible values of W_{rsf}. In this way we could simulate the approximate animal performance at Starkey while replicating animal distributions to the extent possible. We also were interested in finding coefficients where the simulated weight gains did not change sharply with small changes in the coefficients. Using these criteria we selected a W_{mass} of 1,000 and W_{rsf} of 10,000, and W_{qual} of 1, and then simulated a range of values for the WB_{mass} and WB_{qual} coefficients in equation (2). These simulations were to examine how selecting for forage biomass versus energy within a pixel would affect animal performance. The results of this simulation showed that a wide range of coefficients generated the same results for all three species, except for the case when the WB_{qual} coefficient was reduced to less than 10. In the latter case, weights dropped by a maximum of 22 pounds (10 kg) for elk and lesser amounts for the other species. Accordingly, we set both WB_{qual} and WB_{mass} at 10 for the remaining simulations.

In a subsequent set of simulations, the forage production was varied from 10 to 100 percent of normal using the model coefficients selected above. These simulations examined the effect of disturbances like drought on animal performance. The results showed that, as forage production was decreased, weights for cattle and elk were markedly reduced, while mule deer were not affected (Figure 8). The effect of reduced forage production on weight change was nonlinear and started when forage production was about 60 percent of normal for cattle, and 50 percent for elk (Figure 8). For all species, the response resembled the intake rate functions incorporated into the model (Figure 1), and most likely the weight reductions resulted from lower intake rates associated with reduced standing forage biomass. Some slight differences were noted in the simulated animal distributions for between normal and 10 percent forage production, the latter showing more area foraged (Figure 6a,b) .

Simulations to examine how animal performance varied under different population levels showed intraspecific effects for all three species. Simulations where the cattle herd was varied between 2 and 2,500 animals did not result in changes in elk or mule deer weights. However, average weight change per cow was reduced from 34.9 to 3.2 when the herd size was increased (Figure 9). Likewise, when the mule deer population was increased from 2 to 2500 animals, mule deer weights decreased from 17 to 4 pounds (7.8 to 1.7 kg) per animal. Elk population increases from 2 to 2500 animals resulted in elk weights decreasing from 74 to 15 pounds (33.7 to 6.8 kg) per animal. Interspecific effects on animal weights were negligible except in the case of the elk simulations where cattle weights declined from 44 to 35.9 pounds (20.0 to 16.3 kg) per animal when elk were increased from 2 to 2,500 animals. Elk weight decreased by only a fraction 73.7 versus 73.3 pounds (33.5 versus 33.3 kg) per animal and mule deer weights were unchanged when the cattle population was increased from 2 to 2,500.

Discussion

Foraging behavior by free ranging ungulates on large landscapes over time is a complex process that can only be approximated with models (Turner and Wu 1994, Moen et al. 1997, Weisberg et al. 2002). The current work illustrates the inherent complexity of the problem for summer range conditions in the Blue Mountains. While our model does not consider many of compensatory mechanisms in the foraging process, it can replicate animal weight dynamics observed at Starkey as well as provide reasonable predictions of animal distributions. The model demonstrated that both forage biomass and RSF scores need to be included in a simulation model to replicate observed animal distributions and weight changes, and that some balance between the two best summarizes actual foraging behavior at the landscape scale. We found that modeling forage site selection based on RSF scores resulted in significant weight loss for cattle and elk, and to a lesser extent, mule deer. Forage depletion on high RSF pixels probably reduced forage intake rates and led to the lower weight gains. In addition, RSF scores for elk and mule deer did not always reflect selection of the most productive foraging areas, due to other habitat considerations like distance to open roads. When forage site selection was based primarily on standing biomass, the simulated animal distributions were not representative of Starkey telemetry data. Simulations showed that by weighting the RSF about 100 times less than forage biomass to calculate pixel preference scores, the model would produce reasonable animal weights and select high RSF pixels as well.

Comparing empirical animal distribution with those from the simulations were made difficult by the fact that the former were developed from six grazing seasons of data and show more diffuse spatial patterns of animal use compared to simulated distributions. Although the RSF values used for the model were estimated for peak foraging periods, they likely include observations when animals were not foraging as well. Thus without consideration of these other activities in the model there will always be some discrepancy between RSF values and simulated animal foraging patterns. The two data sources could be made more comparable if the animal distributions generated by the forage model were compared with the same number of animal locations simulated directly from the RSF probabilities.

When we measured forage removal with respect to RSF probabilities on the Starkey landscape and changed the RSF weights in the pixel preference equation, we found that the model did indeed lead simulated animals to spend more time foraging in areas with higher RSF scores. Using these methods, additional simulations could be performed to measure the loss of foraging opportunities as a result of selecting foraging pixels on the basis of distance to roads or other human influences. In this way the effect of human disturbance on animal performance could be examined.

We were also able to quantify changes in animal performance resulting from a reduction in forage production at the landscape scale. Reductions in forage production might result from drought or natural disturbance. Changes in animal weight with decreasing forage production closely resembled the functional response of intake rate to decreasing forage biomass for the three species (Figure 1), and shows the importance of forage intake dynamics in the context of modeling animal performance (Gross et al. 1993). Simulating animal performance under a range of forage production values should also consider increased movements (Wickstrom et al. 1984), and, in the case of drought-limited forage production, a reduction in forage quality (Vavra and Phillips 1980, Weisberg et al. 2002). The latter relationship could easily be incorporated into the SFM, although there is little data from which to develop a quantitative relationship. Vavra and Phillips (1980) observed a 20-30 percent reduction in digestible dry matter during a drought year when precipitation was 39 percent of normal. Reductions in forage quality of this magnitude would have a significant impact on simulated animal weights.

We observed negligible interspecific effects on animal weight when population levels of each species were varied between 2 and 2,500 animals. However intraspecific effects were observed for all three species as manifested in reduced weight gain compared to simulations where population levels replicated those at Starkey. Weisberg et al. (2002) also found stronger intraspecific than interspecific competition for forage when they modeled cattle and elk on shared range. Hobbs et al. (1996) in their study of elk and cattle competition found significant reductions in calf weights while cow weights were not significantly unchanged. Competitive effects among the species might be better studied with our model by examining changes in forage intake rates over the season instead of animal weights. Adding calves to the model might also provide a means to study the competition question in more detail. In any event, additional model refinements and a battery of simulations are probably needed to carefully examine questions of competition among the three species.

The major challenge to refine the current model is to determine what mechanisms in the foraging process are the most important determinants of landscape scale foraging behavior and animal performance. Factors such as environmental heterogeneity (Shipley and Spalinger 1995, Etzenhouser et al. 1998, WallisDeVries et al. 1999, Johnson et al. 2002), movement rules (Gross et al. 1995), and cognitive abilities (Bailey 1995), all influence the foraging behavior of ungulates on large landscapes. However, for the purposes of analyzing stocking on summer range in the Blue Mountains, some of the finer details of the foraging process may not be needed in the current model. One important gap in the model is the lack of local data on the functional response of intake rate for cattle, elk, and mule deer for conditions at Starkey. Development of these relationships should be a high priority since these functions are strong determinants of animal performance for scenarios where forage biomass is limited due to high stocking rates or low forage production. Modeling intake rate at the bite level rather than using standing biomass may provide different results than obtained here, since intake rate is poorly correlated with standing biomass for highly selective foragers like mule deer (Spallinger and Hobbs 1993).

Considerable detail could be added to the energetic component of our model by building on previous work (Wickstrom et al. 1984; Hudson and White 1985a,b). For instance, we did not change energy budgets to reflect increased daily movements at lower levels of standing forage biomass. We also did not consider the energy requirements as a function of animal age. Another important addition would be the growth and development of calves for all three species.

Our ultimate goal is to use the SFM to evaluate different grazing management strategies on summer range landscapes in areas like the forest types of the interior western United States, and test various hypotheses about the effects of alternative stocking rates for ungulates. In this regard, the objective might be to identify the existence of key stocking thresholds that correspond to changes in animal performance at the species level (Hobbs et al. 1996). Such a tool is currently not available for use in allotment management planning on lands administered by the U.S. Department of Agriculture, Forest Service (FS) and U.S. Department of Interior, Bureau of Land Management (BLM), the two largest federal land managers in the United States. Moreover, the mechanistic structure of our model, based on individual foraging behavior, could help managers and public interests improve their understanding of how ungulates use the landscape to meet their foraging needs.

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Table 1. Coefficients of resource selection functions for mule deer and elk during six monthly time steps in Main Study Area 1993-1996, Starkey Experimental Forest, northeastern Oregon. Seasons 1-6 correspond to May 16-June 15, June 16-July 15, July 16-August 15, August 16-September 15, September 16-October 15, and October 16-November 15. Coefficients are standardized (top) and non-standardized (bottom). Coefficients for elk when cattle were not present were estimated in Smith-Bally pasture (seasons 2 and 5) and Bear pasture (seasons 3 and 4).

	Season	Intercep	Dist. Edge of Patch	Forage Prod.	Shape of Patch	Dist. Traffic Zero	Dist. Traffic Low	Dist. Traffic Med.	Dist. Traffic High	Perc. Slope	Aspect East West	Aspect North South	Topog Conve x	Soil Depth	Dist. Cover	Perc. Can. Cover	Dist. to Cattle Fence	Elk Dist To Water
Deer	1	-3.4588						-0.4284	-0.3431	0.2505	0.2159		0.2346					
		-25.2478						-0.0005	-0.0003	0.0200	0.2951		0.0449					
	2	-3.8910							-0.5615	0.2326	0.1344		0.1250					
		-15.4409							-0.0003	0.0186	0.1830		0.0239					
	3	-4.4878							-0.5473	0.3817	0.1723	0.2151	0.0818					
		-12.1049							-0.0006	0.0305	0.2353	0.3210	0.0156					
	4	-3.7869							-0.4496	0.2767	0.1254		0.0936		-0.2073			
		-12.3734							-0.0007	0.0221	0.1703		0.0179		-0.0016			
	5	-3.9353						-0.3948	-0.5563	0.2355			0.1174					
		-14.3405						-0.0003	-0.0006	0.0188			0.0224					
	6	-3.9259									0.0811		0.1466		-0.1514			
		-17.8403									0.1097		0.0280		-0.0012			
Elk	1	-2.4546						0.1191		-0.1119			0.1181	0.1470		0.0552		
		-14.0412						0.0001		-0.0089			0.0226	0.0121		0.0025		
	2	-2.8329	-0.0378	-0.0568	-0.0455		-0.2775	0.0741		0.1075	-0.0442	0.1034	0.1944	0.1384				
		-21.2643	-0.0008	-0.0003	-0.2897		-0.0004	0.0001		0.0086	-0.0607	0.1543	0.0371	0.0114				
	No	-2.9761			-0.1288		-0.2905			-0.2912	-0.1899		0.2856	0.1601	-0.2750	0.2510	0.2891	
	cattle	-26.8541			-0.7677		-0.0004			-0.0223	-0.2701		0.0477	0.0126	-0.0021	0.0015	0.0007	
	3	-3.6208	0.1038	0.0377	-0.0681			0.1237	0.2306	0.1190		0.2491	0.1617	0.1851	-0.1919	0.1776		
		-20.3917	0.0022	0.0002	-0.4333			0.0002	0.0002	0.0095		0.3722	0.0309	0.0153	-0.0015	0.0081		
	No	-3.3056			-0.1649		0.3010	0.3256	0.5570	-0.1375	-0.1520	0.1803	0.3226	0.3783	-0.4220			0.1815
	cattle	-32.3572			-0.9822		0.0004	0.0003	0.0008	-0.010	-0.2119	0.2587	0.0534	0.0300	-0.0032			0.0011
	4	-3.0575	0.0992			0.1182	0.0984		0.1946			0.1946	0.1706	0.1527	-0.1558	0.1709		
		-20.4503	0.0021			0.0005	0.0002		0.0003			0.2900	0.0326	0.0126	-0.0012	0.0078		
	No	-2.6522		-0.1112								0.1301	0.1945	0.1697		0.2209		0.1823
	cattle	-19.5567		-0.0005								0.1867	0.0323	0.0134		0.0098		0.0011
	5	-3.1617	0.0463				0.0822					0.2379	0.1598	0.1212	-0.1813	0.1874		
		-19.0188	0.0010				0.0001					0.3556	0.0305	0.0100	-0.0014	0.0085		
	No	-2.2976		-0.2736	-0.1136							0.2324	0.0907		-0.3904			0.2638
	cattle	-9.4488		-0.0012	-0.6781							0.3325	0.0151		-0.0030			0.0016
	6	-3.2960								0.0978		0.1396	0.1757	0.0915	-0.1612	0.0580		
		-20.4223								0.0078		0.2073	0.0336	0.0075	-0.0012	0.0026		

Table 2. Coefficients of resource selection functions for cattle during four monthly time steps in cattle pastures 1993-1996 at Starkey Experimental Forest, northeastern Oregon. Seasons 2-5 correspond to June 16-July 15, July 16-August 15, August 16-September 15, and September 16-October 15. Coefficients are standardized (top) and non-standardized (bottom).

	Season	**Intercept**	**Dist. Edge of Patch**	**Forage Prod**	**Dist. to Road**	**Dist. to Fence**	**Perc. Slope**	**Aspect East West**	**Topog Convex**	**Soil Depth**	**Dist. Cover**	**Perc. Can. Cover**	**Dist. to Water**
Cattle	2	-2.4895	-0.0613		-0.1756	0.3043	-0.4726	-0.1063	-0.0526		-0.2089	-0.2743	0.1252
		2.8039	-0.0014		0.0008	0.0008	-0.0365	-0.1489	-0.0088		-0.0016	-0.0123	0.0008
	3	-3.0240	-0.1597	0.0452	-0.9849		-0.1370	-0.0917	-0.0660	0.0943		0.0563	-0.1300
		4.0840	-0.0033	0.0005	-0.0007		-0.0120	-0.1217	-0.0139	0.0078		0.0028	-0.0007
	4	-2.8177	-0.1728	0.0747			0.0747	-0.0584					-0.7470
		-2.4244	-0.0036	0.0007			0.0007	-0.0754					-0.0009
	5	-2.7450	-0.2228	0.0864		0.1516			-0.4536	0.0711		-0.1650	
		0.9900	-0.1710	0.0004		0.0004			-0.0075	0.0056		-0.0013	

Table 3. Daily energy demands of adult female deer, cow and elk (mcal per day) by month. Data from (Hudson and White 1985a,b; Sheehy 1987; Cook 2002).

Species	**Month**						
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Cattle	23	23	23	22	21	19	18
Elk	10.0	10.5	16.0	15.9	13.2	12.0	11.0
Deer	3.0	3.0	6.3	4.3	4.3	3.6	3.1

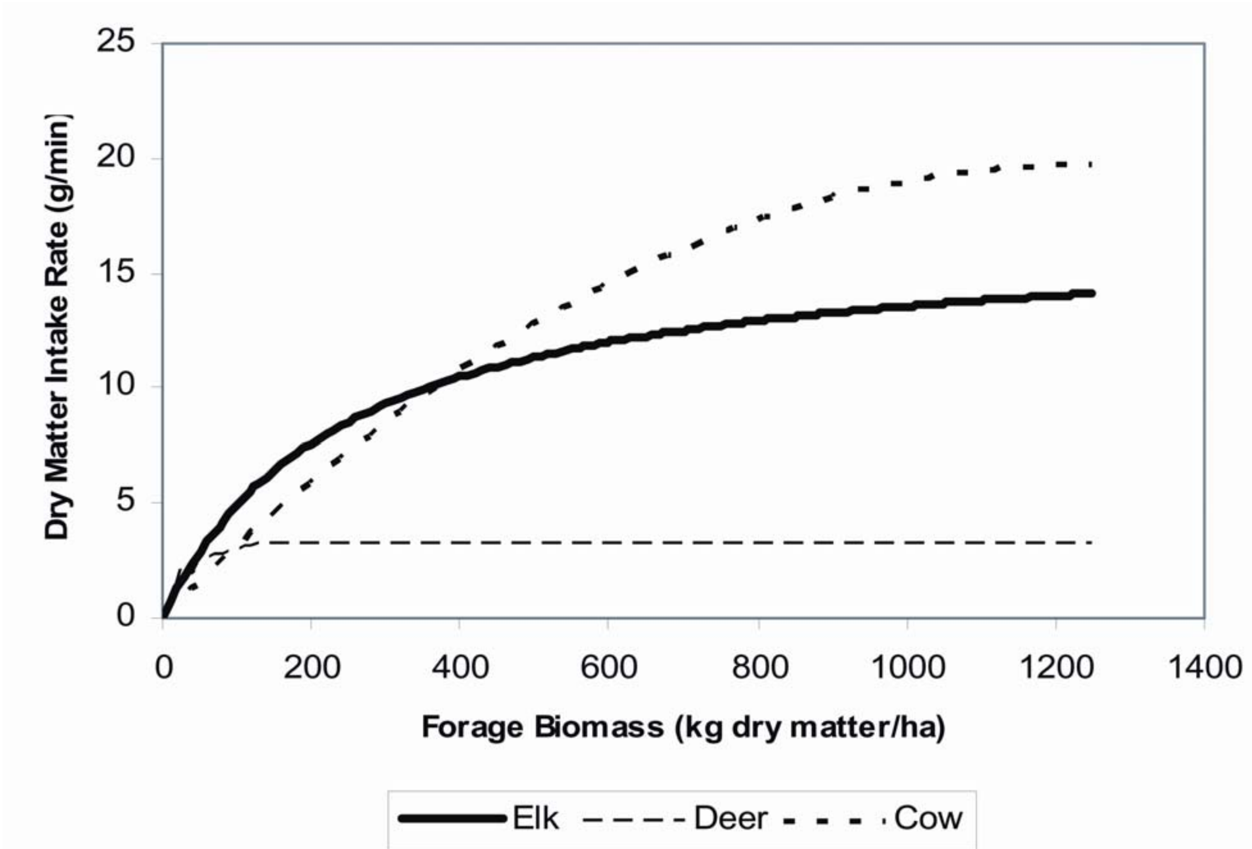

Figure 1. Relationship between standing forage biomass and dry matter intake rate for elk, mule deer and cattle. Functions for elk and deer were developed from data in Wickstrom et al. (1984). The elk relationship was developed from the Wickstrom et al. (1984) mixed forest type relationship. The function for cattle was developed from grazing trials on Starkey and the bison data in Spallinger and Hobbs (1992).

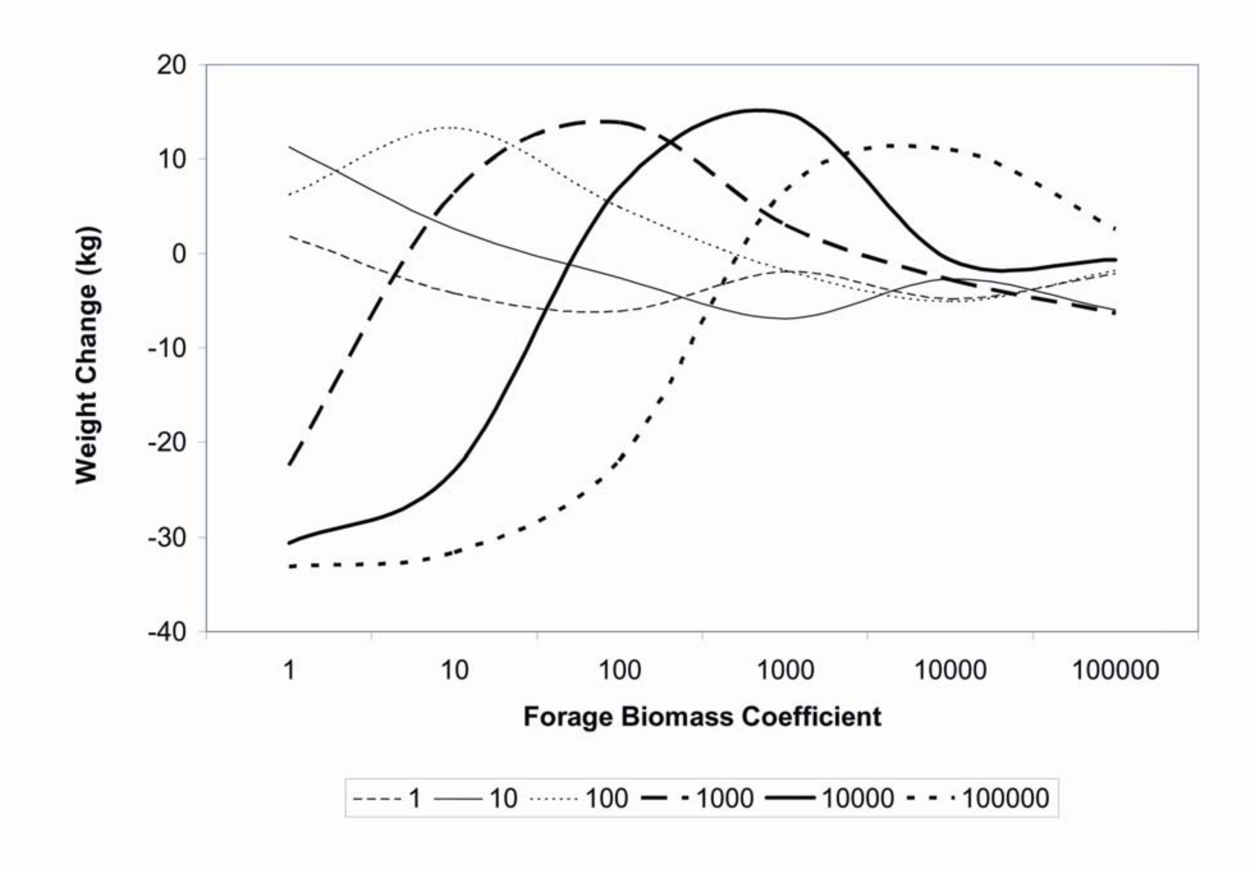

Figure 2. Simulated weight change in cattle for a range of values for W_{rsf} and W_{mass} in equation (1). X-axis contains values for the W_{mass} (forage biomass) weights for equation (1). Legend entries are the values for W_{rsf} in equation (1). Animal populations were 500 cattle, 450 elk, and 250 mule deer.

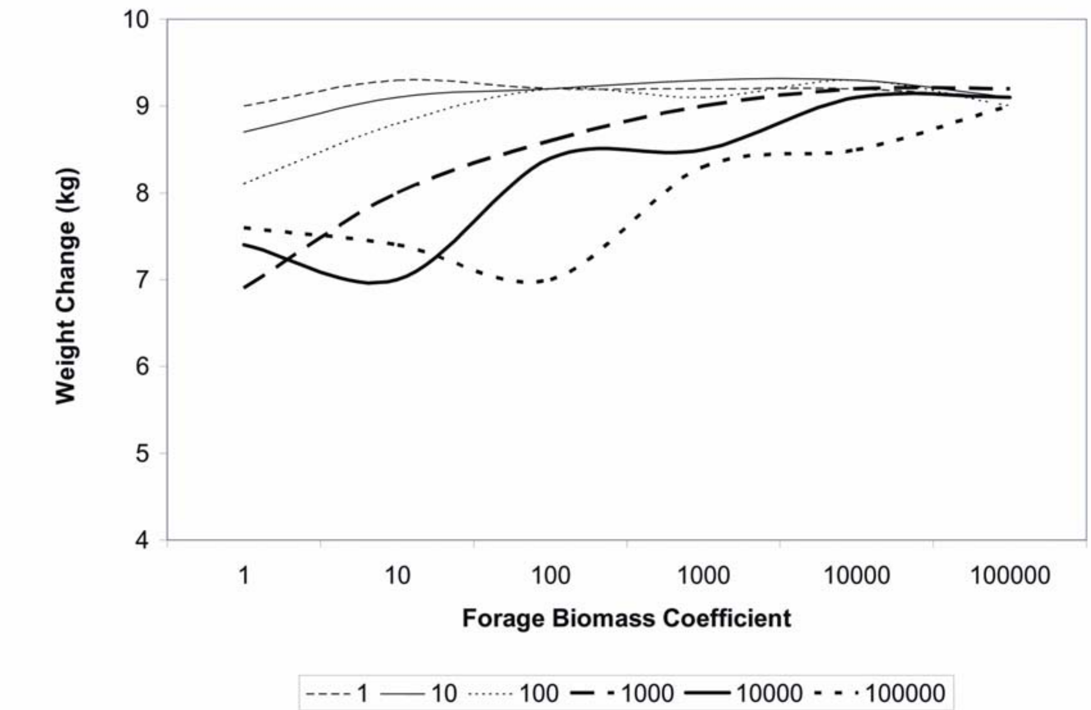

Figure 3. Simulated weight change in mule deer for a range of values for W_{rsf} and W_{mass} in equation (1). X-axis contains values for the W_{mass}. Legend entries are the values for the W_{rsf}. Animal populations were 500 cattle, 450 elk, and 250 mule deer.

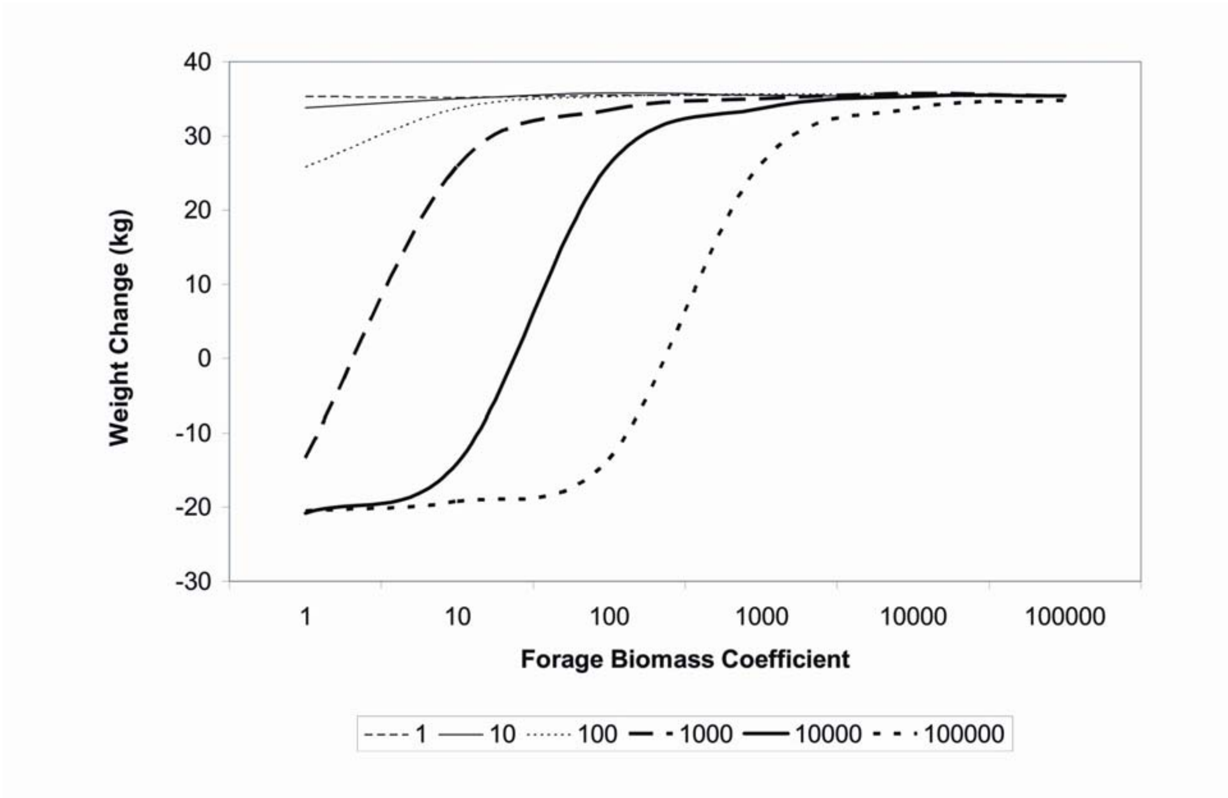

Figure 4. Simulated weight change in elk for a range of values for W_{rsf} and W_{mass} in equation (1). X-axis contains values for the W_{mass} weights for equation (1). Legend entries are the values for the W_{rsf} weights in equation (1). Animal populations were 500 cattle, 450 elk, and 250 mule deer.

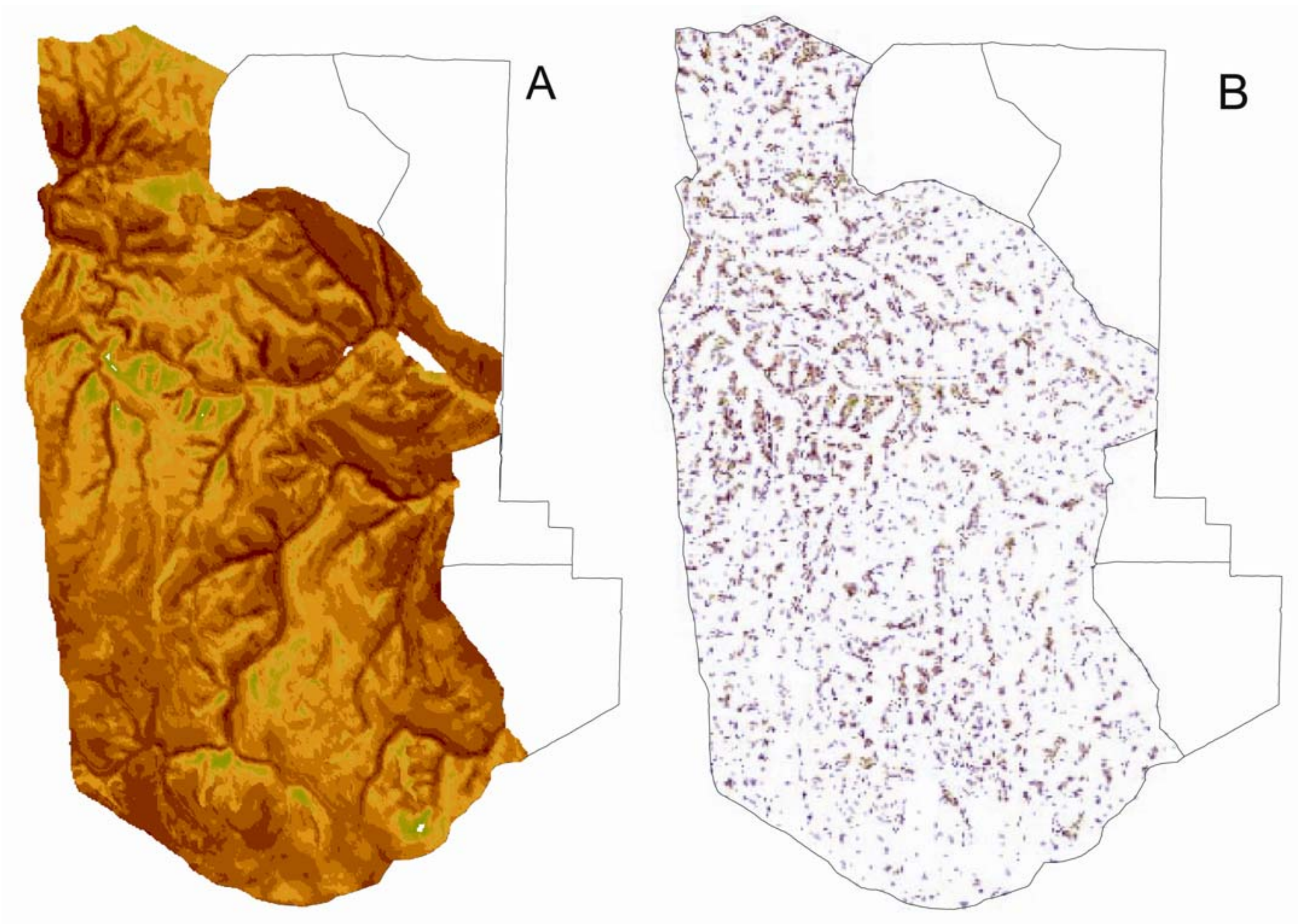

Figure 5. (A) Plot of resource selection functions for elk developed for Starkey data (Coe 2004). Values plotted were the sum of the monthly RSF scores as described in Coe (2004), and range from near 0.15 (white) to 1.5 (black). B) Results of simulation showing relative forage removal by elk within the Starkey area using W_{rsf} of 10,000 and W_{mass} if 1000. Dark areas correspond to areas of highest forage removal.

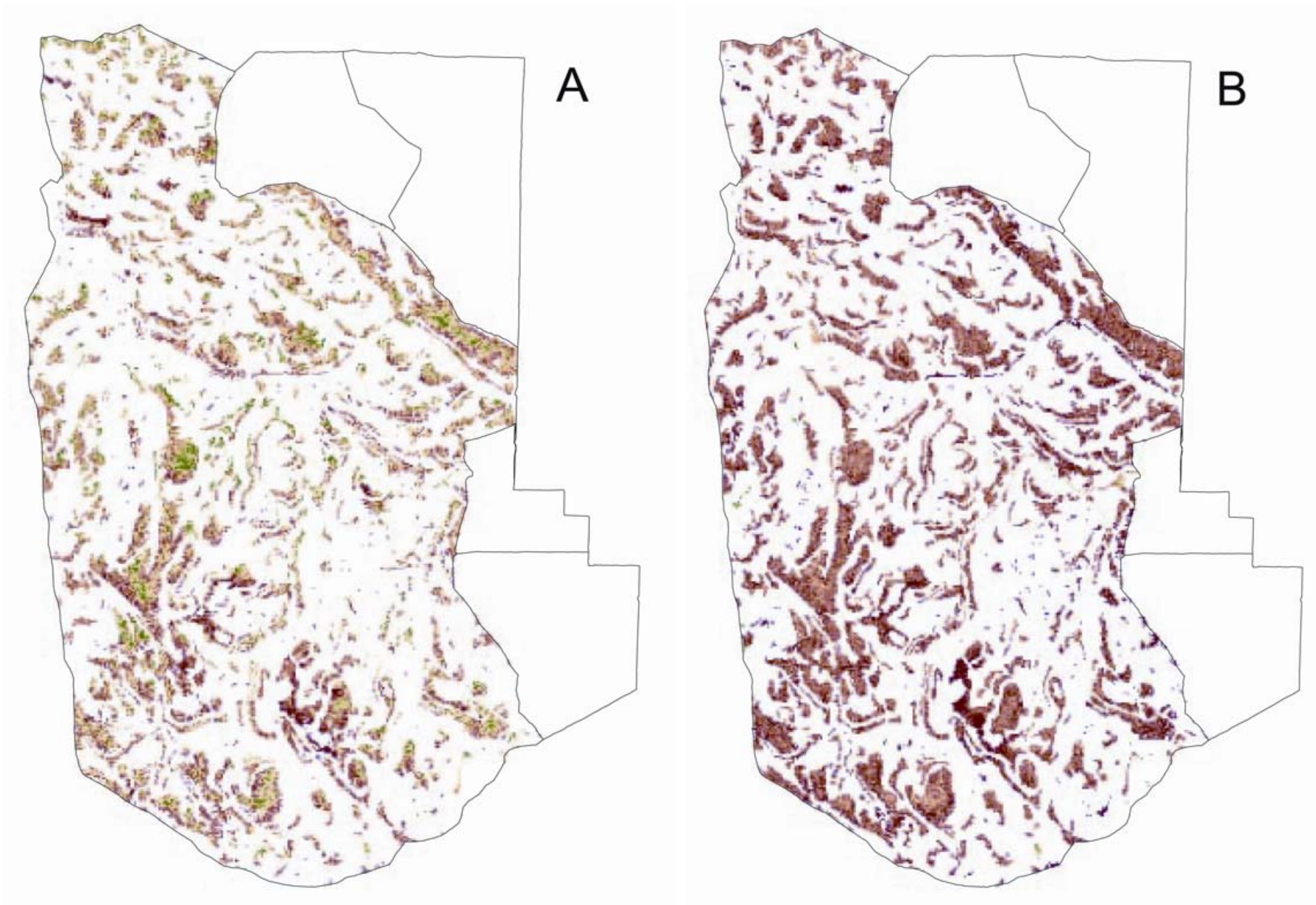

Figure 6. Results of simulation showing relative forage removal by elk within the Starkey area using weights of W_{rsf} of 1000 and W_{mass} if 10,000. Dark areas correspond to areas of highest forage removal. B) Same as (A) with forage production reduced to 10 percent of normal.

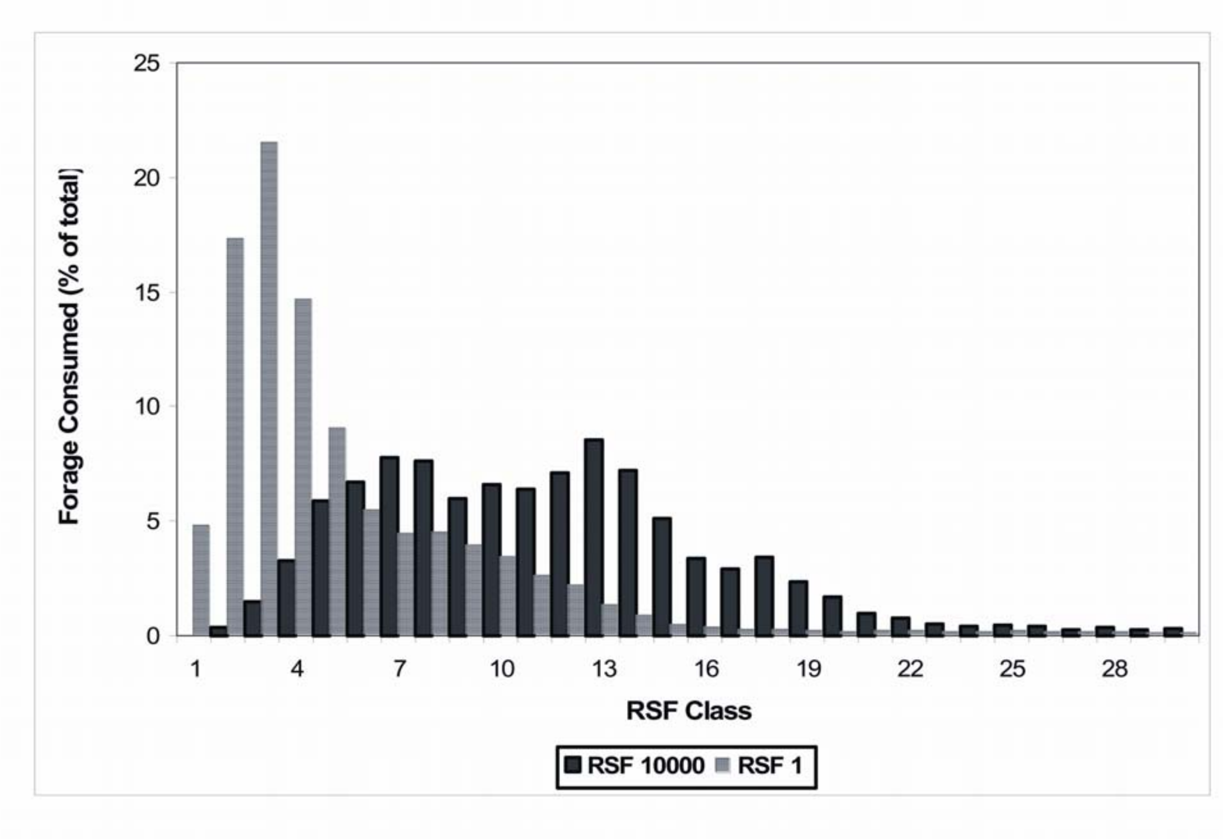

Figure 7. Forage consumption by two simulated elk using W_{rsf} weights of 1 and 10,000 and W_{mass} of 1. Data plotted are the percent of total forage consumed in each RSF class. RSF classes were calculated as RSF x 100. The figure shows that increasing the RSF weight for selecting foraging pixels results in a larger percentage of forage removal from the higher RSF pixels.

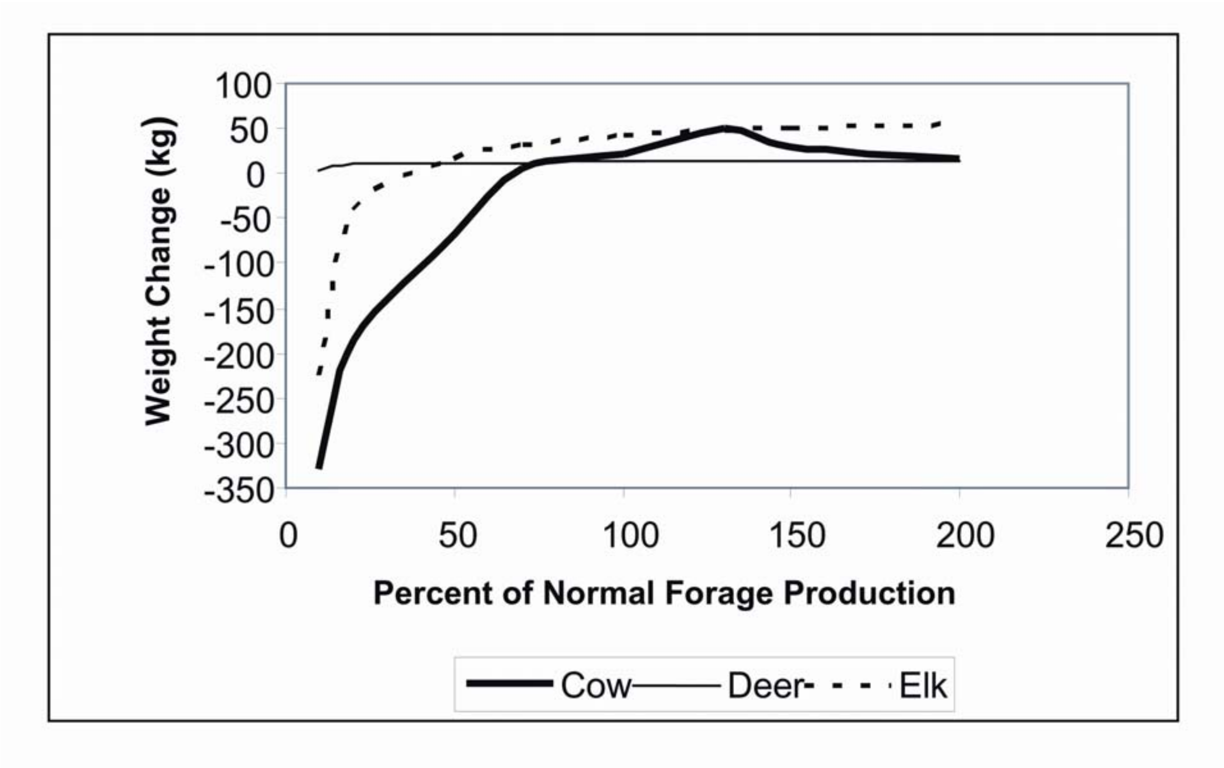

Figure 8. Results of simulations to examine the effect of reductions in forage production on average animal weight change for cattle, elk, and mule deer. Simulations used 500 cows, 60 mule deer and 450 elk. Forage production was reduced by a constant percentage of the normal growth rate throughout the growing season

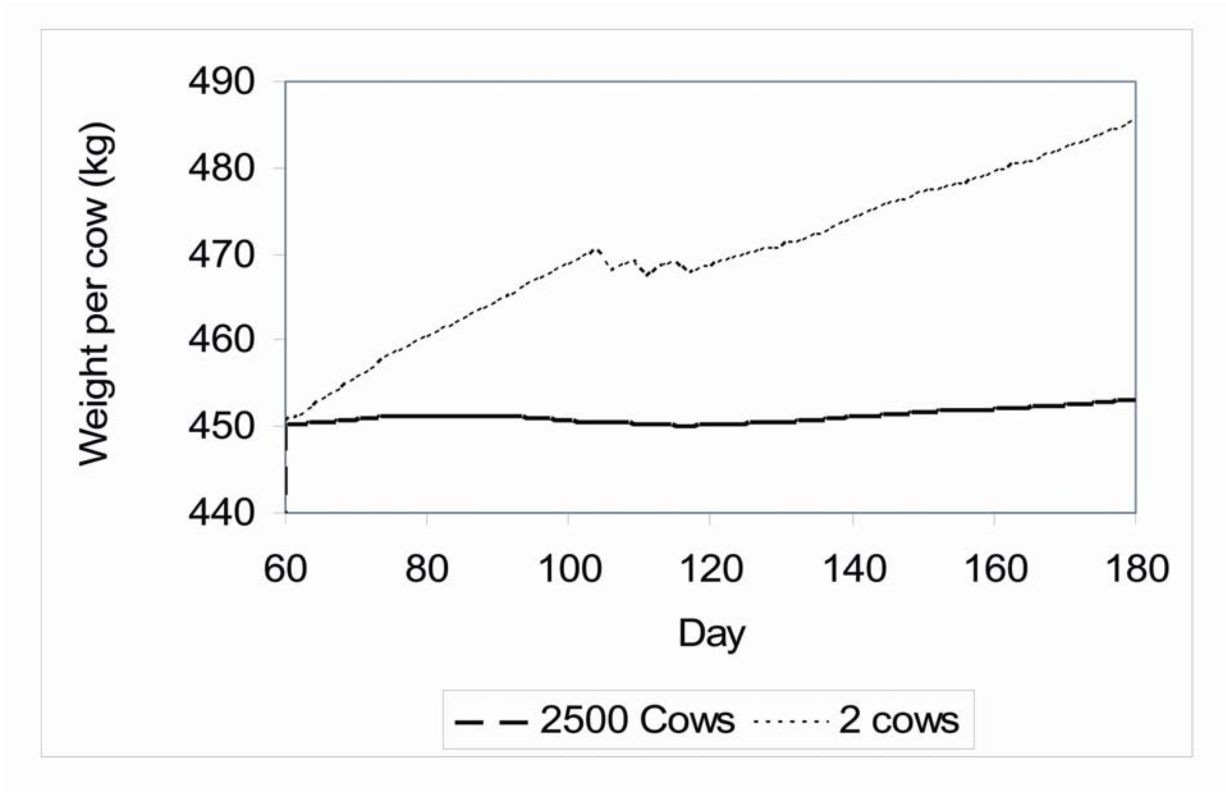

Figure 9. Changes in average animal weight for cattle over the grazing season for a cattle population of 2 and 2500.

Response:

Thank you for your comments and your favorable response to the TMDLs. Rangeland grazing has been identified as a probable source of impairment for both East Fork Jemez River (VCNP boundary to headwaters) and Jaramillo Creek (VCNP boundary to headwaters). Your land management suggestions will be passed along to SWQB's Watershed Protection Section as well as staff at the Valles Caldera National Preserve.

Comment Set B

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copies of all pages, plus exhibits copy retained
sent to D. Clark, R. Curry, M. Dechter, J. Garcia, J. Isaacs, M. Peale, B. Richardson, R. Salazar, D. Trujillo, N. Wells, and K. Wiegner

May 27, 2005
135 Rincon Valverde
Ponderosa, NM
87044

Ms Heidi Henderson
TMDL Coordinator
New Mexico Environment Department
Surface Water Quality Bureau
Harold Runnels Building, Room N2163
1190 St. Francis Drive, P.O. Box 26110
Santa Fe, NM 87502-6110

USPS CMR 7005 3110 0002 1105 3285 Rebecca Y. Perry Pepper

Dear TMDL Coordinator Henderson,

I hope that you are fine. I, and my family, are, as well. Enclosed is my most recent non-technical written public comment on a supporting document to the Jemez River Watershed TMDL named, presently, either Draft Total Maximum Daily Load (TMDL) for Valles Caldera National Preserve Watershed Valles Caldera National Preserve Boundaries to Headwaters, May 15, 2006, or Draft Total Maximum Daily Load (TMDL) For The Jemez River

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Watershed VCNP Boundaries To Headwaters, May 15, 2006; as well as my request for a copy of amended draft of aforementioned TMDL document that is to be presented to WQCC, and should be available 10 days before said presentation to be printed and mailed to me; as well as my invocation of procedural due process should you not be able to address my concerns as requested in this non-technical written public comment. Accordingly, this non-technical written public comment should be acknowledged as adhering to procedural due process in that it contains my informing you of my intent to personally appear at the meeting where same TMDL document is presented to WQCC. Also, accordingly, this non-technical written public comment should be acknowledged as adhering to procedural due process in that it contains my informing you of

May 27, 2006

my intent to present a non-technical oral public comment, at the time of the presentation of said TMDL document; contains the text of my oral public comment; contains the time it will take to deliver my non-technical oral public comment; contains the number of pages of handwritten notes I will hold in my hands, to refer to, during my non-technical oral public comment; contains copies of the exhibits I will distribute to each person present during my non-technical oral public comment, at the time indicated in my non-technical oral public comment; contains the nature and scope of my interest in appearing before WQCC at the presentation of this same TMDL document; contains the names of who I will represent in appearing before WQCC at the presentation of this same TMDL document; contains the mailing address I wish to be notified, in a timely manner of when and where the

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presentation of this same TMDL document will occur so that I might arrive to deliver my non-technical oral public comment and simultaneously distribute copies of my exhibits to those present in a punctual manner; and contains my legal signature.

I have also included a copy of my initial non-technical written public comment, dated May 26, 2006, and mailed, U.S. Postal Service Certified Mail Receipt/Article Number 7005 3110 0002 1105 3292, with a copy of my stamped certified mail receipt. I; for the record; would like to state that all contained in that May 26, 2006 non-technical written public comment is now superseded by the non-technical written public comment that follows here-in; which serves, dually, as the non-technical oral public comment that I am notifying you that I will orally deliver, with exhibits that I will simultaneously

copy retained

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deliver, in person, before WQCC, when NMEDSWQB presents said TMDL document. If it is necessary for me to demand that there be a hearing, according to appropriate procedural due process, concerning NMEDSWQB's presentation of this aforementioned TMDL document (named, at printing, <u>Draft Total Maximum Daily Load (TMDL) for Valles Caldera National Preserve Boundaries to Headwaters, May 15, 2006</u>; and also named, at Valles Caldera N.P. Community Meeting, Thursday, May 25, 2006, conducted by the NMEDSWQB, <u>Draft Total Maximum Daily Load For The Jemez River Watershed VCNP Boundaries To Headwaters, May 15, 2006</u>), concerning the amendment of same TMDL document before presentation to WQCC (or that the presentation of same TMDL document for WQCC approval take on hearing status), then consider this my written, for-the-record, demand

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Rebecca J. Perry-Piper

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that it be so, that I demand a hearing. I will also demand such in my non-technical written public comment contained herein this May 27, 2006 correspondence to you.

-beginning of non-technical written public which I am notifying NMED SWQB I intend to present, reading from notes for 25 minutes and distributing 4 submitted exhibits, as delivery calls for, during the meeting NMED SWQB will have with WQCC to submit a TMDL document named; on May 15, 2006; Draft Total Maximum Daily Load (TMDL) for Valles Caldera National Preserve Watershed Valles Caldera National Preserve Boundaries To Headwaters, and also named; on May 25, 2006; Draft Total Maximum Daily Load (TMDL) for The Jemez River Watershed VCNP Boundaries To Headwaters, May 15, 2006; as amended; or during the hearing I have requested, if I am not

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May 27, 2006

allowed to present my non-technical oral public comment at the meeting SWQB will be presenting before WQCC at before WQCC gives approval to aforementioned TMDL document—

"Greetings. My name is Rebecca G. Perry-Piper. I represent the members of my family who live with me at 135 Rincon Valverde, Ponderosa. I have been a member of the Jemez Watershed Group since August, 2004. Thank you for letting me present my non-technical oral public comment on five concerns I have about the Draft Total Maximum Daily Load (TMDL) document, made public for comment on May 15, 2006, on a part of a still ongoing intensive water survey study for the Jemez River Watershed.

My first concern has to do with the covers, Draft, WQCC-Approved and Final, of the parts of this Jemez River Watershed study,

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Rebecca G. Perry-Piper

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[signature]

-cont comment-

as each is completed. I have no need for a Final Draft cover version in Exhibit 1, which I now ask you to refer to. As we go through this together, I'd like you to imagine that the completed comprehensive Jemez River Watershed intensive water survey study TMDL is going public during a series of consecutive community meetings and that all present at these community meetings; as well as commenting public-at-large; approve of them, from headwaters to the incorporated Village of San Ysidro. Five of these covers are working covers at these imaginary meetings. One is presented to the imaginary public at the imaginary meeting for assurances. Please open Exhibit 1, if you haven't already, and find your first Draft, Part 1, please.

• I propose Part 1 of the Jemez River Watershed document be named <u>Draft Total Maximum Daily</u>

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-cont comment- May 27, 2006

Load (TMDL) For The Jemez River Watershed Rio Grande River To Headwaters (Part 1) (East Fork Jemez River And Jaramillo Creek ■ VCNP Boundary To Head Waters ■ May 15, 2006, skip over the second and third identical WQCC-Approved and Final Approved versions and look at Draft, Part 1, assurances version,

• I propose that this version be approved for Valles Caldera National Preserve's next completed TMDL document for this study on the Jemez River Watershed and that it be named Draft Total Maximum Daily Load (TMDL) For The Jemez River Watershed Rio Grande River To HeadWaters (Part 2) (Vallecito Creek ■ Jemez Pueblo Boundary To USFS Boundary), its undated,

• looking at Draft, Part 3, I propose Part 3 of the Jemez River Watershed document be named Draft Total Maximum Daily Load

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-cont comment-

(TMDL) For The Jemez River Watershed Rio Grande River To Headwaters (Part 3) (East Fork Jemez River, Redondo Creek And Sulphur Creek ■ Rio Jemez To VCNP Boundary ■ Rio Guadalupe ■ USPS Boundary To Headwaters ■ San Antonio Creek, Rio Cebolla and Rio de las Vacas ■ USFS Boundary To VCNP Boundary), it's undated,

- on to Part 4, Draft cover and I propose Part 4 cover be named Draft Total Maximum Daily Load (TMDL) For The Jemez River Watershed Rio Grande River To Headwaters (Part 4) (Rio Jemez ■ Jemez Pueblo Boundary To USFS Boundary ■ Rio Guadalupe ■ Rio Jemez To USFS Boundary), it's undated,
- and, finally, for this, looking at Draft Part 5, I propose that this cover be named Draft Total Maximum Daily Load (TMDL) For The Jemez River Watershed

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-cont comment- May 27, 2006

<u>Rio Grande River To Headwaters (Part 5) (Rio Jemez Jemez Pueblo Boundary To Zia Pueblo Boundary)</u>, its undated. Please, down Exhibit 1.

My second concern has to do with the uses of two abbreviations (TMDL and WRAS); and their plurals; and three words; and their plurals; both capitalized and uncapitalized (watershed, subwatershed and basin), that occur in same TMDL document, May 15, 2006. Exhibit 2 lists the following rules that must be followed for best use practices:

- <u>Rule 1</u>• all uses of the word TMDL should reflect that, at the end of this study as well as during same, there will be only one comprehensive TMDL and it will be the Jemez River Watershed TMDL;
- <u>Rule 2</u>• all uses of the word WRAS should reflect that, at the end of this study as well as during same, there will be only one comprehensive WRAS and it will be the Jemez Watershed Group WRAS;

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Jeffrey J. Perry-Ripi

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May 27, 2006

-cont comment-

- Rule 3 • all uses of the word watershed should reflect that, at the end of this study as well as during same, there will be only one watershed (for science's sake), and it will be the Jemez River Watershed, which is actually the subwatershed in this TMDL study; the Jemez River Watershed is a subwatershed of the Rio Grande River;
- Rule 4 • all uses of the word subwatershed should also reflect that, at the end of this study as well as during same, there will be only one subwatershed (for science's sake) and that the Jemez River Watershed's streams are being studied;
- Rule 5 • all uses of the word basin should reflect that, at the end of this study as well as during same, there will be only one basin and it will be the Rio Grande River Basin;

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Elena Y. Perry-Piper

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-cont comment- May 27, 2006

I ask, in closing on this concern, that all uses of the abbreviations TMDL and WRAS; and words watershed, subwatershed and basin; singular or plural, capitalized or uncapitalized where applicable; that do not follow Rules 1-5 be deleted or changed in the Draft TMDL, as it stood on May 15, 2006, on Pages ii, iii, 1, 4, 5, 6, 7, 8, 10, 12, 14, 15, 17, 18, 19, 20, 37, 38, 39, 41, 44, 45, 46, 49, 50, 51, 52, 53, 54, 55, 57; Appendix C, Pages i, ii, iii, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 before document receives WQCC approval. I ask that the amended version be only Draft status until follow-up is complete. Exhibit 2 down.

My third concern has to do with making sure that the definition of stakeholder that is used in this TMDL document, May 15, 2006, is expanded so as to be including, as shown in

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Rebecca D. Perry-Piper

-cont comment-

Exhibit 3. Look first at Page 53, 7.1, "Coordination", Sentence 4, from the Draft TMDL, May 15, 2006. This sentence reads:

"It includes opportunities for private landowners and public agencies in reducing and preventing impacts to water quality."

"It" refers to WRAS development. Now please turn to the next page in Exhibit 3.

In the future, TMDL stakeholder definition should not exclude any interested party wishing to become a member of the Jemez Watershed Group on the grounds of:

- not owning property in the Jemez River Watershed,
- not residing in the Jemez River Watershed,
- not deriving income from the Jemez River Watershed,
- not utilizing a particular type

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[signature]

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-cont comment- May 27, 2006

of communicative device, process or system, and

- not being able to participate in real-time.

I ask that the stakeholder definition on Page 53, 7.1, "Co-ordination", Sentence 4, in TMDL document, May 15, 2006, be expanded with the 5 points listed on the second page of Exhibit 3 adhered to before WQCC approves this same TMDL document.

My fourth, and last, concern has to do with a concern that was expressed on October 14, 2005, in a non-technical written public comment to NMEDSWQB on <u>Draft Total Maximum Daily Load For The San Juan Watershed (Part Two) Navajo Nation Boundary At The Hogback To Navajo Dam, September 23, 2005, New Mexico Environment Department Surface Water Quality Bureau.</u> Please find the first page, which

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Rebecca G. Perry-Piper

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-cont comment-
is Page 37 from said TMDL document, Figure 4.5 "Residences that fall within 100 meters of the Animas River, NM", the next page in Exhibit 4 is my comment continuing on the subject of this type of data collection. It is the same comment I made, just about, in October, 2005, except it's about 7 months later and this study is in the Jemez River Watershed; coming to Ponderosa on June 21, 2006.

Exhibit 4: Collection Of Addresses Of Residences That Fall Within 100 Meters Of Streams Of The Jemez River Watershed: Is this intensive water survey study continuing to go from waterbody identifior to waterbody identifior gathering addresses of residences built, or hauled, within 100 meters of a stream without asking if they wish to be added to the data bank; without explaining why there needs to be such a data

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-cont comment- May 27, 2006

bank? Granted, since I made a non-technical written public comment on this matter on October 14, 2005, I have never seen a figure like Figure 4.5, on Page 37 of the San Juan Watershed TMDL document, in any other TMDL document I have reviewed since. Again, this practice, if it is still going on, needs to be stopped in the Jemez River Watershed study, now. If the data bank has been compiled, each person that is in the data bank needs to receive a letter notifying them that this has happened, when, who helped give contributing information, who was their personal information given to, and why is this data bank listing every residence within 100 meters of streams in the Jemez River Watershed being compiled, and involuntarily. How could SWQB respond to me, in Final Draft Total Maximum

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-cont comment- May 27, 2006

Daily Load (TMDL) For The San Juan River Watershed (Part Two) Navajo Nation Boundary At The Hogback To Navajo Dam, October 23, 2005, that implementation of the TMDL is on a voluntary basis? If all of the information on said Page 37 isn't voluntary then that's wrong. Did all the folks on Page 37 volunteer that information? WQCC should prohibit such data gathering if its without permission.

The Exhibits are yours to keep. I hope that you will not approve any TMDL document on the Jemez River Watershed study that does not take my concerns into consideration and adhere to my non-technical oral public comment and exhibits.

Thank you,

Rebecca G. "Gert" Perry-Piper

Rebecca G. "Gert" Perry-Piper

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Rebecca G. Perry-Piper

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May 27, 2006

-end of non-technical written public which I am notifying NMED SWQB I intend to present, reading from notes for minutes and distribute 4 submitted exhibits, as delivery calls for, during the meeting NMEDSWQB will have with the WQCC to submit a TMDL document named; on May 15, 2006; <u>Draft Total Maximum Daily Load (TMDL) ,or Valles Caldera National Preserve Watershed Valles Caldera National Preserve Boundaries To Headwaters</u>, and also named; on May 25, 2006; <u>Draft Total Maximum Daily Load (TMDL) ,or The Jemez River Watershed VCNP Boundaries To Headwaters, May 15, 2006</u>; as amended; or during the hearing I have requested, if I am not allowed to present my non-technical oral public comment at the meeting SWQB will be presenting before WQCC at before WQCC gives approval to aforementioned TMDL document-

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May 27, 2006

Heidi, I have enclosed your copy of the Exhibits. I would appreciate it if you would be kind enough to tell me how many commissioners will be present so that I might have enough exhibits prepared. I will also need to know when, where the meeting, where SWQB presents this amended TMDL to WQCC will be, as well as a hearing, if it comes to that.

It was a pleasure to finally organize my thoughts on the matter of this Jemez River Watershed study. I look forward to seeing you again soon. Send all surface-mail to:

Rebecca G. Perry-Piper
135 Rincon Valverde
Ponderosa, NM 87044

Thanks, Rebecca G. "Geit" Perry-Piper

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Sent To Heidi Henderson State of New Mexico Environment Department Office of the Secretary Harold Runnels Building

Street, Apt. No.; or PO Box No. 1190 St Francis Drive P.O. Box 26110

City, State, ZIP+4 Santa Fe, NM 87502

PS Form 3800, June 2002 See Reverse for Instructions

May 26, 2006 superseded
non-technical written public comment on TMDL

Rebecca G. Perry-Piper
5-27-06

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WQCC MEETING/HEARING

NOT AN EXHIBIT FOR WQCC
MEETING/HEARING

-cont non-technical written public comment-
convey the existence of a Valles Caldera Watershed TMDL seperate from a Jemez River Watershed TMDL. Page 4, Paragraphs 1 and 2, begin desensitizing the reader to the use of the plural 'watersheds', in same TMDL. Page 14, in same TMDL, is another example of this overuse of the word 'watersheds', as well as simultaneously overusing the word 'TMDLs'. By the time the reader makes his way to Page 56, in same TMDL, the eyes don't even notice the 's' after 'TMDL' in the last sentence on the same page:

'The cooperation of watershed stakeholders will also be pivotal in the implementation of these TMDLs.'

All of this overuse of 'TMDLs' and 'watersheds' needs to be cleaned up. There is one watershed,

Attachment to document correction to Page 13 of 16, line 4 of May 26, 2005, non-technical written public comment, Rebecca G. Perry-Piper 5-27-06

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* request for letter of assurances, or a hearing, if no hardcopy of amended TMDL received
* 5 attachments enclosed
* copies of all 16 pages sent to Ron Curry, Marty Peale, Bill Richardson, Dennis Trujillo, Nina Wells, Kathleen Wiegner

copy retained

May 26, 2006

135 Rincon Valverde
Ponderosa, NM
87044

-non-technical written public comment on a supporting document to the Jemez River Watershed TMDL named, presently, either Draft Total Maximum Daily Load (TMDL) for Valles Caldera National Preserve Watershed Valles Caldera National Preserve Boundaries to Headwaters, May 15, 2006 or Draft Total Maximum Daily Load (TMDL) For The Jemez River Watershed VCNP Boundaries To Headwaters, May 15, 2006 -

Heidi Henderson
State of New Mexico Environment Department
Surface Water Quality Bureau
Office of the Secretary
Harold Runnels Building
1190 St. Francis Drive
P.O. Box 26110
Santa Fe, NM 87502

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May 26, 2006

-start non-technical written public comment-

Dear Heidi,

Thank you for the informative power point presentation and townball concerning Draft Total Maximum Daily Load (TMDL) For The Jemez River Watershed VCNP Boundaries To Headwaters May 15, 2006. I commend Jill, Adam and you for your efforts.

After thorough review of aforementioned TMDL and Prepared Pursuant to the Clean Water Action Plan and Unified Assessment of New Mexico Watersheds Jemez Watershed Restoration Action Strategy (WRAS) Revised August 2005 Jemez Watershed Group under a 319 Grant administered by the Meridian Institute 2004 Revised August 2005, I would like to submit non-technical written public comment on two concerns I still have. Please respond in writing and surface-mail it to me at the following

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-cont non-technical written public comment
address:

Rebecca G. Perry-Piper
135 Rincon Valverde
Ponderosa, NM 87044

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My first concern, though you and the TMDL Team have been extremely sensitive to my previous concerns on this same subject, is, again, the cover of the present TMDL document for the Jemez River Watershed streams in the Valles Caldera National Preserve that were included. I, as many other citizens do, support the two-year-old Information Quality Act. I advocate for data used by federal regulators, as well as state regulators funded by federal regulators, to be correct. In light of this, I assert that Water Quality Control Commission should not approve said TMDL until the title is changed from what was, firstly, Draft Total Maximum Daily Load

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-cont non-technical written public comment-
(TMDL) For The Valles Caldera National Preserve Watershed VCNP Boundaries To Headwaters, May 15, 2006, to what, secondly, became (as was explained and disseminated to all present at the May 25, 2006 SWQB Community Meeting on said TMDL) Draft Total Maximum Daily Load (TMDL) For The Jemez River Watershed VCNP Boundaries To Headwaters, May 15, 2006, should now become Draft (I have been so bold as to send you my version of the WQCC-Approved cover) Total Maximum Daily Load (TMDL) For The Jemez River Watershed Rio Grande River To Headwaters (Part 1) (East Fork Jemez River And Jaramillo Creek VCNP Boundary To Headwaters), May 15, 2006.

I assert that root principles of fairness dictate that procedural due process be afforded whenever a government

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-cont non-technical written public comment- decision threatens to deprive an individual of a fundamental liberty (State of New Mexico, ex rel. Children, Youth & Families Department v Maria C., 136 N.M. 53, (N.M. Ct. App. 2004). The essence of procedural due process is notice and an 'opportunity to be heard at a meaningful time and in a meaningful manner', State of New Mexico, ex rel. Children, Youth & Families Department v Mafin M., 133 N.M. 827, 70 P.3d 1266 (N.M. 2003).

Accordingly, notice must be 'reasonably calculated, under all circumstances, to apprise interested parties of the pendancy of the action and afford them an opportunity to present their objections', Id. at 314; see also City of Albuquerque v Juarez, 93 N.M. 188, 190, 598 P. 2d 650, 652 (Ct. App. 1979). Increasingly, however, the bureaucratic expectation to access and share real-time, transaction-level data, in a secure

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-cont non-technical public written comment -

May 26, 2006

fashion, overlaid by rapid technological changes in the workplace, represent an increasing national on-site communicative standard that discriminates against stakeholders that have the liberty to choose paper-based, surface-mailed processes for participating in procedural due-process. In light of this paragraph's first two sentences, I assert that the TMDL Team should have surface-mailed me Draft Total Maximum Daily Load (TMDL) For The Valles Caldera National Preserve Watershed VCNP Boundaries To Headwaters, May 15, 2006, so that I could have presented the enclosed version to you, Heidi, and to those present at the May 25, 2006 Community Meeting. I would like a written explanation as to why this cover cannot be used at the TMDL presentation of the WRAS planning meeting for the Jemez Watershed Group on June 21, 2006,

NOT AN EXHIBIT FOR WQCC MEETING/HEARING

-cont non-technical public written comment- copy retained May 26, 2006

in time to ask for a hearing before the 30 day comment period expires. If I cannot be accommodated, I would like for there to be a hearing on this matter. I, personally, do not see why you won't rectify this, and I will be glad to cooperate with you as much as I possibly can to achieve this end.

My second concern has to do with narrow definitions of what a WRAS stakeholder is limiting citizens from bringing much-needed diverse representation into the 'living document' process. As recently as April 24, 2006, I was given this reply to my asking to sit at Rio Puerco Management Committee's table to participate in the update of their 2001 WRAS after the Rio Puerco Watershed TMDL was opened to public comment:

'Your interest in the water-

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-cont non-technical public written comment-
shed adjacent to where you live is appreciated. The State and the USEPA continue to expand the required scope of these documents, hence the need for this one to be updated. The first version gathered input and contributions from life-long resident landowners, involved agencies, and contributing experts in a number of fields of physical and social sciences. I predict that the update will be similarly treated as we encourage the people who occupy and derive their living from their home watershed to take ownership of the ideas and commit to the restorative activities that are strategized via this document and its updates.' It is disturbing to see on Page 53 of Draft Total Maximum Daily Load (TMDL) For The Jemez River Watershed VCNP Boundaries To Headwaters, May 15, 2006,

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-cont non-technical public written comment-
7.0 'Implementation Of TMDLS'
7.1 'Coordination', Paragraph 1,
Sentences 3 and 4 stating:

'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.'

As I was informed by Heidi Henderson, by you, and by Nina Wells, New Mexico Environment Department Environmental Specialist, and fellow Jemez Watershed Group member, a hard-working founding member, Prepared Pursuant to the Clean Water Action Plan and Unified Assessment of New Mexico Watersheds Jemez Watershed Restoration Action Strategy (WRAS) under a 319 Grant ad-

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-cont non-technical written public comment- ministered by The Meridian Institute and Prepared by the Jemez Watershed Group, October 2004 Revised August 2005, will be the presently standing WRAS for the aforementioned TMDL. Let Page 53, of said TMDL, said heading, said paragraph, said sentences, be changed so that Page 4, said WRAS, Paragraph 4, Sentences 1 and 2, become the definition of a WRAS stakeholder:

`JWG Members agreed on the need for diverse stakeholder representation, and identified individuals and stakeholder groups to be involved. Stakeholders currently involved in the JWG include members of the general public, representatives of acequia associations, water users, private landowners, local government, environmental groups, state and

NOT AN EXHIBIT FOR WQCC MEETING/HEARING

-cont non-technical written public comment- federal agencies, and some of the Pueblos.

I would like written assurances that Page 53's narrow stakeholder definition will be changed from that found in the May 15, 2006 TMDL to that found in the JWG WRAS, Revised August 15, 2005, in time to ask for a hearing before the 30 day comment period expires if this cannot be done. The Valles Caldera National Preserve Trust thinks it needs the public to perceive VCNPT as "guarding" the Jemez River Watershed. Jemez Watershed Group thinks it needs the public to perceive it as "respecting" and "caring about" the Jemez River Watershed.

My third concern is about incorrect wording in the May 15, 2006 TMDL. I have categorized these types of incorrect wordings into three categories and have begun to identify where they

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WQCC MEETING/EXHIBIT

-cont non-technical written public comment- are located throughout May 15, 2006 TMDL. The first category is identified as instances where the words 'Valles Caldera Watershed' or 'Valles Caldera National Preserve Watershed' (sometimes VC Watershed, VC watershed, VCNP Watershed, or VCNP watershed) appear in the title, heading, subheading or caption, as well as in tables and figures. I have noticed this to happen at least once, and in some instances, as many as 4 or 5 times, on approximately 36 pages in the May 15, 2006 TMDL. All of these miswordings need to be replaced with wording that recognizes the only watershed being assessed in this TMDL of May 15, 2006, is the Jemez River Watershed.

The second category is identified as instances where a word repeatedly is overused until the reader is so desensitized to the use of this word that "TMDLs" can be used quite openly to

NOT AN EXHIBIT FOR
WQCC MEETING/HEARING

-cont. non-technical written public comment-
convey the existence of a Valles Caldera Watershed TMDL seperate from a Jemez River Watershed. Page 4, Paragraphs 1 and 2, begin desensitizing the reader to the use of the plural 'watersheds', in same TMDL. Page 14, in same TMDL, is another example of this overuse of the word 'watersheds', as well as simultaneously overusing the word 'TMDLs'. By the time the reader makes his way to Page 56, in same TMDL, the eyes don't even notice the 's' after 'TMDL' in the last sentence on the same page:

'The cooperation of watershed stakeholders will also be pivotal in the implementation of these TMDLs.'

All of this overuse of 'TMDLs' and 'watersheds' needs to be cleaned up. There is one watershed,

NOT AN EXHIBIT FOR
WQCC MEETING/HEARING

-cont non-technical written public comment-

the Jemez River Watershed. The May 15, 2006 TMDL needs to reflect this. There is one TMDL and it is the TMDL for the Jemez River Watershed. The May 15, 2006 TMDL needs to reflect this.

The third category is identified as instances where the words "basin", "Basin", "subwatershed or "Subwatershed" are misused to convey the existence of a Valles Caldera or Rio Valles Caldera National Preserve Basin or Watershed. You can find examples of this on Pages i, ii, 1, 5, 14 and 15. I have already discussed that there is only one watershed, the Jemez River Watershed. These flows in the Valles Caldera National Preserve are not subwatersheds, they are streams of the Jemez River Watershed and should not be viewed in such an isolated manner. As for the misuse of the term "basin" and "Basin";

NOT AN EXHIBIT FOR WQCC MEETING/HEARING

-cont non-technical written public comment-
there is only one basin or Basin, the Rio Grande River Basin. It should not be implied that any of these streams of the Jemez River Watershed are in any other basin or Basin. The reader that persists to Appendix B, 'Field Sheets For Assessing Designated Uses And Non-Point Source of Pollution', Field Sheet For Assessing Designated Uses And NonPoint Sources of Pollution, 1 and 2, will see both Jaramillo Creek and East Fork of the Jemez River are in the Rio Grande River Basin as both sheets are filled in at top right. The errors concerning the misuse of 'basin', 'Basin', 'subwatershed' or 'Sub-watershed' need to be corrected.

I would like written assurances that the misuse of the words 'Valles Caldera Watershed', 'Valles Caldera National Preserve Watershed', 'TMDLs', 'watersheds', 'Basins', 'subwatersheds', and/or their

copy retained
May 26, 2006

-cont non-technical written public comment-
near facsimilies or abbreviations, will be deleted from this May 15, 2006 TMDL document and replaced properly, I would like to receive these assurances in time to ask for a hearing before the 30 day period expires if this cannot be done. I see in the Public Participation. Flowchart in Appendix E that you must have the ammended version of the May 15, 2006 TMDL available to the public 10 days before the WQCC meeting for final adoption, I invoke procedural due process, respectfully, be followed and WQCC not hold its meeting until you can present the public with a TMDL document that addresses these 3 significant concerns."

NOT AN EXHIBIT FOR WQCC MEETING-HEARING

-end of non-technical written public comment-

Sincerely,

Rebecca G. Perry-Piper

Rebecca G. Perry-Piper

List of Exhibits Per Commissioner

Exhibit 1: Cover Proposals For Five Parts Of The Jemez River Watershed Study

Exhibit 2: Best Use Practices Of Two Abbreviations and Three Words In Five Parts Of The Jemez River Watershed Study

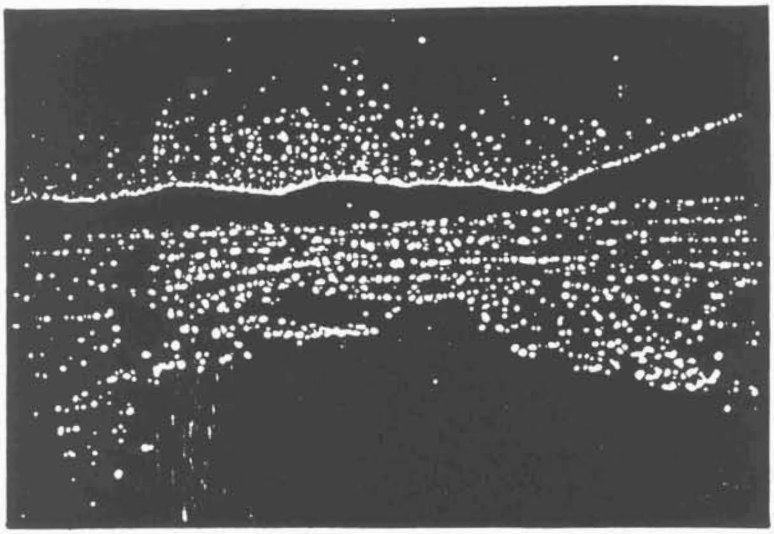
Exhibit 3: Expanding WRAS Stakeholder Definition In Five Parts Of The Jemez River Watershed Study

Exhibit 4: Collection Of Addresses Of Residences That Fall Within 100 Meters Of Streams Of The Jemez River Watershed

San Antonio Creek
Rio Salado

DRAFT
TOTAL MAXIMUM DAILY LOAD (TMDL)
FOR THE
JEMEZ RIVER WATERSHED
RIO GRANDE RIVER TO HEADWATERS
(PART 1.)

(EAST FORK JEMEZ RIVER AND JARAMILLO CREEK - VCNP BOUNDARY TO HEADWATERS)



MAY 15, 2006

WQCC-APPROVED
TOTAL MAXIMUM DAILY LOAD (TMDL)

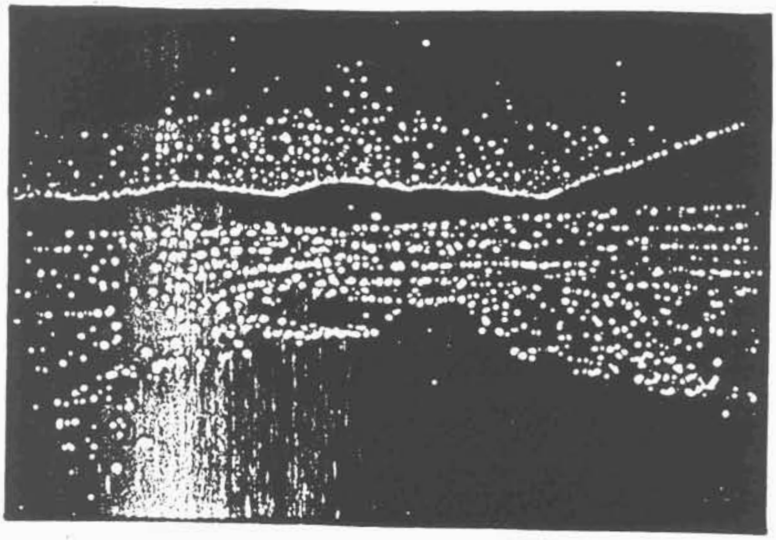
FOR THE

JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 1)

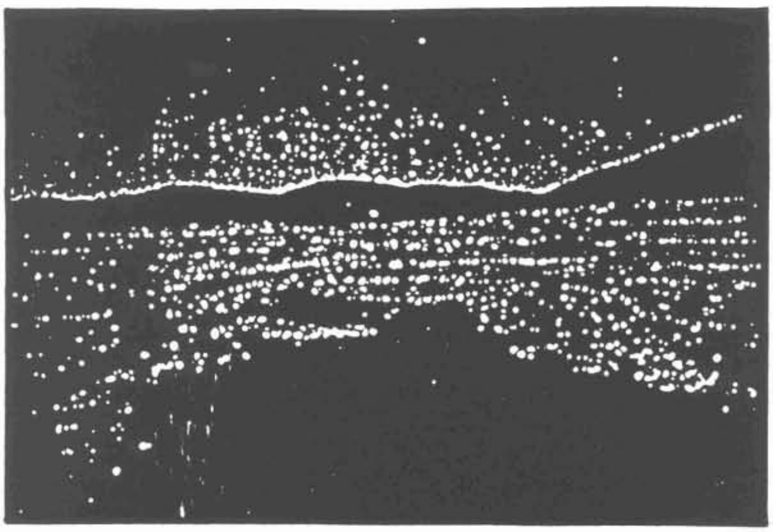
(EAST FORK JEMEZ RIVER AND JARAMILLO CREEK VCNP BOUNDARY TO HEADWATERS) Y)



MAY 15, 2006

FINAL APPROVED
TOTAL MAXIMUM DAILY LOAD (TMDL)
FOR THE
JEMEZ RIVER WATERSHED
RIO GRANDE RIVER TO HEADWATERS
(PART 1.)

(EAST FORK JEMEZ RIVER AND JARAMILLO CREEK VCNP BOUNDARY TO HEADWATERS)



MAY 15, 2006

DRAFT

TOTAL MAXIMUM DAILY LOAD (TMDL)

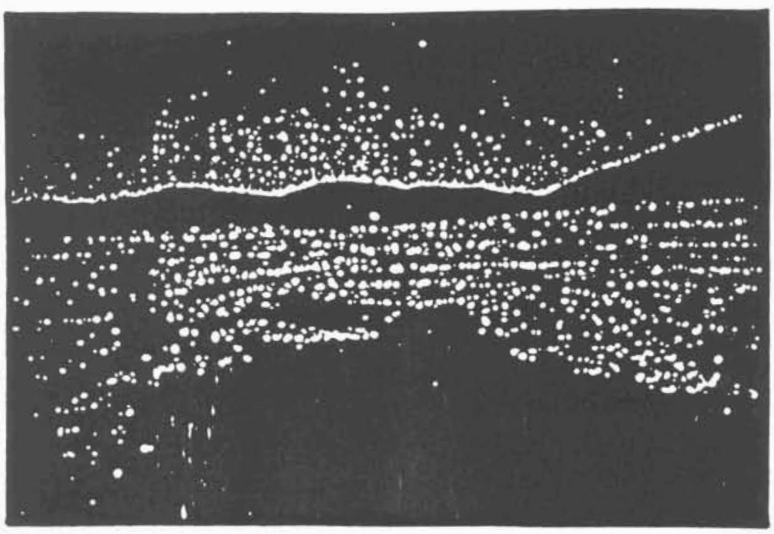
FOR THE

JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 1.)

(**EAST FORK JEMEZ RIVER**, San Antonio Creek, Redondo Creek, and Sulphur Creek - **VCNP BOUNDARY TO HEADWATERS)**



WQCC-APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)

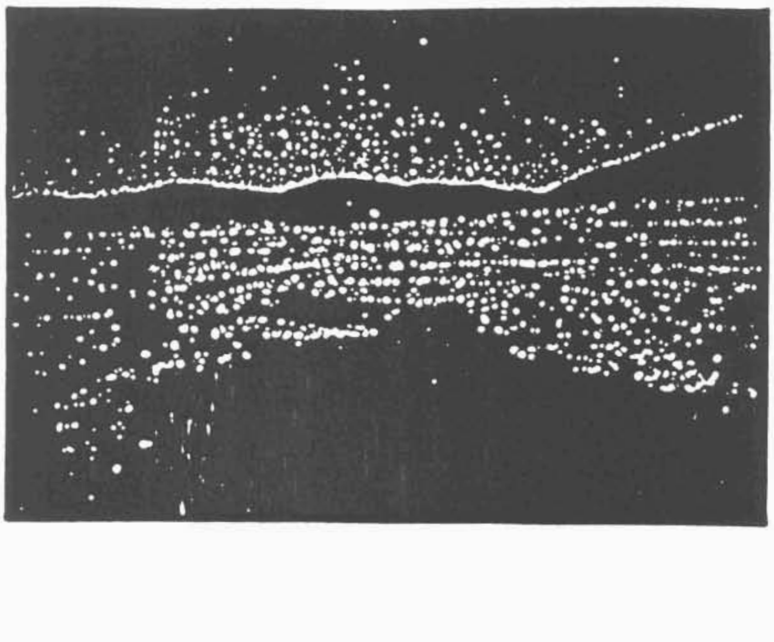
FOR THE

JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 1.)

(**EAST FORK JEMEZ RIVER**, San Antonio Creek, Redondo Creek, and Sulphur Creek - **VCNP BOUNDARY TO HEADWATERS**)



FINAL APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

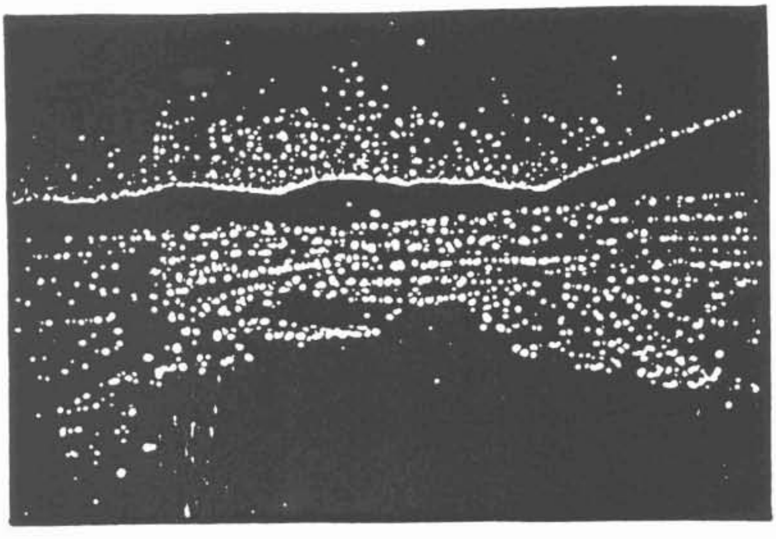
JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 1.)

(**EAST FORK JEMEZ RIVER**, San Antonio Creek, Redondo Creek,

and Sulphur Creek - **VCNP BOUNDARY TO HEADWATERS**)



DRAFT

TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 2)

(Vallecito Creek ▪ Jemez Pueblo BOUNDARY TO USFS BOUNDARY)

WQCC-APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 2.)

(Vallecito Creek ▪ Jemez Pueblo BOUNDARY TO USFS BOUNDARY)

FINAL APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 2.)

(Vallecito Creek ▪ Jemez Pueblo BOUNDARY TO USFS BOUNDARY)

DRAFT

TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

JEMEZ RIVER WATERSHED

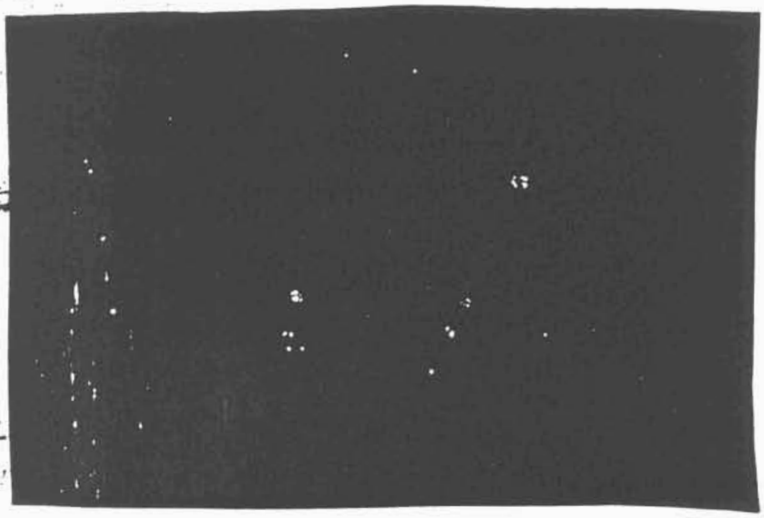
RIO GRANDE RIVER TO HEADWATERS

(PART 3.)

(EAST FORK JEMEZ RIVER, Redondo Creek and Sulphur Creek ▪ Rio JEMEZ TO VCNP BOUNDARY ▪

Rio Guadalupe ▪ USFS BOUNDARY TO HEADWATERS ▪

San Antonio Creek, Rio Cebolla and Rio de las Vacas ▪ USFS BOUNDARY TO VCNP BOUNDARY)



WQCC-APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 3.)

(EAST FORK JEMEZ RIVER, Redondo Creek and Sulphur Creek ▪ Rio JEMEZ TO VCNP BOUNDARY ▪

Rio Guadalupe ▪ USFS BOUNDARY TO HEADWATERS ▪

San Antonio Creek, Rio Cebolla and Rio de las Vacas ▪ USFS BOUNDARY TO VCNP BOUNDARY)

FINAL APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 3.)

(EAST FORK JEMEZ RIVER , Redondo Creek and Sulphur Creek • Rio JEMEZ TO VCNP BOUNDARY •

Rio Guadalupe • USFS BOUNDARY TO HEADWATERS •

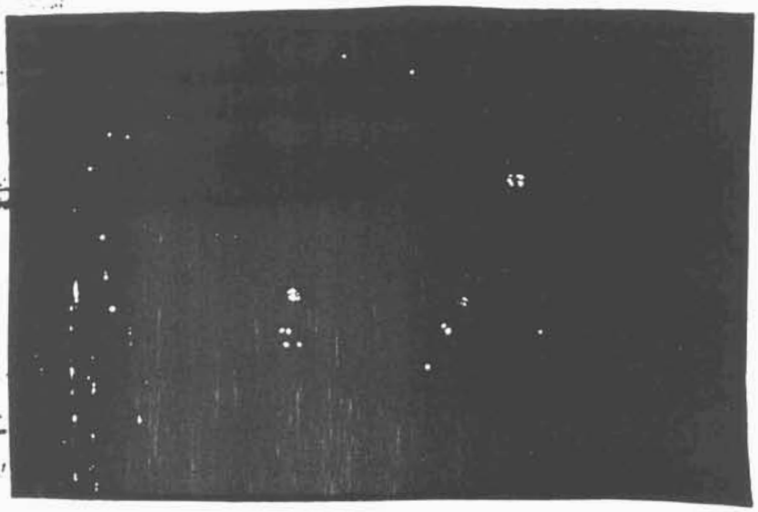
San Antonio Creek, Rio Cebolla and Rio de las Vacas • USFS BOUNDARY TO VCNP BOUNDARY)

DRAFT

TOTAL MAXIMUM DAILY LOAD (TMDL)
FOR THE
JEMEZ RIVER WATERSHED
RIO GRANDE RIVER TO HEADWATERS
(PART 4.)

(Rio JEMEZ - Jemez Pueblo BOUNDARY TO USFS BOUNDARY -

Rio Guadalupe - Rio JEMEZ TO USFS BOUNDARY)



FINAL APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

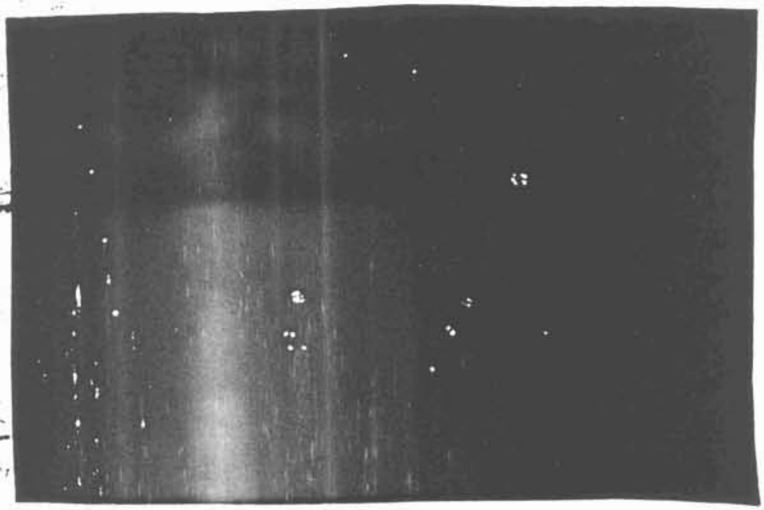
JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 4.)

(Rio JEMEZ - Jemez Pueblo BOUNDARY TO USFS BOUNDARY -

Rio Guadalupe - Rio JEMEZ TO USFS BOUNDARY)

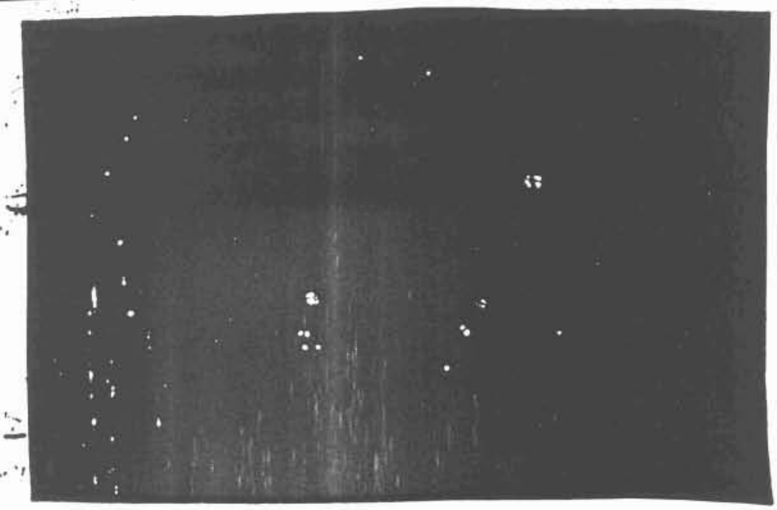


WQCC-APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)
FOR THE
JEMEZ RIVER WATERSHED
RIO GRANDE RIVER TO HEADWATERS
(PART 4.)

(Rio JEMEZ - Jemez Pueblo BOUNDARY TO USFS BOUNDARY -

(Rio Guadalupe - Rio JEMEZ TO USFS BOUNDARY)



DRAFT

TOTAL MAXIMUM DAILY LOAD (TMDL)

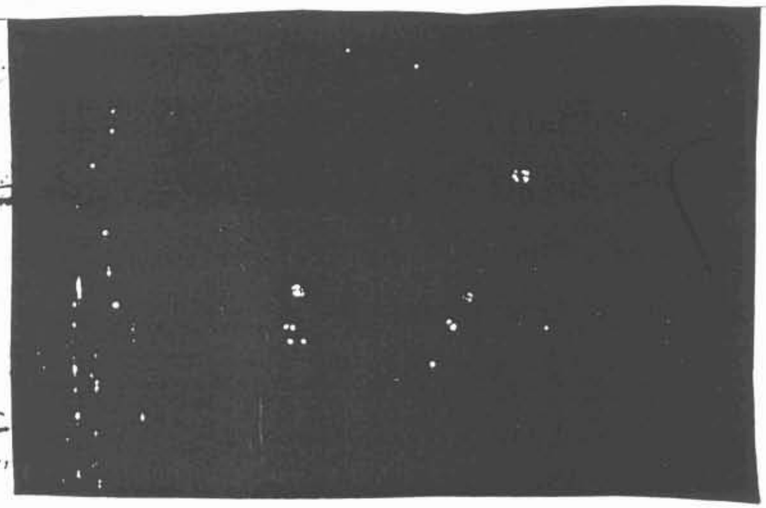
FOR THE

JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 5.)

(Rio JEMEZ - Jemez Pueblo BOUNDARY TO Zia Pueblo BOUNDARY)



FINAL APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)

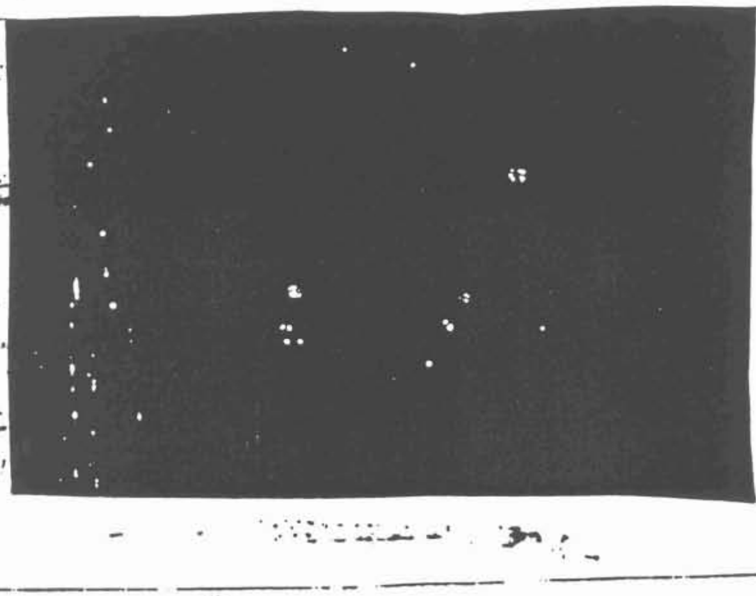
FOR THE

JEMEZ RIVER WATERSHED

RIO GRANDE RIVER TO HEADWATERS

(PART 5.)

(Rio JEMEZ – Jemez Pueblo BOUNDARY TO Zia Pueblo BOUNDARY)



WQCC-APPROVED

TOTAL MAXIMUM DAILY LOAD (TMDL)
FOR THE
JEMEZ RIVER WATERSHED
RIO GRANDE RIVER TO HEADWATERS
(PART 5.)

(Rio JEMEZ Jemez Pueblo BOUNDARY TO Zia Pueblo BOUNDARY)

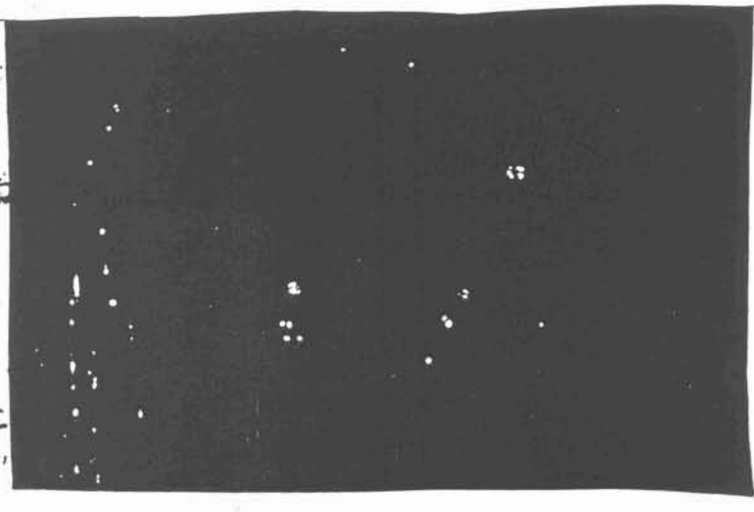


Exhibit 1

May 27, 2006

Rio Grande River To Headwaters (Part 5) (Rio Jemez Jemez Pueblo Boundary To Zia Pueblo Boundary), its undated. Please, down Exhibit 1.

My second concern has to do with the uses of two abbreviations (TMDL and WRAS), and their plurals, and three words, and their plurals; both capitalized and uncapitalized (watershed, subwatershed and basin), that occur in same TMDL document, May 15, 2006. Exhibit 2 lists the following rules that must be followed for best use practices:

• Rule 1 • all uses of the word TMDL should reflect that, at the end of this study as well as during same, there will be only one comprehensive TMDL and it will be the Jemez River Watershed TMDL;

• Rule 2 • all uses of the word WRAS should reflect that, at the end of this study as well as during same, there will be only one comprehensive WRAS and it will be the Jemez Watershed Group WRAS;

May 27, 2006

- Rule 3 • all uses of the word watershed should reflect that, at the end of this study as well as during same, there will be only one watershed (for science's sake), and it will be the Jemez River Watershed, which is actually the subwatershed in this TMDL study; the Jemez River Watershed is a subwatershed of the Rio Grande River;
- Rule 4 • all uses of the word subwatershed should also reflect that, at the end of this study as well as during same, there will be only one subwatershed (for science's sake) and that the Jemez River Watershed's streams are being studied;
- Rule 5 • all uses of the word basin should reflect that, at the end of this study as well as during same, there will be only one basin and it will be the Rio Grande River Basin;

Exhibit 2

Now please turn to the next page in Exhibit 3.

In the future, TMDL stakeholder definition should not exclude any interested party wishing to become a member of the Jemez Watershed Group on the grounds of:

- not owning property in the Jemez River Watershed,
- not residing in the Jemez River Watershed,
- not deriding income from the Jemez River Watershed,
- not being affiliated with any organization or public agency, and
- not utilizing a particular type of communicative device, process or system

I ask that the stakeholder definition on Page 53, 7.1, "Coordination", Sentence 4, in TMDL document May 15, 2006, be expanded with the 5 points above adhered to before WQCC approves this same TMDL document.

Exhibit 3

7.0 IMPLEMENTATION OF TMDLS

7.1 Coordination

Watershed public awareness and involvement will be crucial to the successful implementation of these plans to improve water quality. Staff from SWQB have worked with stakeholders to develop a WRAS for the Jemez Watershed (Jemez Watershed Group 2005). 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, VCNP, and members of the Jemez Watershed Group.

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.

7.2 Time Line

The Jemez Watershed Group was established in 2003 after the first set of Jemez Watershed TMDLs were prepared in 2002. As a result, the Jemez Watershed WRAS was developed and finalized before preparation of these TMDLs. The general implementation timeline is detailed below (Table 7.1).

Table 7.1 Proposed Implementation Timeline

Implementation Actions	Year 1	Year 2	Year 3	Year 4	Year 5
Public Outreach and Involvement	X	X	X	X	X
Form watershed groups	X	X			
WRAS Development		X	X	X	
Establish Performance Targets		X			
Secure Funding		X	X		

Exhibit 4

Collection Of Addresses Of Residences That Fall Within 100 Meters Of Streams Of The Jemez River Watershed

Is this intensive water survey study to continuing to go from waterbody identifior to waterbody identifior gathering addressess of residences built or hauled within 100 meters of a stream without asking if they wish to be added to the data bank; without explaining why there needs to be such a data bank? Granted, since I made a non-technical written public comment on this matter on October 14, 2006, I have never seen a figure like Figure 4.5, on Page 37 of the San Juan Watershed TMDL document, in any other TMDL document I have reviewed since. Again, this practice, if it is still going on, needs to be stopped in the Jemez River Watershed study, now. If the data bank has been compiled, each person that is in the data bank needs to receive a letter notifying them that this has happened, when, who helped give contributing information, who was their personal information given to, and why is this data bank listing every residence within 100 meters of streams in the Jemez River Watershed being compiled, and involuntarily. How could SWQB respond to me, in Final Draft Total Maximum Daily Load (TMDL) For The San Juan River Watershed (Part Two) Navajo Nation Boundary At The Hogback To Navajo Dam, October 23, 2005, that implementation of the TMDL is on a voluntary basis? If all of the information on said Page 37 isn't voluntary then that's wrong. Did all the folks on Page 37 volunteer that information? WQCC should prohibit such data gathering if its without permission.

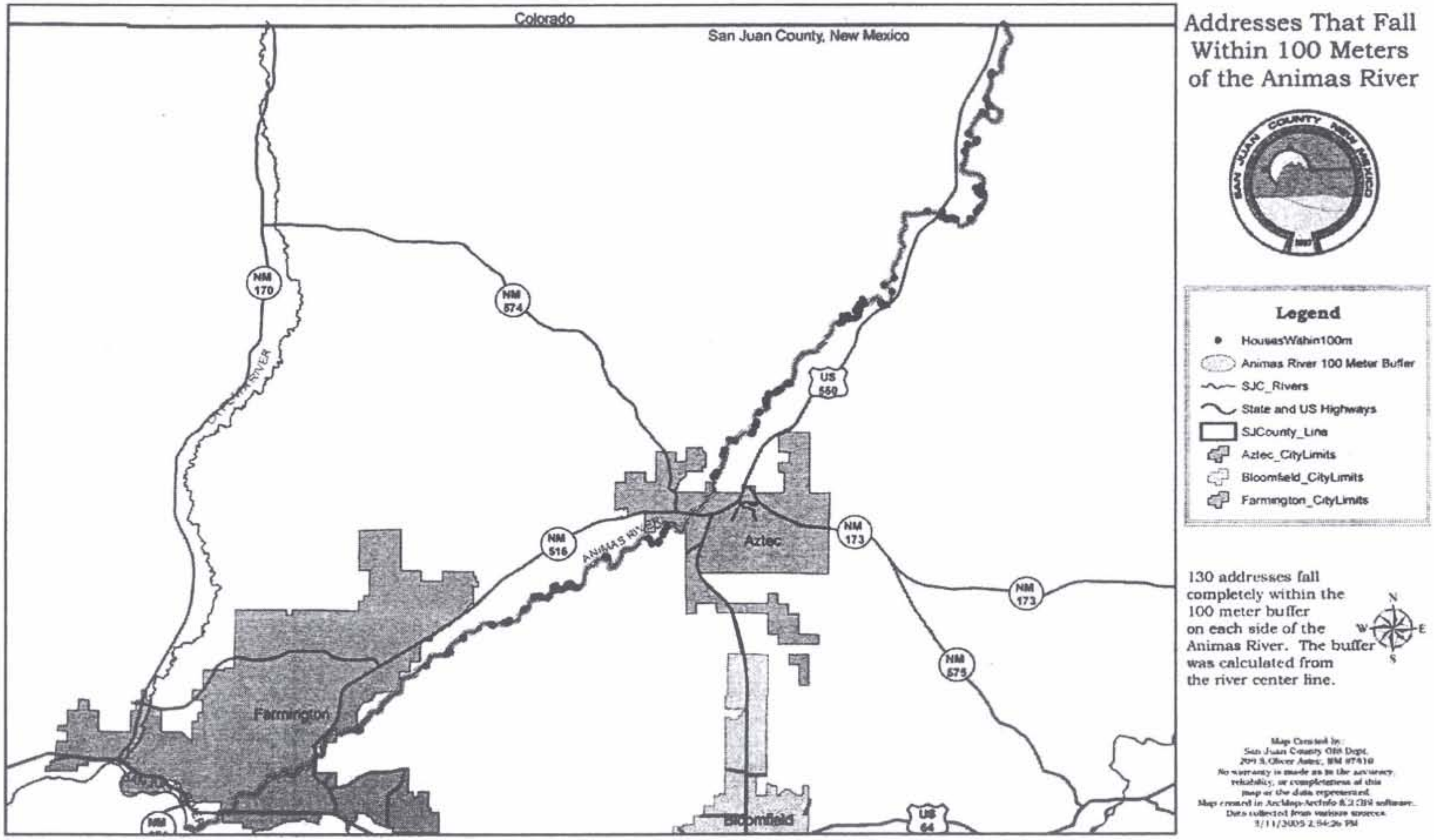


Figure 4.5 Residences that fall within 100 meters of the Animas River, NM

Response:

Thank you for your continued dedication to the Jemez Watershed. We appreciate your continued input in the public participation process through your involvement in the local watershed group and your numerous sets of comments during the TMDL development process.

As you mentioned, the new title page was presented at the May 25, 2006 public meeting in Jemez Springs. Per one of your initial suggestions, the new title will read: Jemez River Watershed (VCNP boundary to headwaters). Also based on your timely reminder, all references to the title within the document will be changed accordingly.

As you requested, copy of the updated TMDL that will include Appendix F-Response to Comments will be sent to you at least 10 days before the July 11, 2006 meeting at which SWQB expects to request approval of the Jemez River Watershed (VCNP boundary to headwaters) TMDL. During the WQCC meeting, the public is generally given an opportunity to provide input. These issues as well as your questions regarding a hearing were addressed in a letter SWQB sent on July 19, 2006 and is included below. Responses to your four specific concerns are detailed here:

1. ***Title page concern***
   The titles of TMDL documents explain the watersheds to be discussed as directly and concisely as possible. TMDLs are written based on a completed water quality survey and, thus, the TMDL document encompasses assessment units within this same watershed area. Any following TMDLs in the Jemez River Watershed will have an appropriate subtitle to designate which portion of the Jemez River Watershed is being discussed.
2. ***Use of TMDL, WRAS, watershed, subwatershed, and basin concern***
   - *Rule 1- TMDLs have been written in two parts due to the fact that some impairments are not able to be assessed with the existing data. Any other necessary TMDLs can be written once the absent water quality data is collected. For subsequent TMDLs, SWQB includes references to each previous TMDL that has been written for that watershed. SWQB is continuing to work on addressing these water quality data gaps during the year of the original survey to avoid TMDL documents that exist in various parts.*
   - *Rule 2-The existing Jemez Watershed WRAS is a living document and can be updated without changing the name of the document.*
   - *Rules 3,4,5- In the current document, the watershed refers to the larger watershed, Jemez River Watershed, whereas the use of "subwatershed" is used to discuss the individual streams. The VCNP itself is not a watershed but a management unit, so the word "watershed" has been removed from discussions involving the assessment units within the VCNP and replaced with the more general term "basin."*
3. ***Stakholder concern***
   SWQB does not exclude anyone from participating in watershed groups. Public notices, however, are generally printed in local papers and posted in local places of note in order to solicit the local interest. Any member of the public is welcome to submit their name and contact information to SWQB in

order to be included in statewide mailings. The statements on page 53 of the TMDL are inclusive statements and do not exclude anyone from participating in the public participation process. Many of SWQB's core documents are made available to the public via the SWQB website, but the Bureau is always willing to provide information via phone calls or surface mail.

4. ***Citizen Addresses***
   The addresses collected for the San Juan Part 2 TMDL document were gathered from public San Juan County records of the location of septic tanks. The information was only used to discuss the nutrient issues in the area. No such addresses were used in the development of the Jemez River Watershed (VCNP boundary to headwaters) TMDL as there were no nutrient TMDLs written for this document.

Thank you for providing your presentation and exhibits.

BILL RICHARDSON
GOVERNOR

State of New Mexico
ENVIRONMENT DEPARTMENT
Surface Water Quality Bureau
Harold Runnels Building Room N2050
1190 St. Francis Drive, P.O. Box 26110
Santa Fe, New Mexico 87502-6110
Telephone (505) 827-0187
Fax (505) 827-0160
Fed Ex (87505)
www.nmenv.state.nm.us

RON CURRY
SECRETARY

CINDY PADILLA
ACTING DEPUTY SECRETARY

June 19, 2006

Rebecca G. Perry-Piper
135 Rincon Valverde
Ponderosa, NM 87044

Dear Ms. Rebecca G. Perry-Piper:

I am currently compiling a response to your comments to be included in the final draft of the TMDL. I will provide you with a hard copy of the final draft TMDL as soon as it is ready, but it will at least be 10 days before the July 11, 2006 Water Quality Control Commission (WQCC) meeting. If that meeting is cancelled, the TMDL will be presented at the August 8, 2006 WQCC meeting. The WQCC generally allows the public to provide input during its meeting after the department's presentation on the proposed TMDLs and before they make their final decision. In case you still feel your comments have not been sufficiently addressed after reading my response to your written comments and after you have had an opportunity to present remaining concerns to the WQCC, I wanted to remind you of your right to request a hearing on the TMDL during the WQCC meeting. Also, we extend an invitation to you to meet with us in our offices in order to address your concerns prior to the July WQCC meeting. Please let us know when a convenient date and time is in order for us to arrange a meeting.

As far as your eight questions that are included in your letter dated June 12, 2006 (which I received on June 19, 2006), I have included answers below:

1) The WQCC Administrator (Joyce Medina) can be reached at: 1190 St. Francis Dr. Santa Fe, NM 87502 or (505) 827-2425. There are 12 members of the WQCC.

2) and 3) Previous WQCC meetings have been held at 9am at the New Mexico State Capitol Building (Room 321) in Santa Fe, NM. . The agenda for the July 11, 2006 meeting is not yet set.

4) Joyce Medina has confirmed that I am scheduled to present the Jemez Watershed (VCNP boundary to headwaters) TMDL after which the public is generally allowed to make comments.

5), 6), and 7) I do not yet know the exact date when the updated draft TMDL will be mailed or by which route it will be mailed. It is not necessary to send any money for postage.

8) I can be reached at (505) 827-2901 in Santa Fe or (505) 222-9571 in Albuquerque (generally on Tuesdays and Wednesdays) during regular business hours.

Sincerely,

Heidi Henderson
TMDL Coordinator
Surface Water Quality Bureau