5.0 TURBIDITY

During the 1999 SWQB sampling monitoring effort in the Red River watershed, turbidity data showed several exceedences of the New Mexico WQS for the assessment unit Pioneer Creek (Red River to Headwaters). As a result, this assessment unit is listed on the 2004-2006 Integrated CWA §303(d)/§305(b) list (NMED/SWQB 2004a) with turbidity as a pollutant of concern (see summary in Table 5.1 and data in Appendix B).

5.1 Target Loading Capacity

Overall, the target values for 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****: 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 New Mexico WQS the segment specific standards for turbidity reads:

> *20.6.4.123 NMAC: In any single sample: turbidity shall not exceed 25 NTU.*

The 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 Pioneer 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 wastewater treatment plant effluent.

Turbidity levels can be inferred from studies that monitor suspended sediment concentrations. Extrapolation from these studies is possible when a site-specific relationship between concentrations of suspended sediments and turbidity is confirmed. Activities that generate varying amounts of suspended sediment will proportionally change or affect turbidity (USEPA 1991). The impacts of suspended sediment and turbidity are well documented in the literature. An increased sediment load is often the most important adverse effect of activities on streams, according to a monitoring guidelines report (USEPA 1991). This impact is largely a mechanical action that severely reduces the available habitat for macroinvertebrates and fish species that utilize the streambed in various life stages. An increase in suspended sediment concentration

will reduce the penetration of light, decreases the ability of fish or fingerlings to capture prey, and reduce primary production (USEPA 1991). As stated in Relyea *et al* (2000) "increased turbidity by sediments can reduce stream primary production by reducing photosynthesis, physically abrading algae and other plants, and preventing attachment of autotrouphs to substrate surfaces".

TSS and turbidity were measured in Pioneer Creek (Table 5.1) during the 1999 survey. The TSS target was derived using a regression equation developed using measured turbidity as the independent variable and measured TSS dependent variable. The equation and regression statistics are displayed below in Figure 5.1. A correlation of $r^2 = 0.58$ was found between TSS and turbidity for Pioneer Creek.

Table 5.1 TSS and Turbidity Data for Pioneer Creek

Sample Date	TSS (mg/L)	Turbidity (NTU)
Pioneer Creek about 400 yards above Red River		
5/10/1999	17	30.3*
5/11/1999	35	26.5*
5/12/1999	12	13.6
5/13/1999	4	10.3
5/28/1999	7	5.65
8/17/1999	16	8.52
8/18/1999	<3.0	3.4
10/25/1999	<3.0	2.76
10/26/1999	8	6.36
10/27/1999	8	1.69
10/28/1999	<3.0	9.11

Notes: *Exceedence of turbidity water quality criterion.
NTU = Nephelometric turbidity units

5.2 Flow

Sediment transport in a stream varies as a function of flow. As flow increases, the amount of sediment being transported increases. Exceedences of the criterion occurred only during high flows in Pioneer Creek. Therefore, the target flow was set at high flow conditions. There is no USGS gage station on this reach and flow was not recorded during the 1999 sampling events, therefore flow had to be estimated for May from the Red River Watershed flow model developed by Daniel B. Stephens & Associates, Inc. (Appendix C). The estimated flow value for May 1999 based on this model is 3.60 million gallons per day (mgd).

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

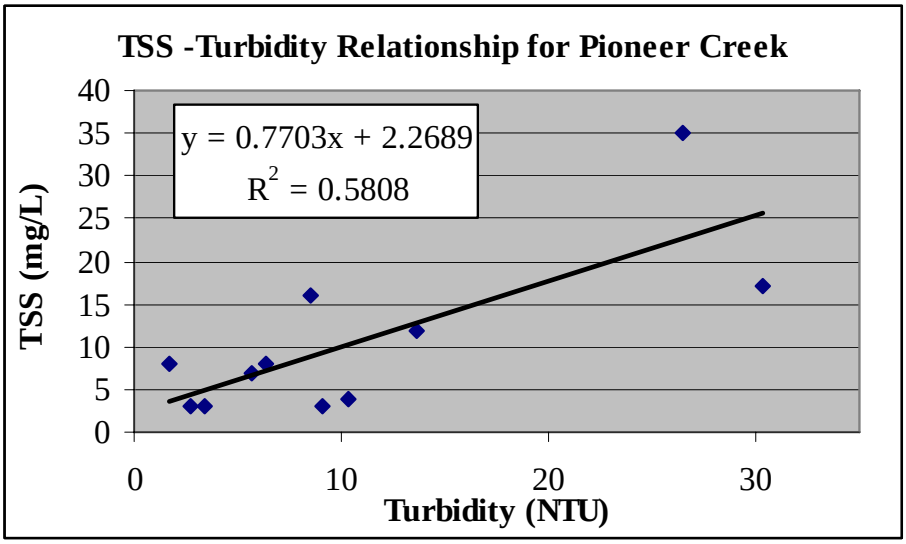

Figure 5.1 Relationship between TSS and Turbidity at Pioneer Creek

5.3 Calculations

Target loads for turbidity (expressed as TSS) are calculated based on a flow, the current water quality standards, and a conversion factor (8.34) that is a used to convert mg/L units to pounds per day (lbs/day) (see Appendix D for Conversion Factor Derivation). The target loading capacity is calculated using **Equation 1**. The results are shown in Table 5.2.

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

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)
Pioneer Creek (Red River to Headwaters	3.60	21.5+*	8.34	646*

Notes:
+ The TSS value was calculated using the relationship established between TSS and turbidity in Figure 5.1 (y=0.7703x + 2.2689, R^2=0.58) using the turbidity standard of 25 NTU for the X variable.
*Values rounded to three significant figures.

Measured loads were also calculated using **Equation 1**. The arithmetic mean of corresponding TSS values when turbidity exceeded the standard was substituted for the standard in **Equation 1**. In order to achieve comparability between the target capacity (i.e., TMDL values) and measured loads, the same flow rates were used for both calculations. 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

Location	Flow (mgd)	TSS Arithmetic Mean+ (mg/L)	Conversion Factor	Measured Load Capacity (lbs/day)
Pioneer Creek (Red River to Headwaters)	3.60	26.0	8.34	781*

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

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 in this assessment unit. Sediment may be a component of some (primarily construction) storm water discharges that contribute to suspended sediment impacts, and should be addressed.

In contrast to discharges from other industrial storm water and individual process wastewater permitted facilities, storm water discharges from construction activities are transient because they occur mainly during the construction itself, and then only during storm events. Coverage under the NPDES CGP for construction sites greater than one acre requires preparation of a SWPPP that includes identification and control of all pollutants associated with the construction activities to minimize impacts to water quality. In addition, the current CGP also includes state specific requirements to implement BMPs that are designed to prevent to the maximum extent practicable, an increase in sediment, or a parameter that addresses sediment (e.g., TSS, turbidity, siltation, stream bottom deposits, etc.) and flow velocity during and after construction compared to pre-construction conditions. In this case, compliance with a SWPPP that meets the requirements of the CGP is generally assumed to be consistent with this TMDL.

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

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

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 20% of the target load calculated in Table 5.2. Results are presented in Table 5.4. Additional details on the MOS chosen are presented in Section 5.7 below.

Table 5.4 Calculation of TMDL for turbidity

Location	WLA (lbs/day)	LA (lbs/day)	MOS (20%) (lbs/day)	TMDL (lbs/day)
Pioneer Creek (Red River to Headwaters	0	517	129*	646

* Values rounded to three significant figures.

The extensive data collection and analyses necessary to determine background turbidity loads for Pioneer Creek 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 necessary to meet the target loads were calculated to be the difference between the target load (Table 5.4) and the measured load (Table 5.3), and are shown in Table 5.5. These load reduction tables are presented for informational purposes only.

Table 5.5 Calculation of Load Reduction for Turbidity (expressed as TSS)

Assessment Unit	Target Load[(a)] (lbs/day)	Measured Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction[(b)]
Pioneer Creek (Red River to Headwaters	517	781	264	34%

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 TMDL, and is calculated as follows: (Measured Load – Target Load) / Measured Load x 100.
* Values rounded to three significant figures.

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

5.5 Identification and Description of Pollutant Sources

Based on measured loads, probable nonpoint pollutant sources that may be contributing to observed turbidity loads are displayed in Table 5.6.

Table 5.6 Pollutant Source Summary for Turbidity

Pollutant Sources	**Magnitude[(a)] (lbs/day)**	**Assessment Unit**	**Potential Sources[(b)]**
Point: None	0	--------	0%
Nonpoint: Turbidity	781	Pioneer Creek (Red River to Headwaters)	100% Acid Mine Drainage Highway/Road/Bridge Runoff (non-construction related) Natural Sources Streambank modifications/destabilization Loss of Riparian Habitat Channelization Urbanized High Density Area Ski Slope Runoff Recreational Pollution Sources (Off Highway vehicles (OHV)

Notes:
(a) Measured load expressed as TSS in lbs/day
(b) From the 2004-2006 Integrated CWA 303(d)/305(b) list. This list of probable sources is based on staff observation and known land use activities in the watershed. These sources are not confirmed or quantified at this time.

5.6 Linkage Between Water Quality and Pollutant Sources

SWQB fieldwork includes an assessment of the potential sources of impairment (NMED/SWQB 1999b). The Pollutant Source(s) Documentation Protocol form and Potential Sources Summary Table in Appendix A provides an approach for a visual analysis of a pollutant source along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. Table 5.6 (Pollutant Source Summary) identifies and quantifies potential sources of nonpoint source impairments along the reach as determined by field reconnaissance and assessment.

Turbidity is an expression of the optical property in water that causes incident light to be scattered or absorbed rather than transmitted in straight lines. It is the condition resulting from suspended solids in the water, including silts, clays, and plankton. Such particles absorb heat in the sunlight, thus raising water temperature, which in turn lowers dissolved oxygen levels. It also prevents sunlight from reaching plants below the surface. This decreases the rate of photosynthesis, so less oxygen is produced by plants. Turbidity may harm fish and their larvae. Turbidity exceedences, historically, are generally attributable to soil erosion, excess nutrients,

various wastes and pollutants, and the stirring of sediments up into the water column during high flow events. Turbidity increases, as observed in SWQB monitoring data, show turbidity values along these reaches that exceed the State Standards for the protection of aquatic habitat, High Quality Coldwater Fishery (HQCWF) designed uses. Through monitoring, and pollutant source documentation, it has been observed that the most probable cause for these exceedences are due to the alteration of the stream's hydrograph and natural causes. Alterations can be historical or current in nature.

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

- cut forests
- clear and cultivate land
- remove stream-side vegetation
- alter the drainage of the land
- channelize watercourses
- withdraw water for irrigation
- build towns and cities
- discharge pollutants into waterways.

Possible effects of these practices on aquatic ecosystems include:

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

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

2. Clearing of trees and shrubs from shorelines which may

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

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

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

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

Additional turbidity and TSS sampling would need to be conducted to more fully characterize probable sources of turbidity in Pioneer Creek. However, sufficient data exist to support development of a turbidity TMDL to address the stream standards violations.

5.7 Margin of Safety

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For the Pioneer Creek TMDLs, there will be no MOS for point sources since there are none. However, for the nonpoint source TMDLs, the MOS is estimated to be **20%** of the TMDL. This MOS incorporates several factors:

•*Errors in calculating nonpoint source loads*

A level of uncertainty does exist in the relationship between TSS and turbidity. In this case, the TSS measure does not include bedload and therefore does not account for a complete measure of sediment load. This does not influence the MOS because we need only be concerned with the turbidity portion of the sediment load, which is the basis for the standard. However, there is a potential to have errors in measurements of nonpoint source loads due to equipment accuracy, time of sampling, etc. Accordingly, a conservative MOS accounts for **10%** the TMDL.

•*Errors in calculating flow*

Flow estimates were based on USGS gages and modeling calculations. 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 Variability

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. Since the critical condition is set to estimate high stream discharge, 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

Based on the lack of point sources in Pioneer Creek, the overwhelming source of turbidity loading is from nonpoint sources. Estimates of future growth are not anticipated to lead to a significant increase in turbidity concentrations that cannot be controlled with BMP implementation in this watershed.