PUBLIC COMMENT DRAFT

TOTAL MAXIMUM DAILY LOADS

FOR THE

UPPER RIO GRANDE WATERSHED

JUNE 13, 2022

Prepared by

New Mexico Environment Department, Surface Water Quality Bureau

Monitoring, Assessment, and Standards Section

Public Draft Released: ***June 13, 2022***

Water Quality Control Commission Approval Date: ***DATE***

U.S. EPA Approval Date: ***DATE***

Effective Date: ***DATE***

Revision Date(s): ______________________________

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For Additional Information please visit:

https://www.env.nm.gov/surface-water-quality/
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Cover photos: LaBelle Creek in the Valle Vidal, 2017 (above), the Rio Grande at Espanola, 2021 (below).
Photos: SWQB staff

Contents

List of Abbreviations

4Q3	4-Day, 3-year low-flow frequency
6T3	Temperature not to be exceeded for 6 or more consecutive hours on more than 3 consecutive days
AU	Assessment Unit
BMP	Best management practices
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cfu	Colony forming units
CGP	Construction general storm water permit
CoolWAL	Cool Water Aquatic Life
CWA	Clean Water Act
^{o}C	Degrees Celsius
DMR	Discharge Monitoring Report
HQCWAL	High Quality Coldwater Aquatic Life
^{o}F	Degrees Fahrenheit
HUC	Hydrologic Unit Code
$j/m^2/s$	Joules per square meter per second
km^2	Square kilometers
LA	Load allocation
lb/day	Pounds per day
mgd	Million gallons per day
mg/L	Milligrams per Liter
mi^2	Square miles
mL	Milliliters
MOS	Margin of safety
MOU	Memorandum 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
NPS	Nonpoint source
QAPP	Quality Assurance Project Plan
SSTEMP	Stream Segment Temperature Model
SWPPP	Storm water pollution prevention plan
SWQB	Surface Water Quality Bureau
TMDL	Total Maximum Daily Load
UAA	Use Attainability Analysis
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WBP	Watershed-based plan
WLA	Waste load allocation
WQCC	Water Quality Control Commission
WQS	Water quality standards (20.6.4 NMAC as amended through 5/22/2020)

EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act (CWA), 33 U.S.C. § 1313, requires states to develop Total Maximum Daily Load (TMDL) management plans for water bodies determined to be water quality limited. A TMDL is defined as "*a written plan and analysis established to ensure that a water body will attain and maintain water quality standards including consideration of existing pollutant loads and reasonably foreseeable increases in pollutant loads*" (USEPA, 1999). A TMDL defines 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. It further identifies potential methods, actions, or limitations that could be implemented to achieve water quality standards. TMDLs are defined in Title 40 Code of Federal Regulations, Section 130.2(i) (40 C.F.R. § 130.2(i)) as the sum of individual Waste Load Allocations (WLAs) for point sources, and Load Allocations (LAs) for nonpoint source and background conditions, and a Margin of Safety (MOS) in acknowledgement of various sources of uncertainty in the analysis.

The New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB) conducted a water quality survey of the Upper Rio Grande basin in 2017 and 2018. Water quality monitoring stations were located to evaluate the impact of tributary streams and ambient water quality conditions. Impairments addressed in this TMDL document, as well as existing approved TMDLs, are shown on Tables ES-1 to ES-24, below. Additional information regarding these impairments is available in the 2020-2022 Clean Water Act §303(d)/§305(b) Integrated Report and List (IR) (NMED/SWQB, 2020a).

The next water quality monitoring survey of the Upper Rio Grande basin is scheduled for 2027-2028, at which time TMDLs 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 TMDL will be adjusted accordingly. When a water body achieves water quality standards (WQS), it will be assigned to the appropriate category in the IR.

Table ES-1. TMDL for Chuckwagon Creek (Comanche Creek to headwaters)					
New Mexico Standards Segment	20.6.4.123 NMAC				
Assessment Unit Identifier	NM-2120.A_833				
NPDES Permit(s)	None				
Segment Length	2.7 miles				
Parameters of Concern	Turbidity				
Designated Uses Affected	High quality coldwater aquatic life				
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande				
Scope/size of Watershed	1.25 square miles				
Land Type	21g – Volcanic Subalpine Forests; 21j – Grassland Parks				
Land Use/Cover	83.0% evergreen forest, 13.5% shrubland, 3.2% deciduous forest				
Land Management	100% Forest Service				
Geology	69.5% mafic volcanic, 30.2% Metamorphic, <1% Alluvium				
Probable Sources	Loss of riparian habitat; Grazing in riparian zone				
IR Category	5/5A				
Priority Ranking	High				
Existing TMDLs	None				
Turbidity (lb TSS/day)	**Duration (consecutive days)**	**WLA**	**MOS (15%)**	**LA**	**TMDL**
	3	0.00	2.78	15.72	18.5
	4	0.00	2.46	13.94	16.4
	5	0.00	2.25	12.75	15.0
	6	0.00	2.04	11.56	13.6
	7	0.00	1.94	10.96	12.9
	14	0.00	1.52	8.58	10.1
	30	0.00	1.09	6.17	7.26

Table ES-2. TMDL for Costilla Creek (Diversion abv Costilla to Comanche Creek)	
New Mexico Standards Segment	20.6.4.123 NMAC
Assessment Unit Identifier	NM-2120.A_820
NPDES Permit(s)	None
Segment Length	19.59 miles
Parameters of Concern	Total recoverable aluminum
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	218 square miles
Land Type	21b – Crystalline Subalpine Forests; 21c - Crystalline Mid-Elevation Forests; 21d – Foothill Shrublands; 22b – San Luis Alluvial Flats and Wetlands
Land Use/Cover	59.7% evergreen forest, 18.0% shrubland, 9.4% grassland, 8.2% deciduous forest, 1.7% mixed forest, 1.7% wetlands
Land Management	72.6% Private, 27.3% Forest Service, <1% State Land Office
Geology	38.1% igneous metamorphic, 31.6% unconsolidated, 24.0% igneous volcanic, 4.2% sedimentary, 2.0% igneous intrusive
Probable Sources	Crop production; Highway/road/bridge runoff; Other recreation (angling, campgrounds); Pavement/impervious surfaces; Rangeland grazing; Rural residential area; Sand/gravel/rock mining or quarries; Site clearance; Water diversion
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
	WLA + LA + MOS = TMDL
Total recoverable aluminum (lb/day)	0 + 174.3 + 30.7 = 205

Table ES-3. TMDL for Fernandez Creek (Comanche Creek to headwaters)	
New Mexico Standards Segment	20.6.4.123 NMAC
Assessment Unit Identifier	NM-2120.A_834
NPDES Permit(s)	None
Segment Length	2.85 miles
Parameters of Concern	Plant nutrients
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	2.68 square miles
Land Type	21g – Volcanic Subalpine Forests; 21j – Grassland Parks
Land Use/Cover	75.2% evergreen forest, 13.6% shrubland, 10.0% deciduous forest
Land Management	62.8% Forest Service, 37.2% Private
Geology	56.3% Felsic volcanic, 23% Alluvium, 20.5% Mafic volcanic, <1% Metamorphic
Probable Sources	Grazing in riparian zone
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
	WLA + MOS + LA = TMDL
Plant Nutrients (lb/day)	Total Phosphorus: 0 + 0.008 + 0.072 = 0.08 Total Nitrogen: 0 + 0.078 + 0.702 = 0.78

Table ES-4. TMDL for Grassy Creek (Comanche Creek to headwaters)	
New Mexico Standards Segment	20.6.4.123 NMAC
Assessment Unit Identifier	NM-2120.A_836
NPDES Permit(s)	None
Segment Length	3.48 miles
Parameters of Concern	*E. coli,* Temperature
Designated Uses Affected	Primary contact, High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	1.88 square miles
Land Type	21b – Crystalline Subalpine Forests; 21e – Sedimentary Subalpine Forests; 21j – Grassland Parks
Land Use/Cover	47.7% evergreen forest, 37.2% shrubland, 8.4% deciduous forest, 6.1% grassland
Land Management	100% Forest Service
Geology	43.6% Metamorphic, 24.3% Carbonates, 14.6% Alluvium, 11.6% Intrusive or plutonic, 5.9% Sedimentary
Probable Sources	Grazing in riparian zone; Loss of riparian habitat
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
	WLA + LA + MOS = TMDL
E. coli (cfu/day)	0 + (3.05×10^8) + (3.39×10^7) = (3.39×10^8)
Temperature (kJ/day)	0 + (2.07×10^7) +(5.18×10^6) = (2.59×10^7)

Table ES-5. TMDL for LaBelle Creek (Comanche Creek to headwaters)	
New Mexico Standards Segment	20.6.4.123 NMAC
Assessment Unit Identifier	NM-2120.A_839
NPDES Permit(s)	None
Segment Length	2.94 miles
Parameters of Concern	Total recoverable aluminum, *E. coli,* sedimentation/siltation
Designated Uses Affected	High quality coldwater aquatic life, Primary contact
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	1.75 square miles
Land Type	21g – Volcanic Subalpine Forests; 21j – Grassland Parks
Land Use/Cover	41.3% shrubland, 39.7% evergreen forest, 16.2% grassland, 1.8% deciduous forest, 1.0% wetlands
Land Management	100% Forest Service
Geology	53.4% Alluvium, 21.2% Mafic volcanic, 16.4% Intrusive or plutonic, 9.0% metamorphic,
Probable Sources	Grazing in riparian zone; Loss of riparian habitat;
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	Temperature (2011)
	WLA + LA + MOS = TMDL
Total recoverable aluminum (lb/day)	0 + 2.07 + 0.36 = 2.43
E. coli (cfu/day)	0 + (1.94×10^8) + (2.16×10^7) = (2.16×10^8)
Sedimentation/siltation (lb TSS/day)	0 + 2.64 + 0.66 = 3.30

Table ES-6. TMDL for North Fork Tesuque Creek (Tesuque Creek to headwaters)	
New Mexico Standards Segment	20.6.4.121 NMAC
Assessment Unit Identifier	NM-2118.A_32
NPDES Permit(s)	None
Segment Length	2.4 miles
Parameters of Concern	Total recoverable aluminum
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	1.64 square miles
Land Type	21a – Alpine Zone; 21b – Crystalline Subalpine Forests
Land Use/Cover	48.9% evergreen forest, 23.7% deciduous forest, 13.9% shrubland, 9.6% mixed forest, 3.9% grassland
Land Management	100% Forest Service
Geology	100% Metamorphic
Probable Sources	Highway/road/bridge runoff; Other recreation (campground, hiking trails); Pavement/impervious surfaces; Rangeland grazing;
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
	WLA + MOS + LA = TMDL
Total recoverable aluminum (lb/day)	0 + 0.15 + 0.83 = 0.98

Table ES-7. TMDL for Placer Creek (Red River to headwaters)	
New Mexico Standards Segment	20.6.4.123 NMAC
Assessment Unit Identifier	NM-2120.A_706
NPDES Permit(s)	None
Segment Length	3.41 miles
Parameters of Concern	Turbidity
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	2.0 square miles
Land Type	21b – Crystalline Subalpine Forests; 21g – Volcanic Subalpine Forests; 21h - Volcanic Mid-Elevation Forests
Land Use/Cover	85.1% evergreen forest, 5.8% deciduous forest, 4.7% shrubland, 3.8% mixed forest
Land Management	89.4% Forest Service, 10.6% Private
Geology	51.7% Intrusive or plutonic, 23.8% Mafic volcanic, 16.5% Alluvium, 1.5% Felsic volcanic, 1.1% Metamorphic
Probable Sources	Abandoned mine lands; Highway/road/bridge runoff; Urban runoff
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	Dissolved aluminum (2006)
Turbidity (lb TSS/day)	

Duration (consecutive days)	WLA	MOS (15%)	LA	TMDL
3	0.00	2.06	11.64	13.7
4	0.00	2.01	11.39	13.4
5	0.00	1.98	11.22	13.2
6	0.00	1.94	10.96	12.9
7	0.00	1.92	10.88	12.8
14	0.00	1.82	10.28	12.1
30	0.00	1.68	9.52	11.2

Table ES-8. TMDL for Red River (Rio Grande to Placer Creek)	
New Mexico Standards Segment	20.6.4.122 NMAC
Assessment Unit Identifier	NM-2119_10
NPDES Permit(s)	NMDGF/Red River State Fish Hatchery - NM0030147 (3 outfalls); Chevron Mining, Inc./Questa Mine - NM0022306 (4 outfalls); Town of Red River WWTP - NM0024899
Segment Length	21.16 miles
Parameters of Concern	Turbidity
Designated Uses Affected	Coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	189 square miles
Land Type	21c - Crystalline Mid-Elevation Forests; 21h - Volcanic Mid-Elevation Forests; 21d – Foothill Shrublands; 22f – Taos Plateau
Land Use/Cover	71.1% evergreen forest, 11.4% shrubland, 7.5% grassland, 4.2% deciduous forest, 2.1% barren land, 1.5% developed, 1.1% mixed forest
Land Management	82.5% Forest Service, 12.9% Private, 4.2% Bureau of Land Management, <1% State Land Office, <1% Tribal
Geology	28.7% metamorphic, 24.5% mafic volcanic, 16.1% alluvium, 15.9% intrusive or plutonic, 11.9% felsic volcanic, 2.3% carbonate
Probable Sources	Abandoned mine lands; Dams/impoundments; Habitat modification (Exotic species); Flow alteration; Highway/road/bridge runoff; Industrial point source discharge; Mine tailings; Municipal point source discharge; Natural sources; Off-road vehicles; Other recreation (angling, campgrounds, hiking trails); Permitted aquaculture; Rangeland grazing; Rural residential area; Water diversion; Wildlife other than waterfowl
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
Turbidity (lb TSS/day)	

Duration (consecutive days)	Combined WLA*	MOS (10%)	LA	TMDL
3	5396	782	1642	7820
4	4696	681	1433	6810
5	4229	613	1288	6130
6	3761	545	1144	5450
7	3529	512	1079	5120
14	2596	376	788	3760
30	1662	241	507	2410

Table ES-9. TMDL for Rio Chupadero (USFS bnd to headwaters)	
New Mexico Standards Segment	20.6.4.121 NMAC
Assessment Unit Identifier	NM-2118.A_40
NPDES Permit(s)	None
Segment Length	6.05 miles
Parameters of Concern	Sedimentation/siltation
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	6.31 square miles
Land Type	21b – Crystalline Subalpine Forests; 21c - Crystalline Mid-Elevation Forests
Land Use/Cover	87.3% evergreen forest, 5.5% deciduous forest, 3.6% mixed forest, 3.2% shrubland
Land Management	93.5% Forest Service, 6.5% Private
Geology	55.3% Metamorphic, 42.0% Intrusive or plutonic, 2.7% Alluvium
Probable Sources	Highway/road/bridge runoff; Other recreation (dispersed camping); Rangeland grazing
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
	WLA + MOS + LA = TMDL
Sedimentation/siltation (lb TSS/day)	0 + 1.27 + 5. 06 = 6.33

Table ES-10. TMDL for Rio en Medio (Aspen Ranch to headwaters)	
New Mexico Standards Segment	20.6.4.121 NMAC
Assessment Unit Identifier	NM-2118.A_42
NPDES Permit(s)	None
Segment Length	3.05 miles
Parameters of Concern	Sedimentation/siltation
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	2.4 square miles
Land Type	21a – Alpine Zone; 21b – Crystalline Subalpine Forests; 21c - Crystalline Mid-Elevation Forests; 21d – Foothill Shrublands; 22h – North Central New Mexico Valleys and Mesas
Land Use/Cover	71.4% evergreen forest, 9.6% deciduous forest, 9.3% shrubland, 8.1% mixed forest, 1.1% grassland
Land Management	100% Forest Service
Geology	100% Metamorphic
Probable Sources	Highway/road/bridge runoff; Other recreation (camping, hiking trails, ski area); Rangeland grazing; Waste from pets
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
	WLA + MOS + LA = TMDL
Sedimentation/siltation (lb TSS/day)	0 + 2.92 + 11.68 = 14.6

Table ES-11. TMDL for Rio Fernando de Taos (R Pueblo d Taos to headwaters)	
New Mexico Standards Segment	20.6.4.123 NMAC
Assessment Unit Identifier	NM-98.A_001, NM-2120.A_513 and NM-2120.A_512
NPDES Permit(s)	None
Segment Length	23.59 miles
Parameters of Concern	Specific conductance
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	71.6 square miles
Land Type	21f – Sedimentary Mid-Elevation Forests; 21d - Foothill Shrublands; 22f - Taos Plateau
Land Use/Cover	78.0% evergreen forest, 7.3% shrubland, 5.1% developed, 3.8% deciduous forest, 2.7% mixed forest, 1.6% grassland, 1.2% wetlands
Land Management	79.6% Forest Service, 16.3% Private, 4.1% Tribal, <1% Bureau of Land Management
Geology	80.4% carbonates, 17.4% alluvium, <1% mafic volcanic, <1% metamorphic, <1% intrusive or plutonic, <1% evaporites
Probable Sources	Grazing in riparian zone; Habitat modification (Exotic species); Highway/road/bridge runoff; On-site treatment systems; Other recreation (angling); Rangeland grazing; Rural residential area; Sand/gravel/rock quarry; Urban municipal area; Water diversion
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	*E. coli* (2012), Specific conductance (2004), Temperature (2004)
	WLA + LA + MOS = TMDL
Specific conductance (lb TDS/day)	0 + 776.7 + 86.3 = 863

Table ES-12. TMDL for Rio Frijoles (Rio Medio to Pecos Wilderness)	
New Mexico Standards Segment	20.6.4.121 NMAC
Assessment Unit Identifier	NM-2118.A_60
NPDES Permit(s)	None
Segment Length	15.35 miles
Parameters of Concern	Turbidity
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	37.6 square miles
Land Type	21b – Crystalline Subalpine Forests; 21c - Crystalline Mid-Elevation Forests; 21d – Foothill Shrublands; 22h – North Central New Mexico Valleys and Mesas
Land Use/Cover	76.7% evergreen forest, 12.5% shrubland, 5.3% grassland, 2.9% deciduous forest, 2.8% mixed forest
Land Management	80.6% Forest Service, 16.8% Private, 2.3% BLM, <1% Tribal
Geology	83.0% metamorphic, 13.3% Intrusive or plutonic, 3.6% Alluvium
Probable Sources	Forest fire (200, 2011, 2013); Grazing in riparian zone; Habitat modification (Exotic species); Highway/road/bridge runoff; Rangeland grazing; Rural residential area; Water diversion
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
Turbidity (lb TSS/day)	(see table below)

Turbidity (lb TSS/day):

Duration (consecutive days)	WLA	MOS (10%)	LA	TMDL
3	0.00	34.5	310.5	345
4	0.00	30.45	273.6	304
5	0.00	27.8	250.2	278
6	0.00	25.1	225.9	251
7	0.00	23.8	214.2	238
14	0.00	18.4	165.6	184
30	0.00	13.0	117.0	130

Table ES-13. TMDL for Rio Grande (Ohkay Owingeh bnd to Embudo Creek)	
New Mexico Standards Segment	20.6.4.114 NMAC
Assessment Unit Identifier	NM-2111_10
NPDES Permit(s)	None
Segment Length	14.07 miles
Parameters of Concern	Temperature
Designated Uses Affected	Marginal coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	5820 square miles
Land Type	22f – Taos Plateau 22h – North Central New Mexico Valleys and Mesas; 22g – Rio Grande Floodplain
Land Use/Cover	46.3% shrubland, 30.1% evergreen forest, 5.6% grassland, 4.8% cultivated crops, 3.9% wetlands, 3.8% deciduous forest, 1.6% developed, 1.3% mixed forest
Land Management	47.4% Private, 29.3% Forest Service, 15.3% Bureau of Land Management,; 4.3% State, 3.1% Tribal, <1% Dept of Defense
Geology	38.0% unconsolidated, 35.7% igneous volcanic, 15.0% sedimentary, 8.1% metamorphic, 3.1% igneous intrusive
Probable Sources	Crop production; Dams/impoundments; Drought; Highway/road/bridge runoff; Rural residential area; Site clearance; Streambank modification ; Water diversion
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	Turbidity (2005)
	WLA + MOS + LA = TMDL
Temperature (kJ/day)	0 + (8.52×10^{9}) + (4.82×10^{10}) = (5.68×10^{10})

Table ES-14. TMDL for Rio Grande (Santa Clara Pueblo bnd to Ohkay Owingeh bnd)	
New Mexico Standards Segment	20.6.4.114 NMAC
Assessment Unit Identifier	NM-2111_11
NPDES Permit(s)	None
Segment Length	0.69 miles
Parameters of Concern	Temperature
Designated Uses Affected	Marginal coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	8950 square miles
Land Type	22g – Rio Grande Floodplain
Land Use/Cover	70.0% evergreen forest, 13.4% shrubland, 9.3% grassland, 3.7% mixed forest, 2.5% deciduous forest
Land Management	40.8% Private, 36.5% Forest Service, 12.1% Bureau of Land Management, 5.8% Tribal, 4.3% State, <1% Fish & Wildlife Service, <1% Dept of Defense
Geology	35.1% unconsolidated, 29.4% sedimentary, 26.4 igneous volcanic, 6.7% metamorphic, 2.2% igneous intrusive
Probable Sources	Crop production; Dams/impoundments; Inappropriate waste disposal; Pavement/impervious surfaces; Rural residential area; Sand/gravel/rock mining or quarries; Site clearance; Streambank modification ; Water diversion
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	Turbidity (2005)
	WLA + MOS + LA = TMDL
Temperature (kJ/day)	0 + (9.96×10^{9}) + (5.64×10^{10}) = (6.64×10^{10})

Table ES-15. TMDL for Rio Medio (Rio Frijoles to headwaters)	
New Mexico Standards Segment	20.6.4.121 NMAC
Assessment Unit Identifier	NM-2118.A_023
NPDES Permit(s)	None
Segment Length	17.88 miles
Parameters of Concern	Total recoverable aluminum, Temperature, Turbidity
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	54.7
Land Type	21a – Alpine Zone; 21b – Crystalline Subalpine Forests; 21c - Crystalline Mid-Elevation Forests; 21d – Foothill Shrublands; 22h – North Central New Mexico Valleys and Mesas
Land Use/Cover	70.0% evergreen forest, 13.4% shrubland, 9.3% grassland, 3.7% mixed forest, 2.5% deciduous forest
Land Management	94.6% Forest Service, 2.9% Private, 2.5% BLM, <1% Private
Geology	80.4% Metamorphic, 15.2% Intrusive or plutonic, 3.6% Carbonates, <1% Alluvium
Probable Sources	Crop production; Dam/impoundment; Drought; Forest fire (2002, 2013); Grazing in riparian zone; Habitat modification (Exotic species); Loss of riparian habitat; Rural residential area; Site clearance; Water diversion
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
	WLA + MOS + LA = TMDL
Total recoverable aluminum (lb/day)	0 + 5.9 + 33.2 = 39.1
Temperature (kJ/day)	$0 + (1.13 \times 10^8) + (6.42 \times 10^8) = (7.55 \times 10^8)$
Turbidity (lb TSS/day)	see table below

Duration (consecutive days)	WLA	MOS (10%)	LA	TMDL
3	0.00	53.2	478.8	532
4	0.00	41.4	372.6	414
5	0.00	35.1	315.0	350
6	0.00	29.7	267.3	297
7	0.00	27.3	245.7	273
14	0.00	19.5	175.5	195
30	0.00	14.0	126.0	140

Table ES-16. TMDL for Rio Nambe (Nambe Pueblo bnd to headwaters)	
New Mexico Standards Segment	20.6.4.121 NMAC
Assessment Unit Identifier	NM-2118.A_43
NPDES Permit(s)	None
Segment Length	9.23 miles
Parameters of Concern	Temperature
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	33.1 square miles
Land Type	21a – Alpine Zone; 21b – Crystalline Subalpine Forests; 21c - Crystalline Mid-Elevation Forests
Land Use/Cover	51.2% evergreen forest, 31.4% grassland, 14.1% shrubland, 1.6% mixed forest, 1.4% deciduous forest
Land Management	89.2% Forest Service, 9.8% Tribal, <1% Private, <1% National Park Service
Geology	98.4% metamorphic, 1.1% alluvium, <1% intrusive or plutonic
Probable Sources	Drought; Fire suppression; Forest fire (2003, 2011); Other recreation (hiking trails); Rangeland grazing
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
	WLA + LA + MOS = TMDL
Temperature (kJ/day)	0 + (2.76×10^8) + (4.89×10^7) = (3.25×10^8)

Table ES-17. TMDL for Rio Pueblo de Taos (Arroyo del Alamo to R Grande del Rancho)	
New Mexico Standards Segment	20.6.4.122 NMAC
Assessment Unit Identifier	NM-2119_30
NPDES Permit(s)	NM0024066 – Town of Taos WWTP
Segment Length	5.46 miles
Parameters of Concern	Plant Nutrients
Designated Uses Affected	Coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	388 square miles
Land Type	22f – Taos Plateau
Land Use/Cover	74.1% forest, 13.6% shrubland, 5.4% grassland, 3.8% developed, 1.8% wetlands, 1.0% cultivated crops
Land Management	48.6% Forest Service, 33.2% Tribal land, 18.2% Private
Geology	63.4% Sedimentary, 21.5% Unconsolidated, 8.4% Igneous, 2.8% Unconsolidated and Sedimentary, 2.1% Igneous and Metamorphic, 1.8% Metamorphic
Probable Sources	Highway/road/bridge runoff; Municipal point source discharge; Other recreation (angling); Rural residential area; Site clearance;
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	Stream Bottom Deposits (2004), Temperature (2004)
	WLA + LA + MOS = TMDL
Plant Nutrients (lb/day)	Total Phosphorus 1.02 + 0.72 + 0.09 = 1.83 Total Nitrogen 7.01 + 4.96 + 0.63 = 12.6

Table ES-18. TMDL for Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)	
New Mexico Standards Segment	20.6.4.122 NMAC
Assessment Unit Identifier	NM-2119_20
NPDES Permit(s)	None
Segment Length	2.38 miles
Parameters of Concern	Turbidity
Designated Uses Affected	Coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	420 square miles
Land Type	22f – Taos Plateau
Land Use/Cover	66.1% evergreen forest, 17.3% shrubland, 5.0% grassland, 3.6% developed, 2.7% deciduous forest, 2.3% mixed forest, 1.6% wetlands
Land Management	44.9% Forest Service, 32.7% Tribal, 21.8% Private, <1% BLM
Geology	56.2% Carbonates, 31.2% Alluvium, 10.8% Metamorphic, <1% Intrusive or plutonic, <1% Mafic volcanic, <1% Evaporites
Probable Sources	Habitat modification (Exotic species); Highway/road/bridge runoff; Inappropriate waste disposal; Rural residential area
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	Temperature (2004)

Turbidity (lb TSS/day)

Duration (consecutive days)	WLA	MOS (10%)	LA	TMDL
3	0.00	76.2	685.8	762
4	0.00	61.9	557.1	619
5	0.00	53.8	484.2	538
6	0.00	46.8	421.2	468
7	0.00	43.7	393.3	437
14	0.00	33.0	297.0	330
30	0.00	25.0	225.0	250

Table ES-19. TMDL for Rio Quemado (Santa Cruz River to headwaters)	
New Mexico Standards Segment	20.6.4.121 and 20.6.4.123 NMAC
Assessment Unit Identifier	NM-2120.A_120 and NM-2118.A_52
NPDES Permit(s)	None
Segment Length	20.18 miles
Parameters of Concern	Total recoverable aluminum, *E. coli*
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	42.3 square miles
Land Type	21a – Alpine Zone; 21b – Crystalline Subalpine Forests; 21c - Crystalline Mid-Elevation Forests; 21d – Foothill Shrublands; 22h – North Central New Mexico Valleys and Mesas
Land Use/Cover	63.7% evergreen forest, 26.1% shrubland, 2.8% barren land, 2.2% mixed forest, 1.4% developed, 1.3% pasture/hay, 1.2% grassland, 1.1% deciduous forest
Land Management	60.0% Forest Service; 33.7% Private; 4.1% Bureau of Land Management; <1% State Land Office
Geology	69.4%% Metamorphic, 15.7% Alluvium, 14.9% Intrusive or plutonic
Probable Sources	Crop production; Forest fire (2002); Habitat modification (Exotic species); Grazing in riparian zone; Highway/road/bridge runoff; Inappropriate waste disposal; Loss of riparian habitat; Rangeland grazing; Rural residential area; Site clearance; Water diversion
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	*E. coli* (2012)
	WLA + MOS + LA = TMDL
Total recoverable aluminum (lb/day)	0 + 7.74 + 43.9 = 51.6

Table ES-20. TMDL for Sanchez Canyon (Costilla Creek to headwaters)	
New Mexico Standards Segment	20.6.4.123 NMAC
Assessment Unit Identifier	NM-2120.A_822
NPDES Permit(s)	None
Segment Length	6.32 miles
Parameters of Concern	Turbidity
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	7.83 square miles
Land Type	21g – Volcanic Subalpine Forests; 21c - Crystalline Mid-Elevation Forests; 21d – Foothill Shrublands
Land Use/Cover	81.1% evergreen forest, 10.2% deciduous forest, 6.4% shrubland, 1.5% mixed forest
Land Management	97.6% Private, 2.4% NM Game & Fish
Geology	40.1% Metamorphic, 25.5% Mafic volcanic; 18.2% Alluvium; 16.2% Felsic volcanic
Probable Sources	Grazing in riparian zone; Habitat modification (Exotic species); Highway/road/bridge runoff; Rangeland grazing; Rural residential area
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None

	Duration (consecutive days)	WLA	MOS (15%)	LA	TMDL
Turbidity (lb TSS/day)	3	0.00	75.0	425.0	500
	4	0.00	41.4	234.4	276
	5	0.00	27.8	157.6	185
	6	0.00	18.8	106.0	125
	7	0.00	15.3	86.9	102
	14	0.00	6.9	39.3	46.2
	30	0.00	3.1	17.8	20.9

Table ES-21. TMDL for Santa Cruz River (Santa Clara Pueblo bnd to Santa Cruz Dam)	
New Mexico Standards Segment	20.6.4.114 NMAC
Assessment Unit Identifier	NM-2111_50
NPDES Permit(s)	None
Segment Length	8.37 miles
Parameters of Concern	Total recoverable aluminum
Designated Uses Affected	Marginal coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	181 square miles
Land Type	22h – North Central New Mexico Valleys and Mesas; 22g – Rio Grande Floodplain
Land Use/Cover	53.7% evergreen forest, 33.7% shrubland, 4.9% grassland, 2.1% mixed forest, 1.8% developed, 1.6% deciduous forest, 1.1% barren land
Land Management	60.0% Forest Service; 19.7% Private; 19.7% Bureau of Land Management, <1% State Land Office, <1% Tribal
Geology	57.6% metamorphic, 28.5% alluvium, 12.8% intrusive or plutonic, 1.1% carbonate
Probable Sources	Crop production; Dams/impoundments; Grazing in riparian zone; Highway/road/bridge runoff; Inappropriate waste disposal; Loss of riparian habitat; Off-road vehicles; Rural residential area; Site clearance; Water diversion
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	*E. coli* (2012)
	WLA + MOS + LA = TMDL
Total recoverable aluminum (lb/day)	0 + 29.6 + 167.4 = 197

Table ES-22. TMDL for Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	
New Mexico Standards Segment	20.6.4.121 NMAC
Assessment Unit Identifier	NM-2118.A_51
NPDES Permit(s)	None
Segment Length	1.01 miles
Parameters of Concern	Total recoverable aluminum, Temperature
Designated Uses Affected	High quality coldwater aquatic life
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	96 square miles
Land Type	22h North Central New Mexico Valleys and Mesas
Land Use/Cover	71.0% evergreen forest, 15.3% shrubland, 7.4% grassland, 3.0% mixed forest, 2.6% deciduous forest
Land Management	85.4% Forest Service, 8.2% Private, 6.2% Bureau of Land Management, <1% Tribal, <1% State Land Office
Geology	78.3% metamorphic, 15.7% intrusive or plutonic, 3.9% alluvium, 2.1% carbonate
Probable Sources	Drought; Highway/road/bridge runoff; Inappropriate waste disposal; Other recreation (angling, hiking trails);
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
	WLA + MOS + LA = TMDL
Total recoverable aluminum (lb/day)	0 + 12.2 + 68.8 = 81.0
Temperature (kJ/day)	0 + (1.92×10^8) + (1.09×10^9) = (1.28×10^9)

Table ES-23. TMDL for Ute Creek (Costilla Creek to headwaters)	
New Mexico Standards Segment	20.6.4.123 NMAC
Assessment Unit Identifier	NM-2120.A_821
NPDES Permit(s)	None
Segment Length	9.01 miles
Parameters of Concern	*E. coli*
Designated Uses Affected	Primary contact
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	14.7 square miles
Land Type	21a – Alpine Zone; 21b – Crystalline Subalpine Forests; 21c - Crystalline Mid-Elevation Forests; 21d – Foothill Shrublands;
Land Use/Cover	56.7% evergreen forest, 19.9% grassland, 9.7% shrubland, 8.6% deciduous forest, 2.5% mixed forest, 1.1% barren land
Land Management	100% Private
Geology	65.4% Metamorphic, 34.6% Alluvium
Probable Sources	Crop production; Highway/road/bridge runoff; Livestock feeding operation; Rangeland grazing; Rural residential area; Site clearance; Water diversion
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
	WLA + LA + MOS = TMDL
E. coli (cfu/day)	0 + (1.03 x 10^9) + (1.14 x 10^8) = (1.14 x 10^9)

Table ES-24. TMDL for Vidal Creek (Comanche Creek to headwaters)	
New Mexico Standards Segment	20.6.4.123 NMAC
Assessment Unit Identifier	NM-2120.A_841
NPDES Permit(s)	None
Segment Length	4.73 miles
Parameters of Concern	Total recoverable aluminum, *E. coli*
Designated Uses Affected	High quality coldwater aquatic life, primary contact
USGS Hydrologic Unit Code	13020101 – Upper Rio Grande
Scope/size of Watershed	6.28 square miles
Land Type	21b – Crystalline Subalpine Forests; 21j – Grassland Parks
Land Use/Cover	55.2% evergreen forest, 23.0% shrubland, 16.8% grassland, 2.1% deciduous forest, 2.9% wetlands
Land Management	99.9% Forest Service, <1% Private
Geology	51.1% Metamorphic, 27.1% Alluvium, 21.7% Sedimentary
Probable Sources	Grazing in riparian zone; Loss of riparian habitat
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
	WLA + LA + MOS = TMDL
Total recoverable aluminum (lb/day)	0 + 12.3 + 2.2 = 14.5
E. coli (cfu/day)	0 + (6.11×10^8) + (6.79×10^7) = (6.79×10^8)

1.0 BACKGROUND

1.1 Watershed Description

This document establishes TMDLs for 24 Assessment Units (AUs) in the upper Rio Grande watershed (**Figure 1.1**). Assessments of impairment were based on data collected during the 2017-18 SWQB water quality survey. Hydrologic Unit Code (HUC) 13020101 covers 8427.58 square km of north central New Mexico, encompassing almost all of Taos County, NM and small portions of Rio Arriba and Santa Fe Counties, NM and Costilla County, CO. The upper Rio Grande watershed includes the Nambe, Picuris, Pojoaque, Santa Clara, and Taos Pueblos, and most of the Ohkay Owingeh, San Ildefonso and Tesuque Pueblos. The main population centers are the Town of Taos and the City of Española. Major tributaries entering the Rio Grande in northern NM include, from north to south, Costilla Creek, Red River, Rio Hondo, Rio Pueblo de Taos, Embudo Creek, and the Santa Cruz River. There is also significant inflow from seeps and springs.

Table 1.1 SWQB monitoring stations where water quality impairments were documented in the 2020-2022 Integrated CWA §303(d)/§305(b) List for the TMDL Assessment Units. Locations shown on Figures 1.1 – 1.3

Site #	Station ID	Station name
1	28Chuckw000.1	Chuckwagon Cr abv Comanche Cr
2	28Costil005.7	Costilla Creek above Costilla at Hwy 196 bridge
3	28Fernan000.1	Fernandez Cr abv Comanche Cr
4	28Grassy000.1	Grassy Creek above Comanche Creek
5	28LaBell000.1	La Belle Cr abv Comanche Cr
6	28NFkTes000.6	N. Fork of Tesuque Cr abv Hyde Park (475) Rd
7	28Placer000.2	Placer Creek, about 400 yds above Red River
8	28RedRiv000.9	Red River above Rio Grande
9	28RChupa014.3	Rio Chupadero at FR 102
10	28REnMed016.3	Rio en Medio 200 m below ski area parking lot
11	28RFerna001.5	Rio Fernando de Taos near Lower Ranchito
12	28RFerna028.7	Rio Fernando de Taos above Apache Canyon
13	28RFerna008.2	Rio Fernando de Taos at USGS gage
14	28RFrijo000.1	Rio Frijoles abv Santa Cruz R
15	28RGrand623.6	Rio Grande near Los Luceros
16	28RGrand609.5	Rio Grande above Espanola at Valdez Bridge
17	28RMedio000.1	Rio Medio above Santa Cruz River
18	28RNambe007.3	Rio Nambe abv Nambe Pueblo bnd
19	28RPuebT008.2	Rio Pueblo de Taos below Los Cordovas
20	28RPuebT000.1	Rio Pueblo de Taos above Rio Grande
21	28RQuema006.9	Rio Quemado @ CR 81 in Cordova
22	28RQuema000.1	Rio Quemado abv Santa Cruz R
23	28Sanche000.2	Sanchez Creek above Costilla Creek
24	28SanCru003.2	Santa Cruz R @ NM 106
25	28SanCru019.1	Santa Cruz River at USGS gage 08291000
26	28UteCre000.3	Ute Creek above Costilla Creek at Hwy 196 in Amalia
27	28VidalC000.1	Vidal Creek above Comanche Creek

Table 1.2 Point source permits discharging into the TMDL Assessment Units. Locations shown on Figures 1.1 – 1.3

Site #	NPDES Permit Number	Site name
A	NM0024899	Town of Red River Wastewater Treatment Plant, Outfall 001
B	NM0022306	Questa Mine, Outfalls 001 and 005
C		Questa Mine, Outfall 004
D		Questa Mine, Outfall 002
E	NM0030147	Red River State Fish Hatchery, Outfalls 001, 002 and 003
F	NM0024066	Town of Taos, Wastewater Treatment Plant, Outfall 001

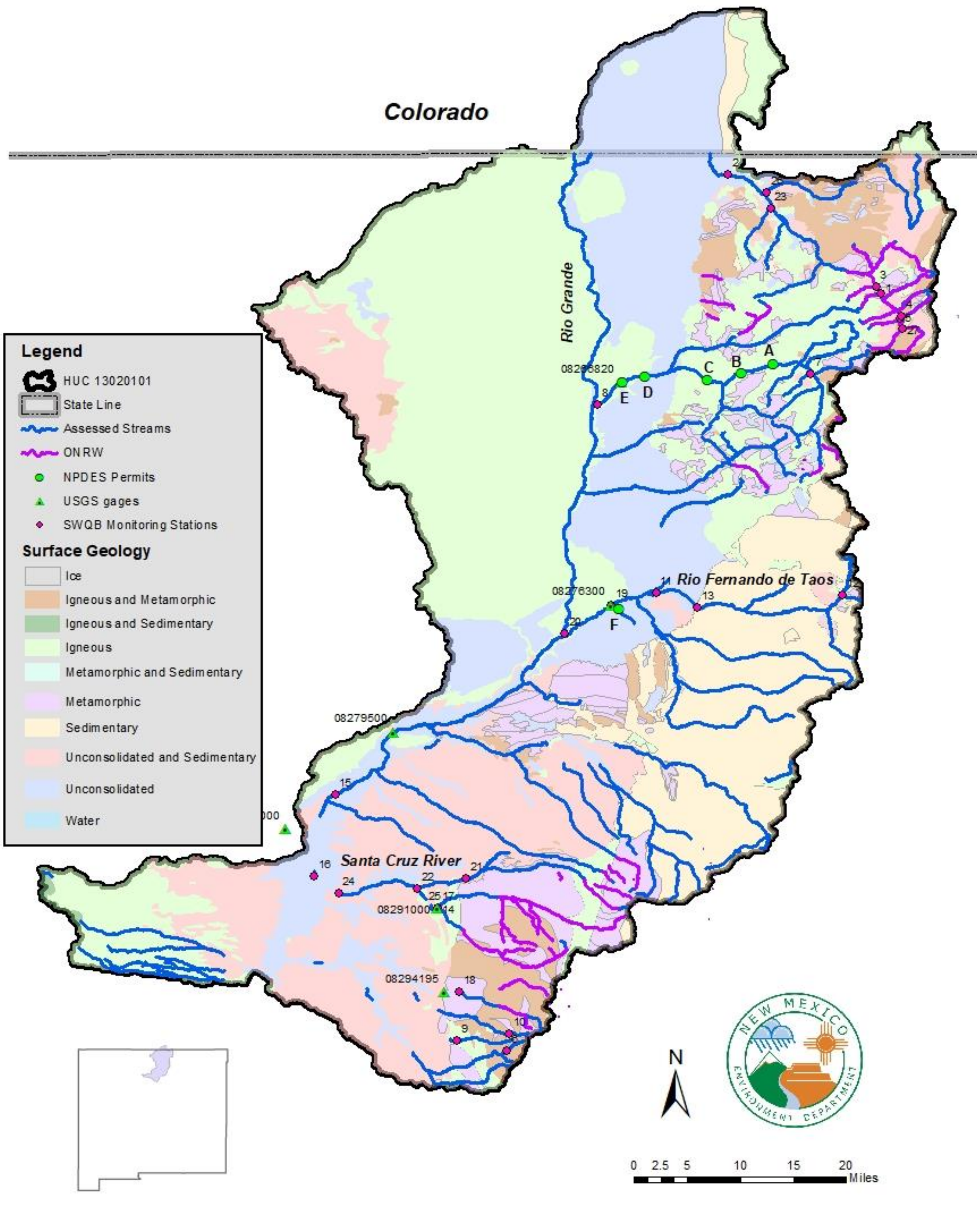

Figure 1.1 Surface geology of the Upper Rio Grande HUC-8

In the Upper Rio Grande region, crust forming the North American tectonic plate is pulling apart, causing two more or less parallel faults. The section of land dropping down between them is called the Rio Grande Rift. The rift becomes wider from north to south. The geology of the Upper Rio Grande basin consists of a complex distribution of Precambrian metamorphic rocks, Paleozoic sedimentary rocks and Tertiary volcanics (**Figure 1.1**). Volcanic features include several shield volcanos north of Taos, and the Taos Plateau volcanic field, mostly west of the river (Bauer, 2011; Chronic, 1987).

The Rio Grande divides two distinct geologic areas. The area west of the river mainly consists of late Quaternary to Tertiary basalts formed as a result of tectonic events associated with the Rio Grande Rift. The Tertiary basalt flows are interbedded with sands and gravels, which were deposited during periods of erosion between volcanic events. The Rio Grande has incised a spectacular steep-walled canyon running north-south through these basalt flows, from the Colorado border to Velarde, NM. Within the gorge, river flow is augmented by a number of springs, most of which are cold, but some are warm.

Immediately east of the river, recent alluvial deposits cover much of the basalt deposits. The source of this alluvial material is the Sangre de Cristo mountain chain, a southern extension of the Rocky Mountains which parallels the river. The Sangre de Cristos mainly consist of Precambrian metamorphic rocks (amphibolites, granitic gneiss, and mica schist) and granitic stocks. Dikes of rhyolite, monzonite porphyry, latite and andesite are also present. Not as common, but still notable, are the scattered deposits of Pennsylvanian sediments including conglomerates, sandstones, shales and limestones. Portions of the Sangre de Cristo range are highly mineralized and as a result support historical and current mining operations.

Land cover in HUC 13020101 is 47.0% shrubland, 40.0% evergreen forest, 5.3% grassland, 2.1% developed, 1.8% deciduous forest, 1.1% cultivated crops, 1.0% mixed forest (**Figure 1.2**). Land ownership is 35.6% US Forest Service, 30.4% private, 16.6% Bureau of Land Management, 12.9% tribal, 4.3% state, and less than 1% each US Department of Energy and National Park Service (**Figure 1.3**). Current land uses include grazing, mining, and forest products. Additionally, the area is heavily utilized by the public for fishing, hunting, camping, off-road vehicles, river rafting, and skiing.

In order to promote settlement, reward patrons of the government, and create a buffer zone to separate hostile Indians from the more populated regions of New Mexico, Spain (and later Mexico) made land grants to individuals, towns, and groups throughout its northern frontier lands. The number of grants made between the end of the 17th century to the middle of the 19th century total about 295. Approximately half of the Upper Rio Grande basin in New Mexico was included in these historical land grants.

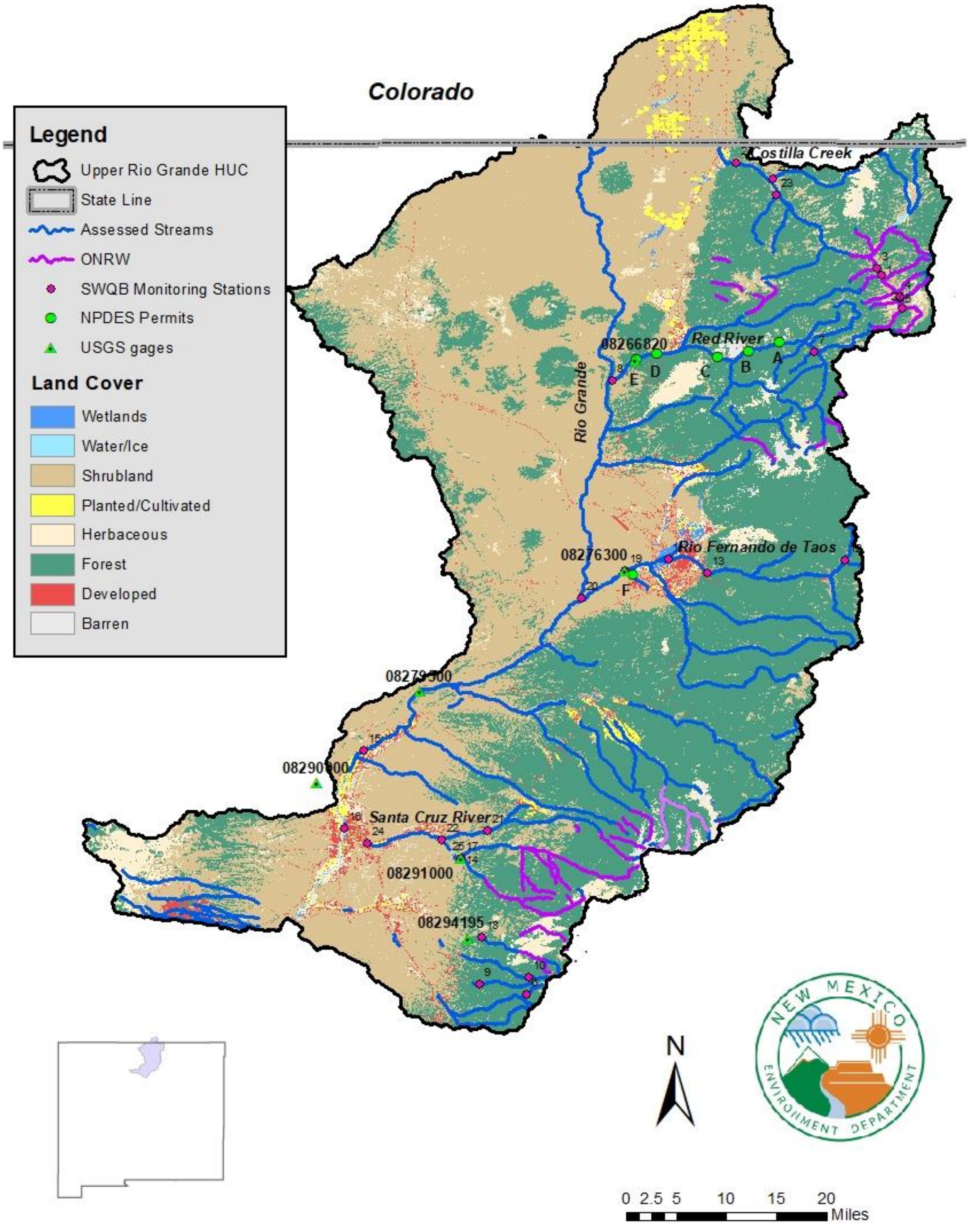

Figure 1.2 Land cover in the Upper Rio Grande HUC-8

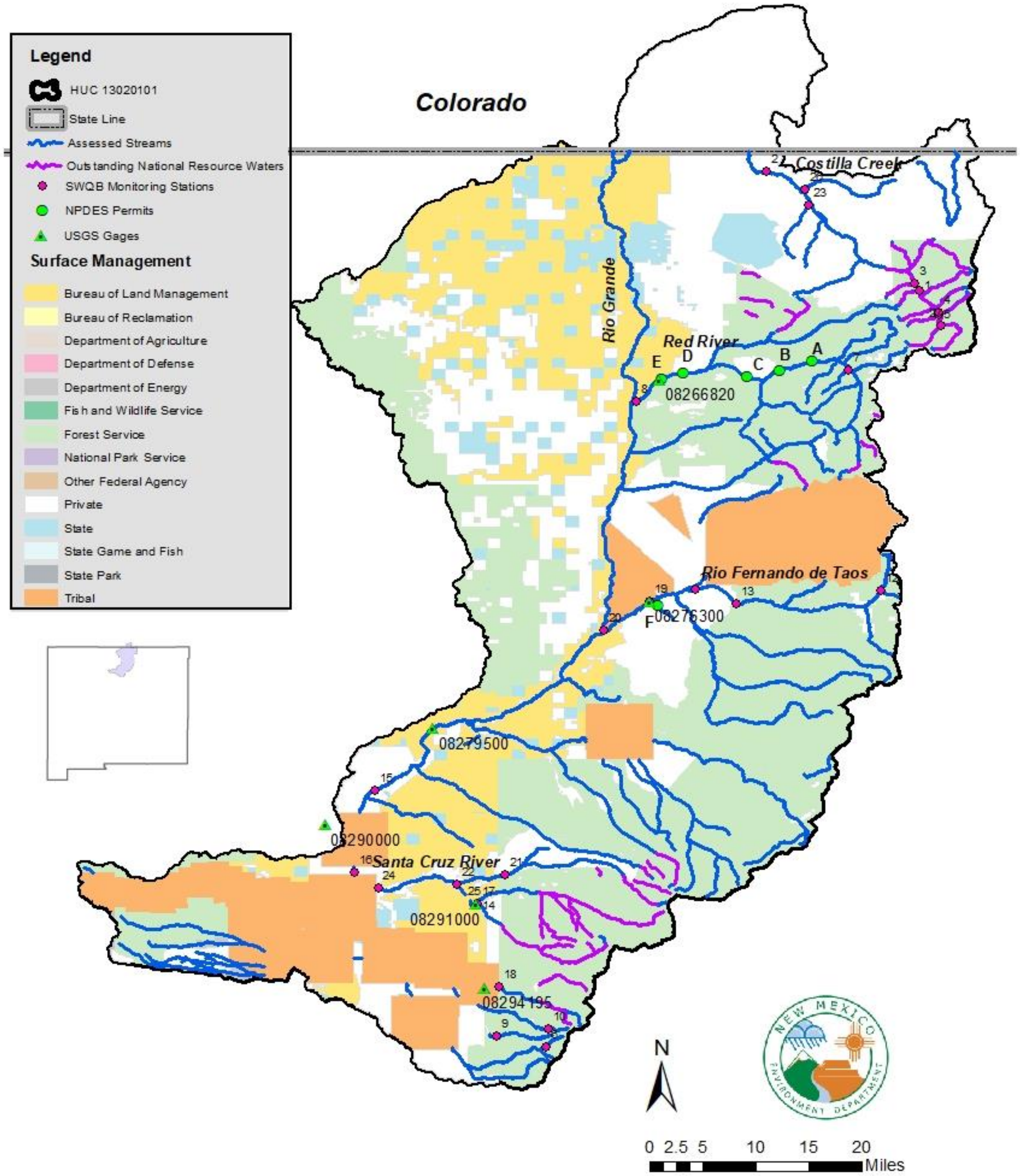

Figure 1.3 Land ownership in the Upper Rio Grande HUC-8

Species listed by the federal Fish & Wildlife Service (USFWS) and/or the New Mexico Department of Game & Fish as Threatened or Endangered, which are known to occur in the Upper Rio Grande HUC, are shown on **Table 1.3** (Natural Heritage New Mexico NMBiotics Database, https://nhnm.unm.edu, accessed on July 22, 2021). Of those, all except the salamander have primary habitat association with aquatic, riparian and/or wetland habitats (Biota Information System of New Mexico, https://www.bison-m.org, accessed July 22, 2021). USFWS designated Critical Habitat for the Southwestern willow flycatcher in the Upper Rio Grande basin (USFWS Environmental Conservation Online System, https://ecos.fws.gov/ecp/, accessed on July 22, 2021) extends along the Rio Grande from the Rio Pueblo de Taos down into Santa Clara Pueblo (excluding Ohkay Owingeh), a portion of the Rio Grande del Rancho, and a short stretch of the Rio Fernando de Taos. In 2020, the USFWS designated Critical Habitat for the Western yellow-billed cuckoo along a continuous 6-mile reach of the Rio Grande north of Ohkay Owingeh.

Table 1.3 Federal and state listed species known to occur in the Upper Rio Grande HUC.

Common Name	Scientific Name	Federal Status*	State Status**
Rio Grande Silvery Minnow	*Hybognathus amarus*	LE	E
Jemez Mountains Salamander	*Plethodon neomexicanus*	LE	E
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	LE	E
New Mexican Meadow Jumping Mouse	*Zapus hudsonius luteus*	LE	E
Western Yellow-billed Cuckoo	*Coccyzus americanus occidentalis*	LT	SGCN

**Federal Status: LE – listed Endangered; LT – listed Threatened. **State Status: E – Endangered; SGCN – Species of Greatest Conservation Need.*

North American river otters were reintroduced to the Rio Pueblo de Taos in 2008-2010, and have colonized the northern Rio Grande, Red River, and Rio Chama watersheds. To improve genetic diversity, nine more otters were released in the spring of 2021. They are categorized as a Protected Furbearer species with a closed season under state law and regulations.

The vast and varied URG basin can be conveniently divided into smaller regions with their own distinctive characteristics:

1.1.1 Costilla Creek/ Valle Vidal

The Comanche Creek watershed is one part of the larger Valle Vidal Unit of the Carson National Forest. Under the Maxwell Land Grant, granted by the Mexican government and then recognized by the United States Government, the owner, Lucien Maxwell, employed more than 500 people who cultivated many acres and ran large herds of sheep and cattle. Mining was also a common activity in the watershed after gold was discovered in the late 1800s in the Maxwell Land Grant (Quivira Coalition, 2020). Heavy grazing pressure (thousands of cattle and sheep) continued in the watershed up to the time the energy company Penzoil acquired the land in the 1960s. The Valle Vidal Unit was donated to the USFS by Pennzoil in 1982 in exchange for a tax debt. Today, the Valle Vidal region is grazed by livestock in the summer months, and is popular with the public for camping, fishing and hunting.

Identified waters of the Valle Vidal, including a short reach of Costilla Creek along with all of Comanche Creek and its tributaries, were designated as Outstanding National Resource Waters (ONRWs; 20.6.4.9

D(2) NMAC) as of February 2006. ONRWs are streams, lakes and wetlands that receive additional protection against degradation under the State of New Mexico's Standards for Interstate and Intrastate Surface Waters and the federal Clean Water Act. An ONRW designation is the highest level of protection against degradation that can be afforded a waterbody under the State of New Mexico's Water Quality Standards. **Table 1.4** lists the west side Valle Vidal ONRW waters and their impairment status as documented following the 2017-2018 SWQB water quality monitoring survey.

Table 1.4 Valle Vidal ONRW waters impairment status

Water Body	Existing Impairments as of ONRW designation (confirmed 2017-18)	New Impairments (based on 2017-18 data)	New De-listings
Chuckwagon Creek	NONE	turbidity	NONE
Comanche Creek	DO, temperature	NONE	NONE
Costilla Creek (diversion abv Costilla to Comanche Cr)	Temperature	Total recoverable aluminum	NONE
Costilla Creek (Comanche Creek to Costilla Dam)	Benthic macroinvertebrates	NONE	NONE
Fernandez Creek	NONE	Plant nutrients	NONE
Gold Greek	Temperature	NONE	NONE
Grassy Creek	NONE	Temperature, *E. coli*	Turbidity
Holman Creek	Temperature, turbidity	NONE	NONE
LaBelle Creek	Temperature	Total recoverable aluminum, *E. coli*, sedimentation/siltation	NONE
Little Costilla	NONE	NONE	NONE
Vidal Creek	DO, temperature	Total recoverable aluminum, E. coli	NONE

1.1.2 Red River

The Red River valley, including the village of Red River, is a popular recreation area, with a small ski resort and extensive off-road vehicle, camping and fishing activity. Downstream of Red River, the Chevron Questa Mine, previously known as the Molycorp Mine, operated intermittently from 1920 until 2014. Open pit mining took place from 1965 to 1983. The site includes a former open pit and underground molybdenum mine and milling facility on 3 square miles of land along State Highway 38, and tailing impoundments on about 1.5 square miles of land near the village of Questa. While the mine was operating, 328 million tons of acid-generating waste rock were excavated and deposited in nine large waste rock piles. After molybdenum was extracted from ore, the tailing was transported by pipeline to a tailing facility near the village of Questa, where it was impounded. Mining operations, waste disposal, and spills have caused contamination of soil, sediment, surface water and groundwater.

Questa Mine cleanup has included removal actions to address immediate threats to human health and the environment. Long-term, the site is being addressed through federal, state and potentially responsible party actions. The site was placed on the National Priorities List on September 16, 2011. EPA selected the remedy in a December 20, 2010 Record of Decision. The above information, and additional details of the clean-up, is provided on the USEPA Superfund Site Profile at https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.Cleanup&id=0600806#bkground.

The Town of Red River Wastewater Treatment Plant discharges permitted effluent to the Red River near the top of the AU, upstream from the mine. The Red River State Fish Hatchery, operated by the NM Department of Game & Fish, discharges permitted effluent to the Red River between the Chevron tailings facility and the confluence with the Rio Grande.

1.1.3 Taos area to Embudo

The Rio Grande gorge reaches its greatest depth in the stretch between Questa and Pilar, between thick basalt columns. With headwaters in the Carson National Forest and Taos Pueblo, the Rio Hondo, Rio Pueblo de Taos and Embudo Creek are major tributaries of the Rio Grande in the area north and south of the Town of Taos. Major land uses in this area include the Taos Ski Valley resort, urban and exurban development, irrigated agriculture, and dispersed rangeland grazing. This section of the Rio Grande is popular for private and commercial recreational float trips. The Orilla Verde National Recreation Area, near Pilar, is administered by the Bureau of Land Management, and offers camping, hiking, floating, biking, and rock climbing.

1.1.4 Embudo to Santa Fe

The Rio Grande opens out to the broad Española Valley, flowing through the city of Española. Much of the riparian zone along this reach belongs to the Ohkeh Owingeh, Santa Clara, and San Ildefonso Pueblos. Water bodies flowing through tribal lands are outside the jurisdiction of NMED. Partly because of their large component of volcanic ash, Tertiary deposits erode into barren badlands north and south of Española (Chronic, 1987). The Santa Cruz River is dammed above the village of Chimayo, creating Santa Cruz Lake. Land uses are similar to those in the Taos area. Headwaters streams originate on west-facing slopes of the Sangre de Cristo mountains, on land managed by the Santa Fe National Forest.

1.2 Water Quality Standards

Water quality standards for the **Rio Grande** (Ohkay Owingeh bnd to Embudo Creek), **Rio Grande** (Santa Clara Pueblo bnd to Ohkay Owingeh bnd), and **Santa Cruz River** (Santa Clara Pueblo bnd to Santa Cruz Dam) are set forth in the following sections of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4 NMAC), 2020, https://www.env.nm.gov/surface-water-quality/wqs/):

20.6.4.114 RIO GRANDE BASIN: - The main stem of the Rio Grande from the Cochiti pueblo boundary upstream to Rio Pueblo de Taos excluding waters on San Ildefonso, Santa Clara and Ohkay Owingeh pueblos, Embudo creek from its mouth on the Rio Grande upstream to the Picuris Pueblo boundary, the Santa Cruz river from the Santa Clara pueblo boundary upstream to the Santa Cruz dam, the Rio Tesuque except waters on the Tesuque and Pojoaque pueblos, and the Pojoaque river from the San Ildefonso pueblo boundary upstream to the Pojoaque pueblo boundary. Some Rio Grande waters in this segment are under the joint jurisdiction of the state and San Ildefonso pueblo.

A. Designated uses: irrigation, livestock watering, wildlife habitat, marginal coldwater aquatic life, primary contact and warmwater aquatic life; and public water supply on the main stem Rio Grande.

B. Criteria:

(1) The use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses, except that the following segment-specific criteria apply: 6T3 temperature 22°C (71.6°F) and maximum temperature 25°C (78.8°F). In addition, the following criteria based on a 12-month rolling average are applicable to the public water supply use for monitoring and public disclosure purposes only:

Radionuclide	**pCi/L**
Americium-241	1.9
Cesium-137	6.4
Plutonium-238	1.5
Plutonium-239/240	1.5
Strontium-90	3.5
Tritium	4,000

(2) At mean monthly flows above 100 cfs, the monthly average concentration for: TDS 500 mg/L or less, sulfate 150 mg/L or less and chloride 25 mg/L or less.

[20.6.4.114 NMAC - Rp 20 NMAC 6.1.2111, 10/12/2000; A, 5/23/2005; A, 12/1/2010]

Water quality standards for **North Fork Tesuque Creek** (Tesuque Creek to headwaters), **Rio Chupadero** (USFS bnd to headwaters), **Rio en Medio** (Aspen Ranch to headwaters), **Rio Frijoles** (Rio Medio to Pecos Wilderness), **Rio Medio** (Rio Frijoles to headwaters), **Rio Nambe** (Nambe Pueblo bnd to headwaters), **Rio Quemado** (Santa Cruz River to Rio Arriba Cnty bnd), and **Santa Cruz River** (Santa Cruz Reservoir to Rio Medio) are set forth in the following sections of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4 NMAC), 2020, https://www.env.nm.gov/surface-water-quality/wqs/):

20.6.4.121 RIO GRANDE BASIN: - Perennial tributaries to the Rio Grande in Bandelier national monument and their headwaters in Sandoval county and all perennial reaches of tributaries to the Rio Grande in Santa Fe county unless included in other segments and excluding waters on tribal lands.

A. Designated uses: domestic water supply, high quality coldwater aquatic life, irrigation, livestock watering, wildlife habitat and primary contact; and public water supply on Little Tesuque creek, the Rio en Medio, and the Santa Fe River.

B. Criteria: the use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses, except that the following segment-specific criteria apply: specific conductance 300 µS/cm or less; the monthly geometric mean of E. coli bacteria 126 cfu/100 mL or less, single sample 235 cfu/100 mL or less.

[20.6.4.121 NMAC - Rp 20 NMAC 6.1.2118, 10/12/2000; A. 5/23/2005; A, 12/1/2010; A, 2/14/2013]

[NOTE: The segment covered by this section was divided effective 5/23/2005. The standards for the additional segments are under 20.6.4.126, 20.6.4.127 and 20.6.4.128 NMAC.]

Water quality standards for **Red River** (Rio Grande to Placer Creek), **Rio Pueblo de Taos** (Arroyo del Alamo to Rio Grande del Rancho) and **Rio Pueblo de Taos** (Rio Grande to Arroyo del Alamo) are set forth in the following sections of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4 NMAC), 2020, https://www.env.nm.gov/surface-water-quality/wqs/):

20.6.4.122 RIO GRANDE BASIN: - The main stem of the Rio Grande from Rio Pueblo de Taos upstream to the New Mexico-Colorado line, the Red river from its mouth on the Rio Grande upstream to the mouth of Placer creek, and the Rio Pueblo de Taos from its mouth on the Rio Grande upstream to the mouth of the Rio Grande del Rancho. Some Rio Grande and Rio Pueblo de Taos waters in this segment are under the joint jurisdiction of the state and Taos pueblo.

A. Designated uses: coldwater aquatic life, fish culture, irrigation, livestock watering, wildlife habitat and primary contact.

B. Criteria: the use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses, except that the following segment-specific criteria apply: the monthly geometric mean of E. coli bacteria 126 cfu/100 mL or less, single sample 235 cfu/100 mL or less.

[20.6.4.122 NMAC - Rp 20 NMAC 6.1.2119, 10/12/2000; A, 5/23/2005; A, 12/1/2010]

Water quality standards for **Chuckwagon Creek** (Comanche Creek to headwaters), **Costilla Creek** (Diversion abv Costilla to Comanche Creek), **Fernandez Creek** (Comanche Creek to headwaters), **Grassy Creek** (Comanche Creek to headwaters), **LaBelle Creek** (Comanche Creek to headwaters), **Placer Creek** (Red River to headwaters), **Rio Fernando de Taos** (UFSF bnd at canyon to Tienditas Creek), **Rio Quemado** (Rio Arriba Cnty bnd to headwaters), **Sanchez Canyon** (Costilla Creek to headwaters), **Ute Creek** (Costilla Creek to headwaters), and **Vidal Creek** (Comanche Creek to headwaters) are set forth in the following sections of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4 NMAC), 2020, https://www.env.nm.gov/surface-water-quality/wqs/):

20.6.4.123 RIO GRANDE BASIN: - Perennial reaches of the Red river upstream of the mouth of Placer creek, all perennial reaches of tributaries to the Red river, and all other perennial reaches of tributaries to the Rio Grande in Taos and Rio Arriba counties unless included in other segments and excluding waters on Santa Clara, Ohkay Owingeh, Picuris and Taos pueblos.

A. Designated uses: domestic water supply, high quality coldwater aquatic life, irrigation, livestock watering, wildlife habitat and primary contact; and public water supply on the Rio Pueblo and Rio Fernando de Taos.

B. Criteria: the use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses, except that the following segment-specific criteria apply: specific conductance 400 µS/cm or less (500 µS/cm or less for the Rio Fernando de Taos); the monthly geometric mean of E. coli bacteria 126 cfu/100 mL or less, single sample 235 cfu/100 mL or less; and phosphorus (unfiltered sample) less than 0.1 mg/L for the Red river.

[20.6.4.123 NMAC - Rp 20 NMAC 6.1.2120, 10/12/2000; A, 5/23/2005; A, 12/1/2010]

[**NOTE:** The segment covered by this section was divided effective 5/23/2005. The standards for the additional segment are under 20.6.4.129 NMAC.]

Criteria applicable to existing, attainable or designated uses unless otherwise specified in an AU's specific segment are set forth at 20.6.4.900 NMAC. General criteria that apply to all surface waters of the state at all times, unless a specified standard is provided elsewhere in the NMAC, are set forth at 20.6.4.13 NMAC.

1.3 Antidegradation and TMDLs

New Mexico's antidegradation policy, which is based on the requirements of 40 C.F.R. § 131.12, describes how waters are to be protected from degradation (20.6.4.8(A) NMAC). At a minimum, the policy mandates that "the level of water quality necessary to protect the existing uses shall be maintained and protected in all surface waters of the state." Furthermore, the policy's requirements must be met whether or not a segment is impaired. TMDLs are consistent with this policy because implementation of a TMDL restores water quality so that existing uses (defined at 20.6.4.7(E)(3) as the highest quality of water that has been attained since 1975) are protected and water quality criteria are achieved.

The Antidegradation Policy Implementation Procedure establishes the process for implementing the antidegradation policy (Appendix A of NMED/SWQB, 2020b, https://www.env.nm.gov/surface-water-quality/wqmp-cpp/). However, certain specific requirements in the Antidegradation Policy Implementation Procedure do not apply to the Water Quality Control Commission's (WQCC) establishment of TMDLs because these types of water quality-related actions already are subject to extensive requirements for review and public participation, as well as various limitations on degradation imposed by state and federal law (NMED/SWQB, 2020b).

1.4 Water Quality Monitoring Survey

The 2017-18 survey included the Rio Grande and its tributaries from a point near County Road 502 on San Ildefonso Pueblo, in Santa Fe County, to the Colorado state line. Streams were divided into AUs based on differing geological and hydrological properties, and each AU was assessed individually using data from one or more monitoring sites located within the AU. Based on a variety of factors, selected monitoring locations were sampled for water quality constituents several times over the two years, and geomorphology and continuously logged data were collected at selected perennial AUs. Geomorphology parameters were measured following the then-current revision of the SWQB Standard Operating Procedure 5.0, Physical Habitat Measurements (https://www.env.nm.gov/surface-water-quality/sop/). Data-logged parameters may include temperature, turbidity, dissolved oxygen, pH, and/or conductivity, and were measured following the then-current revision of the SWQB Standard Operating Procedures 6.1-6.4, Sondes and Thermographs (https://www.env.nm.gov/surface-water-quality/sop/). Follow-up monitoring was conducted in 2019 in order to fill data gaps. Impaired AUs addressed in this TMDL report, and the associated monitoring stations, are shown on **Figures 1.1-1.3**.

Monitoring occurs during the non-winter months (March through November); focuses on physical, chemical, and biological conditions in perennial waters; and includes sampling for most pollutants that have numeric and/or narrative criteria in the WQS. More detail about the 2017-18 water quality survey can be found in the survey summary report (NMED/SWQB, 2020c, https://www.env.nm.gov/surface-water-quality/water-quality-monitoring/). Additional data meeting SWQB data standards for assessability was submitted by Amigos Bravos, a non-profit environmental advocate based in northern NM.

1.5 Hydrologic Conditions

In order to characterize streamflow conditions in which the thermograph and water chemistry data were collected, discharge data were obtained for 2017 and 2018 from several USGS gages in the basin. A representative sampling of gage discharge data (**Figures 1.4-1.8**) shows that 2017 was a year of somewhat higher than normal flows, while 2018 flows were much lower than normal. The entire Upper Rio Grande area was in a condition of extreme to exceptional drought for the entire 2018 SWQB sampling season, whereas none of the area experienced drought conditions during the 2017 season (https://droughtmonitor.unl.edu/Maps/MapArchive.aspx).

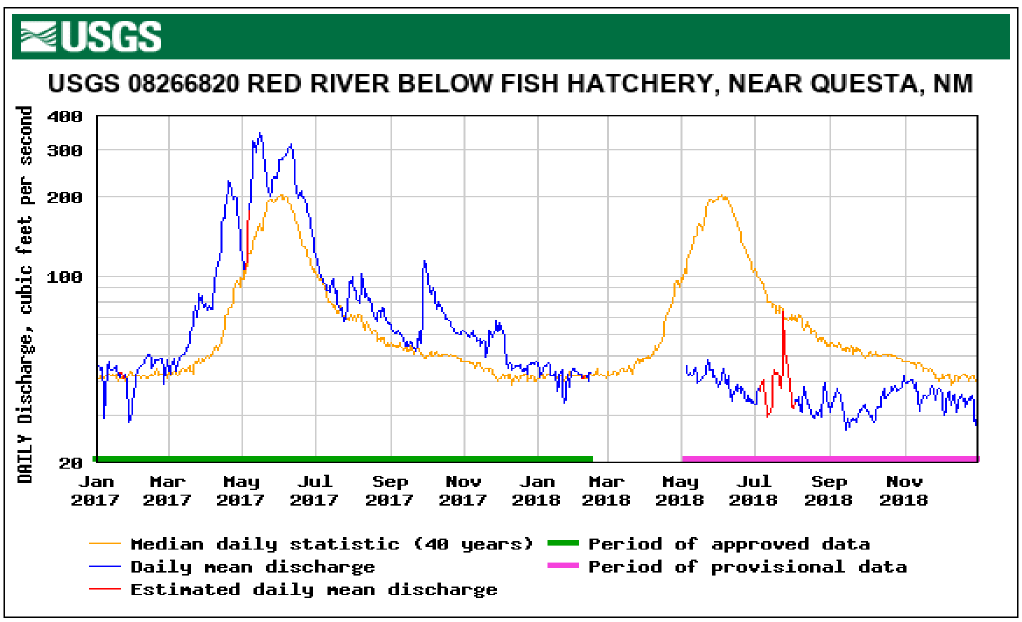

Figure 1.4 Daily discharge in 2017 and 2018 for the Red River below the Red River Fish Hatchery.

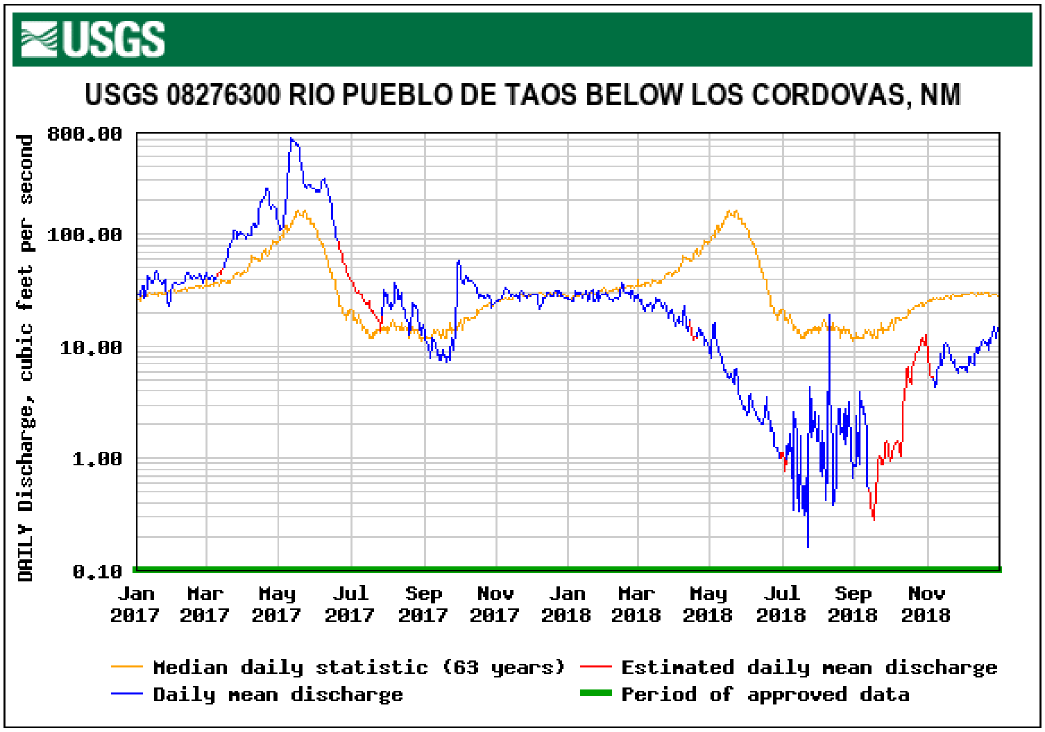

Figure 1.5 Daily discharge in 2017 and 2018 for the Rio Pueblo de Taos below Los Cordovas.

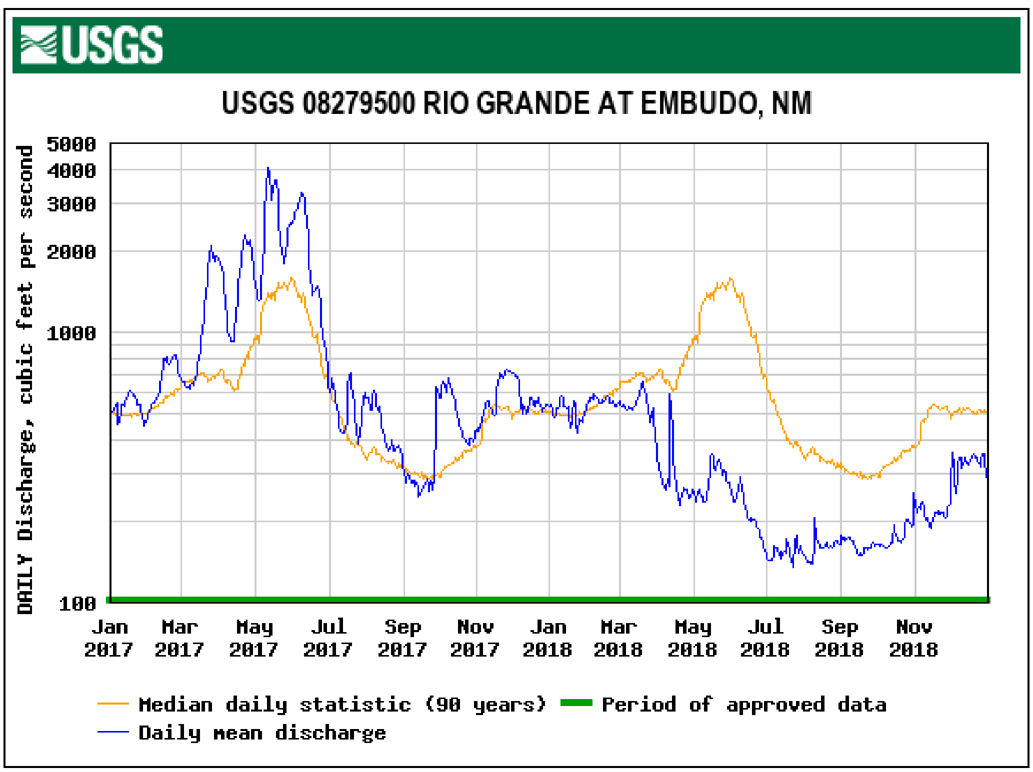

Figure 1.6 Daily discharge in 2017 and 2018 for the Rio Grande at Embudo, NM.

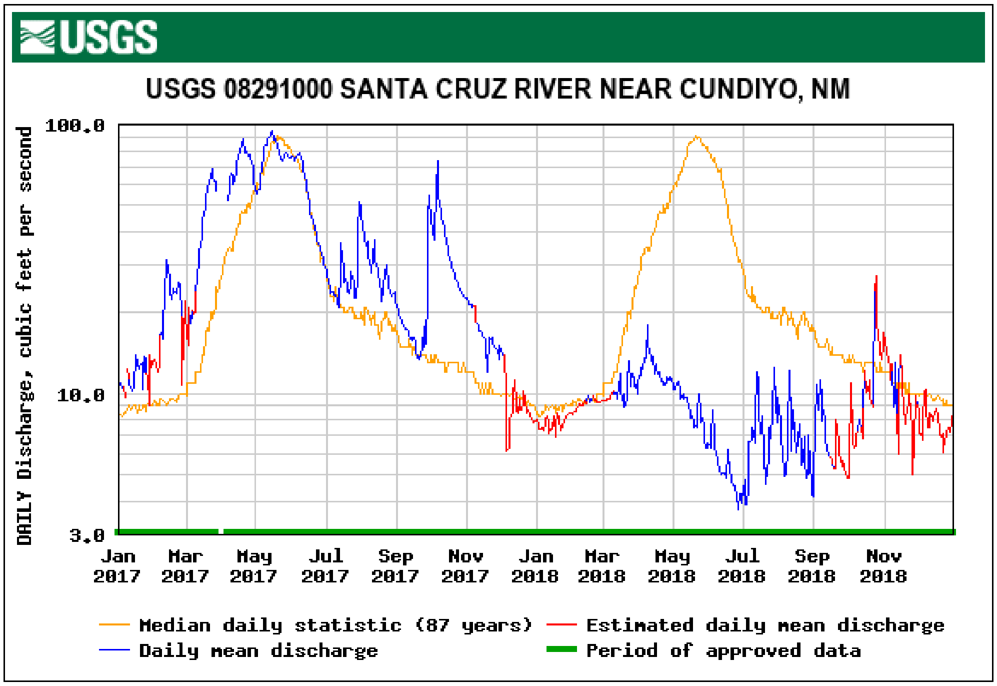

Figure 1.7 Daily discharge in 2017 and 2018 for the Santa Cruz River near Cundiyo.

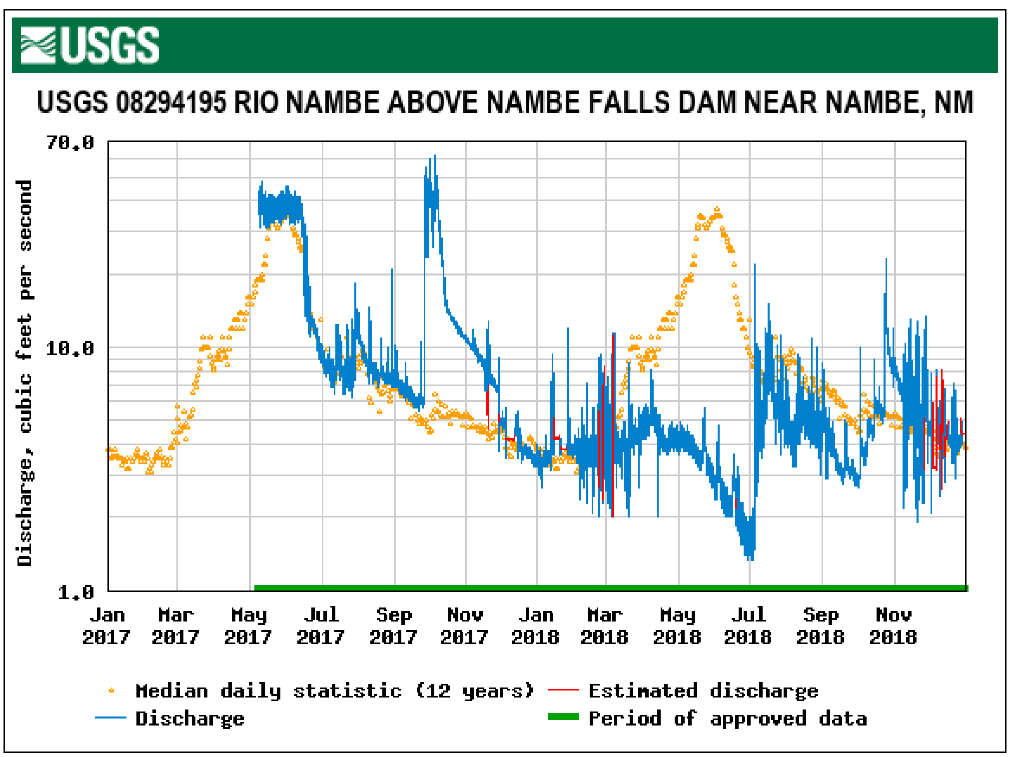

Figure 1.8 Daily discharge in 2017 and 2018 for the Rio Nambe above Nambe Falls Dam near Nambe, NM.

The Rio Nambe gage above the dam **(Figure 1.8)** is situated just below 7000 ft elevation, in a narrow band where the base of the Sangre de Cristo mountains abuts flatter alluvial mesa-and-valley terrain. At this location, the gage likely reflects snowmelt more precisely than the gages at lower elevations. As with other Upper Rio Grande gages, the upper Rio Nambe experienced normal to above normal discharge in 2017. Like the other gages it was far below normal in the spring of 2018, reflecting diminished, or absent, snowmelt. However, this stream recovered to normal base flow levels by the beginning of July 2018, unlike the other gages, most of which did not recover to normal levels by the end of that calendar year.

1.6 TMDL Uncertainties

Per EPA guidance (EPA, 2002), TMDLs "should contain documentation supporting the TMDL analysis, including the basis for any assumptions; a discussion of strengths and weaknesses in the analytical process; and results from any water quality modeling." Uncertainties and assumptions in the TMDL process are detailed in the individual Margin of Safety subsections for each TMDL parameter. Uncertainties and assumptions related to the size of the available datasets and/or flow are detailed in the Target Loading Capacity and Flow subsections for each TMDL parameter. When modeling is used to develop a TMDL, water quality modeling results are summarized in the individual TMDL parameter sections and detailed in an appendix to the TMDL. In general, weaknesses in the TMDL analytical process include the limited availability of water quality data during the assessment process, limited flow and habitat measurements for TMDL development, and limited flow and water quality long-term gaging sites to be used during both the assessment and TMDL processes. Strengths in the TMDL analytical process include the robust assessment processes outlined in the Comprehensive Assessment and Listing Methodology (CALM; NMED/SWQB, 2019a) especially related to assessments of narrative water quality standards, such as nutrients, sedimentation, and turbidity. Additional strengths include the use of regression equations to calculate TMDLs such as turbidity and specific conductance as well as the collection and subsequent discussion of NPDES permit effluent data as part of the TMDL development process.

2.0 ALUMINUM

Chronic high levels of aluminum (Al) can be toxic to fish, benthic invertebrates, and some single-celled plants. Aluminum concentrations from 0.1 to 0.3 mg/L (100 to 300 ug/L) increase mortality and retard growth, gonadal development, and egg production of fish. Information on the toxic forms of aluminum in natural waters suggests that soluble trivalent aluminum (Al^{3+}) exerts a toxic effect on fish by binding to the negative charge of gill tissues, thereby disrupting ionoregulatory and respiratory balance (Exley et al.., 1991; Gensemer and Playle, 1999). This charge interaction is complicated by subsequent polymerization of insoluble, positive-charged Al oxyhydroxides to fish gill tissues and thus both soluble and insoluble forms are implicated in the toxic response of fish to Al (Gensemer and Playle, 1999).

In 2010, the WQCC updated the aquatic life use (ALU) criteria for aluminum from dissolved aluminum to hardness-dependent total recoverable aluminum (TR Al). In 2012, USEPA approved the change for use in waters where the pH is above 6.5. Aluminum-impaired waters of the Upper Rio Grande basin were within the applicable pH range during all of the 2017-2018 sampling events. The term “total recoverable” refers to the analytical method used in laboratory analysis, and is essentially interchangeable with the term “total”. “Total recoverable” is used here to reflect the language in 20.6.4.900.I NMAC, specifically, “For aluminum, the criteria are based on analysis of total recoverable aluminum in a sample that is filtered to minimize the mineral phase as specified by the department.” Based on recommendations from an aluminum filtration study conducted by SWQB staff (NMED/SWQB, 2012), if the turbidity exceeds 30 NTU, samples that will be analyzed for TR Al are filtered using a filter of 10 µm pore size that minimizes mineral-phase aluminum without restricting amorphous or colloidal phases. To be conservative, the TMDLs are calculated to protect against exceedance of the chronic criterion, which is more stringent than the acute criterion.

2.1 Target Loading Capacity

To meet aquatic life designated uses, the SWQB Comprehensive Assessment and Listing Methodology (NMED SWQB, 2019a) says that for any one chemical/physical pollutant, there shall be no more than one exceedance of the acute criterion, and no more than one exceedance of the chronic criterion in three years. Exceedances of the WQS were identified by assessment of the data from the 2017-2018 SWQB Upper Rio Grande intensive water quality survey, as shown on **Table 2.1**. Consequently, these AUs were listed on the 2020-2022 Integrated CWA §303(d)/§305(b) List (NMED/SWQB, 2020) for aluminum. Results of laboratory analyses of the samples are shown in **Appendix A**.

In the case of the Rio Quemado, both AUs are newly impaired for TR Al. The lower AU adds only 2 sq mi to the 40 sq mi watershed (the valley narrows down) and calculated critical flows are similar between them. One watershed TMDL will be calculated for the lower AU critical flow and assigned to cover both impaired assessment units. For the remainder of this report section, the combined AUs will be referred to as “Rio Quemado (Santa Cruz River to headwaters)”. Within the Santa Cruz River watershed, in addition to the Rio Quemado, the Rio Medio, and the Santa Cruz River above and below the reservoir, Santa Cruz Lake is also newly impaired for TR Al. An aluminum TMDL for Santa Cruz Lake is under development.

Table 2.1 Exceedances of the Hardness-based Total Recoverable Al WQS

Assessment Unit	Exceedances (chronic)	Exceedances (acute)
Costilla Creek (Diversion abv Costilla to Comanche Creek)	2/4	0/4
LaBelle Creek (Comanche Creek to headwaters)	2/4	2/4
North Fork Tesuque Creek (Tesuque Creek to headwaters)	4/4	2/4
Rio Medio (Rio Frijoles to headwaters)	2/4	1/4
Rio Quemado (Rio Arriba Cnty bnd to headwaters)*	2/6	2/6
Rio Quemado (Santa Cruz River to Rio Arriba Cnty bnd)*	2/4	2/4
Santa Cruz River (Santa Clara Pueblo bnd to Santa Cruz Dam)	2/6	1/6
Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	2/4	1/4
Vidal Creek (Comanche Creek to headwaters)	2/7	0/7

** Since both AUs of the Rio Quemado are listed as impaired for TR Al, the TMDL will be established for the lower AU, to represent loading from the entire watershed.*

2.2 Flow

Total recoverable aluminum exceedances tend to occur at higher flows for a given water body. Total recoverable aluminum concentrations measured during the lowest flow conditions did not exceed the applicable water quality criteria during the 2017-2018 Upper Rio Grande survey. Therefore, a higher flow value that corresponds with a higher probability of water quality exceedances was selected as the critical flow for TR Al. Critical flow values were estimated by averaging concurrent flow measurements/estimates that were equal to or greater than the lowest flow at which an exceedance was documented for each water body.

Critical flows calculated using the above method are presented in **Table 2.2**. The critical flow was converted from cubic feet per second (cfs) to million gallons per day (mgd) using a conversion factor of 0.646. The TMDL itself is a value calculated at a defined critical condition as part of a 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 in-stream water quality is the goal of SWQB efforts.

Table 2.2 Critical Flow for Total Recoverable Aluminum TMDLs

Assessment Unit	Critical Flow (cfs)	Critical Flow (mgd)
Costilla Creek (Diversion abv Costilla to Comanche Creek)	60.27	38.93
LaBelle Creek (Comanche Creek to headwaters)	1.88	1.21
North Fork Tesuque Creek (Tesuque Creek to headwaters)	2.28	1.47
Rio Medio (Rio Frijoles to headwaters)	18.12	11.71
Rio Quemado (Santa Cruz River to headwaters)	22.82	14.74
Santa Cruz River (Santa Clara Pueblo bnd to Santa Cruz Dam)	81.29	52.51
Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	33.4	21.58
Vidal Creek (Comanche Creek to headwaters)	4.73	3.06

2.3 TMDL Calculations

The TMDL is defined as the mass of pollutant that can be carried under critical flow conditions without violating the target concentration for that constituent. A conversion factor is used to correct the TMDL units to lb/day. The TMDL is calculated based on simple dilution using **Equation 2.1**:

Equation 2.1 *Critical flow (mgd) x WQS (mg/L) x Conversion Factor (8.34) = TMDL (lb/day)*

TMDLs are presented on **Table 2.3** for the critical flow condition. Chronic aluminum criteria were calculated at the average hardness value that was measured during the survey sampling events that resulted in exceedances of the WQS (data shown in **Appendix B**).

Table 2.3 Calculation of Target Loads

Assessment Unit	Chronic TR Al criterion (mg/l)	Flow (mgd)	Conversion Factor	TMDL (lb/day)
Costilla Creek (Diversion abv Costilla to Comanche Creek)	0.63	38.9	8.34	205
LaBelle Creek (Comanche Creek to headwaters)	0.24	1.21	8.34	2.43
North Fork Tesuque Creek (Tesuque Creek to headwaters)	0.08	1.47	8.34	0.98
Rio Medio (Rio Frijoles to headwaters)	0.40	11.7	8.34	39.1
Rio Quemado (Santa Cruz River to headwaters)	0.42	14.7	8.34	51.6
Santa Cruz River (Santa Clara Pueblo bnd to Santa Cruz Dam)	0.45	52.5	8.34	197
Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	0.45	21.6	8.34	81.0
Vidal Creek (Comanche Creek to headwaters)	0.57	3.06	8.34	14.5

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 at all times is the goal. The TMDL is further allocated to a MOS, WLA (permitted point sources), and LA (non-point sources), according to **Equation 2.2:**

Equation 2.2 *WLA + LA + MOS = TMDL.*

2.3.1 Margin of Safety

The 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 aluminum TMDL, the MOS was developed using a combination of conservative assumptions and explicit allocations. Therefore, this MOS is the sum of the following two elements:

- *Implicit Margin of Safety*

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

  Calculating the TMDL based on chronic rather than acute WQS.

  Using the average hardness value during exceedance events, rather than the average hardness of all samples. Hardness is often, though not always, lower at high flows, leading to a lower calculated chronic TR Al standard and smaller TMDL.

- *Explicit Margin of Safety*

  An **explicit MOS of 15%** was assigned to the aluminum impaired AUs, to account for the low number of sampling events, and the inherent error in flow measurements and estimations.

2.3.2 Waste Load Allocation

There are no active individual National Pollutant Discharge Elimination System (NPDES) permits that discharge to the aluminum impaired AUs, therefore the WLA for these TMDLs is zero.

Sediment and associated contaminants are considered components of industrial storm water discharges covered under NPDES General Permits. Stormwater discharges from construction activities are transient, occurring mainly during the construction itself, and then only during storm events. Coverage under the NPDES Construction General Permit (CGP) for construction sites greater than one acre, or less than one acre if they are part of a common plan of development, 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. The 2022 CGP also includes state-specific requirements to implement site-specific interim and permanent stabilization, and managerial and structural solids, erosion, and sediment control Best Management Practices (BMPs), and/or other controls.   The SWPPP must include site-specific interim and permanent stabilization, managerial, and structural solids, erosion and sediment control BMPs and/or other controls that are designed to prevent to the maximum extent practicable an increase in the sediment yield and flow velocity from pre-construction, pre-development conditions to assure that applicable standards in 20.6.4 NMAC, including the antidegradation policy, and TMDL WLAs are met. This requirement applies to discharges both during construction and after construction operations have been completed. Currently in the 2022 CGP, EPA defines "sediment-related parameter" as a pollutant parameter that is closely related to sediment such as turbidity, total suspended solids (TSS), total suspended sediment, transparency, sedimentation, and siltation. For discharge covered under the CGP to a water that is impaired for a parameter other than a sediment-related parameter or nutrients, EPA will inform the operator if any additional controls are necessary to meet water quality standards.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the 2021 NPDES Multi-Sector General Permit (MSGP). The MSGP also requires preparation of a SWPPP. Based on the industrial sector, some of the industrial facilities and activities covered under the MSGP have technology based effluent limitation and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values reflect State of New Mexico WQS.

It is not possible to calculate individual WLAs for facilities covered by the General Permits at this time using the available tools. While these sources are not given individual allocations, they are addressed through other means, including BMPs, and other stormwater pollution prevention conditions. Implementation of a SWPPP that meets the requirements of a General Permit is generally assumed to be consistent with this TMDL. Loads that are in compliance with the General Permits are therefore currently included as part of the LA.

2.3.3 Load Allocation

In order to calculate the LA, the WLA and the MOS were subtracted from the TMDL, as shown on **Table 2.4**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see Section 2.3.1 for details).

Table 2.4 TMDL Allocations for Total Recoverable Aluminum (all units in lb/day)

Assessment Unit	WLA	LA	15% MOS	TMDL
Costilla Creek (Diversion abv Costilla to Comanche Creek)	0	174.3	30.7	205
LaBelle Creek (Comanche Creek to headwaters)	0	2.07	0.36	2.43
North Fork Tesuque Creek (Tesuque Creek to headwaters)	0	0.83	0.15	0.98
Rio Medio (Rio Frijoles to headwaters)	0	33.2	5.9	39.1
Rio Quemado (Santa Cruz River to Rio Arriba Cnty bnd)	0	43.9	7.7	51.6
Santa Cruz River (Santa Clara Pueblo bnd to Santa Cruz Dam)	0	167.4	29.6	197
Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	0	68.8	12.2	81.0
Vidal Creek (Comanche Creek to headwaters)	0	12.3	2.2	14.5

2.3.4 Load Reduction

The extensive data collection and analysis necessary to determine background aluminum loads 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.

Table 2.5 Load Reduction Estimate to meet WQS for Total Recoverable Aluminum

Assessment Unit	Target Load (lb/day)[a]	Measured Load (lb/day)[b]	Load Reduction[c]
Costilla Creek (Diversion abv Costilla to Comanche Creek)	173	206	16%
LaBelle Creek (Comanche Creek to headwaters)	2.07	18.2	89%
North Fork Tesuque Creek (Tesuque Creek to headwaters)	0.83	4.78	83%
Rio Medio (Rio Frijoles to headwaters)	33.2	167	80%
Rio Quemado (Santa Cruz River to headwaters)	43.9	313	86%
Santa Cruz River (Santa Clara Pueblo bnd to Santa Cruz Dam)	168	701	76%
Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	68.8	200	66%
Vidal Creek (Comanche Creek to headwaters)	12.4	21.2	42%

(a) Target Load = TMDL – MOS. 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.

*(b) The measured load is the magnitude of point and nonpoint sources. It is calculated at the TMDL critical flow using the mean measured TR Al concentration from sampling events that were used to calculate the critical flow (**Appendix A**).*

(c) 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.

2.4 Probable Pollutant Sources

SWQB conducted an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Revision 2, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; see also **Appendix B**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. The list of probable sources is not intended to single out any particular landowner or land management activity and generally includes several sources per pollutant.

Table 2.6 displays probable pollutant sources that have the potential to contribute to aluminum impairment within each AU in the TMDL study areas, as determined by field reconnaissance and knowledge of watershed activities. The draft probable source list will be reviewed and modified as necessary, with watershed group/stakeholder input during the TMDL public meeting and comment period. Probable sources of impairment will be further evaluated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

Table 2.6 Probable sources of excessive total recoverable aluminum for Upper Rio Grande basin TMDL Assessment Units.

Assessment Unit	Probable Sources
Costilla Creek (Diversion abv Costilla to Comanche Creek)	Crop production; Highway/road/bridge runoff; Other recreation (angling, campgrounds); Pavement/impervious surfaces; Rangeland grazing; Rural residential area; Sand/gravel/rock mining or quarries; Site clearance; Water diversion
LaBelle Creek (Comanche Creek to headwaters)	Grazing in riparian zone; Loss of riparian habitat
North Fork Tesuque Creek (Tesuque Creek to headwaters)	Highway/road/bridge runoff; Other recreation (campground, hiking trails); Pavement/impervious surfaces; Rangeland grazing
Rio Medio (Rio Frijoles to headwaters)	Crop production; Drought; Forest fire (2002, 2013); Grazing in riparian zone; Habitat modification (Exotic species); Loss of riparian habitat; Rural residential area; Site clearance; Water diversion
Rio Quemado (Santa Cruz River to headwaters)	Crop production; Forest fire (2002); Grazing in riparian zone; Habitat modification (Exotic species); Highway/road/bridge runoff; Inappropriate waste disposal; Loss of riparian habitat; Rangeland grazing; Rural residential area; Site clearance; Water diversion
Santa Cruz River (Santa Clara Pueblo bnd to Santa Cruz Dam)	Crop production; Dams/impoundments; Grazing in riparian zone; Highway/road/bridge runoff; Inappropriate waste disposal; Loss of riparian habitat; Off-road vehicles; Rural residential area; Site clearance; Water diversion
Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	Highway/road/bridge runoff; Inappropriate waste disposal; Other recreation (angling, hiking trails)
Vidal Creek (Comanche Creek to headwaters)	Grazing in riparian zone; Loss of riparian habitat

In general, increased metals in the water column can commonly be linked to sediment transport and accumulation where the metals are a constituent part of the watershed geology. Aluminum (Al) is the third most common element in the Earth's crust and the most common metal. Aluminum is present in natural waters in a complex of chemical forms. There is an exchangeable fraction of Al with soils, sediments, and precipitated organic material. However the Geochemical Atlas of Europe (FOREGS, 2005) found that "[p]atterns in stream water (Al) data are markedly different from distributions in the solid sample media, indicating predominance of exogenic factors (topography, climate, vegetation) over bedrock geology control for Al in streams." Anthropogenic surface disturbance may be considered an exogenic factor. All of the AUs newly listed for TR Al impairment in 2020 are located in areas of surface geology which are high in aluminum oxide content, including mafic volcanic rocks (14-18% Al), felsic volcanic rocks (12-16% Al) (https://opentextbc.ca/geology/chapter/3-3-crystallization-of-magma/) , and alluvium derived from those sources (**Figure 1.1**).

Aluminum is relatively insoluble at pH 6 to 8, but the solubility of Al increases under more acidic and more alkaline conditions, in the presence of complexing ligands, and at lower temperatures (Gensemer and Playle, 1999). Therefore, in addition to sediment mobilized by overland flow, normal aqueous chemical processes enhanced by the slight natural acidity of snow and rain are capable of dissolving some of the abundant, naturally-occurring aluminum and delivering it into a river system. Aqueous Al is comprised of inorganic Al hydroxy species, of which gibbsite is the most abundant in the pH range (7.25-8.88) encountered during the 2017-2018 survey. At pH values greater than 7, aluminum concentration would be expected to increase with increasing pH. However, no correlation of TR Al with pH was apparent in the TMDL AUs during the 2017-2018 survey (see monitoring data in **Appendix A**). Instead flow appears to be the parameter most correlated with TR Al concentration. Out of 22 stream sampling events with results that showed exceedance of the applicable TR Al WQS, across 10 impaired AUs, 17 occurred in 2017, by far the wetter of the two survey years.

Wildfires can affect the physical, chemical, and biological quality of streams, rivers, and lakes. After a fire, increased runoff provides a pathway for the transport of chemical-laden sediment to surface water, which may have substantial water quality impacts. Forest fires can result in increased water temperature due to reduced infiltration and loss of shading vegetation. Potential wildfire impacts to water quality are discussed on the SWQB website at https://www.env.nm.gov/surface-water-quality/wildfire-impacts-on-surface-water-quality/. Most watershed effects will naturally recover within 5 to 10 years after the fire, but some aspects of watershed structure and function, as well as areas of most severe fire intensity, may continue to recover for 15-20 years (Bixby et al., 2015). Therefore, runoff following forest fire has been added to the Probable Source list (**Table 2.6**) for those TMDL AUs where fires occurred during the 20 years preceding the 2017-18 water quality survey.

2.5 Consideration of Seasonal Variation

Normal aqueous chemical processes, enhanced by the slight natural acidity of snow and rain, are capable of rendering some of the abundant, naturally-occurring aluminum available to a river system, and, as a result of snowmelt, one might expect to see higher aluminum concentrations during spring sampling events in mountainous AUs. However, there was no apparent seasonal pattern to the exceedances documented in 2017-18.

2.6 Future Growth

Growth estimates by county are available from the University of New Mexico Geospatial and Population Studies (GPS) (https://gps.unm.edu/pru/projections, accessed 5/19/22). These estimates project growth to the year 2040. Costilla Creek (Diversion abv Costilla to Comanche Creek), LaBelle Creek (Comanche Creek to headwaters), and Vidal Creek (Comanche Creek to headwaters) are located in Taos County. Rio Medio (Rio Frijoles to headwaters), Rio Quemado (Santa Cruz River to headwaters), and Santa Cruz River (Santa Clara Pueblo bnd to Santa Cruz Dam) flow through both Rio Arriba and Santa Fe Counties. North Fork Tesuque Creek (Tesuque Creek to headwaters) and Santa Cruz River (Santa Cruz Reservoir to Rio Medio) are in Santa Fe County.

GPS projects that Santa Fe County will continue to grow, while the populations of Taos and Rio Arriba Counties will decline, as detailed on **Table 2.7**. Future population change will have only indirect bearing on water quality in the LaBelle Creek (Comanche Creek to headwaters) and Vidal Creek (Comanche Creek to headwaters) AUs since they are located in an unpopulated headwaters area of the Carson National Forest.

Table 2.7 County Population Estimates

County	2020	2025	2030	2035	2040	Change (2020-2040)
Taos	32,795	32,635	32,360	31,938	31,412	- 4.2%
Rio Arriba	38,721	37,883	36,903	35,752	34,485	-10.9%
Santa Fe	150,488	153,311	155,641	157,291	158,420	5.3%

Estimates of future growth are not anticipated to lead to a significant increase in aluminum that cannot be controlled with BMP implementation. BMPs should be utilized and improved upon while continuing to improve watershed conditions and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

3.0 *E. COLI*

Escherichia coli (E. coli) is a species of coliform bacteria that is present in the intestinal tracts and feces of warm-blooded animals. Most *E. coli* are harmless and are actually an important part of a healthy human intestinal tract. However, some strains of *E. coli* are pathogenic, meaning they can cause illness, either diarrhea or illness outside of the intestinal tract. It is also used as an indicator of the potential presence of other pathogens that may present human health concerns.

Bacterial data collected from the impaired AUs during the 2017-18 SWQB water quality survey of the Upper Rio Grande basin are shown in **Appendix A** and summarized on **Table 3.1**, below. Samples were assessed by comparing the *E. coli* results to the applicable single sample criterion. Assessment of the data identified exceedances of the New Mexico water quality standards for *E. coli* bacteria. As a result, these AUs are listed on the Integrated CWA §303(d)/ §305(b) List with *E. coli* as an impairment of the primary contact designated use (NMED/SWQB, 2020).

Table 3.1 Exceedances of *E. coli* criteria documented during the 2017-18 SWQB survey

Assessment Unit	Water Quality Criterion* (single sample, cfu/100mL)	Number of Exceedances
Grassy Creek (Comanche Creek to headwaters)	235	3/8
LaBelle Creek (Comanche Creek to headwaters)	235	2/9
Rio Quemado (Rio Arriba Cnty bnd to headwaters)	235	6/9
Ute Creek (Costilla Creek to headwaters)	235	2/4
Vidal Creek (Comanche Creek to headwaters)	235	2/8

**Although the default single sample criterion for primary contact is 410 cfu/mL, these assessment units have segment-specific single sample criteria of 235 cfu/100 mL or less (20.6.4.121 and 20.6.4.123 NMAC).*

In the case of the Rio Quemado, the headwaters AU is newly impaired, but the lower AU, Rio Quemado (Santa Cruz R to Rio Arriba Cnty bnd), already has a TMDL for *E. coli* (accessible at https://www.env.nm.gov/surface-water-quality/tmdl/), which was established in 2012. The lower AU adds only 2 sq mi to the 40 sq mi watershed (the valley narrows down) and calculated critical flows are similar between them. The existing TMDL of 2.39 x 10^9 cfu/100mL will be assigned as a watershed TMDL to cover both impaired assessment units. For the remainder of this report section, the two AUs collectively will be referred to as "Rio Quemado (Santa Cruz R to headwaters)".

3.1 Target Loading Capacity

The TMDL is a value calculated at a defined critical flow condition as part of a planning process designed to achieve water quality standards. For these *E. coli* TMDLs, the appropriate critical flow condition is at low flow in order to be protective when the assimilative capacity of a stream is at its lowest. For this TMDL document, target values for *E. coli* bacteria are based on achievement of the monthly geometric mean numeric criterion of 126 cfu/100 mL associated with the primary contact designated use. The monthly geometric mean criterion is utilized in TMDL calculations to provide a conservative protective value. If the single sample criterion was used and achieved as a target, the geometric mean criterion may still not be achieved.

3.2 Flow

According to the New Mexico Water Quality Standards, the low flow critical condition for numeric criteria (excluding human health-organism only criteria) set in 20.6.4.97 through 20.6.4.900 NMAC and 20.6.4.13(F) NMAC is defined as the 4-day, 3-year low-flow frequency (4Q3) (20.6.4.11(B)(2) NMAC). The 4Q3 is the annual lowest four (4) consecutive day flow that occurs with a frequency of at least once every three (3) years.

Critical flow values used to calculate the *E. coli* TMDLs were obtained using a regression model. Because these streams are ungaged, an analysis method developed by Waltemeyer (2002) was used to estimate the critical low flow. In Waltemeyer's analysis, two regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico (i.e., statewide and mountainous regions above 7,500 ft in elevation). The average elevation of each of the Upper Rio Grande basin *E. coli* impaired watersheds is above 7,500 ft, so the mountainous regions regression equation was used. The following mountainous regions regression equation (**Equation 3.1**) is based on data from 40 gaging stations located above 7,500 ft in elevation with non-zero discharge (Waltemeyer, 2002):

Equation 3.1 $4Q3 = 7.3287 \times 10^{-5} DA^{0.70} {P_w}^{3.58} S^{1.35}$

Where:

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

Table 3.2 Calculation of 4Q3 for *E. coli* TMDLs

Assessment Unit	Average Elevation (ft)	Drainage Area (mi^2)	Average Basin Slope (ft/ft)	Mean Winter Precipitation (in)	4Q3 (cfs)	4Q3 (mgd)
Grassy Creek (Comanche Creek to headwaters)	10000	1.88	0.26	11.4	0.11	0.07
LaBelle Creek (Comanche Creek to headwaters)	9740	1.75	0.18	11.5	0.07	0.05
Ute Creek (Costilla Creek to headwaters)	10,400	14.7	0.3	10.1	0.75	0.24
Vidal Creek (Comanche Creek to headwaters)	9920	6.28	0.18	12.5	0.22	0.14

The 4Q3 values calculated using Waltemeyer's method are presented in **Table 3.2**. Parameters used in the calculation were determined using the StreamStats online GIS application developed by the USGS (https://streamstats.usgs.gov/ss/). The critical flow was converted from cubic feet per second (cfs) to million gallons per day (mgd) using a conversion factor of 0.646. The TMDL itself is a value calculated at a defined critical condition as part of a 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 instream water quality is the goal of SWQB efforts.

3.3 TMDL Calculations

The WQS for bacteria are expressed as colony forming units (cfu) per unit volume. TMDLs for bacteria (**Table 3.3**) were calculated based on critical flow values (**Table 3.2**), water quality standards, and a conversion factor to correct the TMDL units to cfu/day, using **Equation 3.2**.

Equation 3.2: $$C\ as \frac{cfu}{100mL} * 1000\frac{mL}{L} * \frac{L}{0.264\ gallons} * Q\ in\ 1{,}000{,}000\frac{gallons}{day} = cfu/day$$

Where C = water quality criterion for bacteria
Q = the critical stream flow in million gallons per day (mgd)

Table 3.3 Calculation of TMDLs

Assessment Unit	Geometric Mean *E. coli* criterion (cfu/100 mL)	Critical Flow (mgd)	Conversion Factor	TMDL* (cfu/day)
Grassy Creek (Comanche Creek to headwaters)	126	0.07	3.79×10^7	3.39×10^8
LaBelle Creek (Comanche Creek to headwaters)	126	0.05	3.79×10^7	2.16×10^8
Ute Creek (Costilla Creek to headwaters)	126	0.24	3.79×10^7	1.14×10^9
Vidal Creek (Comanche Creek to headwaters)	126	0.14	3.79×10^7	6.79×10^8

**Result may appear to be imprecise since the TMDL was calculated using exact flow values, which were then rounded to two signification figures for readability of the table.*

3.3.1 Margin of Safety (MOS)

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For these bacteria TMDLs, the MOS was developed using a combination of conservative assumptions and inputs and explicit recognition of potential errors in flow calculations. Therefore, the MOS is the sum of the following:

- *Conservative Assumptions:*

  E. coli bacteria do not readily degrade in the environment; and,

  Basing the target load capacity on the geometric mean criterion rather than the higher-concentration single sample criterion; and

- *Explicit recognition of potential errors:*

  There is inherent error in all flow estimations; a conservative **explicit MOS for this element is 10%.**

3.3.2 Waste Load Allocation (WLA)

There are no active individual National Pollutant Discharge Elimination System (NPDES) individual permits that discharge to the *E. coli* impaired TMDL drainages. Therefore no WLA is assigned for this TMDL.

Sediment and associated contaminants are considered components of industrial storm water discharges covered under NPDES General Permits. Stormwater discharges from construction activities are transient, occurring mainly during the construction itself, and then only during storm events. Coverage under the NPDES Construction General Permit (CGP) for construction sites greater than one acre, or less than one acre if they are part of a common plan of development, 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. The 2022 CGP also includes state-specific requirements to implement site-specific interim and permanent stabilization, and managerial and structural solids, erosion, and sediment control Best Management Practices (BMPs), and/or other controls. The SWPPP must include site-specific interim and permanent stabilization, managerial, and structural solids, erosion and sediment control BMPs and/or other controls that are designed to prevent to the maximum extent practicable an increase in the sediment yield and flow velocity from pre-construction, pre-development conditions to assure that applicable standards in 20.6.4 NMAC, including the antidegradation policy, and TMDL WLAs are met. This requirement applies to discharges both during construction and after construction operations have been completed. Currently in the 2022 CGP, EPA defines "sediment-related parameter" as a pollutant parameter that is closely related to sediment such as turbidity, total suspended solids (TSS), total suspended sediment, transparency, sedimentation, and siltation. For discharge covered under the CGP to a water that is impaired for a parameter other than a sediment-related parameter or nutrients, EPA will inform the operator if any additional controls are necessary to meet water quality standards.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the 2021 NPDES Multi-Sector General Permit (MSGP). The MSGP also requires preparation of a SWPPP. Based on the industrial sector, some of the industrial facilities and activities covered under the MSGP have technology based effluent limitation and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values reflect State of New Mexico WQS.

It is not possible to calculate individual WLAs for facilities covered by the General Permits at this time using the available tools. The discharges from these permits are typically transitory as the activities are temporary. Loads that are in compliance with the General Permits are therefore currently included as part of the Load Allocation (LA). While these sources are not given individual allocations, they are addressed through other means, including BMPs, stormwater pollution prevention conditions, and other requirements.

3.3.4 Load Allocation (LA)

In order to calculate the LA, the WLA and MOS are subtracted from the TMDL using the equation below.

$$WLA + LA + MOS = TMDL$$

Since there is no WLA, the LA is equal to the TMDL minus the 10% MOS. Results of the load calculations are presented in **Table 3.4**. The extensive data collection and analyses necessary to determine background *E. coli* loads are beyond the resources available for this study. It is assumed that a portion of the LA is made up of natural background loads. It is important to note that WLAs and LAs are estimates based on a specific flow condition. Under differing hydrologic conditions, the loads will change. Successful implementation of this TMDL will be determined based on achievement of the *E. coli* standards under all flow conditions.

Table 3.4 Load allocations for *E. coli* (units are in cfu/day)

Assessment Unit	WLA	LA	10% MOS	TMDL
Grassy Creek (Comanche Creek to headwaters)	0	3.05×10^8	3.39×10^7	3.39×10^8
LaBelle Creek (Comanche Creek to headwaters)	0	1.94×10^8	2.16×10^7	2.16×10^8
Ute Creek (Costilla Creek to headwaters)	0	1.03×10^9	1.14×10^8	1.14×10^9
Vidal Creek (Comanche Creek to headwaters)	0	6.11×10^8	6.79×10^7	6.79×10^8

E. coli impairment determinations were based on exceedances of the State's single sample criteria and the TMDL is written to address the monthly geometric mean standard. As such, a simple comparison of the numbers would not necessarily represent an amount of contaminant reduction that would result in removing the impairment, and would instead result in an overestimation of the actual reduction necessary. Neither Section 303 of the Clean Water Act nor 40 C.F.R. Part 130.7 requires states to include discussions of percent reductions in TMDL documents. Although NMED believes that it is often useful to discuss the magnitude of water quality exceedances in the TMDL report, the "percent reduction" value can be calculated in multiple ways and as a result is often misinterpreted. Therefore, a percent reduction value is not provided for *E. coli* TMDLs.

3.4 Identification and Description of Pollutant Sources

SWQB conducted an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Revision 2, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; see also **Appendix B**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. The list of probable sources is not intended to single out any particular landowner or land management activity and generally includes several sources per pollutant. Pollutant sources that may contribute to each impairment were determined by field reconnaissance and evaluation (**Table 3.5**). Probable sources of bacteria impairments will be evaluated, refined, and changed as necessary through the Watershed Based Plans.

Table 3.5 Probable sources of excessive *Escherichia coli* for Upper Rio Grande basin TMDL Assessment Units.

Assessment Unit	Probable Sources
Grassy Creek (Comanche Creek to headwaters)	Grazing in riparian zone;
LaBelle Creek (Comanche Creek to headwaters)	Grazing in riparian zone;
Rio Quemado (Santa Cruz R to headwaters)	Crop production; Forest fire (2002); Grazing in riparian zone; Habitat modification (Exotic species); Inappropriate waste disposal; Loss of riparian habitat; Rangeland grazing; Rural residential area; Site clearance; Water diversion
Ute Creek (Costilla Creek to headwaters)	Crop production; Highway/road/bridge runoff; Livestock feeding operation; Rangeland grazing; Rural residential area; Site clearance; Water diversion
Vidal Creek (Comanche Creek to headwaters)	Grazing in riparian zone;

Among the potential sources of coliform bacteria are municipal point source discharges such as wastewater treatment facilities, septic tanks which are poorly maintained, improperly installed, or missing, livestock grazing of uplands and riparian areas, and waste from pets and wildlife. Howell et al. (1996) found that bacteria concentrations in underlying sediment increase when cattle have direct access to streams. Natural sources of *E. coli* are also present in the form of wildlife such as elk, deer, waterfowl and other warm-blooded animals.

In addition to the initial loading, several ambient parameters have been documented to influence coliform bacteria survival and, potentially, regrowth, in freshwater bodies (Howell et al., 1996; Wcislo and Chrost, 2000). Abiotic factors include visible light, ultraviolet light, temperature, organic and metal pollutants, dissolved organic matter, suspended sediment concentration and particle size, and pH. Biotic, or ecological, factors include viral parasites and protozoan predators. Bacterial concentrations may become elevated when bacteria-laden sediment is re-suspended during storm events or by other subsequent disturbance such as trampling by livestock (Howell et al., 1996) or wildlife.

Further study would be needed in order to determine exact sources of *E. coli* and their relative contributions. One method of characterizing sources of bacteria is Bacterial, or Microbial, Source Tracking (BST or MST). The extensive data collection and analyses necessary to determine bacterial sources are beyond the resources available for this TMDL. While sufficient data currently exist to support development of *E. coli* TMDLs to address the stream standards exceedances, a BST dataset would likely be useful to better identify the sources of *E. coli* impacting the stream.

3.5 Consideration of Seasonal Variation

Federal regulations (40 C.F.R. § 130.7(c)(1)) require that TMDLs take into consideration seasonal variation in watershed conditions and pollutant loading. Data used in the calculation of these TMDLs were collected during the spring, summer, and fall of 2017 and 2018 in order to ensure coverage of potential seasonal variation in the system. In Ute Creek, exceedances of the WQS were documented only in early spring of each survey year, possibly as a result of overland flow from snowmelt. In the TMDL AUs located in the Valle Vidal, exceedances were documented in July, September and October of both years. This pattern is consistent with the findings of Hulvey et al. (2021) that *E. coli* peaked in midsummer in Utah streams running through grazed or ungrazed grasslands, with higher peaks in the grazed meadows. In the Rio Quemado (Rio Arriba Cnty bnd to headwaters), exceedances were distributed throughout the sampling period in both years, indicating a persistent source of bacteria, such as faulty septic systems or year-round riparian grazing.

3.6 Future Growth

Growth estimates by county are available from the University of New Mexico Geospatial and Population Studies (GPS) (https://gps.unm.edu/pru/projections, accessed 5/19/22). Four out of the 5 current E. coli TMDL AUs fall within Taos County. The Rio Quemado (Santa Cruz R to headwaters) AU flows through Rio Arriba and Santa Fe Counties.

GPS projects that Santa Fe County will continue to grow, while the populations of Taos and Rio Arriba Counties will decline, as detailed on **Table 3.6**. Future population change will have only indirect bearing on water quality in the LaBelle Creek (Comanche Creek to headwaters) and Vidal Creek (Comanche Creek to headwaters) AUs since they are located in an unpopulated headwaters area of the Carson National Forest.

Table 3.6 County Population Estimates

County	2020	2025	2030	2035	2040	Change (2020-2040)
Taos	32,795	32,635	32,360	31,938	31,412	- 4.2%
Rio Arriba	38,721	37,883	36,903	35,752	34,485	-10.9%
Santa Fe	150,488	153,311	155,641	157,291	158,420	5.3%

Estimates of future growth are not anticipated to lead to a significant increase in *E. coli* that cannot be controlled with BMP implementation. BMPs should be utilized and improved upon while continuing to improve watershed conditions and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

4.0 PLANT NUTRIENTS

Phosphorus and nitrogen are essential for proper functioning of ecosystems. However, excess nutrients cause conditions unfavorable for the proper functioning of aquatic ecosystems. Nuisance levels of algae and other aquatic vegetation (macrophytes) can develop rapidly in response to nutrient enrichment when other factors (e.g., light, temperature, substrate) are not limiting (**Figure 4.1**). However, the magnitude of nutrient concentration that constitutes an "excess" is difficult to determine and varies by ecoregion.

Phosphorus and nitrogen generally drive the productivity of algae and macrophytes in aquatic ecosystems, therefore they are regarded as the primary limiting nutrients in freshwaters. The main reservoirs of natural phosphorus are rocks and natural phosphate deposits. Weathering, leaching, and erosion are all processes that breakdown rock and mineral deposits allowing phosphorus to be transported to aquatic systems via water or wind. The breakdown of mineral phosphorus produces inorganic phosphate ions ($H_2PO_4^-$, HPO_4^{2-}, and PO_4^{3-}) that can be absorbed by plants from soil or water (USEPA, 1999). Phosphorus primarily moves through the food web as organic phosphorus (after it has been incorporated into plant or algal tissue) where it may be released as phosphate in urine or other waste by heterotrophic consumers and reabsorbed by plants or algae to start another cycle (Nebel and Wright, 2000).

The largest global reservoir of nitrogen is the atmosphere. About 80% of the atmosphere by volume consists of nitrogen gas (N_2). Although nitrogen is plentiful in the environment, it is not readily available for biological uptake. Nitrogen gas must be converted to other forms, such as ammonia (NH_3 and NH_4^+), nitrate (NO_3^-), or nitrite (NO_2^-) before plants and animals can use it. Conversion of gaseous nitrogen into usable mineral forms occurs through three biologically mediated processes of the nitrogen cycle: nitrogen fixation, nitrification, and ammonification (USEPA, 1999). Mineral forms of nitrogen can be taken up by plants and algae and incorporated into their tissue. Nitrogen follows the same pattern of food web incorporation as phosphorus and is released in waste primarily as ammonium compounds. The ammonium compounds are usually converted to nitrates by nitrifying bacteria, making it available again for uptake, starting the cycle anew (Nebel and Wright, 2000).

Rain, overland runoff, groundwater, drainage networks, and industrial and residential waste effluents transport nutrients to receiving waterbodies. Once nutrients have been transported into a waterbody they can be taken up by algae, macrophytes, and microorganisms either in the water column or in the benthos; they can sorb to organic or inorganic particles in the water column and/or sediment; they can accumulate or be recycled in the sediment; or they can be transformed and released as a gas from the waterbody (**Figure 4.1**).

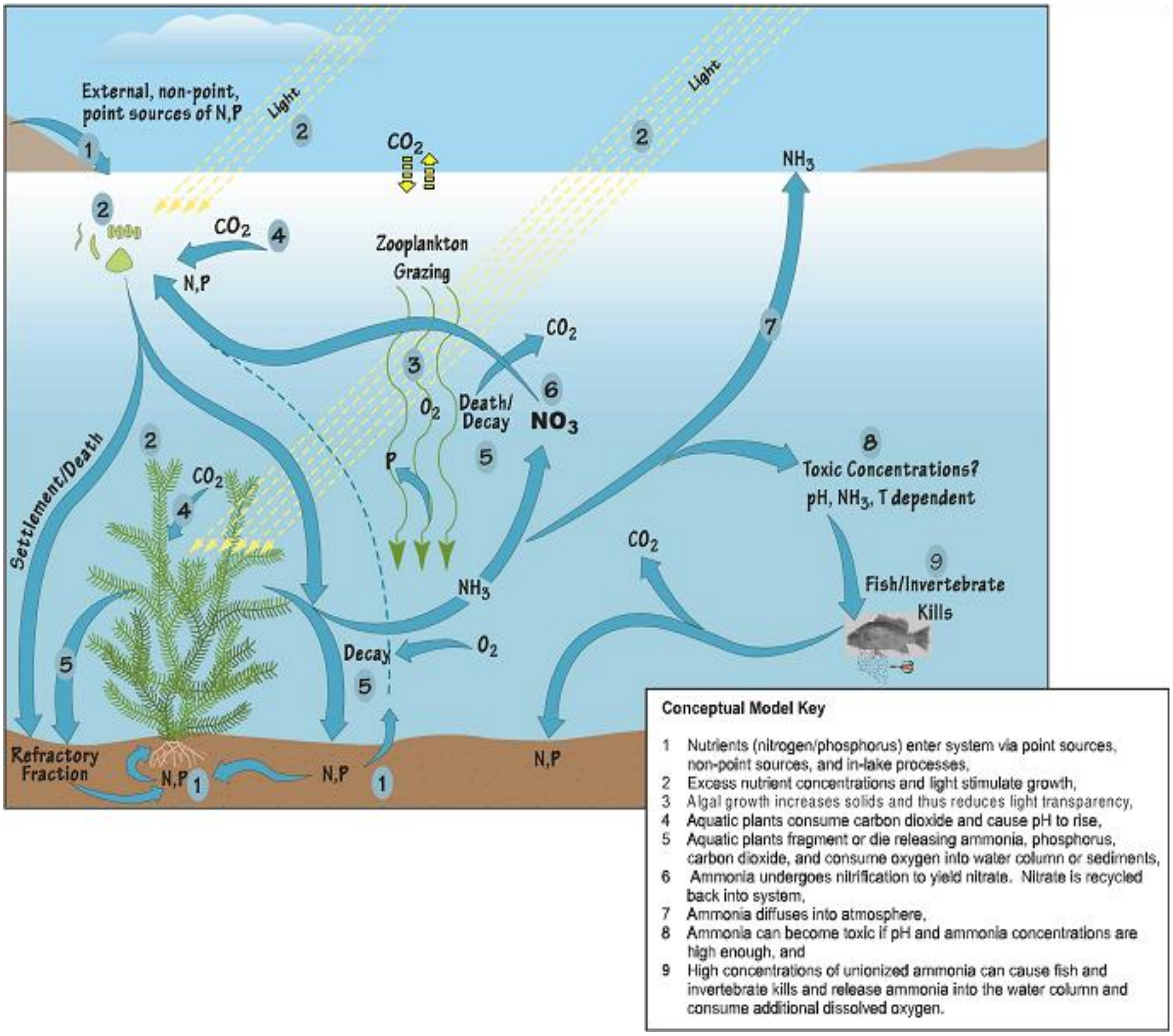

Figure 4.1 Nutrient conceptual model (USEPA 1999)

4.1 Target Loading Capacity

The intent of nutrient criteria, whether numeric or narrative, is to limit nutrient inputs in order to control the excessive growth of attached algae and higher aquatic plants. Controlling algae and plant growth preserves aesthetic and ecologic characteristics along the waterway. While conceptually there may be a number of possible combinations of total nitrogen (TN) and total phosphorus (TP) concentrations that are protective of water quality, the application of simple chemical limitation concepts to a complex biologic system to determine these combinations is challenging. One of the primary reasons for this is that different species of algae and higher aquatic plants will have different nutritional needs. Some species will thrive in nitrogen limited environments while others will thrive in phosphorous limited environments. Because of the diversity of nutritional needs amongst organisms, numeric thresholds for both TN and TP are required to preserve the aesthetic and ecologic characteristics along a waterway. Focusing on one nutrient or trading a decrease in one for an increase in the other may simply favor a particular species without achieving water quality standards.

New Mexico has a narrative criterion for plant nutrients set forth in Subsection E of 20.6.4.13 NMAC:

> ***Plant Nutrients:*** *Plant nutrients from other than natural causes shall not be present in concentrations which will produce undesirable aquatic life or result in the dominance of nuisance species in surface waters of the state.*

This narrative criterion can be challenging to assess because the relationships between nutrient levels and impairment of designated uses are not defined, and distinguishing nutrients from "other than natural causes" is difficult. Numeric thresholds are necessary to establish targets for TMDLs, to develop water quality-based permit limits and source control plans, and to support designated uses within the watershed.

In 2015 and 2016, SWQB collaborated with Tetra Tech, Inc., the EPA Region 6, and EPA's National Nutrient Criteria Program Nutrient Scientific Technical Exchange Partnership and Support (N-STEPS) program on a project to revise nutrient impairment thresholds in New Mexico. This project follows EPA's nutrient criteria guidance (EPA, 2010) and Empirical Approaches for Nutrient Criteria Derivation (EPA, 2009). Statistical analyses of available state and regional data were conducted to refine nutrient thresholds using defined reference conditions, relationships between cause and response variables and a verified classification system. The resultant candidate thresholds were evaluated by SWQB staff, and the selected thresholds were used to revise this nutrient listing methodology. The 100+ page report (Jessup et al., 2015) detailing the N-STEPS effort is available at https://www.env.nm.gov/surface-water-quality/nutrients/. SWQB also generated and posted a shorter document which summarizes the steps taken to determine the candidate thresholds, and SWQB's logic regarding final threshold selection (NMED/SWQB, 2016).

Nutrient assessments were conducted on data collected during the 2017-2018 Upper Rio Grande water quality survey. Detailed assessment of various water quality parameters indicated plant nutrient impairment in two stream AUs (**Table 4.1**). Data contributing to the impairment determinations are shown in **Appendix A**. Fernandez Creek is a tributary to Comanche Creek in the Valle Vidal. Comanche Creek is not nutrient impaired and Fernandez Creek is its only tributary listed for such impairment. The Rio Pueblo de Taos is a major tributary of the Rio Grande, and conveys runoff from a large extent of the west face of the Sangre de Cristo mountains.

Table 4.1 Nutrient impaired watersheds and assessment units

AU_ID	Assessment Unit
NM-2120.A_834	Fernandez Creek (Comanche Creek to headwaters)
NM-2119_30	Rio Pueblo de Taos (Arroyo del Alamo to R Grande del Rancho)

Phosphorous is found in water primarily as orthophosphate. In contrast nitrogen may be found as several dissolved species, all of which must be considered in nutrient loading. Total nitrogen is defined by SWQB as the sum of nitrate+nitrite (NO_2+NO_3), and Total Kjeldahl Nitrogen (TKN) (NMED/SWQB, 2017). At the present time, there is no USEPA-approved method to test for total nitrogen, however adding the results of USEPA methods 351.2 (TKN) and 353.2 (NO_2+NO_3) is appropriate for estimating total nitrogen. While not an EPA-approved method, Method SM4500-N for Total Nitrogen using a persulfate digest, was an approved method in the then-current SWQB QAPP (NMED/SWQB, 2018) and is used in cases where a lower detection limit is needed. Daily delta DO, a nutrient response variable, is defined as the difference between the maximum and minimum DO concentration within a 24-hour period. The applicable threshold values for these TMDLs are shown on **Table 4.2**. These threshold values were used for water quality assessments and as a starting point for TMDL development.

Table 4.2 Causal and response variable thresholds for plant nutrients TMLDs. Units are in mg/L.

AU	Site Class	TN	TP	Delta DO
Fernandez Creek (Comanche Creek to headwaters)	TN (Steep) TP (Steep)	0.30	0.030	1.79
Rio Pueblo de Taos (Arroyo del Alamo to R Grande del Rancho)	TN (Moderate) TP (Flat-Moderate)	0.42	0.061	4.08

4.2 Flow

According to the New Mexico Water Quality Standards, the low flow critical condition for numeric criteria (excluding human health-organism only criteria) set in NMAC 20.6.4.97 through 20.6.4.900 and NMAC 20.6.4.13(F) is defined as the 4-day, 3-year low-flow frequency (4Q3, NMAC 20.6.4.11(B)(2)). The 4Q3 is the annual lowest four (4) consecutive day flow that occurs with a frequency of at least once every three (3) years.

Critical flow for the Rio Pueblo de Taos was determined from daily discharge data from 1958 through 2020, of USGS Gage 08276300 Rio Pueblo de Taos Below Los Cordovas, NM, using the DFLOW software program, (USGS gage locations are shown on Figures 1.1-1.3). The calculated 4Q3 is 3.60 mgd.

Because Fernandez Creek is ungaged, an analysis method developed by Waltemeyer (2002) was used to estimate the critical low flow. In Waltemeyer's analysis, two regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico (i.e., statewide and mountainous regions above 7,500 ft in elevation). The average elevation of the Fernandez Creek drainage is above 7,500 ft, so the mountainous regions regression equation was used. The following mountainous regions regression equation (**Equation 4.1**) is based on data from 40 gaging stations located above 7,500 ft in elevation with non-zero discharge (Waltemeyer, 2002):

Equation 4.1 $4Q3 = 7.3287 \times 10^{-5} DA^{0.70} {P_w}^{3.58} S^{1.35}$

Where:

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

Table 4.3 Flow summary for nutrient-impaired Assessment Unit

Watershed	Average Elevation (ft)	DA (mi^2)	S (ft/ft)	P_w (in)	4Q3 (cfs)	4Q3 (mgd)
Fernandez Creek (Comanche Creek to headwaters)	10100	2.63	0.35	14.3	0.48	0.31

The 4Q3 value calculated using Waltemeyer's method is presented in **Table 4.3**. Parameters used in the calculation were determined using the StreamStats online GIS application developed by the USGS (https://streamstats.usgs.gov/ss/). The critical flow was converted from cubic feet per second (cfs) to million gallons per day (mgd) using a conversion factor of 0.646.

The TMDL itself is a value calculated at a defined critical condition as part of a planning process designed to achieve water quality standards. Since flows vary throughout the year, the actual load at any given time will vary based on the changing flow. Management of the load to improve stream water quality is the goal of SWQB efforts.

4.3 TMDL Calculation

This subsection describes the relationship between the numeric nutrient targets and the allowable pollutant level by determining the total assimilative capacity of the waterbody, or loading capacity, for the pollutant. The loading capacity is the maximum amount of pollutant loading that a waterbody can receive while meeting its water quality objectives.

As a river flows downstream it has a specific carrying capacity for nutrients. This carrying capacity, or TMDL, is defined as the mass of pollutant that can be carried under critical flow conditions without violating the target concentration for that constituent. These TMDLs were developed based on simple dilution calculations using critical flows, the numeric target, and a conversion factor to correct the TMDL units to lb/day. The specific carrying capacity of a receiving water for a given pollutant, was estimated using **Equation 4.2**. The calculated daily carrying capacities (i.e. TMDLs) for TP and TN are summarized in **Table 4.4**.

Eq. 4.2: *Critical flow (4Q3) x WQS(mg/L) x Conversion Factor = TMDL (lb/day)*

Table 4.4 TMDLs for TP & TN

TMDL Watershed	Parameter	Critical Flow (mgd)	In-Stream Target (mg/L)	Conversion Factor	TMDL (lb/day)
Fernandez Creek (Comanche Creek to headwaters)	Total Phosphorus Total Nitrogen	0.31	0.030 0.30	8.34	0.08 0.78
Rio Pueblo de Taos (Arroyo del Alamo to R Grande del Rancho)	Total Phosphorus Total Nitrogen	3.60	0.061 0.42	8.34	1.83 12.6

The TMDL is further allocated to a MOS, WLA (permitted point sources), and LA (nonpoint sources), according to the formula: *WLA + LA + MOS = TMDL.*

4.3.1 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. The MOS can be expressed either implicitly or explicitly. An implicit MOS is incorporated by making conservative assumptions in the TMDL analysis, such as allocating a conservative load to background sources. An explicit MOS is applied by reserving a portion of the TMDL and not allocating it to any other sources.

For this nutrient TMDL, the margin of safety was developed using a combination of conservative assumptions and explicit recognition of potential errors. Therefore, this margin of safety is the sum of the following two elements:

- *Conservative Assumptions*
    - Treating phosphorus and nitrogen as pollutants that do not readily degrade in the environment.

- *Explicit Recognition of Potential Errors*
    - There is inherent error in flow estimation, both measured and calculated; a conservative MOS for this element in ungaged streams is **10 %**, a conservative MOS for this element in gaged streams is **5%**.

4.3.3 Load Allocation

In order to calculate the LA, the WLA and the MOS were subtracted from the TMDL, as shown on **Table 4.6**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see Section 4.3.1 for details).

Table 4.6 Plant nutrient Load Allocation (units are in lb/day)

Assessment Unit	Parameter	WLA	LA	MOS	TMDL
Fernandez Creek (Comanche Creek to headwaters)	Total Phosphorus Total Nitrogen	0 0	0.072 0.702	0.008 0.078	0.08 0.78
Rio Pueblo de Taos (Arroyo del Alamo to R Grande del Rancho)	Total Phosphorus Total Nitrogen	1.02 7.01	0.72 4.96	0.09 0.63	1.83 12.6

4.3.4 Load Reduction

The extensive data collection and analysis necessary to determine background nutrient loads 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.

Table 4.7 Calculation of load reductions for TP and TN . Units are in lb/day.

TMDL Watershed	Parameter	Target Load[a]	Measured Load[b]	Load Reduction	Percent Reduction[c]
Fernandez Creek (Comanche Creek to headwaters)	Total Phosphorus	0.072	0.144	0.072	50%
	Total Nitrogen	0.702	< 0.377	None	None
Rio Pueblo de Taos (Arroyo del Alamo to R Grande del Rancho)	Total Phosphorus	1.74	8.47	6.73	79%
	Total Nitrogen	11.99	23.72	11.73	49%

(a) Target Load = TMDL – MOS. 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.

*(b) The measured load is the magnitude of point and nonpoint sources. It is calculated using mean measured concentration values at the TMDL critical flow (**Appendix A**).*

(c) 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.

4.3.2 Waste Load Allocation

Waste Load Allocation for the Town of Taos WWTP is shown on **Table 4.5**. Implementation of Permit NM0024066 is further discussed in Section 10.1.2 of this report. There are no active individual National Pollutant Discharge Elimination System (NPDES) permits that discharge to Fernandez Creek, therefore the WLA for this TMDL is zero.

Sediment and associated contaminants are considered components of industrial storm water discharges covered under NPDES General Permits. Stormwater discharges from construction activities are transient, occurring mainly during the construction itself, and then only during storm events. Coverage under the NPDES Construction General Permit (CGP) for construction sites greater than one acre, or less than one acre if they are part of a common plan of development, 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. The 2022 CGP also includes state-specific requirements to implement site-specific interim and permanent stabilization, and managerial and structural solids, erosion, and sediment control Best Management Practices (BMPs), and/or other controls. The SWPPP must include site-specific interim and permanent stabilization, managerial, and structural solids, erosion and sediment control BMPs and/or other controls that are designed to prevent to the maximum extent practicable an increase in the sediment yield and flow velocity from pre-construction, pre-development conditions to assure that applicable standards in 20.6.4 NMAC, including the antidegradation policy, and TMDL WLAs are met. This requirement applies to discharges both during

Table 4.5 Plant nutrients Waste Load Allocation for the Town of Taos Wastewater Treatment Plant, permit number NM0024066

Phase	Parameter	Water Quality Target (mg/L)	Waste Load Allocation (lb/day)
1st (Currently achieved)	Total Nitrogen	11 [a]	96.6 [a]
	Total Phosphorus	4 [a]	35.1 [a]
2nd (Interim limit)	Total Nitrogen	TBD [b]	TBD [b]
	Total Phosphorus	TBD [b]	TBD [b]
nth (Water quality based)	Total Nitrogen	0.42 [c]	7.01 [d]
	Total Phosphorus	0.061 [c]	1.02 [d]

TBD = to be determined

(a) Based on the 85th percentile of 2018-2022 effluent concentration data. The loading limit was based on the maximum 30-day average flow (1.053 mgd) from the most recent two years of data.

(b) To be evaluated next permit cycle and TMDL revised if necessary. See Section 10.1.

(c) Targets based on in-stream nutrient targets discussed in Section 4.1.

(d) TMDL calculated using Equation 4.2 and 2.0 mgd permitted design flow.

construction and after construction operations have been completed. Currently in the 2022 CGP, EPA defines "sediment-related parameter" as a pollutant parameter that is closely related to sediment suchas turbidity, total suspended solids (TSS), total suspended sediment, transparency, sedimentation, and siltation. For discharge covered under the CGP to a water that is impaired for a parameter other than a sediment-related parameter or nutrients, EPA will inform the operator if any additional controls are necessary to meet water quality standards.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the 2021 NPDES Multi-Sector General Permit (MSGP). The MSGP also requires preparation of a SWPPP. Based on the industrial sector, some of the industrial facilities and activities covered under the MSGP have technology based effluent limitation and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values reflect State of New Mexico WQS.

It is not possible to calculate individual WLAs for facilities covered by the General Permits at this time using the available tools. The discharges from these permits are typically transitory as the activities are temporary. Loads that are in compliance with the General Permits are therefore currently included as part of the Load Allocation (LA). While these sources are not given individual allocations, they are addressed through other means, including BMPs, stormwater pollution prevention conditions, and other requirements.

4.4 Identification and Description of Pollutant Sources

SWQB conducted an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Revision 2, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; see also **Appendix B**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. The list of probable sources is not intended to single out any particular landowner or land management activity and generally includes several sources per pollutant.

Table 4.8 displays probable pollutant sources that have the potential to contribute to nutrient impairment within the TMDL AUs, as determined by field reconnaissance and knowledge of watershed activities. The draft probable source list will be reviewed and modified as necessary, with watershed group/stakeholder input during the TMDL public meeting and comment period. Probable sources of impairment will be further evaluated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

Table 4.8 Probable sources of excessive plant nutrients for Upper Rio Grande basin TMDL Assessment Units.

Assessment Unit	Probable Sources
Fernandez Creek (Comanche Creek to headwaters)	Grazing in riparian zone
Rio Pueblo de Taos (Arroyo del Alamo to R Grande del Rancho)	Highway/road/bridge runoff; Municipal point source discharge; Other recreation (angling); Rural residential area; Site clearance

As described in Section 4.2, the presence of plant nutrients in a stream can vary as a function of flow. As flow decreases through water diversions and/or drought-related stressors, the stream cannot effectively dilute its constituents, which causes the concentration of plant nutrients to increase. Nutrients generally reach a waterbody from land uses that are in close proximity to the stream because the hydrological pathways are shorter and have fewer obstacles than land uses located away from the riparian corridor. During the growing season (i.e. in agricultural return flow) and in storm water runoff, distant land uses can become hydrologically connected to the stream, thus transporting nutrients from the hillslopes to the stream during these time periods.

In addition to agriculture, there are several other human-related activities that influence nutrient concentrations in rivers and streams. Residential areas contribute nutrients from septic tanks, landscape maintenance, as well as backyard livestock (e.g., cattle, horses) and pet wastes. Urban development contributes nutrients by disturbing the land and consequently increasing soil erosion, by increasing the impervious area within the watershed, and by directly applying nutrients to the landscape. Recreational activities such as hiking and biking can also contribute nutrients to the stream by reducing plant cover and increasing soil erosion (e.g., trail network, streambank destabilization), direct application of human waste, campfires and/or wildfires, and dumping trash near the riparian corridor.

Undeveloped, or natural, landscapes also can deliver nutrients to a waterbody through decaying plant material, soil erosion, and wild animal waste. Another nutrient source is atmospheric deposition, which adds nutrients directly to the waterbody through dryfall and precipitation. Atmospheric phosphorus and nitrogen can be found in both organic and inorganic particles, such as pollen and dust, as well as anthropogenic sources such as combustion and agriculture. The contributions from these natural sources are generally considered to represent background levels.

4.5 Consideration of Seasonal Variability

Section 303(d)(1) of the CWA requires TMDLs to be "established at a level necessary to implement the applicable WQS with seasonal variation." Data used in the calculation of the Fernandez Creek TMDL were collected during the summer and fall. All sampling events, in both survey years, documented TP exceedances, but there were not enough data points to establish any seasonal pattern or lack thereof.

Data used in the calculation of the Rio Pueblo de Taos TMDL were collected from spring through fall of both survey years. TP exceedances were documented by all but one sampling event. Four of the 8 sampling events documented TN exceedances, with three of those occurring in late summer or fall.

The critical condition used for calculating the TMDL is considered to be conservative and protective of the water quality standard under all flow conditions. Calculations made at the critical flow, in addition to using other conservative assumptions as described in the previous section on MOS, should be protective of the water quality standards designed to preserve aquatic life in the stream. It was assumed that if critical conditions were met during this time, coverage of any potential seasonal variation would also be met.

4.6 Future Growth

Growth estimates by county are available from the University of New Mexico Geospatial and Population Studies (GPS) (https://gps.unm.edu/pru/projections, accessed 5/19/22). The Fernandez Creek (Comanche Creek to headwaters) and Rio Pueblo de Taos (Arroyo del Alamo to R Grande del Rancho) AUs fall within Taos County.

GPS projects that the population of Taos County will decline, as detailed on **Table 4.9**. Future population change will have only indirect bearing on water quality in Fernandez Creek since it is located in an unpopulated headwaters area of the Carson National Forest.

Table 4.9 Taos County Population Estimates

County	2020	2025	2030	2035	2040	Change (2020-2040)
Taos	32,795	32,635	32,360	31,938	31,412	- 4.2%

Estimates of future growth are not anticipated to lead to a significant increase in plant nutrients from non-point sources that cannot be controlled with BMP implementation. BMPs should be utilized and improved upon while continuing to improve watershed conditions and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

5.0 SEDIMENTATION

Stream bottom substrate provides optimum habitat for many fish and aquatic insect communities when it does not include excessive fine sediment filling the interstitial spaces. Excessive fine sediment occurs when biologically-important habitat components such as spawning gravels and cobble surfaces are physically covered by fines (Chapman and McLeod, 1987). Substrate fining decreases intergravel oxygen and results in reduced or eliminated quality and quantity of habitat for fish, macroinvertebrates, and algae (Lisle 1989; Waters 1995). Chapman and Mcleod (1987) found that bed material size is related to habitat suitability for fish and macroinvertebrates and that excess fine sediment decreased both density and diversity of aquatic insects.

Sediment loads that exceed a stream's sediment transport capacity often trigger changes in stream morphology (Leopold et al., 1964). Streams that become overwhelmed with sediment often go through a period of accelerated channel widening and streambank erosion before returning to a stable form (Rosgen, 1996). These morphological changes can accelerate erosion, reduce habitat diversity (pools, riffles, etc.) and place additional stress on the designated aquatic life use.

5.1 Target Loading Capacity

The New Mexico WQS (20.6.4.13 NMAC) include a general narrative standard for "bottom deposits and suspended or settleable solids", which reads:

> *"Surface waters of the state shall be free of water contaminants including fine sediment particles (less than two millimeters in diameter), precipitates or organic or inorganic solids from other than natural causes that have settled to form layers on or fill the interstices of the natural or dominant substrate in quantities that damage or impair the normal growth, function or reproduction of aquatic life or significantly alter the physical or chemical properties of the bottom."*

The assessment approach used to determine these sedimentation impairments is described in detail in Appendix G of the SWQB Comprehensive Assessment and Listing Methodology (CALM; NMED/SWQB, 2019a; https://www.env.nm.gov/surface-water-quality/calm/). Target values for this TMDL were based on the numeric thresholds identified in the CALM. The CALM establishes a procedure for determining impairment due to excessive sedimentation/siltation in perennial, wadeable streams. Bedded sediments cannot be treated as introduced pollutants such as pesticides because they are not uniquely generated through human input or disturbance. Rather, bedded sediments are components of natural systems that are present even in pristine settings and to which stream organisms have evolved and adapted. Therefore, the detection of a sediment imbalance is more complicated than detecting an absolute concentration or percentage that represents a clear biological impact.

The SWQB and USEPA Region 6 contracted with Tetra Tech, Inc., to develop sediment translators or thresholds. The contractor generally followed the steps provided in USEPA's Framework for developing suspended and bedded sediment water quality criteria (USEPA, 2006). This effort included the identification of sediment characteristics that are expected under the range of environmental settings in New Mexico, especially in undisturbed or best available reference streams. Examining the relationships between biological measures and sediment indicators helped to identify where disturbance had caused sediment imbalance and biologically relevant habitat degradation. The analysis resulted in threshold recommendations for two bedded sediment indicators for New Mexico perennial streams (**Table 3.1**) – percent Sand & Fines (%SaFN) and log Relative Bed Stability calculated without bedrock (LRBS_NOR) -- for three different site classes, Mountains, Foothills, and Xeric. The site classes are defined by Level 3 and 4 ecoregions (Griffith et al., 2006) and distinguish sediment expectations across New Mexico. The report detailing this effort (Jessup et al., 2010) is available at https://www.env.nm.gov/surface-water-quality/sedimentation/.

Table 5.1. Bedded sediment indicators (from Jessup et al., 2010)

Sediment Indicator	Description
Percent Sand & Fines (%SaFN)	**The percentage of systematically selected streambed substrate particles that are ≤2.0 mm in diameter from reach-wide pebble count.**
Log Relative Bed Stability (LRBS)	**A measure of the relationship of the median particle size in a stream reach compared to the critical particle size calculated to be mobilized by standardized fluvial stresses in the reach.** Median particle size is determined using a reach-wide pebble count (Peck et al., 2006). Critical particle size is calculated from channel dimensions, flow characteristics, and channel roughness factors (Kaufmann et al., 2008). The measure is expressed as a logarithm of the ratio of geometric mean to critical particle size.
LRBS_NOR	**RBS without bedrock or hardpan (log10).** This measure regards only the potentially mobile streambed particles in determining the geometric mean particle size, and improved associations between the bedded sediment measure and biological responses in the TetraTech analyses (Jessup et al., 2010)

To determine if there is excessive sedimentation/siltation in the study stream reach, two levels of assessment are performed in sequential order. The first level considers the simpler indicator of biological impairment, and then refines the assessment with the second indicator of geomorphic impairment as needed when the first level threshold is exceeded. The % SaFN sediment indicator is used in the Level One assessment because it is easily measured and related strongly with biological metrics. If the %SaFN indicates excessive fine sediment in the stream bed, a Level Two survey is performed to collect data used to calculate the LRBS_NOR value.

In minimally disturbed streams, the measured geometric mean particle size should trend towards the expected particle size (i.e., the size the stream is capable of moving as bedload at bankfull flow). The LRBS_NOR indicator considers site-specific hydraulic potential for moving bed sediments, so that the observed amount of fine sediments is considered impaired only when the streambed is more easily mobilized and transported than expected. It incorporates stream channel, shape, slope, flow, and sediment supply. The LRBS_NOR measure is appropriate as a second-tier indicator because it is scaled to hydro-geomorphic factors of the individual sites, as well as to the broader site classes, thus allowing evaluation of the potential of the specific site in terms of retaining or flushing fine sediments.

Table 5.2 Sedimentation indicator thresholds based on biological responses and reference distributions (Jessup et al., 2010)

Site Class	% Sand and Fines	LRBS_NOR Units
Mountain	< 20	> -1.1
Foothill	< 37	> -1.3
Xeric	< 74	> -2.5

If the calculated LRBS_NOR is greater than the applicable site class threshold in **Table 5.2**, the AU is regarded as **Full Support** with respect to New Mexico's narrative sedimentation/siltation standard found at NMAC 20.6.4.13 NMAC. If the calculated LRBS_NOR is less than or equal to the applicable site class threshold, the AU is considered **Non Support**.

During the 2017-18 survey, impairment relative to the narrative criterion for sedimentation in 20.6.4.13 NMAC was documented in LaBelle Creek (Comanche Creek to headwaters), Rio Chupadero (USFS bnd to headwaters), and Rio en Medio (Aspen Ranch to headwaters), due to exceedances of numeric sedimentation thresholds (**Table 5.3**).

Table 5.3 Numeric thresholds applied to Assessment Units impaired for sedimentation

Assessment Unit	Ecoregion/Site Class	% Sand and Fines Threshold	% Sand and Fines Observed	LRBS_NOR Threshold	Calculated LRBS_NOR
LaBelle Creek (Comanche Creek to headwaters)	21j/Mountain	20	61.9	-1.1	-1.77
Rio Chupadero (USFS bnd to headwaters)	21c/Mountain	20	31.4	-1.1	-1.13
Rio en Medio (Aspen Ranch to headwaters)	21b/Mountain	20	22.9	-1.1	-1.25

A load-based indicator is needed in order to generate a TMDL based on mass balance. Turbidity is correlated with TSS for a given water body. Jessup et al. (2010) suggest an interpretation of the indicator value distributions for sites which fully support their designated uses, using the 90^{th} percentile value for Mountain and Foothills sites and the 75^{th} percentile value for Xeric sites (**Table 5.4**). Therefore the target Total Suspended Solids (TSS) value for each of the sedimentation TMDL AUs will be 8.75 mg/L. Monitoring data for these three AUs for flow, TSS and turbidity are presented in **Appendix A**.

Table 5.4 Suspended sediment indicator percentiles for fully supporting sites and all sites in three site classes

		Fully Supporting Sites			All Sites		
		Valid N	75th	90th	Valid N	25th	Median
Mountains	Turbidity (ntu)	68	4.88	9.50	217	1.25	3.10
	TSS (mg/L)	70	5.05	8.75	221	3.00	3.89
FootHills	Turbidity (ntu)	24	12.18	19.30	136	2.33	5.99
	TSS (mg/L)	24	9.88	16.12	138	3.71	6.71
Xeric	Turbidity (ntu)	83	68.50	191.76	289	5.60	16.00
	TSS (mg/L)	85	60.23	262.80	295	7.00	17.00

5.2 Flow

The TMDL is a value calculated at a defined critical flow condition as part of a planning process designed to achieve water quality standards. For these sedimentation TMDLs, the appropriate critical flow condition is at low flow in order to be protective when the assimilative capacity of a stream is at its lowest. According to the New Mexico Water Quality Standards, the low flow critical condition for numeric criteria (excluding human health-organism only criteria) set in 20.6.4.97 through 20.6.4.900 NMAC and Subsection F of 20.6.4.13 NMAC is defined as the 4-day, 3-year low-flow frequency (4Q3, 20.6.4.11(B)(2) NMAC). The 4Q3 is the annual lowest four (4) consecutive day flow that occurs with a frequency of at least once every three (3) years.

Critical flow values used to calculate the sedimentation/siltation TMDLs were obtained using a regression model. Because these streams are ungaged, an analysis method developed by Waltemeyer (2002) was used to estimate the critical low flow. In Waltemeyer's analysis, two regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico (i.e., statewide and mountainous regions above 7,500 ft in elevation). The average elevation of each of the Upper Rio Grande basin sedimentation impaired watersheds is above 7,500 ft, so the mountainous regions regression equation was used. The following mountainous regions regression equation (**Equation 5.1**) is based on data from 40 gaging stations located above 7,500 ft in elevation with non-zero discharge (Waltemeyer, 2002):

Equation 5.1 $4Q3 = 7.3287 \times 10^{-5} DA^{0.70} {P_w}^{3.58} S^{1.35}$

Where:

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

The 4Q3 values calculated using Waltemeyer's method are presented on **Table 5.5**. Parameters used in the calculation were determined using the StreamStats online GIS application developed by the USGS (https://streamstats.usgs.gov/ss/). The critical flow was converted from cubic feet per second (cfs) to million gallons per day (mgd) using a conversion factor of 0.646. The TMDL itself is a value calculated at a defined critical condition as part of a 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 instream water quality is the goal of SWQB efforts.

Table 5.5 Calculation of Critical Flow for Sedimentation/Siltation TMDLs

Assessment Unit	Average Elevation (ft)	Drainage Area (mi^2)	Average Basin Slope (ft/ft)	Mean Winter Precipitation (in)	4Q3 (cfs)	4Q3 (mgd)
LaBelle Creek (Comanche Creek to headwaters)	9740	1.75	0.18	11.5	0.07	0.05
Rio Chupadero (USFS bnd to headwaters)	8910	6.31	0.35	8.35	0.13	0.08
Rio en Medio (Aspen Ranch to headwaters)	10800	2.4	0.36	12.8	0.31	0.20

5.3 TMDL Calculations

The TMDL is defined as the mass of pollutant that can be carried under critical flow conditions without violating the target concentration for that constituent. The TMDL is calculated based on simple dilution using critical flow, the numeric target, and a conversion factor to correct the TMDL units to lb/day , according to the formula:

Critical flow (4Q3) x WQS x Conversion Factor = TMDL

TMDLs are presented on **Table 5.6** for the critical low flow condition.

Table 5.6 Calculation of TMDLs

Assessment Unit	TSS Indicator Value (mg/l)	Critical Flow (mgd)	Conversion Factor	TMDL (lb/day)
LaBelle Creek (Comanche Creek to headwaters)	8.75	0.05	8.34	3.30
Rio Chupadero (USFS bnd to headwaters)	8.75	0.08	8.34	6.33
Rio en Medio (Aspen Ranch to headwaters)	8.75	0.20	8.34	14.6

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 is the goal of SWQB efforts. The TMDL is further allocated to a MOS, WLA (permitted point sources), and LA (nonpoint sources), according to the formula: *WLA + LA + MOS = TMDL.*

5.3.1 Margin of Safety (MOS)

The 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, the MOS was developed using explicit allocations. Therefore, this MOS is the sum of the following two elements:

- Explicit Recognition of Potential Errors:
  - Uncertainty exists in the relationship between TSS and deposition of excess sediment. A conservative MOS for this element is **10%**.
  - There is error inherent in flow estimation. A conservative MOS for this element in is **10%**.

Total MOS for these TMDLs is **20%**.

5.3.2 Waste Load Allocation (WLA)

There are no active individual National Pollutant Discharge Elimination System (NPDES) permits that discharge to the sedimentation impaired AUs, therefore the WLA for these TMDLs is zero.

Sediment and associated contaminants are considered components of industrial storm water discharges covered under NPDES General Permits. Stormwater discharges from construction activities are transient, occurring mainly during the construction itself, and then only during storm events. Coverage under the NPDES Construction General Permit (CGP) for construction sites greater than one acre, or less than one acre if they are part of a common plan of development, 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. The 2022 CGP also includes state-specific requirements to implement site-specific interim and permanent stabilization, and managerial and structural solids, erosion, and sediment control Best Management Practices (BMPs), and/or other controls. The SWPPP must include site-specific interim and permanent stabilization, managerial, and structural solids, erosion and sediment control BMPs and/or other controls that are designed to prevent to the maximum extent practicable an increase in the sediment yield and flow velocity from pre-construction, pre-development conditions to assure that applicable standards in 20.6.4 NMAC, including the antidegradation policy, and TMDL WLAs are met. This requirement applies to discharges both during construction and after construction operations have been completed. Currently in the 2022 CGP, EPA defines "sediment-related parameter" as a pollutant parameter that is closely related to sediment such as turbidity, total suspended solids (TSS), total suspended sediment, transparency, sedimentation, and siltation. For discharge covered under the CGP to a water that is impaired for a parameter other than a sediment-related parameter or nutrients, EPA will inform the operator if any additional controls are necessary to meet water quality standards.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the 2021 NPDES Multi-Sector General Permit (MSGP). The MSGP also requires preparation of a SWPPP. Based on the industrial sector, some of the industrial facilities and activities covered under the MSGP have technology based effluent limitation and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values reflect State of New Mexico WQS.

It is not possible to calculate individual WLAs for facilities covered by the General Permits at this time using the available tools. The discharges from these permits are typically transitory as the activities are temporary. Loads that are in compliance with the General Permits are therefore currently included as part of the Load Allocation (LA). While these sources are not given individual allocations, they are addressed through other means, including BMPs, stormwater pollution prevention conditions, and other requirements.

5.3.3 Load Allocation (LA)

In order to calculate the LA, the WLA and the MOS were subtracted from the target capacity (TMDL), as shown on **Table 5.7**. The MOS was developed using explicit recognition of potential errors (see Section 5.3.1 for details).

Table 5.7 TMDL Allocations for Total Suspended Solids to Meet WQS for Sedimentation/siltation (units are in lb/day)

Assessment Unit	WLA	LA	20% MOS	TMDL
LaBelle Creek (Comanche Creek to headwaters)	0	2.64	0.66	3.30
Rio Chupadero (USFS bnd to headwaters)	0	5.06	1.27	6.33
Rio en Medio (Aspen Ranch to headwaters)	0	11.68	2.92	14.6

The extensive data collection and analyses necessary to determine background sediment loads 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 target load for TSS is the TMDL minus the MOS, in this case equal to the LA. Because the relationship of stream bottom sediment to instantaneous TSS loads is complex and includes a temporal element, a measured load cannot be calculated from available data, so TSS load reduction estimates are not presented for sedimentation/siltation impairments. One indicator of implementation progress could be achievement of the % SaFN threshold indicator (**Table 5.8**).

Table 5.8 Reduction of % Sand and Fines needed to fall below the % Sand and Fines threshold indicator value for sedimentation/siltation.

Assessment Unit	Ecoregion/Site Class	% Sand and Fines Threshold	% Sand and Fines Observed	Reduction
LaBelle Creek (Comanche Creek to headwaters)	21j/Mountain	20	61.9	68%
Rio Chupadero (USFS bnd to headwaters)	21c/Mountain	20	31.4	36%
Rio en Medio (Aspen Ranch to headwaters)	21b/Mountain	20	22.9	13%

5.4 Identification and Description of Pollutant Sources

SWQB conducted an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Revision 2, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; see also **Appendix B**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. The list of probable sources is not intended to single out any particular landowner or land management activity and generally includes several sources per pollutant.

Table 5.9 displays probable pollutant sources that have the potential to contribute to sedimentation impairment within each AU in the TMDL study area. The draft probable source list will be reviewed and modified as necessary, with watershed group/stakeholder input during the TMDL public meeting and comment period. Probable sources of impairment will be further evaluated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

Table 5.9 Probable sources of excessive sedimentation/siltation for Upper Rio Grande basin TMDL Assessment Units.

Assessment Unit	Probable Sources
LaBelle Creek (Comanche Creek to headwaters)	Grazing in riparian zone; Loss of riparian habitat
Rio Chupadero (USFS bnd to headwaters)	Highway/road/bridge runoff; Other recreation (dispersed camping); Rangeland grazing
Rio en Medio (Aspen Ranch to headwaters)	Highway/road/bridge runoff; Other recreation (camping, hiking trails, ski area); Rangeland grazing; Waste from pets

Although natural rates of sediment input vary among and within regions, human activities can alter these inputs. Excessive watershed erosion from these activities can transport large amounts of fine sediments into streams, leading to frequent bed mobility and poor instream habitat. Conversely, some human alterations like dredging, channelization or upstream impoundments, may lead to a lack of fine sediments in some parts of the channel, but an excess in other places. Clearing vegetation from banks and riparian areas may increase siltation and reduce large woody debris in streams. Logging or farming up to the stream banks, building roads across or along streams, dredging and straightening the stream channel, and building dams or other diversion structures in the stream channel may destabilize stream banks and change bottom substrate size and composition. Even in streams draining relatively pristine watersheds that are at equilibrium between sediment supply and transport, one might expect different characteristic values of Relative Bed Stability that are dependent upon the natural rates of erosion. In the absence of human activities, these natural erosion rates would depend upon climate, basin geology, geomorphology, channel position within the watershed, and related features such as glaciers and natural landslide frequency (Kaufman et al., 2008).

The headwaters of the sedimentation impaired AUs occur on land managed by the Carson and Santa Fe National Forests. Flow in the Rio en Medio may be affected by the withdrawal of water for operations of the Ski Santa Fe resort, permitted from November 1 to March 31.

Wildfires can affect the physical, chemical, and biological quality of streams, rivers, and lakes. After a fire, increased runoff provides a pathway for the transport of chemical-laden sediment to surface water, which may have substantial water quality impacts. Forest fires can result in increased water temperature due to reduced infiltration and loss of shading vegetation. Potential wildfire impacts to water quality are discussed on the SWQB website at https://www.env.nm.gov/surface-water-quality/wildfire-impacts-on-surface-water-quality/. Most watershed effects will naturally recover within 5 to 10 years after the fire, but some aspects of watershed structure and function, as well as areas of most severe fire intensity, may continue to recover for 15-20 years (Bixby et al., 2015).

The Medio Fire burned almost 5,000 acres of the Rio en Medio watershed in the mountains near Santa Fe in September 2020. The SWQB Watershed Protection Section developed a contract with Keystone Restoration Ecology using a price agreement created by the New Mexico Department of Game & Fish for "Ecological Restoration Projects" to conduct post-fire restoration in this area. Natural recovery has been relatively good, but there is still a lot of bare ground and fine sediment moving through the system, including in the Rio en Medio itself.

5.5 Consideration of Seasonal Variation

The sediment moving capacity of a stream is exponentially related to flow velocity and discharge. Therefore, most of the work of streams is accomplished during floods, when stream velocity and discharge (and therefore capacity) are many times their level during low flow conditions. This work is in the form of bed scouring (erosion), sediment transport (bed and suspended loads), and sediment deposition. It is likely that the excess fine sediment loading and deposition occur during periods of higher flow, which in northern New Mexico are most likely to occur during spring snowmelt and summer monsoon storms. TSS samples were collected throughout the sampling seasons of 2017 and 2018, capturing the spring, summer and fall seasons. In LaBelle Creek (Comanche Creek to headwaters) and Rio Chupadero (USFS bnd to headwaters), there was no evident seasonal pattern to turbidity and TSS results. In the Rio en Medio (Aspen Ranch to headwaters), only one sampling event documented high turbidity and TSS results, in July of 2017.

5.6 Future Growth

Growth estimates by county are available from the University of New Mexico Geospatial and Population Studies (GPS) (https://gps.unm.edu/pru/projections, accessed 5/19/22). The LaBelle Creek (Comanche Creek to headwaters) AU falls within Taos County. The Rio Chupadero (USFS bnd to headwaters) and Rio en Medio (Aspen Ranch to headwaters) AUs flow through Santa Fe County.

GPS projects that Santa Fe County will continue to grow, while the population of Taos County will decline, as detailed on **Table 5.10**. Future population change will have only indirect bearing on water quality in LaBelle Creek since it is located in an unpopulated headwaters area of the Carson National Forest.

Table 5.10 County Population Estimates

County	2020	2025	2030	2035	2040	Change (2020-2040)
Taos	32,795	32,635	32,360	31,938	31,412	- 4.2%
Santa Fe	150,488	153,311	155,641	157,291	158,420	5.3%

Estimates of future growth are not anticipated to lead to a significant increase in sedimentation that cannot be controlled with BMP implementation. BMPs should be utilized and improved upon while continuing to improve watershed conditions and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

6.0 SPECIFIC CONDUCTANCE

Conductivity is measured by SWQB in microSiemens per centimeter (µS/cm). The conductivity of rivers in the United States generally ranges from 50 to 1500 µmhos/cm (an equivalent unit of measure). Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µS/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates (Behar, 1997). Conductivity is influenced by water temperature, increasing as temperatures rise. Specific conductance (SC) is conductivity corrected to 25°C.

The electrical conductivity of water is directly related to the concentration of dissolved solids in the water because total dissolved solids (TDS) concentrations are equal to the sum of positively charged ions (cations) and negatively charged ions (anions) in the water. These electrically charged dissolved particles make ordinary natural water a good conductor of electricity. Conversely, pure water has a high electrical resistance, and resistance is frequently used as a measure of its purity.

TDS reflects the total amount of all inorganic and organic substances – including minerals, salts, and metals – that are dissolved within a volume of water. Higher concentrations of TDS may occur during and after precipitation events. In the United States, elevated TDS is often due to natural environmental features such as mineral springs, carbonate deposits, salt deposits, and silt, the decomposition of leaves and plankton, and the weathering erosion of rocks. Other sources may include stormwater and agricultural runoff, mining operations, industrial wastewater, and sewage.

6.1 Target Loading Capacity

The NM Water Quality Control Commission has adopted numeric water quality criteria for SC to protect the designated use of High Quality Coldwater Aquatic Life (HQCWAL). The HQCWAL use designation requires that a stream have water quality, streambed characteristics, and other attributes of habitat sufficient to protect and maintain HQCWAL. For this TMDL document, target values for SC are based on the reduction in TDS necessary to achieve numeric SC criteria. The general SC WQS for HQCWAL is 400 µS/cm, however the Rio Fernando de Taos has a stream-specific WQS of 500 µS/cm.

Table 6.1 Exceedances of the Specific Conductance Water Quality Standard

Assessment Unit	WQS (µS/cm)	Exceedances
Rio Fernando de Taos (Tienditas Creek to headwaters)	500	5/6
Rio Fernando de Taos (UFSF bnd at canyon to Tienditas Creek)	500	6/7
Rio Fernando de Taos (R Pueblo d Taos to USFS bnd at canyon)	500	5/9

The Rio Fernando de Taos comprised one single AU when it was first listed for SC in 2000. A 2004 Upper Rio Grande TMDL addressed this single AU. In 2006 it was split at Tienditas Creek, and in 2010 the lower AU was split again at the USFS boundary, making a total of three AUs. During the 2017-18 SWQB water quality survey, all three AUs of the Rio Fernando de Taos were documented to exceed the applicable WQS. The SC impairment of the lowest AU has been consistently confirmed over the years, including the 2017-18 survey. The middle AU had the SC listing removed in 2012, was confirmed as not impaired in 2014 with new data, but was relisted in 2020 based on the 2017-18 survey. The headwaters AU was reported to be in full support of HQCWAL in 2014, but was also relisted for SC in 2020 based on the 2017-18 survey. An error has been detected in the calculation of critical flow for the 2004 SC TMDL, so a new TMDL is presented here, applicable to the entire Rio Fernando de Taos water body**,** referred to in the remainder of this section as the Rio Fernando de Taos (R Pueblo de Taos to headwaters).

6.2 Flow

40 C.F.R. § 130.7(c)(1) requires states to calculate a TMDL using critical conditions for stream flow. The TMDL is a value calculated at a defined critical flow condition as part of a planning process designed to achieve water quality standards. For this TMDL, the appropriate critical flow condition is at low flow in order to be protective when the assimilative capacity of a stream is at its lowest. The low flow, or 4Q3, is defined as the 4-day, 3-year low-flow frequency. The 4Q3 is the annual lowest four (4) consecutive day flow that occurs with a frequency of at least once every three (3) years (Waltemeyer 2002).

SC in a stream can vary as a function of flow. As flow decreases, TDS can increase, thereby increasing the SC. It is often necessary to estimate critical flow for a portion of a watershed where there is no active flow gage. 4Q3 derivations for ungaged streams were based on analysis methods described by Waltemeyer (2002). In this analysis, two regression equations for estimating 4Q3 were developed based on physiographic regions of NM (i.e., statewide and mountainous regions above 7500 feet in elevation). The 4Q3 was estimated using the regression equation for mountainous regions because the mean elevation for this AU is above 7500 feet in elevation (Table 4.1). The following regression equation for mountainous regions above 7500 feet in elevation is based on data from 40 gaging stations with non-zero discharge (Waltemeyer 2002):

Equation 6.1

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

where,

DA = Drainage area (mi^2)
P_w = Average basin precipitation Oct-Apr (inches)
S = Average basin slope (ft/ft)

Variables for input to the Waltemeyer equation were obtained using the USGS StreamStats web tool (https://streamstats.usgs.gov/ss/). The 4Q3 value was converted from cubic feet per second (cfs) to units of million gallons per day (mgd) using the conversion factor 0.646.

Table 6.2 Calculation of 4Q3 for the Rio Fernando de Taos (R Pueblo d Taos to headwaters)

Average Elevation (ft.)	Drainage Area (mi^2)	Mean winter precipitation (in)	Average basin slope (ft/ft)	4Q3 (cfs)	4Q3 (mgd)
8000	71.6	8.56	0.27	0.54	0.35

The TMDL itself is a value calculated at a defined critical condition, 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 and achieve WQS is the goal of SWQB efforts.

6.3 TMDL Calculations

In order to calculate a mass-based load, total dissolved solids (TDS) is used as a surrogate for SC. TDS to SC ratios range from 0.5 to 0.9 mg/L:µS/cm (American Public Health Association, 1998). Specific correlation should be derived by site if TDS values are available. TDS and SC data from the 2017-18 SWQB sampling season can be found in **Appendix A**. Data was collected from one station in each AU. The range of TDS:SC ratios did not differ between the stations. The TDS:SC ratios from the sampling events of May 10-11, 2017, when the river was in flood flow, were outliers. Therefore all available data, excepting those dates, was used in calculation of the TMDL and measured load. The TDS:SC ratio average value was 0.591. The WQS to protect the designated HQCWAL use states that SC shall not exceed 500 µmhos/cm. The TDS concentration required to achieve State WQS is defined by **Equation 6-2.**

$$\text{TDS (mg/L)} \cong \text{SC } (\mu\text{S/cm}) \times \text{(ratio)}$$

Using the site-specific ratio and an SC value of 500 µS/cm /cm, the TDS concentration required to achieve the WQS is:

$$500\ \mu\text{S/cm} \times 0.591 = 295.5\ \text{mg/L TDS}$$

The TMDL for TDS is calculated based on the 4Q3 flow, the applicable WQS, and a conversion factor of 8.34, that is used to correct the TMDL units to pounds per day (lb/day).

Equation 6.3

Critical Flow (mgd) x WQS (mg/L) x 8.34 = TMDL (lb/day)

Table 6.3 Calculation of TMDL for TDS (as SC indicator) for the Rio Fernando de Taos (R Pueblo d Taos to headwaters)

4Q3 Flow (mgd)	TDS to meet SC Standard (mg/L)	Conversion Factor	TMDL (lb/day)
0.35	295.5	8.34	863

The TMDL is further allocated to a MOS, WLA (permitted point sources), and LA (non-point sources), according to the formula: *WLA + LA + MOS = TMDL*.

6.3.1 Margin of Safety (MOS)

The 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 TDS (as SC surrogate) TMDL, the MOS was developed using a combination of conservative assumptions and explicit allocations. Therefore, this MOS is the sum of the following two elements:

- *Implicit Margin of Safety*
  Treating TDS as a conservative pollutant, meaning a pollutant that does not readily degrade in the environment, was used as a conservative assumption in developing these loading limits.

- *Explicit Margin of Safety*
  An explicit MOS of 10% was assigned to the SC impaired AU, to account for the inherent error in estimation of streamflow.

6.3.2 Waste Load Allocation

There are no active individual National Pollutant Discharge Elimination System (NPDES) permits that discharge to the sedimentation impaired AUs, therefore the WLA for these TMDLs is zero.

Sediment and associated contaminants are considered components of industrial storm water discharges covered under NPDES General Permits. Stormwater discharges from construction activities are transient, occurring mainly during the construction itself, and then only during storm events. Coverage under the NPDES Construction General Permit (CGP) for construction sites greater than one acre, or less than one acre if they are part of a common plan of development, 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. The 2022 CGP also includes state-specific requirements to implement site-specific interim and permanent stabilization, and managerial and structural solids, erosion, and sediment control Best Management Practices (BMPs), and/or other controls. The SWPPP must include site-specific interim and permanent stabilization, managerial, and structural solids, erosion and sediment control BMPs and/or other controls that are designed to prevent to the maximum extent practicable an increase in the sediment yield and flow velocity from pre-construction, pre-development conditions to assure that applicable standards in 20.6.4 NMAC, including the antidegradation policy, and TMDL WLAs are met. This requirement applies to discharges both during construction and after construction operations have been completed. Currently in the 2022 CGP, EPA defines "sediment-related parameter" as a pollutant parameter that is closely related to sediment such as turbidity, total suspended solids (TSS), total suspended sediment, transparency, sedimentation, and siltation. For discharge covered under the CGP to a water that is impaired for a parameter other than a sediment-related parameter or nutrients, EPA will inform the operator if any additional controls are necessary to meet water quality standards.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the 2021 NPDES Multi-Sector General Permit (MSGP). The MSGP also requires preparation of a SWPPP. Based on the industrial sector, some of the industrial facilities and activities covered under the MSGP have technology based effluent limitation and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values reflect State of New Mexico WQS.

It is not possible to calculate individual WLAs for facilities covered by the General Permits at this time using the available tools. The discharges from these permits are typically transitory as the activities are temporary. Loads that are in compliance with the General Permits are therefore currently included as part of the Load Allocation (LA). While these sources are not given individual allocations, they are addressed through other means, including BMPs, stormwater pollution prevention conditions, and other requirements.

6.3.3 Load Allocation

Load Allocation (LA) is pollution from any non-point source(s) or natural background and is addressed through Best Management Practices. Since there are no WLAs for this AU, the LA is equal to the TMDL value minus the MOS, as shown on **Table 6.4**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see Section 6.3.1 for details).

Table 6.4 Load Allocation of TMDL for TDS (as SC Surrogate) for the Rio Fernando de Taos (R Pueblo d Taos to headwaters)

WLA (lb/day)	LA (lb/day)	MOS (lb/day)	TMDL (lb/day)
0	776.7	86.3	863

6.3.4 Load Reduction

Table 6.5 Load Reduction Estimate to meet WQS for TDS (as SC surrogate)

Assessment Unit	Target Load [(a)] (lb/day)	Measured Load [(b)] (lb/day)	Load Reduction [(c)]
Rio Fernando de Taos (R Pueblo d Taos to headwaters)	776.7	1198	35.2%

(a) Target Load = TMDL – MOS. 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.
*(b) The measured load is calculated using mean measured concentration values (**Appendix A**) at the critical flow, for comparison with the target load. Values from all three AUs were used, and the May 10-11, 2017 sampling event was excluded.*
(c) Load reduction is the percent by which 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.

The extensive data collection and analyses necessary to determine natural background TDS loads 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 levels. Results are presented in **Table 6.5**.

6.4 Identification and Description of Pollutant Source(s)

SWQB conducted an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Revision 2, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; see also **Appendix B**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. The list of probable sources is not intended to single out any particular landowner or land management activity and generally includes several sources per pollutant.

Table 6.6 displays probable pollutant sources that have the potential to contribute to specific conductance impairment within each AU in the TMDL study area. The draft probable source list will be reviewed and modified as necessary, with watershed group/stakeholder input during the TMDL public meeting and comment period. Probable sources of impairment will be further evaluated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

Table 6.6 Pollutant Source Summary

Assessment Unit	Probable Sources
Rio Fernando de Taos (R Pueblo de Taos to headwaters)	Forest fire (2003); Grazing in riparian zone; Habitat modification (Exotic species); Highway/road/bridge runoff; Loss of riparian habitat; On-site treatment systems; Other recreation (angling); Rangeland grazing; Rural residential area; Sand/gravel/rock quarry; Urban municipal area; Water diversion

Exceedances occurred at all but the highest flood flows (**Appendix A**). Conductivity in streams and rivers is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock tend to have lower conductivity because granite is composed of more inert materials that do not dissolve into ionic components when washed into the water. On the other hand, streams that run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water. Groundwater inflows can have the same effects depending on the bedrock they flow through. In addition, discharges to streams can change the conductivity depending on their make-up. For example, a failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate.

Wildfires can affect the physical, chemical, and biological quality of streams, rivers, and lakes. After a fire, increased runoff provides the pathway for the transport of chemical-laden sediment to surface water, which may have substantial water quality impacts. Potential wildfire impacts to water quality are discussed on the SWQB website at https://www.env.nm.gov/surface-water-quality/wildfire-impacts-on-surface-water-quality/. The Encebado Fire (5008 acres), in 2003, may have increased TDS in runoff to the Rio Fernando de Taos.

6.5 Consideration of Seasonal Variation

Data used in the calculation of this TMDL were collected during high and low flow seasons in order to ensure coverage of any potential seasonal variation in the system. Exceedances were observed in spring, summer and fall at all monitoring stations in 2018. Exceedances were also observed in spring, summer and fall of 2017 at the upper two stations, but only in November of that year at the lowest station, representing the Rio Fernando de Taos (R Pueblo de Taos to USFS bnd at canyon) AU.

6.6 Future Growth

Growth estimates by county are available from the University of New Mexico Geospatial and Population Studies (GPS) (https://gps.unm.edu/pru/projections, accessed 5/19/22). These estimates project growth to the year 2040. The Rio Fernando de Taos (R Pueblo de Taos to headwaters) AU is located within Taos County. GPS projects that the population of Taos County will decline, as detailed on **Table 6.7**.

Table 6.7 Taos Water Planning Region Population Estimates

County	2020	2025	2030	2035	2040	Change (2020-2040)
Taos	32,795	32,635	32,360	31,938	31,412	- 4.2%

Estimates of future growth are not anticipated to lead to a significant increase in specific conductance that cannot be controlled with BMP implementation. BMPs should be utilized and improved upon while continuing to improve watershed conditions and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

7.0 TEMPERATURE

Water temperature influences the metabolism, behavior, and mortality of fish and other aquatic organisms. Natural temperatures of a water body fluctuate daily and seasonally. These natural fluctuations do not eliminate indigenous populations, but may affect existing community structure and geographical distribution of species. Anthropogenic impacts such as thermal pollution, deforestation, flow modification and climate change can modify these natural temperature cycles, often leading to deleterious impacts on aquatic life communities. Such modifications may contribute to changes in geographic distribution of species and their ability to persist in the presence of additional stressors such as introduced species. One mechanism by which temperature affects fish is that warmer water has a lower capacity for dissolved oxygen. Water temperature within the stream substrate can influence the growth of insects and salmon eggs. In addition to direct effects, the toxicity of many chemical contaminants increases with temperature (Caissie, 2006).

7.1 Target Loading Capacity

Fish and other aquatic organisms have specific ranges of temperature tolerance and preference. Cold water fish such as salmonids (salmon and trout) are especially vulnerable to increased water temperature. For that reason, coldwater criteria are typically designed primarily to support reproducing populations of salmonids. A coolwater Aquatic Life Use (ALU) was approved by the WQCC in October 2010, to support aquatic life whose physiologic tolerances are intermediate between those of warmwater and coldwater aquatic life (NMED/SWQB, 2009). Acute temperature criteria (such as New Mexico's T_{MAX}) are intended to protect aquatic life from lethal exposures, whereas chronic criteria (the 4T3 or 6T3) protect from sub-lethal exposures sufficient to cause long-term detrimental effects (Todd et al., 2008). The acute and chronic criteria are established to protect the most sensitive members of fish communities, based on laboratory studies of the upper thermal limits of individual species.

For this TMDL document, target values for temperature are based on the reduction in thermal loading necessary to achieve numeric criteria. Temperature criteria for ALUs in New Mexico are shown on **Table 7.1**. New Mexico's aquatic life temperature criteria are expressed as $T_{MAX,}$ 4T3 and 6T3. T_{MAX} is the maximum recorded temperature, 4T3 means the temperature not to be exceeded for four or more consecutive hours in a 24-hour period on more than three consecutive days, and 6T3 means the temperature not to be exceeded for six or more consecutive hours in a 24-hour period on more than three consecutive days.

Table 7.1 Aquatic Life Use Temperature (°C) Water Quality Criteria

Criterion	*High Quality Coldwater*	*Coldwater*	*Marginal Coldwater*	*Coolwater*	*Warmwater*	*Marginal Warmwater*
4T3	20	---	---	---	---	---
6T3	---	20	25	---	---	---
T_{MAX}	23	24	29	29	32.2	32.2

Assessment of the 2017-18 Upper Rio Grande watershed thermograph data determined that four AUs exceeded the T_{MAX} for their designated ALU, two of which also exceeded the applicable chronic criterion (4T3 or 6T3). For those AUs, the TMDL is calculated using the T_{MAX} criterion as a goal. Two additional AUs exceeded their chronic temperature criteria, while not exceeding the T_{MAX}. For those AUs, the TMDL is calculated using the chronic criterion as a goal. Temperature data are presented in **Appendix A**.

Table 7.2 Aquatic Life Use designations of the temperature TMDL AUs

Assessment Unit	Designated ALU
Grassy Creek (Comanche Creek to headwaters)	High Quality Coldwater
Rio Grande (Ohkay Owingeh bnd to Embudo Creek)	Marginal Coldwater
Rio Grande (Santa Clara Pueblo bnd to Ohkay Owingeh bnd)	Marginal Coldwater
Rio Medio (Rio Frijoles to headwaters)	High Quality Coldwater
Rio Nambe (Nambe Pueblo bnd to headwaters)	High Quality Coldwater
Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	High Quality Coldwater

7.2 Flow

The TMDL is a value calculated at a defined critical flow condition as part of a planning process designed to achieve water quality standards. For this temperature TMDL, the appropriate critical flow condition is at low flow in order to be protective when the assimilative capacity of a stream is at its lowest. According to the New Mexico Water Quality Standards, the low flow critical condition for numeric criteria (excluding human health-organism only criteria) set in 20.6.4.97 through NMAC 20.6.4.900 and Subsection F of NMAC 20.6.4.13 is defined as the 4-day, 3-year low-flow frequency (4Q3, NMAC 20.6.4.11(B)(2)). The 4Q3 is the annual lowest four consecutive day flow that occurs with a frequency of at least once every three years.

Table 7.3 Critical flow calculated from discharge gage data

Assessment Unit	USGS Gage	4Q3 Critical Flow (cfs)
Rio Grande (Ohkay Owingeh bnd to Embudo Creek)	USGS 08279500 RIO GRANDE AT EMBUDO, NM*	222
Rio Grande (Santa Clara Pueblo bnd to Ohkay Owingeh bnd)	USGS 08279500 RIO GRANDE AT EMBUDO, NM plus USGS 08290000 RIO CHAMA NEAR CHAMITA, NM	295
Rio Medio (Rio Frijoles to headwaters)	08291000 SANTA CRUZ RIVER NEAR CUNDIYO, NM **	3.21
Rio Nambe (Nambe Pueblo bnd to headwaters)	8294195 RIO NAMBE ABOVE NAMBE FALLS DAM NEAR NAMBE, NM	1.59
Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	08291000 SANTA CRUZ RIVER NEAR CUNDIYO, NM*	5.42

** gage located near the top of the AU*
*** the gage is located just downstream of the confluence of the Rio Medio with the Rio Frijoles. Critical flow calculated from gage data was split with the Rio Frijoles based on proportional watershed area.*

Where gage data was available (USGS gage locations are shown on **Figure 1.1-1.3**), critical flows were determined from USGS discharge gage data, using the DFLOW software program, and are shown on **Table 7.3.** The estimated critical flow for the Rio Grande (Ohkay Owingeh bnd to Embudo Creek) and Rio Grande

(Santa Clara Pueblo bnd to Ohkay Owingeh bnd) are likely overestimates, due to the presence of multiple points of diversion below the Embudo gage.

Because Grassy Creek is ungaged, a regression model developed by Waltemeyer (2002) was used to estimate the critical low flow. In Waltemeyer's analysis, two regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico (i.e., statewide and mountainous regions above 7,500 ft in elevation). The average elevation of the Grassy Creek watershed is above 7,500 ft, so the mountainous regions regression equation was used. The following mountainous regions regression equation (**Equation 7.1**) is based on data from 40 gaging stations located above 7,500 ft in elevation with non-zero discharge (Waltemeyer, 2002):

Equation 7.1 $4Q3 = 7.3287 \times 10^{-5} DA^{0.70} {P_w}^{3.58} S^{1.35}$

Where:

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

The 4Q3 value calculated using Waltemeyer's method are presented in **Table 7.4**. Parameters used in the calculation were obtained using the StreamStats online GIS application developed by the USGS (https://streamstats.usgs.gov/ss/). The TMDL is a value calculated at a defined critical condition as part of a 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 is the goal of SWQB efforts.

Table 7.4 Variables used for Waltemeyer's regression estimation of critical flow value for Grassy Creek

Assessment Unit	Average Elevation (ft)	Drainage Area (mi^2)	Mean Winter Precipitation (in)	Average Basin Slope (ft/ft)	4Q3 (cfs)
Grassy Creek (Comanche Creek to headwaters)	10000	1.88	11.4	0.24	0.11

7.3 TMDL Calculations

The calculation of a TMDL is governed by the basic equation,

WQS criterion x flow x conversion factor = TMDL target capacity

For temperature TMDLs, the WQS criterion is a temperature specified either by the designated ALU or segment-specific criteria, and it can be either a maximum temperature or time-duration temperature such as the 4T3 or 6T3. The 4Q3 low-flow is generally used for the critical flow unless another flow statistic or multiple flow conditions are more appropriate for the situation. The conversion factor is a variable needed to correct the TMDO units to kJ/day. Substituting the appropriate unit conversion factors, the equation used for temperature is the following:

$$WQS\ (^{o}C)\ x\ Flow\ (cfs)\ x\ (1.023\ x\ 10^{7}) = TMDL\ (kJ/day)$$

Details of the derivation of the temperature TMDL equation are presented in Appendix C. **Table 7.5** shows the TMDL calculation values for each TMDL AU.

Table 7.5 Temperature TMDL calculations

Assessment Unit Name	Target temperature (°C)	4Q3 critical flow (cfs)	Conversion factor	TMDL (kJ/day)
Grassy Creek (Comanche Creek to headwaters)	23	0.11	1.023×10^{7}	2.59×10^{7}
Rio Grande (Ohkay Owingeh bnd to Embudo Creek)	25⁺	222	1.023×10^{7}	5.68×10^{10}
Rio Grande (Santa Clara Pueblo bnd to Ohkay Owingeh bnd)	22*⁺	295	1.023×10^{7}	6.64×10^{10}
Rio Medio (Rio Frijoles to headwaters)	23	3.21	1.023×10^{7}	7.55×10^{8}
Rio Nambe (Nambe Pueblo bnd to headwaters)	20*	1.59	1.023×10^{7}	3.25×10^{8}
Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	23	5.42	1.023×10^{7}	1.28×10^{9}

*⁺ Segment-specific criterion. *Chronic criterion used as a goal for TMDL.*

The TMDL is further allocated to a Margin of Safety (MOS), Waste Load Allocation (WLA; permitted point sources), and Load Allocation (LA; nonpoint sources), according to the formula:

$$WLA + LA + MOS = TMDL$$

7.3.1 Margin of Safety (MOS)

The CWA requires that each TMDL be calculated with a MOS, 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.

An implicit MOS for the Rio Grande (Santa Clara Pueblo bnd to Ohkay Owingeh bnd) and Rio Nambe (Nambe Pueblo bnd to headwaters) TMDLs is introduced by using the chronic criteria as T_{MAX} targets. This implicit MOS may serve to offset uncertainty about irrigation withdrawals below the Chamita and Embudo gages.

Because of the uncertainty in determining critical low flow, an **explicit MOS of 5%** is assigned to the TMDLs where gage data was available. An **explicit MOS of 10%** is assigned to the TMDL for Grassy Creek, where the critical flow was estimated using the Waltemeyer regression.

In recognition of the likelihood of future increases to air temperature and evaporative demand, an **additional explicit 10% MOS** is added for each AU for climate change.

7.3.2 Waste Load Allocation (WLA)

There are no active individual National Pollutant Discharge Elimination System (NPDES) individual permits that discharge to the temperature TMDL AUs. The City of Española WWTP discharges to the Rio Grande within Santa Clara Pueblo, just downstream of the Rio Grande (Santa Clara Pueblo bnd to Ohkay Owingeh bnd) AU, and therefore does not require a WLA. There are no Municipal Separate Storm Sewer System (MS4) permits in these AUs. Therefore, no WLA is assigned.

There may be storm water discharges from industrial, including construction, activities covered under the National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP) or Multi-Sector General Permit (MSGP). Excess temperature loading may be a component of some storm water discharges covered under general NPDES permits. Stormwater discharges from industrial, including construction, activities are generally considered transient because they occur mainly during the construction itself and/or only during storm events.

Coverage under the USEPA NPDES CGP for construction sites one acre or greater or smaller if part of a common plan of development require preparation of a Storm Water Pollution Prevention Plan (SWPPP) that includes identification and control of pollutants associated with the construction activities to minimize impacts to water quality. The current CGP also includes state-specific requirements to implement site-specific interim and permanent stabilization, managerial, and structural solids, erosion, and sediment control Best Management Practices (BMPs), and/or other controls. BMPs are designed to prevent to the maximum extent practicable an increase in sediment load to the water body or an increase in a sediment-related parameter, such as total suspended solids, turbidity, siltation, stream bottom deposits, etc. BMPs also include measures to reduce flow velocity during and after construction compared to pre-construction conditions. Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the current NPDES MSGP. The MSGP also requires preparation of a SWPPP. Some of the industrial facilities and activities covered under the MSGP have technology based effluent limitation and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values reflect State of New Mexico WQS.

It is not possible to calculate individual WLAs for facilities covered by the General Permits at this time using the available tools. Loads that are in compliance with the General Permits are therefore currently included as part of the Load Allocation (LA). While these sources are not given individual allocations, they are addressed through other means, including BMPs, stormwater pollution prevention conditions, and other requirements. State certification of federal permits ensure that applicable water quality standards, including the antidegradation policy, are met. Compliance with a CGP or MSGP SWPPP that meets the requirements of the general permits is generally assumed to be consistent with this TMDL.

7.3.3 Load Allocation (LA)

Load Allocation is pollution from any nonpoint source(s) or natural background and is addressed through Best Management Practices (BMPs). Since there are no WLAs for these AUs, the LA is equal to the TMDL value minus the MOS.

Table 7.6 Temperature TMDL load allocations. Units are kilojoules per day.

Assessment Unit	MOS	WLA	LA	TMDL
Grassy Creek (Comanche Creek to headwaters)	5.18×10^6	0	2.07×10^7	2.59×10^7
Rio Grande (Ohkay Owingeh bnd to Embudo Creek)	8.52×10^9	0	4.82×10^{10}	5.68×10^{10}
Rio Grande (Santa Clara Pueblo bnd to Ohkay Owingeh bnd)	9.96×10^9	0	5.64×10^{10}	6.64×10^{10}
Rio Medio (Rio Frijoles to headwaters)	1.13×10^8	0	6.42×10^8	7.55×10^8
Rio Nambe (Nambe Pueblo bnd to headwaters)	4.89×10^7	0	2.76×10^8	3.25×10^8
Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	1.92×10^8	0	1.09×10^9	1.28×10^9

7.4 Identification and Description of Pollutant Source(s)

SWQB conducted an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Revision 2, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; see also **Appendix B**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. The list of probable sources is not intended to single out any particular landowner or land management activity and generally includes several sources per pollutant.

Table 7.7 displays probable pollutant sources that have the potential to contribute to temperature impairments. The draft probable source list will be reviewed and modified, as necessary, with watershed group/stakeholder input during the TMDL public meeting and comment period. Probable sources of temperature impairments can be further evaluated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

Table 7.7 Probable sources of excessive temperature for Upper Rio Grande basin TMDL Assessment Units.

Assessment Unit	Probable Sources
Grassy Creek (Comanche Creek to headwaters)	Grazing in riparian zone; Loss of riparian habitat
Rio Grande (Ohkay Owingeh bnd to Embudo Creek)	Crop production; Dams/impoundments; Drought; Highway/road/bridge runoff; Loss of riparian habitat; Rural residential area; Site clearance; Streambank modification; Water diversion
Rio Grande (Santa Clara Pueblo bnd to Ohkay Owingeh bnd)	Crop production; Dams/impoundments; Inappropriate waste disposal; Loss of riparian habitat; Pavement/impervious surfaces; Rural residential area; Sand/gravel/rock mining or quarries; Site clearance; Streambank modification; Water diversion
Rio Medio (Rio Frijoles to headwaters)	Crop production; Dam/impoundment; Drought; Forest fire (2002, 2013); Grazing in riparian zone; Habitat modification (Exotic species); Loss of riparian habitat; Rural residential area; Site clearance; Water diversion
Rio Nambe (Nambe Pueblo bnd to headwaters)	Drought; Fire suppression; Forest fire (2003, 2011); Other recreation (hiking trails); Rangeland grazing
Santa Cruz River (Santa Cruz Reservoir to Rio Medio)	Drought; Highway/road/bridge runoff; Other recreation (angling, hiking trails)

A variety of factors can impact stream temperature (**Figure 7.1**). Decreased effective shade levels may result from reduction of riparian vegetation. When canopy densities are reduced, thermal loading increases in response to the increase in incident solar radiation. Likewise, it is well documented that past hydromodification activities have led to channel incision and widening. Wider stream channels also increase the stream surface area exposed to sunlight, thereby increasing heat transfer. Riparian area and channel morphology disturbances may also be attributed to past or 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 influx, and (2) increasing stream surface area exposed to solar radiation.

Riparian vegetation, stream morphology, hydrology, climate, geographic location, and aspect all 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, elevated summertime stream temperatures attributable to anthropogenic causes may 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;

3. Reduced summertime base flows that result from instream impoundments and withdrawals and/or inadequate riparian vegetation; and,
4. Inflow from heated surfaces, such as road pavement, buildings, bare land, etc. and the flow of water over hardened channel bottoms and walls.

Loss of a functioning riparian system may lower and sometimes eliminate baseflows. Although removal of upland vegetation has been shown, in some cases, 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 reaches, where the stream loses water through infiltration to the surrounding ground as it flows downstream, increased temperatures can result in increased streambed infiltration, which can result in lower base flow (Constrantz et al., 1994).

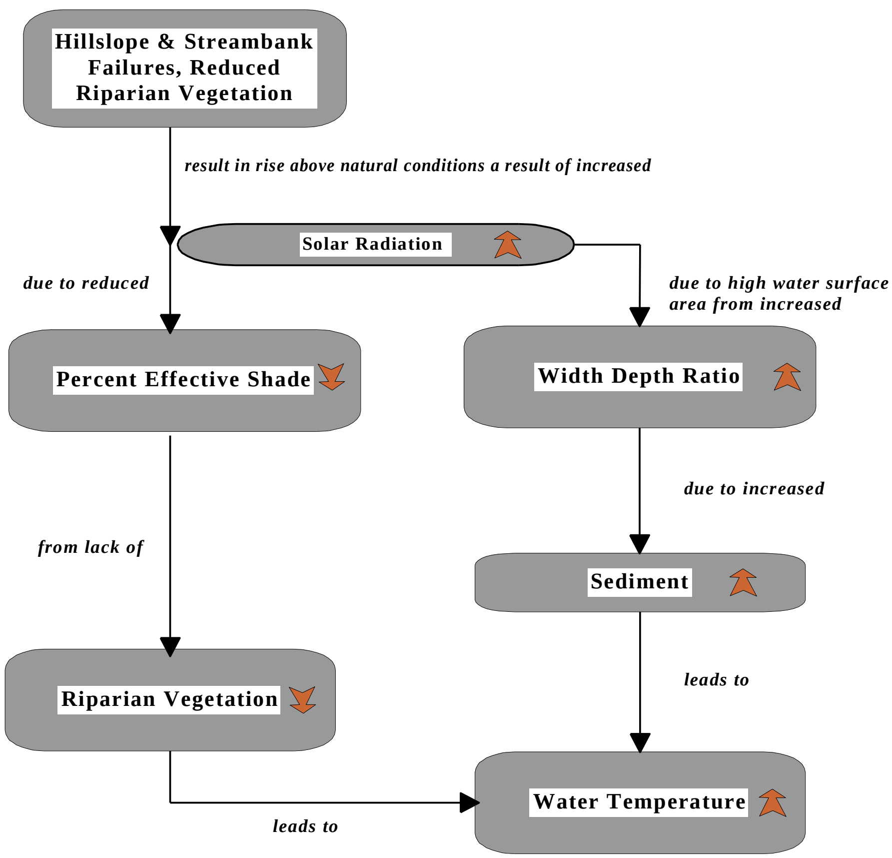

Figure 7.1 Factors Impacting Stream Temperature

Vegetation density increases will provide necessary shading, as well as encourage bank-building processes in severe hydrologic events (see Section 6 of this report for modeling of shade increases to reduce water temperature). However shade is only one avenue which may be pursued to decrease water temperature and ultimately meet WQS. Changes in geomorphological parameters might also prove useful. For example, unstable channels may be characterized by excess sedimentation. Many aquatic organisms respond to high temperature by seeking thermal refuge, moving into cooler tributaries or small cold patches within the stream. Creation of thermal refuges, or enhanced connectivity, may mitigate the effects of increased water temperature (Caissie, 2006).

Water temperature in Grassy Creek, Rio Medio and Rio Nambe might benefit from increases in riparian vegetation, as well as actions to reduce sediment delivery and improve geomorphic stability. There is little opportunity for additional vegetation or channel restoration on the Santa Cruz River (Santa Cruz Reservoir to Rio Medio), which is a very short AU confined by bedrock. Probably the best way to decrease water temperature there would be to correct the temperature impairment of the Rio Medio, which contributes approximately 60% of the flow. Other actions might include stabilizing the well-used footpath along the Santa Cruz above the reservoir, and reducing runoff from State Road 503. Increased shade is not likely to directly decrease water temperature in the two impaired Rio Grande AUs, because of the width of the river, however riparian habitat restoration could decrease sediment delivery as well as reducing the temperature of interconnected shallow groundwater. Encouraging beaver activity in the bosque would help to provide temperature refugia for fish by increasing the number of bank burrows.

The U.S. Army Corps of Engineers has proposed to construct 280 acres of habitat measures to restore the bosque in the floodplain communities of the Pueblos of Ohkay Owingeh and Santa Clara by (1) improving hydrologic function by constructing grade restoration facilities (GRFs), high-flow channels, terrace lowering, willow swales, ponds, and wetlands, and (2) restoring native vegetation and habitat by removing exotic species, and restoring riparian gallery forest (USACE, 2017). The Espanola Valley Ecosystem Restoration Project has been fully funded. As of the summer of 2021, the Corps are working with the pueblos on agreements and schedule. The GRFs likely will require additional design work. Vegetation and other features may start implementation within a year. These actions will not affect the Rio Grande (Ohkay Owingeh bnd to Embudo Creek) AU, which is upstream of the project area, but should reduce water temperatures in the Rio Grande (Santa Clara Pueblo bnd to Ohkay Owingeh bnd) AU. The next downstream AU of the Rio Grande over which NMED has jurisdiction is Rio Grande (Cochiti Reservoir to San Ildefonso bnd). It is also temperature impaired and is likely to benefit from the USACE project.

Wildfires can affect the physical, chemical, and biological quality of streams, rivers, and lakes. After a fire, increased runoff provides the pathway for the transport of chemical-laden sediment to surface water, which may have substantial water quality impacts. Forest fires can result in increased water temperature due to reduced infiltration and loss of shading vegetation. Potential wildfire impacts to water quality are discussed on the SWQB website at https://www.env.nm.gov/surface-water-quality/wildfire-impacts-on-surface-water-quality/. Most watershed effects will naturally recover within 5 to 10 years after the fire, but some aspects of watershed structure and function, as well as areas of most severe fire intensity, may continue to recover for 15-20 years (Bixby et al., 2015). Therefore, runoff following forest fire has been added to the Probable Source list (**Table 7.7**) for those TMDL AUs where fires occurred during the 20 years preceding the 2017-18 water quality survey.

7.5 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 variations." Both stream temperature and flow vary seasonally and from year to year. Water temperatures are coolest in the winter and early spring months. Future climate change is expected to increase air temperatures and decrease streamflow, potentially leading to increases in maximum water temperature.

The warmest stream temperatures correspond to prolonged solar radiation exposure, warmer air temperature, and low flow conditions. Maximum temperatures were recorded in the TMDL AUs during the time period of late June to late July, in both 2017 and 2018.

7.6 Future Growth

SWQB acknowledges the projected impact of climate change on the state's water resources. Climate change will put additional stress on New Mexico's water resources and make attainment of water quality standards more difficult to achieve. In addition, shifting temperature and precipitation patterns affect vegetative composition and density and increase wildfire intensity and the propensity for wildfire in non-fire adapted ecosystems. In 2019, Governor Lujan Grisham signed Executive Order 2019-003 on Addressing Climate Change and Energy Waste Prevention. Executive order 2019-003 directs all State agencies to evaluate the impacts of climate change on their programs and operations and integrate climate change mitigation and adaptation practices into their programs and operations.

In general, the strongest influence on in-stream water temperature is the ambient air temperature. Stakeholders should explore options to determine the most appropriate approach for each particular watershed or project, with the ultimate goal being that the stream meets the WQS. The SWQB encourages implementation practitioners to design projects to reduce water temperature well below the WQS, such that currently impaired AUs will be likely to meet WQS standards in the future with sufficient resiliency to warmer air temperatures and potentially lower flows.

Growth estimates by county are available from the University of New Mexico Geospatial and Population Studies (GPS) (https://gps.unm.edu/pru/projections, accessed 5/19/22). These estimates project growth to the year 2040. The Grassy Creek (Comanche Creek to headwaters) AU falls within Taos County. The Rio Grande (Ohkay Owingeh bnd to Embudo Creek) and Rio Grande (Santa Clara Pueblo bnd to Ohkay Owingeh bnd) are in Rio Arriba County. The Rio Medio (Rio Frijoles to headwaters) flows through both Rio Arriba and Santa Fe Counties. The Rio Nambe (Nambe Pueblo bnd to headwaters) and Santa Cruz River (Santa Cruz Reservoir to Rio Medio) AUs are in Santa Fe County.

GPS projects that Santa Fe County will continue to grow, while the populations of Taos and Rio Arriba Counties will decline, as detailed on **Table 7.8**. Future population change will have only indirect bearing on water quality in Grassy Creek since it is located in an unpopulated headwaters area of the Carson National Forest.

Table 7.8 County Population Estimates

County	2020	2025	2030	2035	2040	Change (2020-2040)
Taos	32,795	32,635	32,360	31,938	31,412	- 4.2%
Rio Arriba	38,721	37,883	36,903	35,752	34,485	-10.9%
Santa Fe	150,488	153,311	155,641	157,291	158,420	5.3%

Estimates of future growth are not anticipated to lead to a significant increase in in-stream temperatures that cannot be controlled with BMP implementation. BMPs should be utilized and improved upon while continuing to improve watershed conditions and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

8.0 TURBIDITY

Turbidity is an expression of the optical property in water that causes incident light to be scattered and absorbed rather than transmitted in straight lines. It is a 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.

The impacts of suspended sediment and turbidity are well documented in the scientific literature. An EPA monitoring guidelines report states that increased sediment load is often the most important adverse effect of human activities on streams (USEPA, 1991). An increase in suspended sediment concentration will reduce the penetration of light, decrease the ability of fish or fingerlings to capture prey, and reduce primary production (USEPA, 1991). As stated by 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 autotrophs to substrate surfaces.”

8.1 Target Loading Capacity

The New Mexico WQS has general criteria applicable to all waters of the state. The general narrative standard at 20.6.4.13(J) NMAC 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 assessment approach used to determine impairments of the narrative turbidity standard is described in detail in the Comprehensive Assessment and Listing Methodology (NMED/SWQB, 2019a). Target values for this TMDL were based on the turbidity thresholds identified in the CALM. It relies upon the use of biotranslators to derive numeric thresholds from the narrative standard above. A biotranslator is a physical or chemical water quality parameter that has been isolated and effects an impairment of a quantifiable attribute of an indicator organism. In some cases, the quantifiable attribute may be the lethal dose or concentration of the parameter. In the case of turbidity, the attribute is typically based upon observed behavior and the Severity of Ill Effects (“SEV”) index.

A SEV index of 3.5 was selected to develop thresholds for turbidity impairment in New Mexico. This SEV index value corresponds to the boundary between conditions that effect changes to feeding in aquatic organisms and conditions that have been found to reduce growth rate and habitat size. The relationship between turbidity, duration, and a SEV of 3.5 is given in Equation 8.1, where x is duration in hours and y is the turbidity in Nephelometric Turbidity Units (NTUs) for durations from 7 hours to 720 hours. Shorter-term turbidity excursions are unlikely to impair the growth, function, and reproduction of aquatic life as required by New Mexico’s narrative turbidity water quality standard, while thresholds for durations longer than 720 consecutive hours result in turbidity values that are lower than supported by literature available at the time of the assessment protocol development. The CALM provides a series of turbidity thresholds and durations which are listed in **Table 8.1**.

Equation 8.1

$$x = 37{,}382y^{-1.9887}$$

Where:
x = duration (hours)
y = turbidity (NTU)

Applicable for durations between 7 and 720 hours.

Table 8.1 Turbidity impairment thresholds and durations

Turbidity Threshold (NTU)	Allowable Duration (consecutive hours)	Allowable Duration (consecutive days)
23	72	3
20	96	4
18	120	5
16	144	6
15	168	7
11	336	14
7	720	30

NTU = Nephelometric Turbidity Units

The loading capacity, or TMDL, is the maximum amount of pollutant that a waterbody can receive, at a specific flow, while meeting its water quality objectives. The Red River (Rio Grande to upstream mine boundary) and Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo) turbidity-impaired AUs are designated for coldwater aquatic life use. The other turbidity-impaired AUs in this TMDL document are designated high quality coldwater. The most representative fish to use in determining the appropriate turbidity thresholds for coldwater aquatic life stream segments are salmonids, as that group constitutes the majority of New Mexico's coldwater fish species, and a majority of studies on turbidity in fish have been conducted with them. The numeric thresholds in the CALM have also been supported with studies of turbidity effects on benthic macroinvertebrates.

Turbidity was measured using multiparameter sondes. During the sonde deployments, turbidity exceeded one or more thresholds on **Table 8.1**. Because a TMDL requires a mass-based numeric loading component which cannot be directly derived from turbidity, Total Suspended Solids (TSS) is used as a turbidity surrogate. TSS is a commonly used measurement of suspended material in surface water because it is acceptable for regulatory purposes and is an inexpensive laboratory procedure. Where there are no facilities with NPDES permits discharging into or upstream of the impaired AU, it is assumed that TSS measurements in these ambient stream samples are representative of erosional activities, re-suspension of bedded sediments, or biosolids from livestock and wildlife.

A close relationship can typically be found between turbidity and TSS in a watershed or waterbody. Hence, suspended sediment levels may be inferred from turbidity studies; alternatively, turbidity levels may 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). TSS grab samples and simultaneous turbidity results from the 2017-18 water quality survey are shown in **Appendix A**. The R^2 (coefficient of determination) value is a measure of how well a dataset fits the applied model; R^2 values approaching one represent better fits than R^2 values closer to zero. Based on the R^2 value, equations offering the best fit for the data were selected. The regression equations and statistics for the TMDL AUs are displayed in **Appendix A.**

8.2 Flow

The TMDL is a value calculated at a defined critical flow condition as part of a planning process designed to achieve water quality standards. For these turbidity TMDLs, the appropriate critical flow condition is at low flow in order to be protective when the assimilative capacity of a stream is at its lowest. According to the New Mexico Water Quality Standards, the low flow critical condition for numeric criteria (excluding human health-organism only criteria) set in 20.6.4.97 through 20.6.4.900 NMAC and 20.6.4.13(F) NMAC is defined as the 4-day, 3-year low-flow frequency (4Q3, 20.6.4.11(B)(2) NMAC). The 4Q3 is the annual lowest four consecutive day flow that occurs with a frequency of at least once every three years.

As shown on **Table 8.2**, critical flow was determined from USGS discharge gage data, using the DFLOW software program, where gage data was available (USGS gage locations are shown on **Figures 1.1-1.3**). The 4Q3 value was converted from cubic feet per second (cfs) to units of million gallons per day (mgd) using the conversion factor 0.646.

Table 8.2 Critical flow for turbidity-impaired Assessment Units with USGS gage data available.

Assessment Unit	USGS Gage	4Q3 (cfs)	4Q3 (mgd)
Red River (Rio Grande to Placer Creek)	USGS 08266820 RED RIVER BELOW FISH HATCHERY, NEAR QUESTA, NM	29.8	19.25
Rio Frijoles (Rio Medio to Pecos Wilderness)*	08291000 SANTA CRUZ RIVER NEAR CUNDIYO, NM	2.21	1.43
Rio Medio (Rio Frijoles to headwaters)*	08291000 SANTA CRUZ RIVER NEAR CUNDIYO, NM	3.21	2.07
Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)**	08276300 RIO PUEBLO DE TAOS BELOW LOS CORDOVAS, NM	5.58	3.60

** USGS gage 08291000 is just below the junction of the Rio Frijoles and the Rio Medio, where they come together to form the Santa Cruz River. The 4Q3 gage flow was split between the two AUs proportional to their drainage areas.*
*** Gage is upstream of the AU.*

The critical flow value used to calculate the turbidity TMDL for AUs without available gage data, was obtained using a regression model. An analysis method developed by Waltemeyer (2002) was used to estimate the critical low flow. In Waltemeyer's analysis, two regression equations for estimating 4Q3 were developed based on physiographic regions of NM (i.e., statewide and mountainous regions above 7500 ft in elevation). The average elevation of each of the turbidity impaired watersheds is above 7500 ft, so the mountainous regions regression equation was used. The following mountainous regions regression equation (**Equation 8.2**) is based on data from 40 gaging stations located above 7500 ft in elevation with non-zero discharge (Waltemeyer, 2002):

Equation 8.2 $4Q3 = 7.3287 \times 10^{-5} DA^{0.70} {P_w}^{3.58} S^{1.35}$

Where:

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

The 4Q3 values calculated using Waltemeyer's method are presented in **Table 8.3**. Variables for input to the Waltemeyer equation were obtained using the USGS StreamStats web tool (https://streamstats.usgs.gov/ss/). The critical flow was converted from cubic feet per second (cfs) to million gallons per day (mgd) using a conversion factor of 0.646. The TMDL itself is a value calculated at a defined critical condition as part of a 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 and achieve WQS is the goal of SWQB efforts.

Table 8.3 Calculation of 4Q3 critical flow for turbidity TMDLs without available gage data

Assessment Unit	Average Elevation (ft)	Drainage Area (mi^2)	Average Basin Slope (ft/ft)	Mean Winter Precipitation (in)	4Q3 (cfs)	4Q3 (MGD)
Chuckwagon Creek (Comanche Creek to headwaters)	10000	1.25	0.33	13.4	0.21	0.14
Placer Creek (Red River to headwaters)	10300	2	0.32	14.5	0.37	0.24
Sanchez Canyon (Costilla Creek to headwaters)	9710	7.83	0.3	11.8	0.42	0.27

8.3 TMDL Calculations

Because impairment of a waterbody is dependent on the duration of elevated turbidity, a separate TMDL has been determined for each NTU/duration threshold identified in the turbidity assessment protocol. These TMDLs were developed using the turbidity/duration thresholds identified in the SWQB turbidity assessment protocol (NMED/SWQB, 2015a), the site-specific relationship between turbidity and TSS, the 4Q3 flow condition, and a unit conversion factor to correct the TMDL units into pounds per day (lb/day).

First, using the regression equations shown in **Appendix A**, TSS concentrations for each turbidity threshold were calculated (**Table 8.4**). Then, the 4Q3 critical low flow from Section 8.2, above, and the TSS threshold values were substituted into **Equation 8.3** to determine the TMDL at each turbidity/duration threshold (**Table 8.4**). Note that each TMDL is for a particular turbidity/duration pairing. It should not be extrapolated to longer or shorter durations.

Equation 8.3

$$Critical\ Flow\ (mgd) \times WQS\ (mg/L) \times Unit\ Conversion\ Factor\ (8.34) = Target\ Loading\ Capacity\ (lb/day)$$

Table 8.4 Calculated TSS thresholds and Turbidity-TSS/Duration TMDLs for Upper Rio Grande basin

Assessment Unit	Turbidity (NTU)	TSS (mg/L)	TSS TMDL (lb/day)	Duration (consecutive days)
Chuckwagon Creek (Comanche Creek to headwaters)	23	15.86	18.5	3
	20	14.05	16.4	4
	18	12.84	15.0	5
	16	11.64	13.6	6
	15	11.04	12.9	7
	11	8.63	10.1	14
	7	6.22	7.26	30
Assessment Unit	**Turbidity (NTU)**	**TSS (mg/L)**	**TSS TMDL (lb/day)**	**Duration (consecutive days)**
Placer Creek (Red River to headwaters)	23	6.83	13.7	3
	20	6.68	13.4	4
	18	6.57	13.2	5
	16	6.45	12.9	6
	15	6.38	12.8	7
	11	6.05	12.1	14
	7	5.57	11.2	30
Assessment Unit	**Turbidity (NTU)**	**TSS (mg/L)**	**TSS TMDL (lb/day)**	**Duration (consecutive days)**
Red River (Rio Grande to Placer Creek)	23	48.73	7820	3
	20	42.41	6810	4
	18	38.19	6130	5
	16	33.97	5450	6
	15	31.87	5120	7
	11	23.44	3760	14
	7	15.01	2410	30

Assessment Unit	Turbidity (NTU)	TSS (mg/L)	TSS TMDL (lb/day)	Duration (consecutive days)
Rio Frijoles (Rio Medio to Pecos Wilderness)	23	28.90	345	3
	20	25.53	304	4
	18	23.28	278	5
	16	21.04	251	6
	15	19.91	238	7
	11	15.42	184	14
	7	10.93	130	30
Assessment Unit	**Turbidity (NTU)**	**TSS (mg/L)**	**TSS TMDL (lb/day)**	**Duration (consecutive days)**
Rio Medio (Rio Frijoles to headwaters)	23	30.82	532	3
	20	23.99	414	4
	18	20.30	350	5
	16	17.18	297	6
	15	15.80	273	7
	11	11.32	195	14
	7	8.10	140	30
Assessment Unit	**Turbidity (NTU)**	**TSS (mg/L)**	**TSS TMDL (lb/day)**	**Duration (consecutive days)**
Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)	23	25.39	762	3
	20	20.60	619	4
	18	17.92	538	5
	16	15.59	468	6
	15	14.54	437	7
	11	11.00	330	14
	7	8.33	250	30
Assessment Unit	**Turbidity (NTU)**	**TSS (mg/L)**	**TSS TMDL (lb/day)**	**Duration (consecutive days)**
Sanchez Canyon (Costilla Creek to headwaters)	23	222.03	500	3
	20	122.44	276	4
	18	82.34	185	5
	16	55.37	125	6
	15	45.41	102	7
	11	20.53	46.2	14
	7	9.29	20.9	30

The TMDL is further allocated to a MOS, WLA (permitted point sources), and LA (non-point sources), according to the formula: *WLA + LA + MOS = TMDL* .

8.3.1 Margin of Safety

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source loading estimates, and the model analysis. The MOS can be expressed implicitly, explicitly, or a combination of the two. An implicit MOS is incorporated by making conservative assumptions in the TMDL analysis, such as allocating a conservative load to background sources. An explicit MOS is applied by reserving a portion of the TMDL and not allocating it to any other sources.

The MOS for these TMDLs was developed using a combination of conservative assumptions and allocating an explicit portion of the TMDL in recognition of potential errors. Therefore, this MOS is the sum of the following two elements:

Implicit Margin of Safety

- TSS is a conservative parameter that does not settle out of the water column.

Explicit Margin of Safety

- Uncertainty exists in the relationship between TSS and turbidity. A conservative MOS for this element is **5%**.

- There is inherent error in all flow calculations. A conservative MOS for this element for AUs which used the regression equation to determine critical flow is therefore **10%**. A conservative MOS for this element for AUs which used gage data is **5%**.

Total MOS for TMDLs where flow was estimated using a regression equation is **15%.** Total MOS for TMDLs where gage data was available is **10%**.

8.3.2 Waste Load Allocation

There are no active individual NPDES point source contributions associated with the TMDLs for Chuckwagon Creek, Placer Creek, Rio Frijoles, Rio Medio, Rio Pueblo de Taos, or Sanchez Canyon, therefore the WLA for all of these streams is zero.

There are three facilities with NPDES Individual Permits which discharge into the Red River (Rio Grande to Placer Creek) AU. From upstream to downstream, they are the Town of Red River WWTP (Permit NM0024899, 1 outfall), Chevron Mining, Inc./Questa Mine (Permit NM0022306, 4 outfalls), and the NMDGF/Red River State Fish Hatchery (Permit NM0030147, 3 outfalls). The outfall locations for these sources are shown on **Figures 1.1-1.3**. The Town of Questa operates WWTP lagoons along the Red River, but this facility does not have a discharge permit and does not have authorized point source discharge into the Red River, therefore no WLA will be assigned to the Questa WWTP. Monthly average discharge limits for TSS at the Red River WWTP, the Questa Mine outfalls, and the fish hatchery are listed in **Table 8.5**.

Table 8.5 Red River NPDES discharge limits for Total Suspended Solids.

Outfall	Permit Number	Effective Date	Expiration Date	Design Flow (mgd)	TSS Permit Limit
Red River WWTP	NM0024899	5/1/2017	4/30/2022	0.9	30 mg/L (30-day average) 45 mg/L (7-day average)
Questa Mine 001	NM0022306	11/1/2013, modified 6/1/2016	10/31/2018	none listed*	20 mg/L (monthly average) 30 mg/L (daily max)
Questa Mine 002				none listed*	20 mg/L (monthly average) 30 mg/L (daily max)
Questa Mine 004				none listed*	20 mg/L (monthly average) 30 mg/L (daily max)
Questa Mine 005				none listed*	20 mg/L (monthly average) 30 mg/L (daily max)
Red River State Fish Hatchery	NM0030147	11/1/2017	10/31/2022	10.717	10 mg/L (daily average) 15 mg/L (daily max)

**October 2018-November/December 2021 DMR flow data summarized below*

The Red River WWTP permit (NM0024899) specifies a design flow of 0.9 MGD. According to Discharge Monitoring Report data, during the reporting period May 2017 through March 2022, the 30-day average TSS concentration ranged from 1.3 to 21.5 mg/L, never exceeding the permit concentration limit. Reported 7-day averages ranged from 1.8 to 39.67 mg/L, never exceeding the permit concentration limit. Neither the 30-day average nor the 7-day average load limits (157.7 and 236.6 lb/day, respectively) were exceeded at any time during the reporting period. The highest concentrations and loads were reported in the summer of 2017; there has been no apparent trend since then.

The Chevron Mining-Questa Mine permit (NM0022306) lists four outfalls (001, 002, 004, 005). According to Discharge Monitoring Report data, the average reported daily maximum flow was 1.41 mgd for 001 (October 2018-November 2021) and 0.24 mgd for 002 (October 2018-December 2021). Zero discharge was reported for both 004 and 005 for the October 2018-December 2021 period. Therefore, the total average reported daily maximum discharge flow data reported for the four outfalls is 1.66 mgd. Discharge monitoring report (DMR) data from October 2018-November 2021 show that TSS concentration was below the detection limit (<4 mg/L) for all reports.

The Red River State Fish Hatchery (NM0030147) has three outfalls (001, 002, and 003); the flow listed in the permit (10.717 mgd) is the highest monthly average flow from outfall 001. This flow value listed in the permit for outfall 001 is a composite of the three permitted outfalls. Discharge Monitoring Report (DMR) data from September 2019 through September 2021 show that daily effluent TSS loads were below the detection limit (<3 mg/L) for all reports, except for one excursion in April 2020, when it was 4.5 mg/L daily average, or 6 mg/L daily maximum.

Table 8.6 TSS Waste Load Allocations (lb/day) for Red River NPDES permits

Duration (consecutive days)	TSS (mg/L)	Red River WWTP-NM0024899 (0.9 mgd flow)	Questa Mine-NM0022306 (1.66 mgd flow)	Red River Hatchery-NM0030147 (10.717 mgd flow)	Combined WLA
3	48.73	366	675	4355	5396
4	42.41	318	587	3791	4696
5	38.19	287	529	3413	4229
6	33.97	255	470	3036	3761
7	31.87	239	441	2849	3529
14	23.44	176	325	2095	2596
30	15.01	113	208	1341	1662

Sediment and associated contaminants are considered components of industrial storm water discharges covered under NPDES General Permits. Stormwater discharges from construction activities are transient, occurring mainly during the construction itself, and then only during storm events. Coverage under the NPDES Construction General Permit (CGP) for construction sites greater than one acre, or less than one acre if they are part of a common plan of development, 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. The 2022 CGP also includes state-specific requirements to implement site-specific interim and permanent stabilization, and managerial and structural solids, erosion, and sediment control Best Management Practices (BMPs), and/or other controls. The SWPPP must include site-specific interim and permanent stabilization, managerial, and structural solids, erosion and sediment control BMPs and/or other controls that are designed to prevent to the maximum extent practicable an increase in the sediment yield and flow velocity from pre-construction, pre-development conditions to assure that applicable standards in 20.6.4 NMAC, including the antidegradation policy, and TMDL WLAs are met. This requirement applies to discharges both during construction and after construction operations have been completed. Currently in the 2022 CGP, EPA defines "sediment-related parameter" as a pollutant parameter that is closely related to sediment such as turbidity, total suspended solids (TSS), total suspended sediment, transparency, sedimentation, and siltation. For discharge covered under the CGP to a water that is impaired for a parameter other than a sediment-related parameter or nutrients, EPA will inform the operator if any additional controls are necessary to meet water quality standards.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the 2021 NPDES Multi-Sector General Permit (MSGP). The MSGP also requires preparation of a SWPPP. Based on the industrial sector, some of the industrial facilities and activities covered under the MSGP have technology based effluent limitation and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values reflect State of New Mexico WQS. .

It is not possible to calculate individual WLAs for facilities covered by the General Permits at this time using the available tools. The discharges from these permits are typically transitory as the activities are temporary. Loads that are in compliance with the General Permits are therefore currently included as part of the Load Allocation (LA). While these sources are not given individual allocations, they are addressed through other means, including BMPs, stormwater pollution prevention conditions, and other requirements.

8.3.3 Load Allocation

The Load Allocation (LA) accounts for pollution from any non-point source(s) or natural background and is addressed through Best Management Practices. Where there are no WLAs, the LA is equal to the TMDL value minus the MOS, as shown on **Table 8.7**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see Section 8.3.1 for details). Where there are WLAs, the LA is equal to the TMDL minus the MOS and the WLA.

Table 8.7 TMDL TSS Allocations for Turbidity (all units in lb/day)

Assessment Unit	**Load Allocation**				
Chuckwagon Creek (Comanche Creek to headwaters)	**Duration (consecutive days)**	**WLA**	**MOS (15%)**	**LA**	**TMDL**
	3	0.00	2.78	15.72	18.5
	4	0.00	2.46	13.94	16.4
	5	0.00	2.25	12.75	15.0
	6	0.00	2.04	11.56	13.6
	7	0.00	1.94	10.96	12.9
	14	0.00	1.52	8.58	10.1
	30	0.00	1.09	6.17	7.26
Assessment Unit	**Load Allocation**				
Placer Creek (Red River to headwaters)	**Duration (consecutive days)**	**WLA**	**MOS (15%)**	**LA**	**TMDL**
	3	0.00	2.06	11.64	13.7
	4	0.00	2.01	11.39	13.4
	5	0.00	1.98	11.22	13.2
	6	0.00	1.94	10.96	12.9
	7	0.00	1.92	10.88	12.8
	14	0.00	1.82	10.28	12.1
	30	0.00	1.68	9.52	11.2
Assessment Unit	**Load Allocation**				
Red River (Rio Grande to Placer Creek)	**Duration (consecutive days)**	**Combined WLA***	**MOS (10%)**	**LA**	**TMDL**
	3	5396	782	1642	7820
	4	4696	681	1433	6810
	5	4229	613	1288	6130
	6	3761	545	1144	5450
	7	3529	512	1079	5120
	14	2596	376	788	3760
	30	1662	241	507	2410
**** Individual WLAs discussed above in Section 8.3.2***					

Assessment Unit	Load Allocation				
Rio Frijoles (Rio Medio to Pecos Wilderness)	**Duration (consecutive days)**	**WLA**	**MOS (10%)**	**LA**	**TMDL**
	3	0.00	34.5	310.5	345
	4	0.00	30.45	273.6	304
	5	0.00	27.8	250.2	278
	6	0.00	25.1	225.9	251
	7	0.00	23.8	214.2	238
	14	0.00	18.4	165.6	184
	30	0.00	13.0	117.0	130
Assessment Unit	**Load Allocation**				
Rio Medio (Rio Frijoles to headwaters)	**Duration (consecutive days)**	**WLA**	**MOS (10%)**	**LA**	**TMDL**
	3	0.00	53.2	478.8	532
	4	0.00	41.4	372.6	414
	5	0.00	35.1	315.0	350
	6	0.00	29.7	267.3	297
	7	0.00	27.3	245.7	273
	14	0.00	19.5	175.5	195
	30	0.00	14.0	126.0	140
Assessment Unit	**Load Allocation**				
Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)	**Duration (consecutive days)**	**WLA**	**MOS (10%)**	**LA**	**TMDL**
	3	0.00	76.2	685.8	762
	4	0.00	61.9	557.1	619
	5	0.00	53.8	484.2	538
	6	0.00	46.8	421.2	468
	7	0.00	43.7	393.3	437
	14	0.00	33.0	297.0	330
	30	0.00	25.0	225.0	250
Assessment Unit	**Load Allocation**				
Sanchez Canyon (Costilla Creek to headwaters)	**Duration (consecutive days)**	**WLA**	**MOS (15%)**	**LA**	**TMDL**
	3	0.00	75.0	425.0	500
	4	0.00	41.4	234.4	276
	5	0.00	27.8	157.6	185
	6	0.00	18.8	106.0	125
	7	0.00	15.3	86.9	102
	14	0.00	6.9	39.3	46.2
	30	0.00	3.1	17.8	20.9

8.4 Identification and Description of Pollutant Sources

SWQB conducted an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Revision 2, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; see also **Appendix B**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. The list of probable sources is not intended to single out any particular landowner or land management activity and generally includes several sources per pollutant.

Table 8.8 displays probable pollutant sources that have the potential to contribute to turbidity impairment in the TMDL AUs. The draft probable source list will be reviewed and modified as necessary, with watershed group/stakeholder input during the TMDL public meeting and comment period. Probable sources of impairment will be further evaluated, validated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

Table 8.8 Probable sources of excessive turbidity for Upper Rio Grande basin TMDL Assessment Units.

Assessment Unit	Probable Sources
Chuckwagon Creek (Comanche Creek to headwaters)	Loss of riparian habitat; Grazing in riparian zone
Placer Creek (Red River to headwaters)	Abandoned mine lands; Highway/road/bridge runoff; Urban runoff
Red River (Rio Grande to Placer Creek)	Abandoned mine lands; Dams/impoundments; Habitat modification (Exotic species); Flow alteration; Highway/road/bridge runoff; Industrial point source discharge; Mine tailings; Municipal point source discharge; Natural sources; Off-road vehicles; Other recreation (angling, campgrounds, hiking trails); Permitted aquaculture; Rangeland grazing; Rural residential area; Water diversion; Wildlife other than waterfowl
Rio Frijoles (Rio Medio to Pecos Wilderness)	Forest fire (2000, 2011, 2013); Grazing in riparian zone; Habitat modification (Exotic species); Highway/road/bridge runoff; Rangeland grazing; Rural residential area; Water diversion
Rio Medio (Rio Frijoles to headwaters)	Crop production; Forest fire (2002, 2013); Grazing in riparian zone; Habitat modification (Exotic species); Loss of riparian habitat; Rural residential area; Site clearance; Water diversion
Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)	Habitat modification (Exotic species); Highway/road/bridge runoff; Inappropriate waste disposal; Rural residential area
Sanchez Canyon (Costilla Creek to headwaters)	Grazing in riparian zone; Habitat modification (Exotic species); Highway/road/bridge runoff; Rangeland grazing; Rural residential area

Non-point sources of turbidity are usually attributed to soil erosion, excess nutrients, various wastes and pollutants, and the re-suspension of sediments up into the water column during high flow events. As reflected in SWQB data, turbidity values along the impaired reaches exceeded the applicable standard for the protection of designated uses. The components of a watershed continually change through natural ecological processes such as vegetation succession, erosion, and evolution of stream channels. 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 riparian vegetation, alter the drainage of the land, channelize watercourses, withdraw water for irrigation, build towns and cities, and discharge pollutants into waterways. Disturbances may be historical or current in nature.

Wildfires can affect the physical, chemical, and biological quality of streams, rivers, and lakes. After a fire, increased runoff provides the pathway for the transport of chemical-laden sediment to surface water, which may have substantial water quality impacts. Forest fires can result in increased water temperature due to reduced infiltration and loss of shading vegetation. Potential wildfire impacts to water quality are discussed on the SWQB website at https://www.env.nm.gov/surface-water-quality/wildfire-impacts-on-surface-water-quality/. Most watershed effects will naturally recover within 5 to 10 years after the fire, but some aspects of watershed structure and function, as well as areas of most severe fire intensity, may continue to recover for 15-20 years (Bixby et al.., 2015). Therefore, runoff following forest fire has been added to the Probable Source list (**Table 8.7**) for those TMDL AUs where fires occurred in the drainage area during the 20 years preceding the 2017-18 water quality survey.

A restoration project was initiated on the Red River in 2018 as the result of a Natural Resources Damage Assessment and Restoration settlement between natural resources trustee agencies and Chevron Mining Inc. The project was selected as part of the process to compensate the public for natural resource injuries resulting from hazardous substance releases from the Questa Mine Site. The goal of the project is to restore the natural dimension, pattern and profile of the river, and to improve aquatic habitat along 11,855 linear feet of the Red River within the incorporated limits of the Village of Questa. The New Mexico Environment Department is providing technical and financial oversight for the project on behalf of the New Mexico Office of Natural Resources Trustee.

A second Red River project, implemented through a Village of Questa partnership with NM Department of Game & Fish, Trout Unlimited, Chevron/Questa Mine, Taos Soil and Water Conservation District, the Questa Economic Development Fund Board, and the Village of Questa, will implement stream restoration work between the Eagle Rock Lake area and the confluence of the Red River with Cabresto Creek. Design objectives include improved in-stream habitat, reduced stream-bank erosion, increased density & diversity of riparian vegetation, and improved public access to the river through trails and riparian treatments.

8.5 Consideration of Seasonal Variation

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs take into consideration seasonal variation in watershed conditions and pollutant loading. Higher turbidity values are typically associated with higher flows. However, as precipitation events are infrequent and transitory in nature, the 4Q3 is considered a more conservative estimate of the long-term stream condition. Since the critical flow condition is set to estimate low flow discharge, it is assumed that if critical conditions are met, coverage of any potential seasonal variation will also be met**.** Few high turbidity values were captured by SWQB survey grab sampling. Those that were recorded all occurred during the spring snowmelt period of 2017, the wetter of the two survey years.

8.6 Future Growth

Growth estimates by county are available from the University of New Mexico Geospatial and Population Studies (GPS) (https://gps.unm.edu/pru/projections, accessed 5/19/22). These estimates project growth to the year 2040. Five out of the 7 current turbidity TMDL AUs fall within Taos County. The Rio Medio (Rio Frijoles to headwaters) flows through both Rio Arriba and Santa Fe Counties and the Rio Frijoles (Rio Medio to Pecos Wilderness) is in Santa Fe County. GPS projects that Santa Fe County will continue to grow, while the populations of Taos and Rio Arriba Counties will decline, as detailed on **Table 8.9**.

Table 8.9 Water Planning Region Population Estimates

County	2020	2025	2030	2035	2040	Change (2020-2040)
Taos	32,795	32,635	32,360	31,938	31,412	- 4.2%
Rio Arriba	38,721	37,883	36,903	35,752	34,485	-10.9%
Santa Fe	150,488	153,311	155,641	157,291	158,420	5.3%

Estimates of future growth are not anticipated to lead to a significant increase in turbidity that cannot be controlled with BMP implementation. BMPs should be utilized and improved upon while continuing to improve watershed conditions and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

9.0 MONITORING PLAN

Pursuant to CWA Section 106(e)(1), 33 U.S.C. Section 1251, 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, NMSA 1978, Sections 74-6-1 to -17, 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 revised its 10-year monitoring and assessment strategy (NMED/SWQB, 2016a) and submitted it to USEPA Region 6 for review in June 2016. The strategy details both the extent of monitoring that can be accomplished with existing resources plus expanded monitoring strategies that could be implemented given additional resources. The SWQB utilizes a rotating basin approach to water quality monitoring. In this approach, a select number of watersheds are intensively monitored each year with an established return frequency of approximately every eight to ten years. The next scheduled monitoring date for the Upper Rio Grande watershed is 2027-2028.

The SWQB maintains current quality assurance and quality control plans to cover all monitoring activities. This document, called the Quality Assurance Project Plan, is updated regularly and approved by USEPA Region 6. 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 or TMDL alternatives; water bodies identified as needing ALU verification; the need to monitor unassessed perennial waters; and water bodies receiving point source discharge(s).

Once assessment monitoring is completed, those reaches showing impairment 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 Standard Operating Procedures.

Long-term monitoring for assessments will be accomplished through the establishment of sampling sites that are representative of the water body and which can be revisited approximately every eight 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.

It should be noted that a watershed would not be ignored during the years in between water quality surveys. The rotating basin program will be supplemented with other data collection efforts such as on-going studies being performed by the USGS and USEPA. Data will be analyzed and field studies will be conducted to further characterize acknowledged problems and TMDLs will be developed and implemented accordingly. Both long-term and intensive field studies can contribute to the State's Integrated 303(d)/§305(b) listing process for waters requiring TMDLs.

10.0 IMPLEMENTATION OF TMDLs

When approving TMDL documents, USEPA takes action on the TMDL, LA, WLA, and other components of the TMDL as needed (e.g., MOS and future growth). USEPA does not take action on the implementation section of the TMDL, and USEPA is not bound to implement any recommendations found in this section, in particular if they are found to be inconsistent with CWA and NPDES regulations, guidance, or policy.

10.1 Point Sources

There are four individual NPDES permits that discharge to the assessment units addressed in this document, as shown on **Table 10.1**. Calculation of Waste Load Allocations for the point sources are shown in Sections 4.3.2 and 8.3.2 of this report. Implementation of permit limits is discussed below.

Table 10.1 Individual NPDES permits

NPDES permit/ expiration date	Assessment Unit	Impairment
NM0024899 -Town of Red River Wastewater Treatment Plant	Red River (Rio Grande to Placer Creek)	Turbidity
NM0022306 - Chevron Questa Mine	Red River (Rio Grande to Placer Creek)	Turbidity
NM0030147 - Red River State Fish Hatchery	Red River (Rio Grande to Placer Creek)	Turbidity
NM0024066 -Town of Taos Wastewater Treatment Plant	Rio Pueblo de Taos (Arroyo del Alamo to R Grande del Rancho)	Plant nutrients

10.1.2 Plant Nutrients

The Town of Taos (NPDES permit NM0024066) has indicated in a 2020 letter to SWQB that they intend to request a Temporary Standard (as codified in 20.6.4 NMAC) for plant nutrients. The Town's demonstration to the NM Water Quality Control Commission (WQCC) for a Temporary Standard will need to provide evidence of: 1) how an increase in treatment cost to meet the WLA would cause substantial and widespread economic and social impact so that it can be established that no additional feasible pollutant control technology exists; 2) a statement that because there is no feasible pollutant control technology, the Town is seeking a Temporary Standard based on attaining an interim criterion or effluent condition that reflects the greatest pollutant reduction achievable through best management practices and implementation of a Pollutant Minimization Program (PMP); and, 3) a detailed demonstration of what the PMP includes, a demonstration of how it will incrementally reduce TN and TP, and the timeline needed to implement and show those improvements. This should include a variety of activities along the treatment train from beginning to end (sources to treated effluent). The letter they provided in 2020 is considered a good starting point for this part of the demonstration.

Because a Temporary Standard is a rulemaking action, the demonstration will need to meet state and federal regulatory requirements in order for the WQCC to consider adoption and EPA to approve. Additionally, Temporary Standards (referred to as Water Quality Standard Variances by EPA) as adopted in 20.6.4 NMAC must include a series of elements (see 20.6.4.10(F) NMAC). After a demonstration is completed and ready to file with the WQCC, the rulemaking process is initiated. The rulemaking process will take around 9 to 12 months. A Temporary Standard for Taos WWTP could not be finalized before the next NPDES permit is renewed in June 2023. That should not stop them from seeking the Temporary Standard as the need is still there and will be even after the permit is renewed.

If the Temporary Standard Proposal is not approved by the time of the next permit renewal, it is the policy of the Water Quality Control Commission and EPA to allow schedules of compliance in NPDES permits in order to allow time for the facility modifications necessary to meet requirements. **Table 4.3.2** of this document defines the phases 1, 2, and N (water-quality based goal). The approach to allow implementation in phases is similar to previous TMDLs including the Canadian River TMDL (NMED/SWQB, 2019b) for the cities of Raton and Tucumcari.

10.1.3 Turbidity

Red River WWTP (NM0024899)

The Red River WWTP permit is administratively continued until a new permit is issued. The permit renewal application was released for public comment from April 30 to May 30, 2022. A new permit is expected in June or July of 2022. SWQB has no recommendation to change current permit limits and reporting requirements based on this TMDL.

Red River State Fish Hatchery (NM0030147)

The NM Department of Game & Fish has submitted a renewal application for this permit. SWQB has no recommendation to change current permit limits and reporting requirements based on this TMDL.

Chevron Mining-Questa Mine (NM0022306)

NPDES permit NM0022306 expired 10/31/2018 and has been administratively continued. Questa Mine NPDES Individual Permit modified effective July 1, 2016 authorizes discharge, requiring monitoring and effluent limitations from four separate outfalls (not combined, not composited) and best management practices that prohibit discharge to the Red River of pollutants traceable to point source mine operations, except in trace amounts from selected springs along the river. Under NPDES regulations, this facility would be covered by the Ore Mining and Dressing Effluent Limitations Guidelines Subpart J - Copper, Lead, Zinc, Gold, Silver, and Molybdenum Subcategory at 40 CFR §440. SWQB has no recommendation to change current permit limits and reporting requirements based on this TMDL.

New Outfall 001, located at the former mill site area and the location of the water treatment plant, reportedly began discharge on July 6, 2017. Collected waters from two natural springs adjacent to mine property (Spring 13 and Spring 39 collection systems), underground mine dewatering, groundwater withdrawal wells below rock piles (GWW-1, GWW-2, and GWW-3), and stormwater runoff is treated before discharge. Underground mine dewatering outflow is pumped to an equalization tank and other collected waters are directed into a second equalization tank that feed the water treatment plant. Stormwater from the watershed above the plant, when present, is routed to an adjacent stormwater catchment and then pumped to the water treatment building as a third influent source. Water treatment plant equipment includes mix tanks, clarifiers, ultrafilters, nanofilters, storage tanks, filter presses, pumps, and chemical feed systems.

Outfall 002 is located at the tailings facility and discharges waters collected by a seepage interception system from the tailing impoundments. Upgrades and improvements include new extraction wells added to the existing seepage interception system south of Dam No. 1 and on the eastern flank of Dam No. 4, and an existing seepage barrier to be refurbished and brought back online. A new groundwater extraction system south of the former Dry Maintenance area will be designed and installed to control a molybdenum plume in that area. In January 2004, Chevron Mining, Incorporated (CMI) began operation of a pumpback system to reduce the manganese load discharged at Outfall 002. The pumpback system consists of a new manhole, and the extraction wells, rock-fill drains, and toe drain at the base of Dam No. 1 were replumbed and now discharge into the pumpback manhole. The collected water has not been part of Outfall 002 discharge, but instead has been pumped northward over Dam No. 1 and discharged into a decant pond on the western side of the tailings facility. Water entering the pumpback is plumbed to the existing Outfall 002 collection manhole, then to the Red River.

Outfall 004 and Outfall 005 are permitted for potential stormwater discharge. Outfall 004 is located below a series of catchments in Goathill Gulch below the subsidence area and Outfall 005 is located in the former mill site area, now location of the water treatment plant. Outfall 004 and 005 have not experienced any discharges in the span of the most recent permit.

Operation and proper maintenance of Spring 13 and Spring 39 seepage interception systems, and groundwater withdrawal downgradient of the Sugar Shack waste rock pile, are BMPs that were required to comply with the NPDES permit prohibition against the discharge to the Red River of pollutants traceable to point source mine operations. This TMDL should also cover the springs. Spring discharges must be included in the existing outfalls and cannot increase the TSS concentrations or load allocation.

Various Questa Mine Operators and Contractors may have USEPA NPDES general permits for discharges of Industrial Stormwater from construction and mining reclamation activities. Among other requirements, the USEPA 2021 Multi-Sector General Permit (MSGP) Sector G Metal Mining Sub-Sector G.2 Benchmark Monitoring Concentrations for TSS is 100 mg/L. There are no TSS monitoring requirements in the current modified 2017 Construction General Permit (CGP). The current USEPA CGP became effective on February 17, 2022.

10.2 Nonpoint Sources

10.2.1 WBP and BMP Coordination

Public awareness and involvement will be crucial to the successful implementation of these plans and improved water quality. A Watershed Based Plan (WBP) 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 nonpoint source impacts to water quality. This long-range strategy will become instrumental in coordinating efforts to achieve water quality standards in the watershed. The WBP is essentially the Implementation Plan, or Phase Two of the TMDL process. The completion of the TMDLs and WBP leads directly to the development of on-the-ground projects to address surface water impairments in the watershed. BMPs to be considered as part of on-the-ground projects to address temperature include establishment of additional woody riparian vegetation for shade and/or stream channel restoration work, particularly at road crossings. Additional information about the reduction of nonpoint source pollution can be found online at: https://www.epa.gov/polluted-runoff-nonpoint-source-pollution.

There is an active watershed group and an approved WBP, focused on temperature impairments, for the Comanche Creek watershed (Quivira Coalition, 2020). There is an approved WBP for the Rio Fernando de Taos, focused on bacteria impairments (Amigo Bravos, 2019). SWQB staff will continue to conduct outreach related to the CWA Section 319(h) funding program.

10.2.2 Clean Water Act Section 319(h) Funding

The Watershed Protection Section of the SWQB can potentially provide USEPA Section 319(h) funding to assist in implementation of BMPs to address water quality problems on reaches listed as category 4 or 5 waters on the Integrated 303(d)/§305(b) list. These monies are available to all private, for-profit, and nonprofit organizations that are authenticated legal entities, or governmental jurisdictions including: cities, counties, tribal entities, federal agencies, or agencies of the state. Proposals are submitted through a Request for Proposal (RFP) process. Selected projects require a non-federal match of 40% of the total project cost consisting of funds and/or in-kind services. Funding is potentially available, generally annually, for both watershed-based planning and on-the-ground projects to improve surface water quality and associated habitat. Further information on funding from the CWA Section 319(h) can be found at the SWQB website: https://www.env.nm.gov/surface-water-quality/.

10.3 Other Funding Opportunities and Restoration Efforts

Several other sources of funding exist 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. They can also provide matching funds for appropriate CWA Section 319(h) projects using state revolving fund monies. The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Environmental Quality Incentive Program (EQIP) program can provide assistance to private landowners 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 US Bureau of Land Management (BLM) has several programs in place to provide assistance to improve unpaved roads and grazing allotments.

The SWQB annually makes available CWA Section 604(b) funds through a Request for Quotes (RFQ) process. The SWQB requests quotes from regional public comprehensive planning organizations to conduct water quality management planning as defined under Sections 205(j) and 303(e) and the CWA. The SWQB seeks proposals to conduct water quality management planning with a focus on projects that clearly address the State's water quality goals to preserve, protect and improve the water quality in New Mexico. The SWQB encourages proposals focused on TMDLs and UAAs or other water quality management planning activities that will directly address identified water quality impairments. The SWQB 604(b) RFQ is released annually in September.

The NMED River Stewardship Program (RSP) has the overall goal of addressing the root causes of poor water quality and stream habitat in New Mexico. Objectives include: restoring or maintaining hydrology of streams and rivers to better handle overbank flows and thus reduce flooding downstream; enhancing economic benefits of healthy river systems such as improved opportunities to hunt, fish, float or view wildlife; and providing state matching funds required for federal Clean Water Act grants the SWQB receives each year.

The RSP received $10,000,000 of pandemic economic recovery funds (American Rescue Plan Act State and Local Fiscal Recovery Funds) from the New Mexico Legislature in December 2021 and the New Mexico Legislature appropriated $1,500,000 in state funds during the 2022 Legislative Session,. A competitive Request for Proposals was issued on May 26, 2022 to award over $10,000,000 in available funding. Proposals are due July 26, 2022 and agreements will be awarded in late 2022 or early 2023. Additional funding sources for watershed protection and improvement projects are listed in Appendix C of the New Mexico Nonpoint Source Management Plan, available at https://www.env.nm.gov/surface-water-quality/nps-plan.

Information on additional watershed restoration funding resources is available on the SWQB website at- https://www.env.nm.gov/surface-water-quality/watershed-protection-section/.

11.0 APPLICABLE REGULATIONS AND REASONABLE ASSURANCES

New Mexico's Water Quality Act, NMSA 1978, Sections 74-6-1 to -17 (Act), authorizes the WQCC to "adopt, promulgate and publish regulations to prevent or abate water pollution in the state" and to require permits. The Act authorizes a constituent agency to take enforcement action against any person who violates a water quality standard. The Act states in Section 74-6-12(a):

> *The Water Quality Act does not grant to the commission or to any other entity the power to take away or modify the property rights in water, nor is it the intention of the Water Quality Act to take away or modify such rights.*

In addition, the State of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4.6(C) NMAC) state:

> *Pursuant to Subsection A of Section 74-6-12 NMSA 1978, this part does not grant to the water quality control commission or to any other entity the power to take away or modify property rights in water.*

New Mexico policies are in accordance with the federal CWA Section 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 CWA Section 319 Program has been developed in a coordinated manner with the State's CWA Section 303(d) process. All watersheds that are targeted in the annual § 319 request for proposal 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 NMSA 1978, Section 74-6-10 to issue a compliance order or commence civil action in district court for appropriate relief if NMED determines that actions of a "person" (as defined in the Act) have resulted in a violation of a water quality standard including a violation caused by a NPS. The NMED NPS water quality management program has historically strived for and will continue to promote voluntary compliance to NPS water pollution concerns by utilizing a voluntary, cooperative approach. The State provides technical support and grant monies for implementation of BMPs and other NPS prevention mechanisms through Section 319 of the CWA. Since portions of this TMDL will be implemented through NPS control mechanisms, the New Mexico Watershed Protection Program will target efforts to this and other watersheds with TMDLs.

In order to obtain reasonable assurances for implementation in watersheds with multiple landowners, including federal, state, and private land, NMED has established Memoranda of Understanding (MOUs) with various federal agencies, in particular the U.S. Forest Service and the BLM. MOUs have also been developed with other state agencies, such as the New Mexico Department of Transportation. These MOUs provide for coordination and consistency in dealing with NPS issues.

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

12.0 PUBLIC PARTICIPATION

Public participation will be solicited in development of this TMDL. Pursuant to 40 C.F.R. § 130.7(a), the public participation will be conducted in accordance with Section XIV of the WQMP/CPP (NMED/SWQB, 2020b), and as outlined in Section IV.C of the WQMP/CPP. The draft TMDL will be made available for a 30-day comment period beginning June 13, 2022 and ending on July 13, 2022. The draft document notice of availability will include information on comment submittal and dates/times of the public meetings. It will be advertised via email distribution lists and webpage postings. Public meetings will be held using virtual meeting technology. A response to public comments will be added to the TMDL document as **Appendix D**.

Once the TMDL is approved by the WQCC, the next step for public participation will be development of WBPs and watershed protection projects, including those that may be funded by CWA Section 319(h) grants managed by SWQB.

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APPENDIX A

WATER QUALITY DATA

Total recoverable aluminum data

Exceedances of the applicable criteria are shown in bold red font. Flows that were used in the calculation of critical high flow for the TMDL, are indicated with an asterisk.

Costilla Creek (Diversion abv Costilla to Comanche Creek)
Monitoring station: Costilla Creek above Costilla at Hwy 196 bridge - 28Costil005.7

Date	Hardness (mg/L)	Acute criterion (mg/L)	Chronic criterion (mg/L)	TR Al (mg/L)	Flow (cfs)	pH
4/5/17	64	1.86	0.74	**0.77**	39*	7.99
9/19/17	42	1.04	0.42	0.22	79*	7.76
3/29/18	69	2.06	0.82	0.11	17	8.61
7/24/18	50	1.32	0.53	**0.84**	62.8*	8.12

Mean hardness of samples with WQS exceedance = 57 mg/L

LaBelle Creek (Comanche Creek to headwaters)
Monitoring station: La Belle Cr abv Comanche Cr - 28LaBell000.1

Date	Hardness (mg/L)	Acute criterion (mg/L)	Chronic criterion (mg/L)	TR Al (mg/L)	Flow (cfs)	pH
5/17/17	24	0.48	0.19	**1.6**	2.76*	7.27
9/29/17	32	0.72	0.29	**2.0**	1*	8.06
3/29/18	43	1.08	0.43	0.29	0.1	7.92
7/25/18	59	0.66	0.67	0.06	0.1	8.09

Mean hardness of samples with WQS exceedance = 28 mg/L

North Fork Tesuque Creek (Tesuque Creek to headwaters)
Monitoring station: N. Fork of Tesuque Cr abv Hyde Park (475) Rd - 28NFkTes000.6

Date	Hardness (mg/L)	Acute criterion (mg/L)	Chronic criterion (mg/L)	TR Al (mg/L)	Flow (cfs)	pH
7/17/17	12	0.19	0.08	**0.28**	5*	7.68
10/18/17	12	0.19	0.08	**0.16**	2.97*	7.59
5/15/18	13	0.21	0.08	**0.12**	0.75*	7.68
7/19/18	14	0.23	0.09	**1.0**	0.39*	7.56

Mean hardness of samples with WQS exceedance = 12.75 mg/L

Rio Medio (Rio Frijoles to headwaters)
Monitoring station: Rio Medio above Santa Cruz River - 28RMedio000.1

Date	Hardness (mg/L)	Acute criterion (mg/L)	Chronic criterion (mg/L)	TR Al (mg/L)	Flow (cfs)	pH
3/30/17	27	0.57	0.23	**3.9**	37.0*	7.78
9/11/17	39	0.94	0.38	0.13	8.7*	8.02
7/24/18	54	1.47	0.59	**1.1**	8.67*	7.79
10/17/18	34	0.78	0.31	0.16	8	7.88

Mean hardness of samples with WQS exceedance = 40.5 mg/L

Rio Quemado (Rio Arriba Cnty bnd to headwaters)
Monitoring station: Rio Quemado @ CR 81 in Cordova - 28RQuema006.9

Date	Hardness (mg/L)	Acute criterion (mg/L)	Chronic criterion (mg/L)	TR Al (mg/L)	Flow (cfs)	pH
3/30/17	39	0.94	0.38	**2.7**	23.65*	7.79
5/17/17	27	0.57	0.23	**1.8**	36.04*	7.78
9/11/17	99	3.37	1.35	0.16	0.5	7.97
3/20/18	140	5.42	2.17	0.02	0.3	8.28
7/19/18	200	8.83	3.54	0.08	0.1	8.12
10/17/18	77	2.39	0.96	0.46	0.2	8.17

Mean hardness of samples with WQS exceedance = 33 mg/L

Rio Quemado (Santa Cruz River to Rio Arriba Cnty bnd)
Monitoring station: Rio Quemado abv Santa Cruz R - 28RQuema000.1

Date	Hardness (mg/L)	Acute criterion (mg/L)	Chronic criterion (mg/L)	TR Al (mg/L)	Flow (cfs)	pH
3/30/2017	47	1.22	0.49	**4.0**	14.15*	7.71
5/17/2017	38	0.91	0.36	**1.1**	31.48*	7.95
3/20/2018	130	4.90	1.96	0.04	1.5	8.48
7/19/2018	98	3.33	1.33	0.25	0.05	7.51

Mean hardness of samples with WQS exceedance = 42.5 mg/L

Santa Cruz River (Santa Clara Pueblo bnd to Santa Cruz Dam)
Monitoring station: Santa Cruz R @ NM 106 - 28SanCru003.2 - pH

Date	Hardness (mg/L)	Acute criterion (mg/L)	Chronic criterion (mg/L)	TR Al (mg/L)	Flow (cfs)	pH
3/30/2017	50	1.32	0.53	**1.2**	62.58+*	7.78
5/17/2017	38	0.91	0.36	**2.0**	100*	7.54
9/11/17	180	7.65	3.07	0.02	4.6	8.25
3/20/18	160	6.51	2.61	0.54	5.23	8.22
7/19/18	160	6.51	2.61	0.38	1.5	7.94
9/18/18	190	8.24	3.30	0.02	0.1	8.01

+Flow measured at Santa Cruz River below Santa Cruz Lake - 28SanCru016.0

Mean hardness of samples with WQS exceedance = 44 mg/L

Santa Cruz River (Santa Cruz Reservoir to Rio Medio)
Monitoring station: Santa Cruz River at USGS gage 08291000 - 28SanCru019.1

Date	Hardness (mg/L)	Acute criterion (mg/L)	Chronic criterion (mg/L)	TR Al (mg/L)	Flow (cfs)	pH
3/30/2017	29	0.63	0.25	**2.1**	52*	7.25
10/16/2017	34	0.78	0.31	0.27	33.9*	7.66
4/11/2018	41	1.01	0.40	0.30	12.8	7.67
7/24/2018	59	1.66	0.67	**0.96**	14.3*	7.84

Mean hardness of samples with WQS exceedance = 44 mg/L

Vidal Creek (Comanche Creek to headwaters)
Monitoring station: Vidal Creek above Comanche Creek - 28VidalC000.1

Date	Hardness (mg/L)	Acute criterion (mg/L)	Chronic criterion (mg/L)	TR Al (mg/L)	Flow (cfs)	pH
5/17/2017	35	0.81	0.33	**0.46**	6.12*	7.15
9/29/17	70	2.10	0.84	**1.2**	3.346*	7.98
10/31/17	81	2.56	1.03	0.32	0.4	8.5
3/29/18	63	1.82	0.73	0.54	0.4	7.89
7/25/18	62	1.78	0.71	0.07	0.1	7.89
9/13/18	60	1.70	0.68	0.13	0.09	8.08
9/26/18	57	1.58	0.63	0.06	0.06	8.06

Mean hardness of samples with WQS exceedance = 52.5 mg/L

E.coli data

Exceedances of the applicable criteria are shown in bold red font. MPN is the most probable number of colony forming units, and is equivalent to cfu in the New Mexico WQS. These Assessment Units have segment-specific single sample criteria of 235 cfu/100 mL or less (20.6.4.121 and 20.6.4.123 NMAC).

Grassy Creek (Comanche Creek to headwaters)
Monitoring station: Grassy Creek above Comanche Creek - 28Grassy000.1

Date	E. coli (MPN/100L)	Flow (cfs)
5/17/2017	3.06	1.88
7/24/2017	**365.4**	.5
9/29/2017	**1413.61**	1
10/31/2017	46.38	<1
3/29/2018	1	0.157
7/25/2018	**435.17**	0.05
9/13/2018	186	0.1
9/26/2018	71.73	0.03

LaBelle Creek (Comanche Creek to headwaters)
Monitoring station: La Belle Cr abv Comanche Cr - 28LaBell000.1

Date	E. coli (MPN/100L)	Flow (cfs)
5/17/2017	23.41	2.76
7/24/2017	**686.67**	0.5
9/29/2017	**2419.6**	1
10/31/2017	144.97	<1
3/29/2018	1	0.10
7/25/2018	172.16	0.1
9/13/2018	29.54	0.05
9/26/2018	104.97	0.2
10/10/2018	146.72	0.05

Rio Quemado (Rio Arriba Cnty bnd to headwaters)
Monitoring station: Rio Quemado @ CR 81 in Cordova - 28RQuema006.9

Date	E. coli (MPN/100L)	Flow (cfs)
3/30/2017	**325.54**	23.65
5/17/2017	66.31	36.04
7/17/2017	**980.39**	3.5
9/11/2017	120.07	0.5
10/18/2017	**461.11**	4.87
3/20/2018	3.04	0.3
5/15/2018	**1119.87**	0.58
9/18/2018	**770.1**	0.1
10/17/2018	**1413.61**	0.2

Ute Creek (Costilla Creek to headwaters)
Monitoring station: Ute Creek above Costilla Creek at Hwy 196 in Amalia - 28UteCre000.3

Date	E. coli (MPN/100L)	Flow (cfs)
4/5/2017	**1732.89**	1.17
7/24/2017	77.12	0.75
3/29/2018	**2419.6**	1.995
10/10/2018	9.69	0.2

Vidal Creek (Comanche Creek to headwaters)
Monitoring station: Vidal Creek above Comanche Creek - 28VidalC000.1

Date	E. coli (MPN/100L)	Flow (cfs)
5/17/2017	17.31	6.12
9/29/2017	**2419.6**	3.346
10/31/2017	26.21	0.4
3/29/2018	68.44	0.4
7/25/2018	**2419.57**	0.1
9/13/2018	24.33	0.09
9/26/2018	18.9	0.06
10/10/2018	106.31	0.07

Plant nutrients data

Exceedances of the applicable criteria are shown in bold red font. MDP indicates a missing data point.

Fernandez Creek (Comanche Creek to headwaters)
Monitoring station: 28Fernan000.1
Applicable thresholds: TN (Steep) 0.30 mg/L, TP (Steep) 0.030 mg/L, delta DO 1.79 mg/L

Date	TN (mg/L)	TP (mg/L)	Flow (cfs)
7/24/17	< 0.25	0.042	0.5
10/31/17	< 0.25	0.035	0.7
7/25/18	< 0.25	0.049	0.1
9/13/18	< 0.25	0.037	0.15
Max Delta DO = 2.59 mg/L, deployed 7/5/18 to 7/25/18			

Median measured concentrations: TN = < 0.25, TP = **0.0445**

Rio Pueblo de Taos (Arroyo del Alamo to R Grande del Rancho)
28RPuebT008.2

Applicable thresholds: TN (Moderate) 0.42 mg/L, TP (Flat-Moderate) 0.061 mg/L, delta DO 4.08 mg/L

Date	TN (mg/L)	TP (mg/L)	Flow (cfs)
3/29/17	0.395	0.088	127
5/11/17	1.229	0.295	750
7/19/17	0.36	0.076	7.68
9/13/17	1.3	0.256	10.1
11/7/17	0.68	0.17	30.5
3/21/18	0.3	0.084	23.5
9/5/18	0.33	0.058	4.25
10/30/18	1.74	1.23	4.25
Max Delta DO = 8.31 mg/L, deployed 4/17/18 to 10/9/18			

Median measured concentrations: TN = **0.538**, TP = **0.129**

Unnamed Arroyo (Rio Pueblo de Taos to Taos WWTP) NM0024066 - 28Unnamed000.1

For comparison purposes only; assessment protocol does not apply.

Date	TN (mg/L)	TP (mg/L)	Flow (cfs)
3/29/17	5.99	2.04	2.08
5/11/17	10.33	1.57	4
7/19/17	8.69	2.9	MDP
9/13/17	11.81	3.07	1
11/7/17	8.06	2.45	2.73
3/21/18	3.17	2.38	1
9/5/18	MDP	MDP	0
10/30/18	8.7	3.69	2.51

Sedimentation/Siltation data

Exceedances of the applicable indicator thresholds are shown in bold red font. Threshold values are shown on **Table 5.4** of this report.

LaBelle Creek (Comanche Creek to headwaters)
Monitoring station: La Belle Cr abv Comanche Cr - 28LaBell000.1

Date	TSS (mg/L)	Turbidity (NTU)	Flow (cfs)
5/17/17	5	**13.8**	2.76
7/24/2017	**32**	**28.7**	0.5
9/29/2017	**16**	**33.2**	1
10/31/2017	5	6.3	<1
3/29/2018	3	**13.1**	0.10
7/25/2018	3	4	0.1
9/13/2018	8	4.5	0.05
9/26/2018	**12**	**15**	0.2
10/10/2018	**18**	3	0.05

Rio Chupadero (USFS bnd to headwaters)
Monitoring station: Rio Chupadero at FR 102 - 28RChupa014.3

Date	TSS (mg/L)	Turbidity (NTU)	Flow (cfs)
3/30/2017	**125**	**66.8**	2.5
7/20/2017	**19**	**17.2**	2
5/15/2018	**25**	2.8	0.1
10/17/2018	3	2.1	0.4

Rio en Medio (Aspen Ranch to headwaters)
Monitoring station: Rio en Medio 200 m below ski area parking lot - 28REnMed016.3

Date	TSS (mg/L)	Turbidity (NTU)	Flow (cfs)
5/18/2017	3	3.1	0.23
7/17/2017	**292**	**249.1**	2
5/15/2018	6	3.1	0.53
7/19/2018	6	2.4	3

Specific conductance data

Exceedances of the applicable criteria (500 µS/cm) are shown in bold red font. MDP is a missing data point.

Rio Fernando de Taos (Tienditas Creek to headwaters)
Monitoring station: Rio Fernando de Taos above Apache Canyon - 28RFerna028.7

Date	TDS (mg/L)	SC (uS/cm)	TDS:SC ratio	Flow (cfs)
5/10/2017	172	214	0.804	20.9
7/18/2017	464	**707**	0.656	0.3
9/12/2017	608	**963**	0.631	0.1
11/7/2017	506	**970**	0.523	0.2
3/22/2018	380	**707**	0.537	0.3
5/17/2018	488	**818**	0.597	0.1

Rio Fernando de Taos (UFSF bnd at canyon to Tienditas Creek)
Monitoring station: Rio Fernando de Taos at USGS gage - 28RFerna008.2

Date	TDS (mg/L)	SC (uS/cm)	TDS:SC ratio	Flow (cfs)
5/10/2017	214	267	0.801	100
7/18/2017	358	**555**	0.645	8
9/12/2017	MDP	**562**	--------	0.7
11/7/2017	336	**608**	0.553	1.8
3/22/2018	354	**592**	0.598	3
5/17/2018	358	**622**	0.576	1.2
10/30/2018	440	**739**	0.595	0.01

Rio Fernando de Taos (R Pueblo d Taos to USFS bnd at canyon)
Monitoring station: Rio Fernando de Taos near Lower Ranchito - 28RFerna001.5

Date	TDS (mg/L)	SC (uS/cm)	TDS:SC ratio	Flow (cfs)
4/13/2017	MDP	422	--------	12.1
5/11/2017	228	278	0.820	75
7/18/2017	200	323	0.619	3
9/13/2017	MDP	469	--------	1
11/7/2017	422	**715**	0.590	1.5
3/21/2018	468	**778**	0.602	2.0
5/17/2018	428	**771**	0.555	1
7/17/2018	318	**598**	0.532	0.1
10/30/2018	436	**679**	0.642	0.2

Temperature data

Exceedances of the applicable criteria are shown in bold red font.

AU Name – Thermograph Location	Designated ALU	Chronic Criterion (°C)	Measured Chronic (°C)	T_{MAX} Criterion (°C)	Date of Measured T_{MAX}	Measured T_{MAX} (°C)
Grassy Creek (Comanche Creek to headwaters) - 28Grassy000.1	High Quality Coldwater	(4T3) 20	20.0	23	7/10/2017	**25.6**
Rio Grande (Ohkay Owingeh bnd to Embudo Creek) - 28RGrand623.6	Marginal Coldwater	(6T3) 22*	**24.5**	25*	7/29/2018	**27.8**
Rio Grande (Santa Clara Pueblo bnd to Ohkay Owingeh bnd) - 28RGrand609.5	Marginal Coldwater	(6T3) 22*	**22.2**	25*	7/10/2018	24.7
Rio Medio (Rio Frijoles to headwaters) - 28RMedio000.1	High Quality Coldwater	(4T3) 20	21.9	23	6/28/2018	**23.8**
Rio Nambe (Nambe Pueblo bnd to headwaters) - 28RNambe007.3	High Quality Coldwater	(4T3) 20	**20.9**	23	7/10/2017	22.7
Santa Cruz River (Santa Cruz Reservoir to Rio Medio) - 28SanCru019.1	High Quality Coldwater	(4T3) 20	**20.1**	23	7/26/2018	**23.2**

** segment-specific criterion*

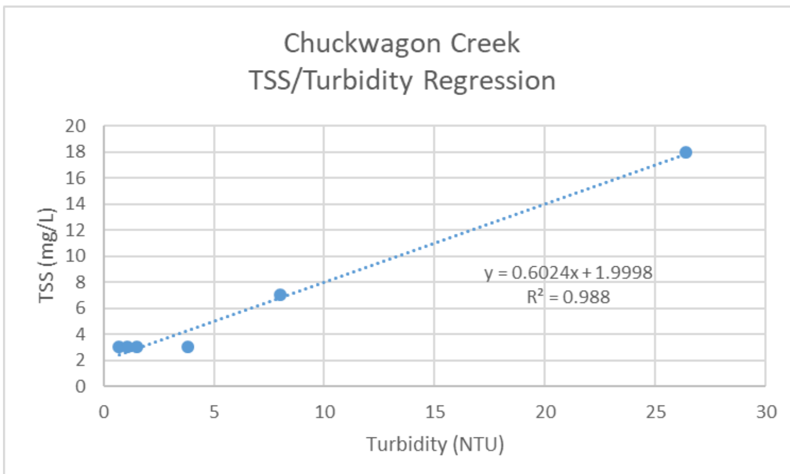
Turbidity data

MDP is a missing data point.

Chuckwagon Creek (Comanche Creek to headwaters)

Monitoring Station: Chuckwagon Cr abv Comanche Cr - 28Chuckw000.1

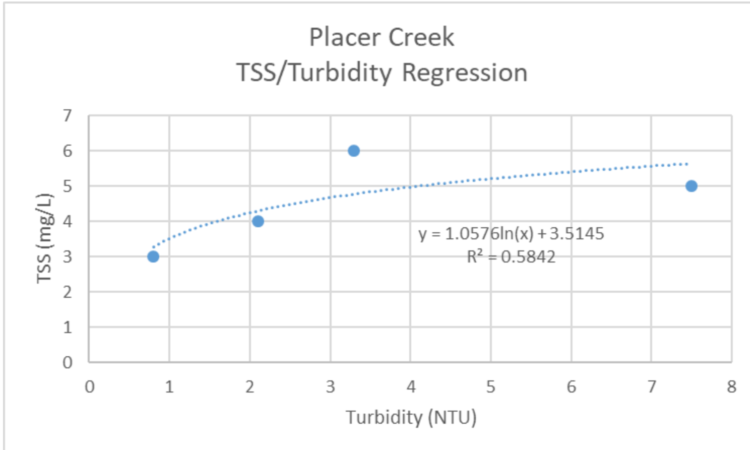
Date	TSS (mg/L)	Turb (NTU)	Flow (cfs)
2017-05-17	18	26.4	4.78
2017-07-24	3	1.1	.75
2017-09-28	7	8.0	1
2017-10-31	3	0.7	<1
2018-03-29	3	3.8	0.154
2018-10-10	3	1.5	0.03



Placer Creek (Red River to headwaters)

Monitoring Station: Placer Creek, about 400 yds above Red River - 28Placer000.2

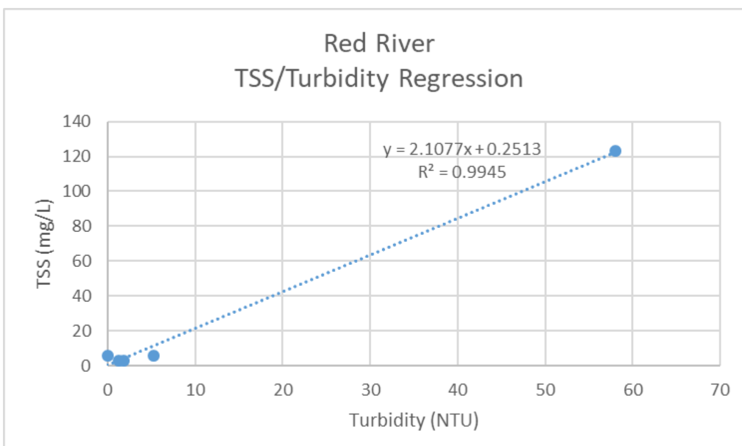
Date	TSS (mg/L)	Turb (NTU)	Flow (cfs)
4/6/2017	5	7.5	0.58
9/21/2017	6	3.3	1
5/23/2018	3	0.8	0.2
9/27/2018	4	2.1	0.05



Red River (Rio Grande to Placer Creek)

Monitoring Station: Red River above Rio Grande – 28RedRiv000.9

Date	TSS (mg/L)	Turb (NTU)	Flow (cfs)
2017-05-17	123	58.0	302.0
2017-07-25	6	5.2	72.1
2017-09-20	6	0	56.9
2017-10-31	3	1.8	64.9
2018-05-24	3	1.3	47.3

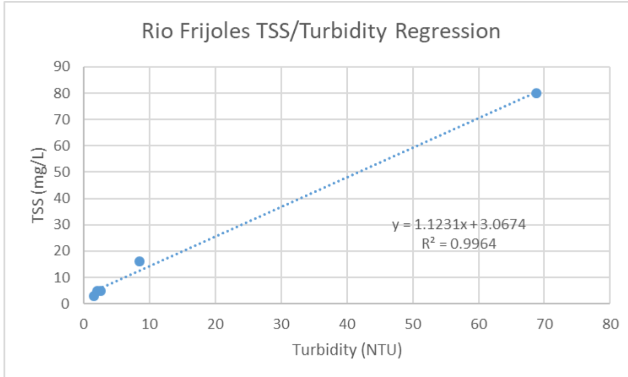


Rio Frijoles (Rio Medio to Pecos Wilderness)

Monitoring Station: Rio Frijoles abv Santa Cruz R- 28RFrijo000.1

Date*	TSS (mg/L)	Turb (NTU)	Flow (cfs)
3/30/2017	80	68.8	15
9/11/2017	3	1.5	8.43
5/21/2009	16	8.5	MDP
7/16/2009	5	2	MDP
9/23/2009	5	2.6	MDP

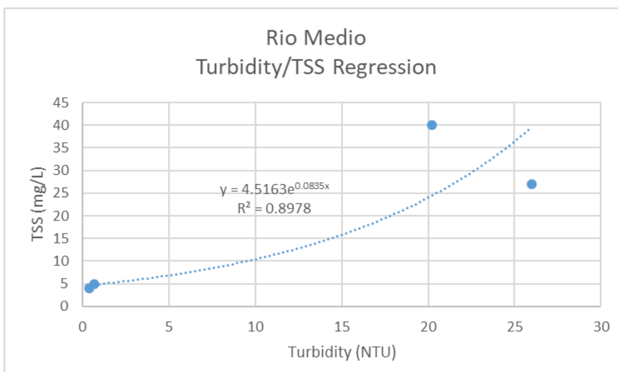
** Data from 2009 were included in this regression due to insufficient data from 2017-18 to derive a correlation.*



Rio Medio (Rio Frijoles to headwaters)

Monitoring Station: Rio Medio above Santa Cruz River - 28RMedio000.1

Date	TSS (mg/L)	Turb (NTU)	Flow (cfs)
3/30/2017	27	26.0	37.0
9/11/2017	5	0.7	8.7
7/24/2018	40	20.2	8.67
10/17/2018	4	0.4	8

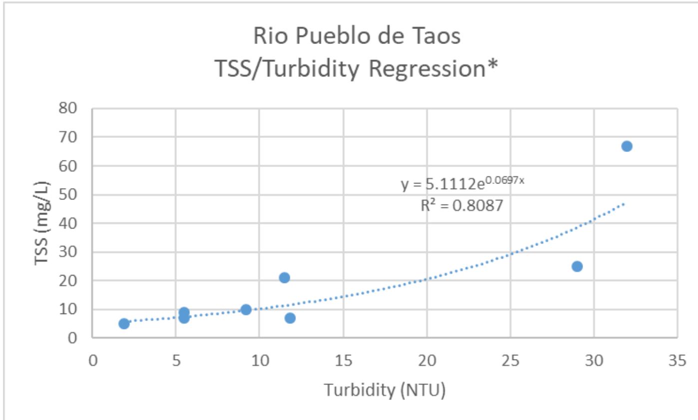


Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)

Monitoring Station: Rio Pueblo de Taos above Rio Grande - 28RPuebT000.1

Date	TSS (mg/L)	Turb (NTU)	Flow (cfs)
3/29/2017	67	32.0	127
5/11/2017*	219	160.1	750
7/19/2017	7	5.5	8.43
9/13/2017	9	5.5	10.1
10/25/2017	5	1.9	30.06
3/21/2018	10	9.2	23.5
5/16/2018	21	11.5	8.43
7/18/2018*	54	97.3	0.44
9/4/2018	25	29	3.99
10/30/2018	7	11.8	7.35

**The two highest turbidity values were dropped from the Rio Pueblo de Taos regression analysis, in order to obtain the most accurate possible relationship between turbidity and TSS within the range of the TMDL thresholds.*

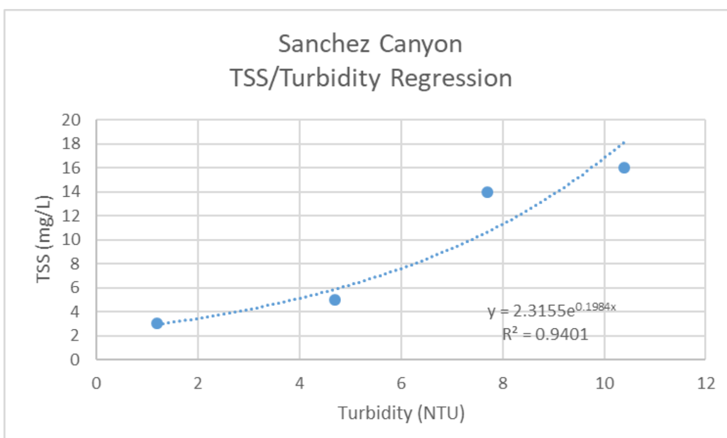


Sanchez Canyon (Costilla Creek to headwaters)

Monitoring Station: Sanchez Creek above Costilla Creek - 28Sanche000.2

Date*	TSS (mg/L)	Turb (NTU)	Flow (cfs)
4/5/2017	14	7.7	0.553
10/31/2017	3	1.2	<1
3/29/2018**	4	12.5	0.34
4/14/2009	5	4.7	MDP
6/9/2009	16	10.4	MDP
8/11/2009**	8	0	MDP

** Data from 2009 were included in this regression due to insufficient data from 2017-18 to derive a correlation.*
***Two apparent outlier points, one from 2009 and one from 2018, were eliminated from the analysis in order to obtain a sufficient degree of correlation for predictive use.*



APPENDIX B
SOURCE DOCUMENTATION

The approach for identifying probable sources of impairment is documented in SWQB Standard Operating Procedure (SOP) 4.1, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/). "Sources" are defined as activities that may contribute pollutants or stressors to a water body (USEPA, 1997). The list of "Probable Sources of Impairment" in the Integrated 303(d)/305(b) List, Total Maximum Daily Load documents (TMDLs), and Watershed-Based Plans (WBPs) is intended to include any and all activities that could be contributing to the identified cause of impairment, which are supported by evidence strong enough to establish presumption but not proof. Probable Source categories are selected from Appendix A of SOP 4.1, which was adapted from the EPA ATTAINS database.

USEPA, through guidance documents, strongly encourages states to include a list of Probable Sources for each listed impairment. According to the 1998 Section 305(b) report guidance, *"…, states must always provide aggregate source category totals…"* in the biennial submittal that fulfills CWA section 305(b)(1)(C) through (E) (USEPA, 1997). The list of "Probable Sources" is not intended to single out any particular land owner or single land management activity and has therefore been labeled "Probable" and generally includes several sources for each known impairment.

Any new impairment listing will be assigned a Probable Source of "Source Unknown." During sampling events, Monitoring Team staff select applicable Probable Sources from a drop-down menu on the Stream/River Field Data Form. Information gathered by the Monitoring Team is used to generate a draft Probable Source list in consequent TMDL planning documents. The TMDL writer then revises the list using aerial imagery, Geographic Information System data, and other available records. The list is also reviewed by Watershed Protection Section staff with knowledge of the AU and watershed. These draft Probable Source lists will be finalized with watershed group/stakeholder input during the pre-survey public meeting, TMDL public meeting, WBP development, and various public comment periods. The Probable Source list in the approved TMDL will be used to update the subsequent Integrated List.

Data on Probable Sources gathered by Monitoring and Assessment Section staff and Watershed Protection Section staff during water quality surveys and watershed restoration projects is housed in the NMED Surface Water Quality Information Database (SQUID). More specific information on Probable Sources of Impairment is provided in individual watershed planning documents (e.g., TMDLs, WBPs, etc.) as they are prepared to address individual impairments by AU.

Literature Cited:

USEPA. 1997. Guidelines for preparation of the comprehensive state water quality assessments (305(b) reports) and electronic uptakes. EPA-841-B-97-002A. Washington, D.C.

APPENDIX C

CALCULATION OF TEMPERATURE TMDL

Calculation of Temperature TMDL

Problem Statement: Convert Temperature Criteria into a Daily Load

Background

The temperature of water is essential for proper metabolic regulation in the aquatic community. Water at a given temperature has a thermal mass that can be represented in units of energy (thermal energy). There are a variety of sources of temperature loading to a waterbody, including air temperature, solar radiation and point source discharge (if present). In addition, how the temperature loading to a stream is translated to the thermal mass of the stream is dependent on its hydrologic characteristics and condition of riparian area (i.e., shading).

The calculation of a TMDL target is governed by the basic equation,

Eq1. *WQS criterion * flow * conversion factor = TMDL target capacity*

For Temperature TMDLs, the WQS criterion is a temperature specified either by the designated Aquatic Life Use (ALU) or site-specific criteria and can be either a maximum temperature or time-duration temperature such as the 4T3 or 6T3.

Flow will generally use the 4Q3 low-flow for the critical flow unless another flow statistic or multiple flow conditions are more appropriate for the situation.

The conversion factor is a variable needed to 1) convert units used by SWQB for flow (in cfs) to cubic meters (m^3) and 2) convert change in water temperature (C) to a volumetric heat capacity ($kJ/(m^3*C)$).

Calculation of Thermal Energy

The thermal loading capacity of a volume is governed by the following equation,

Eq2. *thermal energy = specific heat capacity * mass * change in temperature*

Specific heat capacity is the amount of energy needed to raise the temperature of one kilogram of a substance by 1 degree Celsius.

Mass can be replaced by volume via density.

Accepted Scientific Units for the variables above are:

thermal energy = kilojoule (kJ) (calories are less common and considered archaic)

specific heat capacity = kJ/(kg*C)

mass = kilograms (kg)

change in temperature = Celsius (C)

The specific heat capacity of water at $25^{o}C$ = 4.182 kJ/(kg*C). This is the isobaric (under constant pressure) value for heat capacity at an absolute atmospheric pressure of 585 mmHg. Note: varying water temperature and absolute pressure to minimum and maximum ambient values has negligible effect on the resulting heat capacity.

Calculation of Conversion Factor

Flow (cfs) to (m^3/day)

Eq3. 1 cf/s * 86,400 s/day * 0.0283 m^3/cf = 2445.12 m^3/day

Heat Capacity to Volumetric Heat Capacity

Eq4. 4.182 kJ/(kg*C) * 1000 kg/m^3 = 4,182 kJ/(m^3*C)

Note: water density varies with temperature but only at a fraction of a percent.

Conversion Factor = 2445.12 m^3/day * 4,182 kJ/(m^3*C) = 1.023E+07 kJ/(day*C)

Form of TMDL Equation

Eq5. Δ [**ºC**] x [**cfs]** x 1.023E+07 = TMDL (kJ/day)

Input variables in **bold**, Δ**ºC** = (WQC - 0**ºC)** and **cfs** = critical flow

The resulting value is the increase in kJ/day above 0^{o} Celsius.

APPENDIX D
RESPONSE TO COMMENTS

SWQB will host a virtual public meeting on June 15, 2022 from 2:30 to 4:00 pm and 5:30 to 7:00. Notes from the public meeting will be available in the SWQB TMDL files in Santa Fe.

SWQB received the following public comments on the Upper Rio Grande Watershed TMDL:

Changes made to the TMDL based on public or additional staff comment include:

PLEASE NOTE:
When feasible, original typed letters that were not received electronically were scanned and converted to MSWord. Likewise, when feasible, letters received electronically were also converted to MSWord. All text was converted to Times New Roman 12 font with standard page margins for ease of collation. Contact information such as phone number, street addresses, and e-mail addresses from private citizens were removed for privacy reasons. All original letters of comment are on file at the SWQB office in Santa Fe, NM.