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

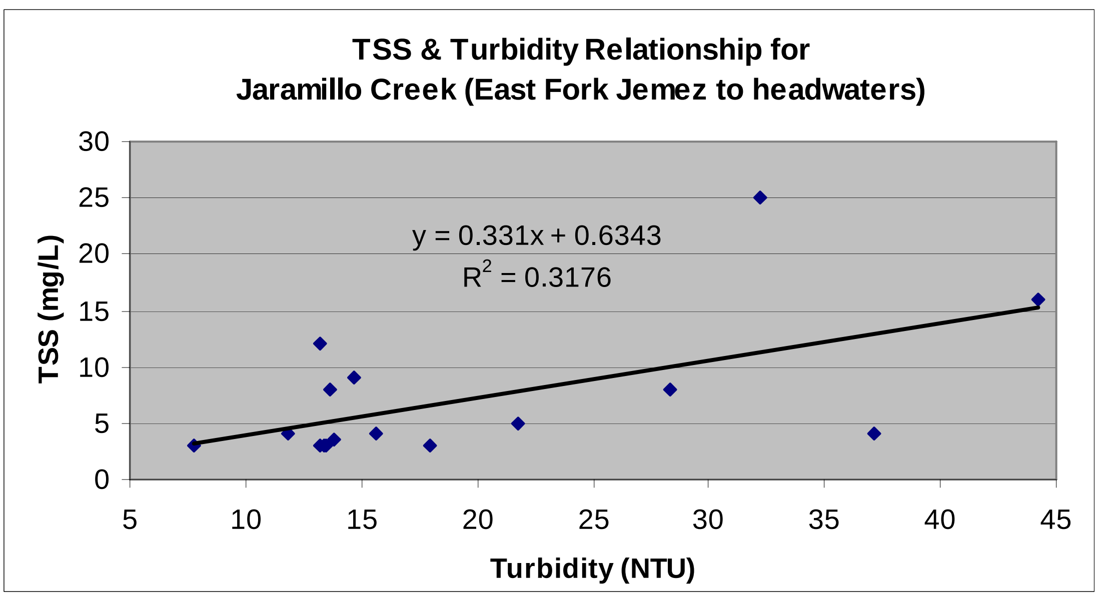

Figure 5.1 Relationship between TSS and Turbidity at Jaramillo Creek (East Fork Jemez to headwaters).

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.