# 3.0 TURBIDITY

## 3.1 Summary

During the SWQB 1999 intensive water quality survey in the Lower Rio Chama watershed, several exceedances of the New Mexico water quality standard for turbidity were documented at sampling stations on Cañones Creek, Rio Nutrias, Rio Vallecitos, and Poleo Creek (see Table 3.1). Consequently, these reaches were listed on the 2000–2002 CWA Integrated §303(d)/§305(b) list for turbidity.

**Table 3.1. Turbidity Exceedances in the Lower Rio Chama Watershed**

| Site | Date (YYMMDD) | Turbidity Standard (NTU) | Field Turbidity Measures (NTU)* | Field Total Suspended Solids (TSS) Measures (mg/L)+ |
|---|---|---|---|---|
| Cañones Creek at Forest Road 167 below Canones | 990422 | 25 | 44.3 | 83 |
| Cañones Creek at Forest Road 167 below Canones | 990727 | 25 | 81.8 | 45 |
| Cañones Creek at Forest Road 167 below Canones | 990428 | 25 | 33.7 | 38 |
| Cañones Creek at Forest Road 167 below Canones | 991006 | 25 | 207.0 | 121 |
| Rio Nutrias at US 84 | 990419 | 25 | 156.0 | 110 |
| Rio Nutrias at US 84 | 990727 | 25 | 87.3 | 188 |
| Rio Nutrias at US 84 | 991006 | 25 | 68.1 | 46 |
| Rio Nutrias at US 84 | 991013** | 25 | 60.6 | 49 |
| Rio Nutrias at US 84 | 020610 | 25 | 233 | 157 |
| Rio Nutrias at US 84 | 020611 | 25 | 378 | 250 |
| Rio Vallecitos 3.9 miles above La Madera at bridge | 990419 | 10 | 13.7 | 8 |
| Rio Vallecitos 3.9 miles above La Madera at bridge | 990420 | 10 | 10.8 | 3k |
| Rio Vallecitos 3.9 miles above La Madera at bridge | 990421 | 10 | 17.6 | 14 |
| Rio Vallecitos 3.9 miles above La Madera at bridge | 990422 | 10 | 14.3 | 4 |
| Rio Vallecitos 8.4 miles above Vallecitos at river crossing | 990419 | 10 | 25.4 | 21 |
| Rio Vallecitos 8.4 miles above Vallecitos at river crossing | 990420 | 10 | 19.9 | 13 |
| Rio Vallecitos 8.4 miles above Vallecitos at river crossing | 990421 | 10 | 16.8 | 9 |
| Rio Vallecitos 8.4 miles above | 990422 | 10 | 14.9 | 9 |

| Site | Date (YYMMDD) | Turbidity Standard (NTU) | Field Turbidity Measures (NTU)* | Field Total Suspended Solids (TSS) Measures (mg/L)+ |
|---|---|---|---|---|
| Vallecitos at river crossing | | | | |
| Poleo Creek at Forest Road 103 | 990419 | 25 | 34.6 | 28 |
| Poleo Creek at Forest Road 103 | 990420 | 25 | 69.2 | 35 |
| Poleo Creek at Forest Road 103 | 990421 | 25 | 143.0 | 93 |
| Poleo Creek at Forest Road 103 | 990422 | 25 | 119.0 | 74 |
| Poleo Creek at Forest Road 103 | 990727 | 25 | 71.4 | 74 |

*Each value represents one field measurement.
+Each value represents one laboratory measurement. Arithmetic means of the TSS values when measured turbidity exceeded the standard are the following (in mg/L): Cañones Creek (71.8), Rio Nutrias (133.3), Poleo Creek (60.8), and Rio Vallecitos (10.1).
**REMAP data.
k indicates sample holding time was exceeded.

## 3.2 Endpoint Identification

### Target Loading Capacity

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

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

> Turbidity 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.

The state's standard leading to an assessment of use impairment is the numeric criteria for turbidity of 25 nephelometric turbidity units (NTU) (Cañones Creek, Rio Nutrias, and Poleo Creek) and 10 NTU (Rio Vallecitos) for the designated use of a high quality coldwater fishery (HQCWF).

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. Since there are no wastewater treatment plants discharging into any of these streams listed for turbidity impairment, it is assumed that TSS measurements in

these ambient stream samples are representative of erosional activities and thus comprised primarily of suspended sediment vs. any potential biosolids from wastewater treatment plant effluent.

Turbidity levels can be inferred from studies that monitor total suspended sediment (TSS) 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 1991a). 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 1991a). This impact is largely a mechanical action that severely reduces the available habitat for macroinvertebrates and fish species that use the streambed in various life stages. An increase in suspended sediment concentration reduces the penetration of light, decreases the ability of fish or fingerlings to capture prey, and reduces primary production (USEPA 1991a). Specifically, increased turbidity by sediments can reduce stream primary production by reducing photosynthesis, physically abrading algae and other plants, and preventing attachment of autotrophs to substrate surfaces (Van Nieuwenhuyse and LaPierre 1986, Brookes 1986).

TSS and turbidity were measured during the 1999 survey (for standards exceedances, see Table 3.1). A correlation (R2) was found between turbidity and TSS for each reach (see Table 3.2 and Appendix B).

**Table 3.2. Relationships Between Turbidity and TSS for Turbidity Impaired Reaches in the Lower Chama Watershed**

| Reach | Correlation ($R^2$) | Regression Equation |
|---|---|---|
| Cañones Creek | .69 | y= 0.4543x + 26.185 |
| Rio Nutrias | .64 | y = 0.5195x + 48.215 |
| Poleo Creek | .90 | y = 0.6443x + 2.9653 |
| Rio Vallecitos | .63 | y = 0.5869x + 1.0263 |

**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 for each reach at a specific flow. When available, U.S. Geologic Survey (USGS) gages are used to estimate flow. Where gages are absent, geomorphologic cross-sectional information is taken at each site and the flows are modeled. Gaged streamflow data are not available for any of the reaches with turbidity impairments. For these reaches, flow was measured by SWQB during the spring sampling run using standard USGS procedures (SWQB/NMED 2001b). The measured flow values are found in Table 3.3.

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 should be a goal to be attained. Meeting the calculated target load may be a difficult objective.

**Calculations**

Target loads for turbidity (expressed as TSS) are calculated based on a flow, the current water quality standards, and a conversion factor (8.34) that is a used to convert milligrams per liter to pounds per day (see Appendix C for the conversion factor derivation). The target loading capacity is calculated using Equation 1. The results are shown in Table 3.3.

*Equation 1.* critical flow (MGD) x standard (mg/L) x 8.34 (conversion factor) = target loading capacity

**Table 3.3. Calculation of Target Loads for Turbidity (Expressed as TSS)**

| Location | Flow+ (MGD) | TSS* (mg/L) | Conversion Factor | Target Load Capacity (lbs/day) |
|---|---|---|---|---|
| Cañones Creek | 6.9 | 37.5 | 8.34 | 2,158 |
| Rio Nutrias | 16.0 | 61.2 | 8.34 | 8,167 |
| Poleo Creek | 1.03++ | 19.1 | 8.34 | 165 |
| Rio Vallecitos | 7.2 | 6.9 | 8.34 | 414 |

+ Since USGS gages were unavailable, flow was measured during the 1999 spring, or highest flowing, sampling run (SWQB/NMED 2001a) Canones on 4/20/99, Rio Nutrias on 4/20/99, and Rio Vallecitos on 7/28/99.
++ Flow for Poleo Creek was not taken directly. This value is a percentage (based on watershed land area) of the flow measured at the Rio Puerco de Chama at Forest Road 103 gage station (SWQB/NMED 2001a).
*The TSS value was calculated using the relationship established between TSS and turbidity in Table 3.2 using the turbidity standard of 25 NTU for the X variable for Cañones Creek, Rio Nutrias, and Poleo Creek, and 10 NTU for Rio Vallecitos.

The measured loads for turbidity (expressed as TSS) were similarly calculated. To achieve comparability between the target and measured loads, the same flows were used for both calculations. The geometric mean of corresponding TSS values when turbidity exceeded the standard was substituted for the standard in Equation 1. The same conversion factor of 8.34 was used. The results are presented in Table 3.4.

**Table 3.4 Calculation of Measured Loads for Turbidity (expressed as TSS)**

| Location | Flow+ (MGD) | TSS Arithmetic Mean * (mg/L) | Conversion Factor | Measured Load Capacity (lbs/day) |
|---|---|---|---|---|
| Cañones Creek | 6.9 | 71.8 | 8.34 | 4,132 |
| Rio Nutrias | 16.0 | 133.3 | 8.34 | 17,788 |
| Poleo Creek | 1.03++ | 60.8 | 8.34 | 522 |
| Rio Vallecitos | 7.2 | 10.1 | 8.34 | 606 |

+ Since USGS gages were unavailable, flow was measured during the 1999 spring, or highest flowing, sampling run (SWQB/NMED 2001a) Canones on 4/20/99, Rio Nutrias on 4/20/99, and Rio Vallecitos on 7/28/99.
++ Flow for Poleo Creek was not taken directly. This value is a percentage (based on watershed land area) of the flow measured at the Rio Puerco de Chama at Forest Road 103 station. (SWQB/NMED 2001a).
* Arithmetic mean of TSS values when measured turbidity exceeded the standard (see Table 3.1).

## Waste Load Allocations and Load Allocations

- Waste Load Allocation

There are no point source contributions associated with this TMDL. The waste load allocation (WLA) is zero.

- Load Allocation

To calculate the load allocation (LA), the waste load allocation and margin of safety (MOS) were subtracted from the target capacity (TMDL) following Equation 2.

*Equation 2.* WLA + LA + MOS = TMDL

The margin of safety is estimated to be 25 percent of the target load calculated in Table 3.3. Results are presented in Table 3.5. Additional details on the margin of safety chosen are presented later in this document.

**Table 3.5. Calculation of the TMDL for Turbidity**

| Location | WLA (lbs/day) | LA (lbs/day) | MOS (25 percent) (lbs/day) | TMDL (lbs/day) |
|---|---|---|---|---|
| Cañones Creek | 0 | 1,618 | 540 | 2,158 |
| Rio Nutrias | 0 | 6,125 | 2,042 | 8,167 |
| Poleo Creek | 0 | 124 | 41 | 165 |
| Rio Vallecitos | 0 | 310 | 104 | 414 |

The extensive data collection and analyses necessary to determine background turbidity loads for all of these reaches were beyond the resources available for this study. It is

therefore assumed that a portion of the load allocation is made up of natural background loads.

The load reductions that would be necessary to meet the target loads were calculated to be the difference between the target load allocation (Table 3.3) and the measured load (Table 3.4), and are shown in Table 3.6.

**Table 3.6. Calculation of Load Reduction for Turbidity (Expressed as TSS)**

| Location | Target Load Allocation (lbs/day) | Measured Load (lbs/day) | Load Reduction (lbs/day) |
|---|---|---|---|
| Cañones Creek | 2,158 | 4,132 | 1,974 |
| Rio Nutrias | 8,167 | 17,788 | 9,621 |
| Poleo Creek | 165 | 522 | 357 |
| Rio Vallecitos | 414 | 606 | 192 |

**Identification and Description of Pollutant Sources**

Potential Sources of pollutants are listed for each segment in Table 3.7.

**Table 3.7. Pollutant Source Summary for Turbidity**

| **Pollutant Sources** (percent from each) | **Magnitude** (WLA + LA + MOS) | **Location** | **Potential Sources** |
|---|---|---|---|
| Point: None (0 percent) | 0 | | |
| Nonpoint: (100 percent)<br><br>Turbidity (expressed as TSS in lbs/day) | | Cañones Creek | Rangeland, Silviculture, Removal of Riparian Vegetation, Streambank Modification/Destabilization |
| | | Rio Nutrias | Agriculture, Removal of Riparian Vegetation, Streambank Modification/Destabilization |
| | | Poleo Creek | Agriculture, Removal of Riparian Vegetation, Streambank Modification/Destabilization |
| | | Rio Vallecitos | Agriculture, Resource Extraction, Hydromodification, Road Maintenance or Runoff, Removal of Riparian Vegetation, Streambank Modification/Destabilization |

**Linkage Between 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. Turbidity also prevents sunlight from reaching plants below the surface. This decreases the rate of photosynthesis, so less oxygen is produced by plants. Turbidity may harm fish and their larvae. Turbidity exceedances, historically, are generally attributable to soil erosion, excess nutrients, various wastes and pollutants, and the stirring of sediments up into the water column during high-flow events. Turbidity increases, as observed in SWQB monitoring data, show turbidity values along these reaches exceeding the state standards for the protection of aquatic habitat, namely the high quality coldwater fishery designated use. Through monitoring, and pollutant source documentation, it has been observed that the most probable causes for these exceedances are the alteration of the stream's hydrograph, grazing impacts, silviculture, resource extraction, removal of riparian vegetation, streambank modification/destabilization, and road maintenance and runoff. 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 the turbidity of the water
    - reduce transmission of sunlight needed for photosynthesis
    - interfere with animal behaviors dependent on sight (foraging, mating, and escaping 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; prevent fry from emerging from the buried gravel bed

2. Clearing of trees and shrubs from riparian areas, 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, construction of drainage ditches, and straightening of 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 through subsequent low flows
    - reduce baseflows

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

SWQB fieldwork includes an assessment of the potential sources of impairment (SWQB/NMED 1999). The Pollutant Source(s) Documentation Protocol form and Potential Sources Summary Table in Appendix D 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 3.7 (Pollutant Source Summary) 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, which is predominantly privately held, but also the upland and upstream areas in a more holistic watershed approach to implementing this TMDL.

The primary sources of impairment for the reaches identified in the state 303 (d) list are the following:

Cañones Creek: Rangeland, Silviculture, Removal of Riparian Vegetation, and Streambank Modification/Destabilization

Rio Nutrias: Agriculture, Removal of Riparian Vegetation, and Streambank Modification/Destabilization

Poleo Creek: Agriculture, Removal of Riparian Vegetation, and Streambank Modification/Destabilization

Rio Vallecitos: Agriculture, Resource Extraction, Hydromodification, Road Maintenance or Runoff, Removal of Riparian Vegetation, and Streambank

Modification/Destabilization

*Cañones Creek*
No turbidity exceedances were found at the upper station on Cañones Creek (Cañones Creek above Chihuahuenos Creek). Field notes from 2002 indicate that at this upper station there was a healthy riparian area with boulders, cobble, and little embeddedness. Field notes indicate that at the lower station, Cañones Creek at Forest Road 167 below Canones, the channel was incising, there was bank erosion, cows were grazing in the riparian area, and a large amount of sand was found on the stream bottom.

According to the Water Quality Survey of this watershed (SWQB/NMED 1991), activities that may contribute to water quality impairments include riparian quality degradation due to livestock grazing, recreation, and silviculture. In addition, the lower Cañones Creek sampling station was located below the town of Cañones and below the irrigation return flows of this community.

*Rio Nutrias*
Samples were taken at one site along this reach. Field notes indicate that turbidity impairments were likely because of a poorly installed and maintained box culvert and over-grazing in the riparian area along the reach.

*Poleo Creek*
Samples were taken at one site on this reach. There are no field notes available for this reach.

*Rio Vallecitos*
The Rio Vallecitos was sampled at two stations along the reach. Exceedances of turbidity were found at both stations. Field notes indicate that the upstream site (Rio Vallecitos 8.4 miles above Vallecitos at river crossing) is in good condition, although there is some channelization and berms alongside the stream. The stream passes through irrigated pasture, some rural development, and historic placer and gypsum mining sites. At the lower station the stream widens, although the riparian vegetation is abundant and the stream substrate consists of boulders with little embeddedness.

## 3.3 Margin of Safety (MOS)

TMDLs should reflect a margin of safety based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there will be no margin of safety for point sources since none are found on any of the reaches. However, for the nonpoint sources, the margin of safety is **25 percent** of the sum of the WLA and LA. This margin of safety is the sum of the following two elements:

- *Errors in calculating nonpoint source loads*
  A level of uncertainty exists 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 margin of safety 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 for error in measurements of nonpoint source loads due to equipment accuracy, time of sampling, and other factors. Accordingly, a conservative MOS for this element is **15 percent**.

- *Errors in calculating flow*

  Flow estimates were based on estimated mean average annual discharge using cross-sectional field data (Appendix B) and USGS Technical Paper 2193 (USGS 1982). A conservative MOS for this element is **10 percent.**

### 3.4 Consideration of Seasonal Variation

Data used in the calculation of this TMDL were collected during spring, summer, and fall to ensure coverage of any potential seasonal variation in the system. Since the critical condition is set to estimate average stream discharge, all data collected throughout the seasons were used in determining the target capacities. Therefore, it is assumed that if critical conditions are met, any potential seasonal variation will therefore be covered.

### 3.5 Future Growth

Estimates of future growth do not indicate a significant increase in turbidity that cannot be controlled with the implementation of best management practices in this watershed.