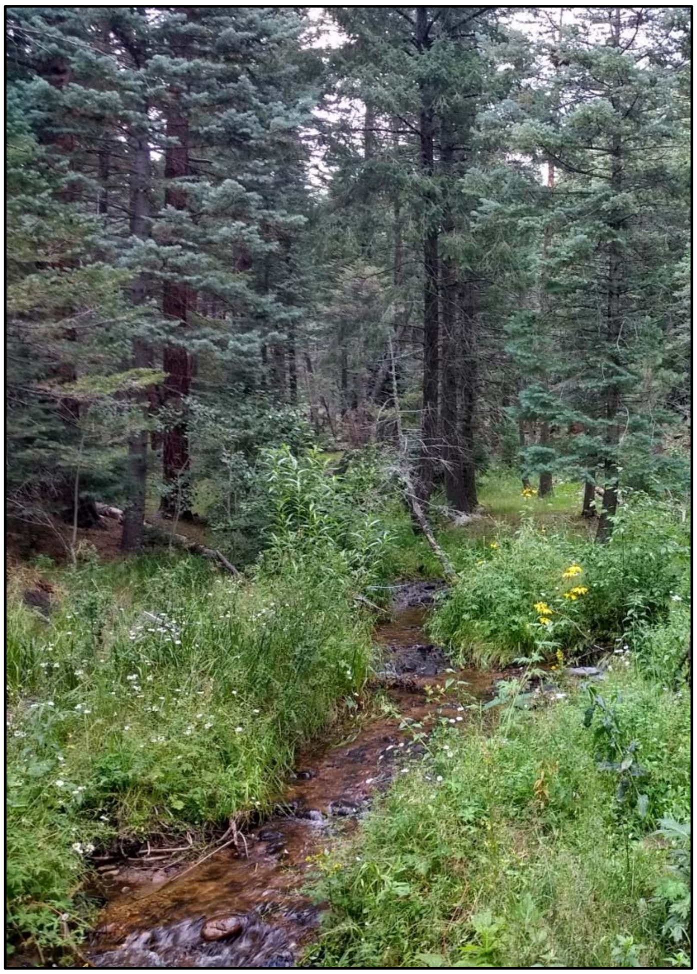
PUBLIC COMMENT DRAFT

TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

DRY CIMARRON, UPPER CANADIAN AND LOWER CANADIAN RIVER BASINS



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Monitoring, Assessments, and Standards Section

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For Additional Information please visit:

www.env.nm.gov/swqb/index.html

~or~

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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
CWAL	Cold Water Aquatic Life
^{o}C	Degrees Celsius
DMR	Discharge Monitoring Report
^{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
lbs/day	Pounds per day
mgd	Million gallons per day
mg/L	Milligrams per Liter
mi^2	Square miles
mL	Milliliters
MCWAL	Marginal Coldwater Aquatic Life
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
RFP	Request for proposal
SEE	Standard Error of the Estimate
SLO	State Land Office
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 2/28/18)

EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act, 33 U.S.C. § 1313(CWA), 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 40 Code of Federal Regulations Part 130 (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 Dry Cimarron and Upper and Lower Canadian basins in 2015-2016. Water quality monitoring stations were located so as to evaluate the impact of tributary streams and ambient water quality conditions. Assessment of data generated during the 2015 and 2016 monitoring efforts was conducted according to the 2016-2018 SWQB Assessment Protocols (NMED/SWQB, 2015). This TMDL document addresses the documented impairments as summarized in Table ES-1, below. Additional information regarding these impairments can be reviewed in the current Clean Water Act §303(d)/§305(b) Integrated Report and List (IR) (NMED/SWQB, 2018a). Previous TMDL reports were completed for the same geographic area in 2007, 2009, 2011 and 2015 (details can be seen at https://www.env.nm.gov/swqb/TMDL/).

The next scheduled water quality monitoring date for the Dry Cimarron and Upper and Lower Canadian basins is 2023-2024, at which time TMDL targets will be re-examined and potentially revised, as this document is considered to be an evolving management plan. In the event that new data indicate that the targets used in this analysis are not appropriate and/or if new standards are adopted, the load capacity will be adjusted accordingly. When water quality standards have been achieved, the reaches will be moved to the appropriate category in the IR.

Table ES-1. TMDL Assessment Units by USGS 8-digit Hydrologic Unit Code

Assessment Unit name	AU_ID	TMDL(s), this report
HUC 11040001 – Cimarron Headwaters		
Dry Cimarron R (Perennial reaches OK bnd to Long Canyon)	NM-2701_00	Nutrients, Temperature
Dry Cimarron River (Long Canyon to Oak Ck)	NM-2701_02	Nutrients, Temperature
Dry Cimarron River (Oak Creek to headwaters)	NM-2701_01	Nutrients
Long Canyon (Perennial reaches abv Dry Cimarron)	NM-2701_20	Nutrients
HUC 11080001 – Canadian Headwaters		
Doggett Creek (Raton Creek to headwaters)	NM-2305.A_255	Nutrients, *E. coli*
Raton Creek (Chicorica Creek to headwaters)	NM-2305.A_253	Nutrients, *E. coli*
East Fork Chicorica Creek (Chicorica Creek to headwaters)	NM-2305.A_252	*E. coli*
Tinaja Creek (West Fork Tinaja Creek to headwaters)	NM-9000.A_019	*E. coli*
HUC 11080004 – Mora		
Coyote Creek (Mora River to Amola Ridge)	NM-2306.A_020	Nutrients
Coyote Creek (Black Lake to headwaters)	NM-2306.A_021	Temperature
Mora River (USGS gage east of Shoemaker to HWY 434)	NM-2305.3.A_00	*E. coli*
HUC 11080005 - Conchas		
Conchas River (Conchas Reservoir to Salitre Creek)	NM-2305.A_010	Nutrients, *E. coli,* Aluminum
HUC 11080006 – Upper Canadian-Ute Reservior		
Pajarito Creek (Perennial prt Canadian R to Vigil Canyon)	NM-2303_10	Temperature
Canadian River (Ute Reservoir to Conchas Reservoir)	NM-2303_00	Temperature

Table ES-2. TMDL for Canadian River (Ute Reservoir to Conchas Reservoir)	
New Mexico Standards Segment	20.6.4.303
Assessment Unit Identifier	NM-2303_00
NPDES Permit(s)	None
Segment Length	60.83
Parameters of Concern	Temperature
Designated Uses Affected	Marginal Warmwater Aquatic Life
USGS Hydrologic Unit Code	11080006 - Upper Canadian-Ute Reservoir
Scope/size of Watershed	8910 square miles
Land Type	26d – Semiarid Canadian Breaks, 26n – Conchas/Pecos Plains
Land Use/Cover	54% shrub/scrub, 40% grassland/herbaceous, 2% evergreen forest, 4% other.
Probable Sources	Dams/diversions, drought-related impacts, exotic species, on-site treatment systems, paved roads, rangeland grazing, residences/buildings, waterfowl, wildlife
Land Management	88% Private, 12% State, 0.2% Bureau of Land Management, 0.11% State Park.
IR Category	5
Priority Ranking	High
WLA + LA + MOS = TMDL	
Temperature	0 + 2.91 x 10^8 + 3.23 x 10^7 = 3.23 x 10^8 kJ/day

Table ES-3. TMDL for Conchas River (Conchas Reservoir to Salitre Creek)	
New Mexico Standards Segment	20.6.4.305
Assessment Unit Identifier	NM-2305.A_010
NPDES Permit(s)	None
Segment Length	34 miles
Parameters of Concern	Aluminum, *E. coli,* Plant nutrients
Designated Uses Affected	Marginal Warmwater Aquatic Life, Primary Contact
USGS Hydrologic Unit Code	11080005 - Conchas
Scope/size of Watershed	514 square miles
Land Type	26n – Conchas/Pecos Plains
Land Use/Cover	63% grassland, 30% shrub/scrub, and 6% evergreen forest.
Probable Sources	Rangeland grazing, stream channel incision, waterfowl
Land Management	89% private, 10% SLO, 1% BLM and less than 1% of BOR and State Parks
IR Category	5
Priority Ranking	High
	WLA + LA + MOS = TMDL
Total Recoverable Aluminum Chronic	0 + 1.50 + 0.17 = 1.67 lb/day
E. coli	0 + 5.27 x 10^8 + 5.86 x 10^7 = 5.86 x 10^8 cfu/day
Plant nutrients Total phosphorus Total nitrogen	 0 + 0.05 + 0.01 = 0.06 lbs/day 0 + 0.59 + 0.07 = 0.65 lbs/day

Table ES-4. TMDL for Coyote Creek (Mora River to headwaters)	
New Mexico Standards Segment	20.6.4.309
Assessment Unit Identifier	NM-2306.A_021 NM-2306.A_020 NM-2306.A_022
NPDES Permit(s)	None
Segment Length	7.73 miles
Parameters of Concern	Temperature
Designated Uses Affected	High Quality Coldwater Aquatic Life
USGS Hydrologic Unit Code	11080004 - Mora
Scope/size of Watershed	24.6 square miles
Land Type	21e – Sedimentary subalpine forests, 21f – Sedimentary mid-elevation forests, 21j – Grassland parks
Land Use/Cover	52% grassland/herbaceous, 36%evergreen forest, 8% shrub/scrub, 0.9% deciduous forest, 0.8% pasture/hay.
Probable Sources	Crop production (dryland), dams/diversions, gravel or dirt roads, irrigated crop production, on-site treatment systems, paved roads, rangeland grazing, residences/buildings, waterfowl
Land Management	89% private, 7% USFS, 3% SLO, <1% NPS, and less than 1% of BLM, NPS and State Parks.
IR Category	5A
Priority Ranking	High
WLA + LA + MOS = TMDL	
Temperature	$0+6.56 \times 10^{7}+7.29 \times 10^{6} = 7.29 \times 107$ kJ/day
Plant nutrients Total phosphorus Total nitrogen	 0 + 0.14 + 0.02 = 0.15 lbs/day 0 + 0.83 + 0.09 = 0.93 lbs/day

Table ES-5. TMDL for Doggett Creek (Raton Creek to headwaters)	
New Mexico Standards Segment	20.6.4.99
Assessment Unit Identifier	NM-2305.A_255
NPDES Permit(s)	NM0020273
Segment Length	3 miles
Parameters of Concern	*E. coli,* plant nutrients
Designated Uses Affected	Primary Contact, Warmwater Aquatic Life
USGS Hydrologic Unit Code	11080001 - Canadian Headwaters
Scope/size of Watershed	2.9 square miles
Land Type	26l - Upper Canadian Plateau
Land Use/Cover	49% grassland, 31% evergreen forest, 15% shrub/scrub and 2% deciduous forest
Probable Sources	Bridges/culverts/RR crossings; Channelization; Gravel or dirt roads; Municipal point source discharge; On-site treatment systems; Paved roads; Pavement/impervious surface; Residences/buildings; Site clearance (land development); Urban runoff/storm sewers; Wildlife other than waterfowl
Land Management	93% private, 6% State, and less than 1% USFS, USFWS, BLM, and BOR
IR Category	5
Priority Ranking	High
WLA + LA + MOS = TMDL	
E. coli	See Raton Creek NM-2305.A_253
Plant nutrients	See Raton Creek NM-2305.A_253

Table ES-6. TMDL for East Fork Chicorica Creek (Chicorica Creek to headwaters)	
New Mexico Standards Segment	20.6.4.98
Assessment Unit Identifier	NM-2305.A_252
NPDES Permit(s)	None
Segment Length	7 miles
Parameters of Concern	*E. coli*
Designated Uses Affected	Primary Contact
USGS Hydrologic Unit Code	11080001 - Canadian Headwaters
Scope/size of Watershed	24 square miles
Land Type	21j - Grassland Parks, 21f - Sedimentary Mid-Elevation Forests, 21d - Foothill Woodlands and Shrublands, 26l - Upper Canadian Plateau
Land Use/Cover	49% grassland, 31% evergreen forest, 15% shrub/scrub and 2% deciduous forest
Probable Sources	Bridges/culverts/RR crossings; Forest fire runoff; Gravel or dirt roads; Highway/road/bridge runoff; Livestock grazing or feeding operation; Low water crossing; Paved roads; Pavement/impervious surface; Rangeland grazing; Residences/buildings; Riprap/wall dike/jetty jack; Wildlife other than waterfowl
Land Management	93% private, 6% State, and less than 1% USFS, USFWS, BLM, and BOR
IR Category	5
Priority Ranking	High
WLA + LA + MOS = TMDL	
E. coli	0 + 4.54 x 10^8 + 5.04 x 10^7 = 5.04 x 10^8 cfu/day

Table ES-7. TMDL for Dry Cimarron River (perennial reaches OK bnd to Long Canyon)	
New Mexico Standards Segment	20.6.4.702
Assessment Unit Identifier	NM-2701_00
NPDES Permit(s)	None
Segment Length	54.59 miles
Parameters of Concern	Plant nutrients, temperature
Designated Uses Affected	Coolwater Aquatic Life Use
USGS Hydrologic Unit Code	11040001 - Cimarron Headwaters
Scope/size of Watershed	905 square miles
Land Type	26f Black Mesa
Land Use/Cover	52% grassland/herbaceous, 26% shrub/scrub, 20% evergreen forest, 0.6 % developed, 0.5% emergent herbaceous wetlands, 0.3% cultivated crops, 0.3% deciduous forest.
Probable Sources	Channel incision, crop production (dryland), dams/diversions, gravel or dirt roads, irrigated crop production, litter, low water crossing, mass wasting, on-site treatment systems, paved/unpaved roads, rangeland grazing, residences/buildings, waterfowl and wildlife
Land Management	79% Private, 21% State, 0.1% National Park Service, 0.04% Bureau of Land Management.
IR Category	5
Priority Ranking	High
WLA + LA + MOS = TMDL	
Temperature	$0 + 8.81 \times 10^7 + 9.79 \times 10^6 = 9.79 \times 10^7$ kJ/day
Plant nutrients Total phosphorus Total nitrogen	 0 + 0.1 + 0.01 = 0.17 lbs/day 0 + 1.02 + 0.11 = 1.79 lbs/day

Table ES-8. TMDL for Dry Cimarron River (Long Canyon to Oak Creek)	
New Mexico Standards Segment	20.6.4.702
Assessment Unit Identifier	NM-2701_02
NPDES Permit(s)	None
Combined Segment Length	23.12 miles
Parameters of Concern	Plant nutrients
Designated Uses Affected	Coolwater Aquatic Life Use
USGS Hydrologic Unit Code	11040001 - Cimarron Headwaters
Scope/size of Watershed	285 square miles
Land Type	26f Black Mesa
Land Use/Cover	52% grassland/herbaceous, 26% shrub/scrub, 20% evergreen forest, 0.6 % developed, 0.5% emergent herbaceous wetlands, 0.3% cultivated crops, 0.3% deciduous forest.
Probable Sources	Bridges/culverts/RR crossings, channelization, crop production, dams/diversions, dumping/garbage/trash/litter, flow alterations, gravel/dirt roads, irrigated crop production, legacy logging, low water crossing, mass wasting, on-site treatment systems (septic), paved roads, rangeland grazing, recent bankfull/overbank flows, residences/buildings, stream channel incision, storm runoff due to construction, waterfowl, wildlife other than waterfowl.
Land Management	79% Private, 21% State, 0.1% National Park Service, 0.04% Bureau of Land Management.
IR Category	5
Priority Ranking	High
WLA + LA + MOS = TMDL	
Plant nutrients	See Dry Cimarron Creek NM-2701_00

Table ES-9. TMDL for Dry Cimarron (Oak Creek to headwaters)	
New Mexico Standards Segment	20.6.4.701
Assessment Unit Identifier	NM-2701_01
NPDES Permit(s)	None
Segment Length	26.53 miles
Parameters of Concern	Plant nutrients
Designated Uses Affected	Coldwater Aquatic Life Use
USGS Hydrologic Unit Code	11040001 - Cimarron Headwaters
Scope/size of Watershed	143 square miles
Land Type	21d Foothill Shrublands, 21j Grassland Parks, 26l Upper Canadian Plateau
Land Use/Cover	52% grassland/herbaceous, 26% shrub/scrub, 20% evergreen forest, 0.6 % developed, 0.5% emergent herbaceous wetlands, 0.3% cultivated crops, 0.3% deciduous forest.
Probable Sources	Bridges/culverts/RR crossings, channelization, crop production, dams/diversions, dumping/garbage/trash/litter, flow alterations, gravel/dirt roads, irrigated crop production, legacy logging, low water crossing, mass wasting, on-site treatment systems (septic), paved roads, rangeland grazing, recent bankfull/overbank flows, residences/buildings, stream channel incision, storm runoff due to construction, waterfowl, wildlife other than waterfowl.
Land Management	79% Private, 21% State, 0.1% National Park Service, 0.04% Bureau of Land Management.
IR Category	5
Priority Ranking	High
WLA + LA + MOS = TMDL	
Plant nutrients	See Dry Cimarron Creek NM-2701_00

Table ES-10. TMDL for Long Canyon (perennial reaches above Dry Cimarron)	
New Mexico Standards Segment	20.6.4.702
Assessment Unit Identifier	NM-2701_20
NPDES Permit(s)	None
Segment Length	8.33 miles
Parameters of Concern	Temperature
Designated Uses Affected	Coolwater Aquatic Life Use
USGS Hydrologic Unit Code	11040001 - Cimarron Headwaters
Scope/size of Watershed	131.11 square miles
Land Type	26f – Black mesa
Land Use/Cover	52% grassland/herbaceous, 26% shrub/scrub, 20% evergreen forest, 0.6 % developed, 0.5% emergent herbaceous wetlands, 0.3% cultivated crops, 0.3% deciduous forest.
Probable Sources	Channel incision, channelization, crop production dry and irrigated, dams/diversions, flow alteration, mass wasting, on-site treatment systems, paved/unpaved roads, rangeland grazing, residence/buildings, wildlife
Land Management	79% Private, 21% State, 0.1% National Park Service, 0.04% Bureau of Land Management.
IR Category	5 /5A
Priority Ranking	High
	WLA + LA + MOS = TMDL
Temperature	$0 + 4.54 \times 10^7 + 5.04 \times 10^6 = 5.04 \times 10^7$ kJ/day

Table ES-11. TMDL for Mora River (USGS gage east of Shoemaker to HWY 434)	
New Mexico Standards Segment	20.6.4.307
Assessment Unit Identifier	NM-2305.3.A_00
NPDES Permit(s)	NM00024996
Combined Segment Length	53 miles
Parameters of Concern	*E. coli*
Designated Uses Affected	Primary Contact
USGS Hydrologic Unit Code	11080004 - Mora
Scope/size of Watershed	144.5 square miles
Land Type	21c - Crystalline Mid-Elevation Forests, 21f - Sedimentary Mid-Elevation Forests, 21d - Foothill Woodlands and Shrublands, 26l - Upper Canadian Plateau
Land Use/Cover	52% grassland/herbaceous, 36%evergreen forest, 8% shrub/scrub, 0.9% deciduous forest, 0.8% pasture/hay.
Probable Sources	Crop production (dryland); Dams/diversions; Gravel or dirt roads; Irrigated crop production; On-site treatment systems; Paved roads; Rangeland grazing; Residences/buildings; Waterfowl
Land Management	89% private, 7% USFS, 3% SLO, <1% NPS, and less than 1% of BLM, NPS and State Parks
IR Category	5
Priority Ranking	High
WLA + LA + MOS = TMDL	
E. coli	2.48×10^{8}+ 4.40×10^{9}+ 5.17×10^{8}= 5.17×10^{9} cfu/day

Table ES-12. TMDL for Pajarito Creek (perennial portions Canadian River to Vigil Canyon)	
New Mexico Standards Segment	20.6.4.303
Assessment Unit Identifier	NM-2303_10
NPDES Permit(s)	NM0020711
Segment Length	27.6 miles
Parameters of Concern	Temperature
Designated Uses Affected	Marginal warmwater aquatic life use
USGS Hydrologic Unit Code	11080006 - Upper Canadian-Ute Reservoir
Scope/size of Watershed	519 square miles
Land Type	26d - Semiarid Canadian Breaks
Land Use/Cover	54% shrub/scrub, 40% grassland/herbaceous, 2% evergreen forest, 4% other.
Probable Sources	Crop production dry land/irrigation, dams/diversions, drought-related impacts, flow alterations, irrigation, litter, livestock operation, riprap, rangeland grazing, roads paved/unpaved, residences/buildings, site clearance, waterfowl, wildlife
Land Management	88% Private, 12% State, 0.2% Bureau of Land Management, 0.11% State Park.
IR Category	5
Priority Ranking	High
WLA + LA + MOS = TMDL	
Temperature	$0 + 5.34 \times 10^7 + 5.93 \times 10^6 = 5.93 \times 10^7$ kJ/day

Table ES-13. TMDL for Raton Creek (Chicorica Creek to headwaters)	
New Mexico Standards Segment	20.6.4.305
Assessment Unit Identifier	NM-2305.A_253
NPDES Permit(s)	NM0029891 and NM0020273
Segment Length	17.6 miles
Parameters of Concern	Plant nutrients
Designated Uses Affected	Marginal warmwater aquatic life use
USGS Hydrologic Unit Code	11080001 - Canadian Headwaters
Scope/size of Watershed	45 square miles
Land Type	21f - Sedimentary Mid-Elevation Forests, 21d - Foothill Shrublands, 26l - Upper Canadian Plateau
Land Use/Cover	49% grassland, 31% evergreen forest, 15% shrub/scrub and 2% deciduous forest
Probable Sources	Bridges/culverts/RR crossings; Gravel or dirt roads; Mass wasting; Rangeland grazing; Stream channel incision
Land Management	93% private, 6% State, and less than 1% USFS, USFWS, BLM, and BOR
IR Category	5
Priority Ranking	High
WLA + LA + MOS = TMDL	
Plant nutrients Total phosphorus Total nitrogen	 0.46 + 0.07 + 0.06 = 0.59 lbs/day 4.88 + 0.78 + 0.63 = 6.29 lbs/day
E. coli	$4.30 \times 10^9 + 6.86 \times 10^8 + 5.54 \times 10^8 = 5.54 \times 10^9$

Table ES-14. TMDL for Tinaja Creek (West Fork Tinaja Creek to headwaters)	
New Mexico Standards Segment	20.6.4.98
Assessment Unit Identifier	NM-9000.A_019
NPDES Permit(s)	None
Combined Segment Length	19 miles
Parameters of Concern	*E. coli*
Designated Uses Affected	Primary Contact
USGS Hydrologic Unit Code	11080001 - Canadian Headwaters
Scope/size of Watershed	49.7 square miles
Land Type	26h – Volcanic Mid-Elevation Forests, 26l - Upper Canadian Plateau
Land Use/Cover	49% grassland, 31% evergreen forest, 15% shrub/scrub and 2% deciduous forest
Probable Sources	Bridges/culverts/RR crossings; Gravel or dirt roads; Mass wasting; Rangeland grazing; Stream channel incision
Land Management	93% private, 6% State, and less than 1% USFS, USFWS, BLM, and BOR
IR Category	5
Priority Ranking	High
WLA + LA + MOS = TMDL	
E. coli	0 + 5.90 x 10^8 + 6.56 x 10^7 = 6.56 x 10^8 cfu/day

1.0 BACKGROUND

1.1 Watershed Description

This document establishes TMDLs for 15 Assessment Units (AUs) in the Canadian and Dry Cimarron watersheds (**Figures 1.1 – 1.3**). Impairment determinations were based on data collected during the 2015-2016 SWQB water quality survey.

1.1.1 Cimarron Headwaters

HUC 11040001 covers 1,696 square miles in northeastern New Mexico, southeastern Colorado and western Oklahoma. The watershed includes the Dry Cimarron River from its headwaters to the Oklahoma border, and its tributaries. The Dry Cimarron in New Mexico extends from the eastern slopes of Johnson Mesa for about 80 miles to the New Mexico/Oklahoma border near Kenton, Oklahoma. The watershed is mostly located in Union County, New Mexico. Average elevation is 5,478 feet above sea level and it receives approximately 16 inches of precipitation per year. The TMDL AUs Dry Cimarron R (Perennial reaches OK bnd to Long Canyon), Dry Cimarron River (Long Canyon to Oak Ck), Dry Cimarron River (Oak Creek to headwaters), and Long Canyon (Perennial reaches abv Dry Cimarron) are within the Cimarron Headwaters HUC.

In New Mexico, the bedrock of the Dry Cimarron watershed is mainly upper Triassic (NMGS, 1987). There is a regional dip in the strata from Kenton, OK to Wedding Cake Butte in New Mexico from the Upper Jurassic Morrison Formation to the Upper Triassic Travesser Formation. The white sandstone at the New Mexico border is Entrada Sandstone over dark siltstones of the Sloan Canyon Formation. The Bell Ranch Formation in the Dry Cimarron River watershed is siltstone and fine-grained gypsiferous sandstone (NMGS 1987). General surface geology of the New Mexico portion of the Cimarron Headwaters HUC is 34% sandstone, 17% fine-grained mixed clastic, 12% medium-grained mixed clastic, 10% basalt, 10% alluvium, 5% landslide, 5% shale, 5% andesite, and 2% eolian (**Figure 1.1**). Surface features include numerous volcanic cones, domes and lave flows (Chronic, 1987).

Land cover for the New Mexico portion of the Cimarron Headwaters HUC includes 52% grassland, 26% shrub/scrub, and 20% evergreen forest (**Figure 1.2**). Land ownership is 79% private, and 21% State, and less than 1% each National Park Service (NPS) and Bureau of Land Management (BLM)_(**Figure 1.3**). Yellow-Billed Cuckoo (*Coccyzus americanus*), Peregrine Falcon (*Falco peregrinus*) and Suckermouth Minnow (*Phenacobius mirabilis*) are listed as either Threatened or Endangered by state and/or federal agencies. No state or federally listed plants are known to occur (NMDGF Environmental Review Tool, https://nmert.org/home, accessed 6/27/18).

Stone spear points produced by early hunter-gatherers were found near Folsom, NM (Chronic, 1987). The Santa Fe Trail roughly paralleled the present US Hwy 64 and old Conestoga wheel ruts can still be seen in places; a tribute to the slow erosion rate in this semi-arid, gravely area of the Great Plains (Chronic 1987). The Cimarron Cutoff branch of the Santa Fe Trail went through southwestern Kansas, the Oklahoma panhandle, and northeastern New Mexico (NMGS, 1987). The first Anglo-Americans to enter the valley of the Dry Cimarron in the mid-nineteenth century were beaver trappers. The subsequent removal of the beaver, and the later arrival of large herds of livestock, initiated an episode of channel destabilization that has resulted in many of the hydro-geomorphic impacts seen today (NMED-SWQB, 2000). Copper mining occurred in the Dry Cimarron River valley from 1889 to 1956.

The Long Canyon subwatershed is 131 mi^2, has an average elevation of 5,244 feet above sea level and receives approximately 16 inches of precipitation per year. The geology of the Long Canyon watershed is predominantly comprised of sandstones, shales, and mudstones as well as locally mineralized sediments (**Figure 1.1**).

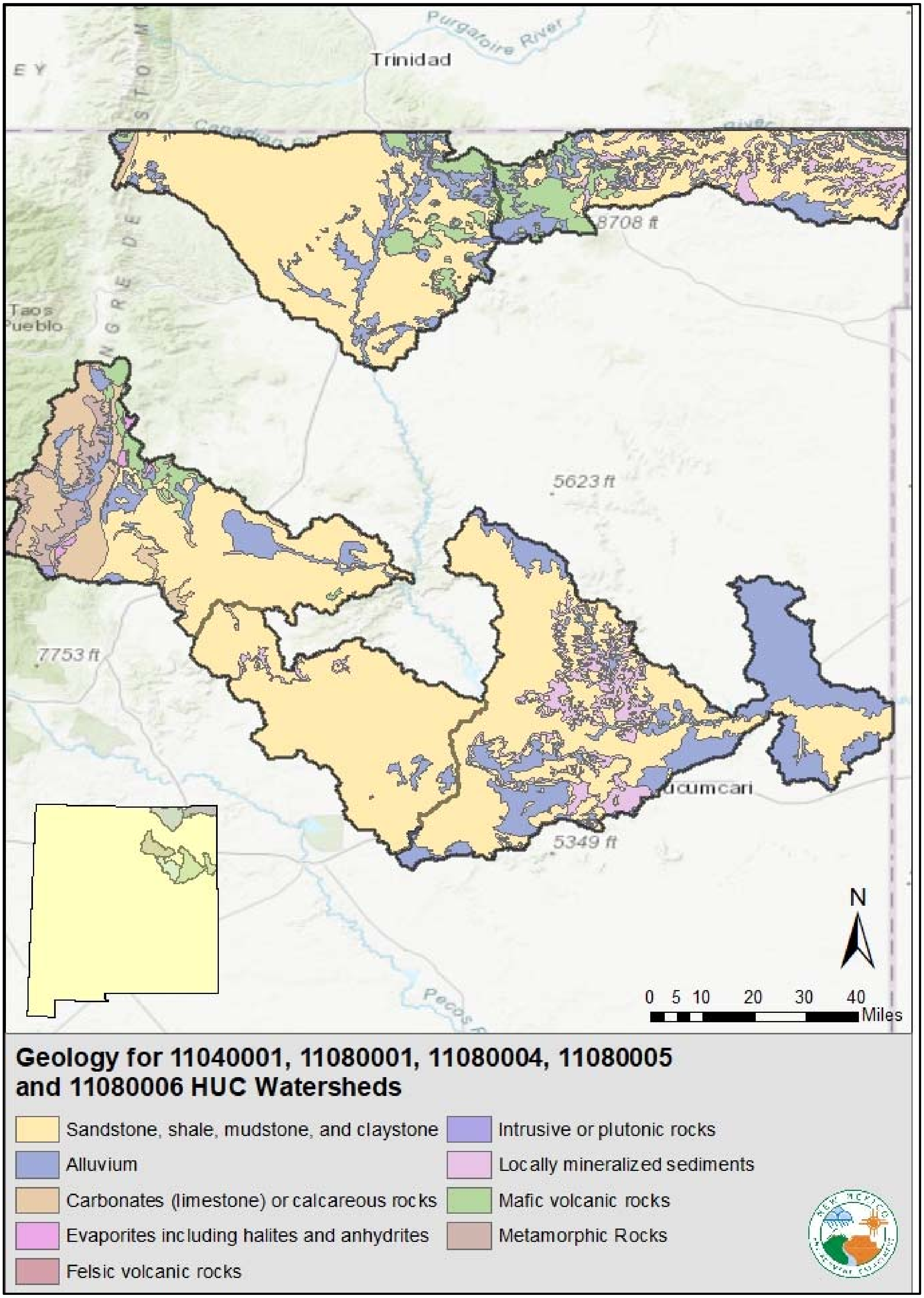


Figure 1.1. Surface geology of the Dry Cimarron and Upper and Lower Canadian River watersheds.

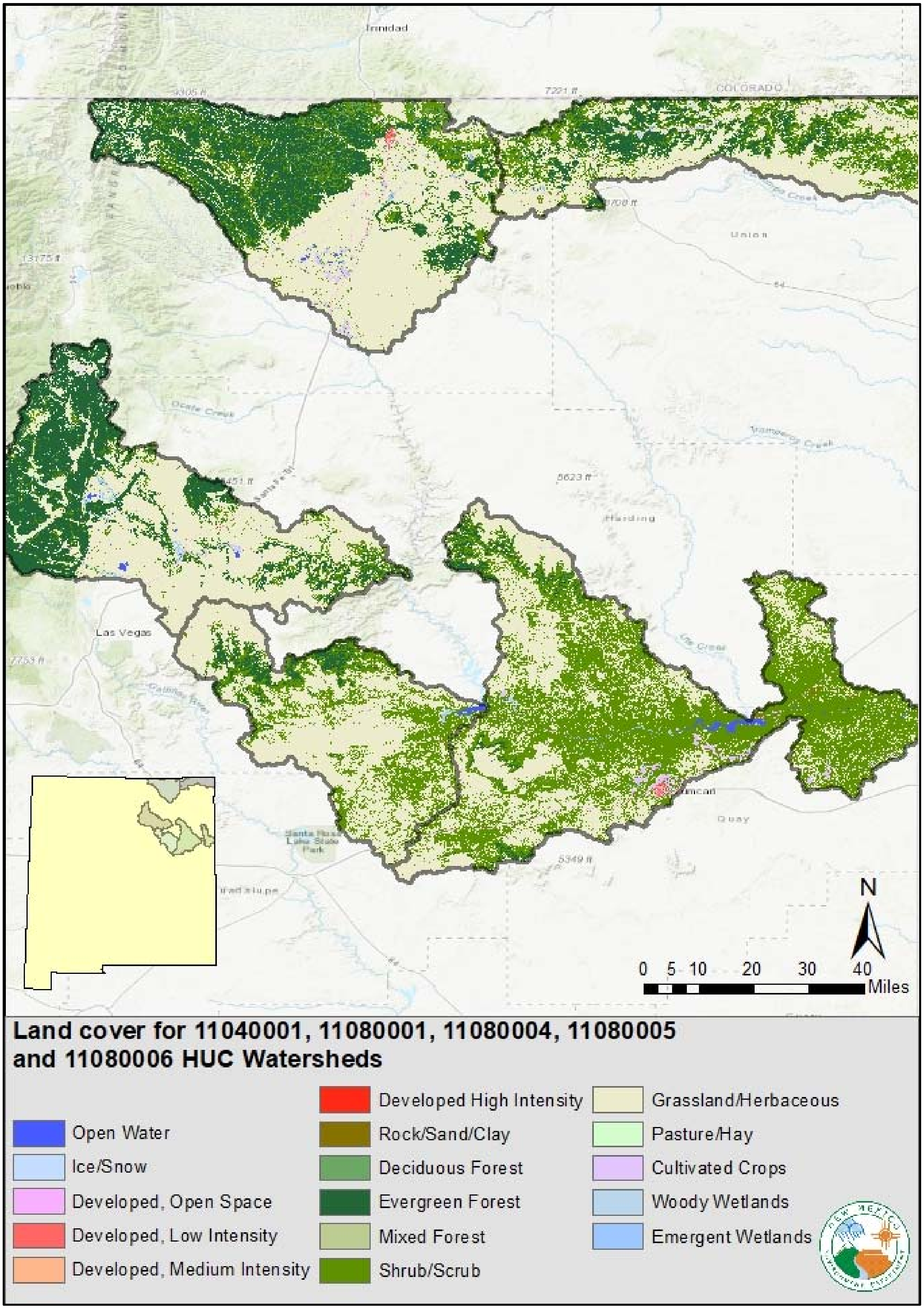


Figure 1.2. Land Cover of the Dry Cimarron and Upper and Lower Canadian River watersheds.

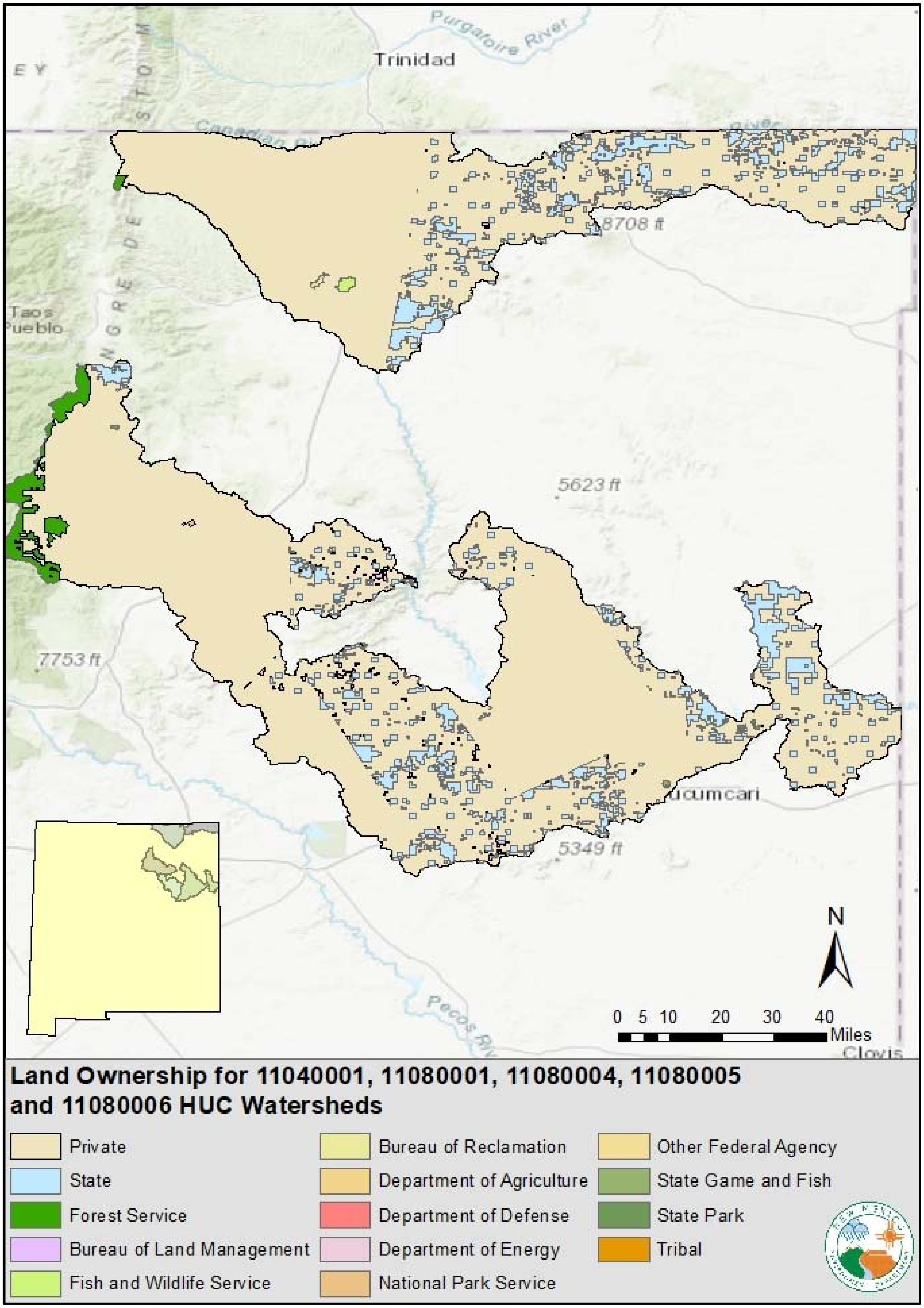


Figure 1.3. Land Ownership of the Dry Cimarron and Upper and Lower Canadian River watersheds.

1.1.2 Canadian River Basin

The Canadian River basin (USGS HUC-8s 11080001, 11080002, 11080003, 11080004, 11080005, 11080006, 11080007, 11080008, and 11090101) is part of the drainage system of the Arkansas River. The Canadian watershed encompasses about one-sixth the land area of New Mexico, approximately 1720 mi^2 (1.1 million acres). Canadian River tributaries flow east and southeast from their origins on the east slopes of the Sangre de Cristo cordillera of northern New Mexico and southern Colorado. As it traverses the Great Plains in a southerly and then easterly direction, several perennial tributaries, including the Vermejo, Cimarron, Mora, and Conchas Rivers join the Canadian River before it exits New Mexico into Texas near Logan, NM.

The laterally extensive pediments, topographically inverted basalt-capped mesas, and stripped structural surfaces of the Las Vegas Plateau of northeastern New Mexico gradually slope to the southeast away from the eastern flank of the Sangre de Cristo Mountains, which form the southern Rocky Mountain front in New Mexico as well as the eastern flank of the Rio Grande rift. The region is dominated by flat-lying sedimentary rocks, with little geologic structure (Chronic, 1987).

The Canadian River is a braided, meandering channel fed by numerous streams and creeks, which drains semi-deserts, plains, prairies, forests, and mountains. The vegetation of the New Mexico portion of the Canadian Watershed includes both the Great Plains and Rocky Mountain floras (Omernik 2006). Several species within this watershed are listed as either threatened or endangered State and/or federal agencies. No state or federally listed plants are known to occur (NMDGF Environmental Review Tool, *https://nmert.org/home*, accessed 6/27/18).

Historic and current land uses in the watershed include farming, ranching, recreation, and municipal (Raton, Springer, Angel Fire, Eagle Nest, and Mora). Much of the land ownership adjacent to the river is private with the exceptions of Maxwell National Wildlife Refuge, Fort Union National Monument near Watrous, and National Forest jurisdiction in the higher elevations. The BLM and State Land Office (SLO) also own and manage tracts in the eastern portions of the watershed. The Canadian watershed is located in Omernick Level III Ecoregion 21 (Southern Rockies) in the headwaters and Level III Ecoregion 26 (Southwestern Tablelands) in the lowlands.

11080001 – Canadian Headwaters

The Canadian Headwaters watershed is bounded by the Sangre de Cristo Mountains to the west and the Great Plains to the east. From a point southeast of Maxwell, NM to its headwaters, the HUC drains approximately 2850 mi^2. Elevation ranges from 11,610 ft at Vermejo Peak to 5640 ft at USGS Gage 07211500 near Taylor Springs, NM. Tributaries to the Canadian Headwaters include: Caliente Canyon Creek, York Canyon Creek, Leandro Creek, Vermejo River, VanBremmer Creek, Raton Creek, Chicorica Creek, Uña de Gato Creek, Blosser Arroyo, and Tinaja Creek. The TMDL AUs Doggett Creek (Raton Creek to headwaters), Raton Creek (Chicorica Creek to headwaters), East Fork Chicorica Creek (Chicorica Creek to headwaters), and Tinaja Creek (West Fork Tinaja Creek to headwaters) are within the Canadian Headwaters HUC.

The geology of the Canadian Headwaters watershed is characterized by sandstone, shale, mudstone, and claystone that are flanked by limestone or calcareous rocks in the west and mafic volcanic rocks in the east. Surface geology in the New Mexico portion of HUC 11080001 is 39% sandstone, 37% shale, 6% alluvium, 6% basalt, 5% landslide, 2% limestone, 1% eolian and 1% felsic volcanic (**Figure**

1.1). Alluvium, basin, and valley fill is found in the river valleys and eastern basins. Raton Mesa is comprised of soft Cretaceous marine shale and the Cretaceous-Tertiary sandstones and shale of the Raton formation (Chronic 1987). An abundance of fossils have been found in the Morrison and Glencarin Formations in the area. The base of the Glencarin formation is a thin layer of fossiliferous sandstone and above this sandstone is marine shale, sandstone, and siltstone, also fossil-containing layers.

Land cover in the New Mexico portion of HUC 11080001 is 49% grassland, 31% evergreen forest, 15% shrub/scrub and 2% deciduous forest (**Figure 1.2**). Land ownership is 93% private, 6% State, and less than 1% USFS, USFWS, BLM, and BOR (**Figure 1.3**). Much of the land ownership adjacent to the river is private with the exceptions of Maxwell National Wildlife Refuge and a small portion of the Valle Vidal in the headwaters of Leandro Creek. The average annual precipitation in Colfax County is 16.34 inches. Average annual snowfall in the study area is 72 inches (or 7.2 inches of precipitation). New Mexican Meadow Jumping Mouse (*Zapus hudsonius luteus*), Piping Plover (*Charadrius melodus*), Bald Eagle (*Haliaeetus leucocephalus*), Peregrine Falcon, Boreal Owl (*Aegolius funereus*), Suckermouth Minnow, and Spotted Bat (*Euderma mmaculatum*) are listed as either Threatened or Endangered by state and/or federal agencies. USFWS has designated Critical Habitat for the New Mexican Meadow Jumping Mouse in the upper reaches of Chicorica Creek (NMDGF Environmental Review Tool, *https://nmert.org/home*, accessed 6/27/18).

11080004 – Mora

The Mora watershed is bounded by the Sangre de Cristo Mountains to the west and the Canadian River and Great Plains to the east. The Mora River watershed from Shoemaker, NM (just east of I-25) to its headwaters drains approximately 1104 mi^2. Elevation ranges from 13,102 ft. at South Truchas Peak to 6145 ft. at the USGS Gage 07221000 near Shoemaker. The average annual precipitation in Mora County ranges from 16 in. on the eastern plains to 25 in. on the mountain valleys. Average annual snowfall ranges from about 30 in. to well over 100 in. at the higher elevations. The TMDL AUs Coyote Creek (Mora River to Amola Ridge), Coyote Creek (Black Lake to headwaters), and Mora River (USGS gage east of Shoemaker to HWY 434) are within the Mora watershed.

The geology of the Mora River watershed is characterized by broad, elevated, north-trending belts of crystalline rocks that are generally flanked by steeply dipping sedimentary rocks in the west and high mesas and extensive dissected plateaus in the east. Surface geology within HUC 11080004 is 35% sandstone, 17% medium-grained mixed clastic, 12% shale, 10% basalt, 8% alluvium, 6% sedimentary, 5% felsic metavolcanics, 3% clastic, 1% limestone and 1% metasedimentary (**Figure 1.1**). The geologic and bedrock hydrologic system are complex. The Mora River and its tributaries originate in the Sangre de Cristo Mountains. Luna and Lujan Creeks form the headwaters of the Mora River. The Mora River valley near Mora is isolated from the alluvial aquifer below by layer of tightly packed fine-grained clay material. Hence the presence of a near-surface water table leading to extensive saturated meadows in the region (S. Dorman, personal communication; Mercer and Lappala, 1972). The river turns east near Watrous and begins to entrench into the plains as it travels towards the Canadian River. All of the perennial streams in Mora County are diverted for irrigation.

There are three main vegetation cover types in the Mora River watershed. They are forest (spruce-fir-pine-aspen in higher elevations and piñon-juniper in lower elevations) in the western mountainous region, rangeland dominated by grama grass on the eastern plains, and agriculture, which is located primarily along narrow, alluvial valleys and river corridors. Land cover within HUC 11080004 is 52% grassland, 36% evergreen forest, and 8% shrub/scrub (**Figure 1.2**). Much of the land adjacent to the river is private, with the exceptions of Fort Union National Monument on Wolf Creek and Coyote Creek State Park and USFS land in the headwaters. Land ownership within HUC 11080004 is 89% private, 7% USFS, 3% SLO, and less than 1% of BLM, NPS and State Parks (**Figure 1.3**).

Southwestern Willow Flycatcher (*Empidonax traillii extimus*), New Mexican Meadow Jumping Mouse, Mexican Spotted Owl (*Strix occidentalis lucida*), Boreal Owl, Southern Redbelly Dace (*Chrosomus erythrogaster)*, Spotted Bat, Pacific Marten (*Martes caurina*), and Star Gyro (*Gyraulus crista*) are listed as either Threatened or Endangered by state and/or federal agencies (NMDGF Environmental Review Tool, *https://nmert.org/home*, accessed 6/27/18). USFWS has designated Critical Habitat for the New Mexican Meadow Jumping Mouse and Southwestern Willow Flycatcher along the Coyote Creek (Williams Canyon to Black Lake) AU, and for the Mexican Spotted Owl on the east slopes of the Sangre de Cristo mountains.

11080005 – Conchas

The Conchas River arises east of Las Vegas, NM, and flows about 50 miles through relatively flat terrain to its confluence with the Canadian River, where it is impounded by the Conchas Dam (built 1939). HUC 11080005 includes Conchas Lake State Park. The TMDL AU Conchas River (Conchas Reservoir to Salitre Creek) is within the Conchas watershed.

Surface geology in HUC 11080005 is 54% medium-grained mixed clastic, 41% sandstone, 2% alluvium and 2% fine-grained mixed clastic (**Figure 1.1**). Land cover in HUC 11080005 is 63% grassland, 30% shrub/scrub, and 6% evergreen forest (**Figure 1.2**). Land ownership in HUC 11080005 is 89% private, 10% SLO, 1% BLM and less than 1% of BOR and State Parks (**Figure 1.3**).

Bald Eagle, Peregrine Falcon, Least Shrew (*Cryptotis parva*), and Paper Pondshell Mussel (*Utterbackia imbecillis*) are listed as either Threatened or Endangered by state and/or federal agencies (NMDGF Environmental Review Tool, *https://nmert.org/home*, accessed 6/27/18).

11080006 – Upper Canadian-Ute Reservoir

HUC 11080006 includes Ute Lake State Park, one of the longest reservoirs in the state, formed by a dam at the confluence of the Canadian River and a tributary called Ute Creek. Ute Reservoir's annual yield of 24,000 acre-feet is intended to provide a renewable source of water for a number of eastern slope communities (NM Bureau of Geology and Mineral Resources, undated). Land cover in HUC 11080006 is 54% shrub/scrub, 40% grassland and 2% evergreen forest (**Figure 1.2**). Land ownership in HUC 11080006 is 88% private, 12% SLO, and less than 1% of BLM and State Parks (**Figure 1.3**). The TMDL AUs Pajarito Creek (Perennial prt Canadian R to Vigil Canyon) and Canadian River (Ute Reservoir to Conchas Reservoir) are within the Upper Canadian-Ute Reservoir watershed.

Ute Lake State Park is in the Pecos Valley section of the Great Plains physiographic province. It lies on the north edge of the Llano Estacado or "staked plains." The Canadian escarpment to the northwest raises 1,000 ft above the mesas, buttes, and plains at Ute Lake. Most of the rocks surrounding the lake, including those that form the bedrock of the dam, belong to the Upper Triassic Chinle Group. The Chinle Group consists of alternating layers of red-brown to buff to maroon to gray mudstone, siltstone, and sandstone that were deposited in continental fluvial and lacustrine environments about 220 million years ago. At Ute Dam surficial deposits of Recent alluvium overlie the Chinle Group and are locally as much as 70 ft thick (NM Bureau of Geology and Mineral Resources, undated). Surface geology in HUC 11080006 is 24%

alluvium, 24% medium-grained mixed clastic, 20% sandstone, 11% fine-grained mixed clastic, 9% mudstone, 7% eolian, 3% coarse-grained mixed clastic, and 2% clastic (**Figure 1.1**).

Peregrine Falcon, Yellow-Billed Cuckoo (*Coccyzus americanus*), Gray Vireo (*Vireo vicinior*), Arkansas River shiner (*Notropis girardi*), Arkansas River speckled chub (*Macrhybopsis tetranema*), and Least Shrew are listed as either Threatened or Endangered by state and/or federal agencies (NMDGF Environmental Review Tool, *https://nmert.org/home*, accessed 6/27/18).

1.2 Water Quality Standards

Table 1.2 Water Quality Standards Segments Associated with the TMDL AUs.

Assessment Unit ID	Assessment Unit name	WQS Segment
NM-2303_00	Canadian River (Ute Reservoir to Conchas Reservoir)	20.6.4.303
NM-2305.A_010	Conchas River (Conchas Reservoir to Salitre Creek)	20.6.4.305
NM-2306.A_021	Coyote Creek (Black Lake to headwaters)	20.6.4.309
NM-2306.A_020	Coyote Creek (Mora River to Amola Ridge)	20.6.4.309
NM-2305.A_255	Doggett Creek (Raton Creek to headwaters)	20.6.4.99
NM-2701_00	Dry Cimarron R (Perennial reaches OK bnd to Long Canyon)	20.6.4.702
NM-2701_02	Dry Cimarron River (Long Canyon to Oak Ck)	20.6.4.702
NM-2701_01	Dry Cimarron River (Oak Creek to headwaters)	20.6.4.701
NM-2305.A_252	East Fork Chicorica Creek (Chicorica Creek to headwaters)	20.6.4.98
NM-2701_20	Long Canyon (Perennial reaches abv Dry Cimarron)	20.6.4.702
NM-2305.3.A_00	Mora River (USGS gage east of Shoemaker to HWY 434)	20.6.4.307
NM-2303_10	Pajarito Creek (Perennial prt Canadian R to Vigil Canyon)	20.6.4.303
NM-2305.A_253	Raton Creek (Chicorica Creek to headwaters)	20.6.4.305
NM-9000.A_019	Tinaja Creek (West Fork Tinaja Creek to headwaters)	20.6.4.98

Water quality standards (WQS) for all assessment units in this document are set forth in the following sections of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4 New Mexico Administrative Code [NMAC] 2018):

20.6.4.98 INTERMITTENT WATERS: All non-perennial surface waters of the state, except those ephemeral waters included under section 20.6.4.97 NMAC or classified in 20.6.4.101-899 NMAC.

A. Designated uses: livestock watering, wildlife habitat, marginal warmwater aquatic life and primary contact.
B. Criteria: the use-specific criteria in 20.6.4.900 NMAC are applicable to the designated uses, except that the following site-specific criteria apply: the monthly geometric mean of E. coli bacteria 206 cfu/100 mL or less, single sample 940 cfu/100 mL or less.

20.6.4.99 PERENNIAL WATERS: All perennial surface waters of the state except those classified in 20.6.4.101-899 NMAC.

A. Designated uses: Warmwater aquatic life, livestock watering, wildlife habitat and primary contact.
B. Criteria: The use-specific criteria in 20.6.4.900 NMAC are applicable to the designated uses, except that the following site-specific criteria apply: the monthly geometric mean of E. coli bacteria 206 cfu/100 mL or less, single sample 940 cfu/100 mL or less.

20.6.4.303 CANADIAN RIVER BASIN: - The main stem of the Canadian river from the headwaters of Ute reservoir upstream to Conchas dam, the perennial reaches of Pajarito and Ute creeks and their perennial tributaries.

A. Designated uses: irrigation, marginal warmwater aquatic life, 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.

20.6.4.305 CANADIAN RIVER BASIN: The main stem of the Canadian river from the headwaters of Conchas reservoir upstream to the New Mexico-Colorado line, perennial reaches of the Conchas river, the Mora river downstream from the USGS gaging station near Shoemaker, the Vermejo river downstream from Rail canyon and perennial reaches of Raton, Chicorica (except Lake Maloya and Lake Alice) and Uña de Gato creeks.

A. Designated uses: irrigation, marginal warmwater aquatic life, livestock watering, wildlife habitat and primary contact.
B. Criteria:
(1) The use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses.
(2) TDS 3,500 mg/L or less at flows above 10 cfs.
[**NOTE:** This segment was divided effective 12-01-10. The standards for Lake Alice and Lake Maloya are under 20.6.4.311 and 20.6.4.312 NMAC, respectively.]

20.6.4.307 CANADIAN RIVER BASIN: - Perennial reaches of the Mora river from the USGS gaging station near Shoemaker upstream to the state highway 434 bridge in Mora, all perennial reaches of tributaries to the Mora river downstream from the USGS gaging station at La Cueva in San Miguel and Mora counties except lakes identified in 20.6.4.313 NMAC, perennial reaches of Ocate creek and its tributaries downstream of Ocate, and perennial reaches of Rayado creek downstream of Miami lake diversion in Colfax county.

A. Designated uses: marginal coldwater aquatic life, warmwater aquatic life, primary contact, irrigation, livestock watering and wildlife habitat.
B. Criteria: the use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses.

20.6.4.309 CANADIAN RIVER BASIN: - The Mora river and perennial reaches of its tributaries upstream from the state highway 434 bridge in Mora except lakes identified in 20.6.4.313 NMAC, all perennial reaches of tributaries to the Mora river upstream from the USGS gaging station at La Cueva, perennial reaches of Coyote creek and its tributaries, the Cimarron river and its perennial tributaries above state highway 21 in Cimarron except Eagle Nest lake, all perennial reaches of tributaries to the Cimarron

river north and northwest of highway 64 except north and south Shuree ponds, perennial reaches of Rayado creek and its tributaries above Miami lake diversion, Ocate creek and perennial reaches of its tributaries upstream of Ocate, perennial reaches of the Vermejo river upstream from Rail canyon and all other perennial reaches of tributaries to the Canadian river northwest and north of U.S. highway 64 in Colfax county unless included in other segments.

A. Designated uses: domestic water supply, irrigation, high quality coldwater aquatic life, livestock watering, wildlife habitat, and primary contact; and public water supply on the Cimarron river upstream from Cimarron and on perennial reaches of Rayado creek and its tributaries.
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 500 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.
[**NOTE:** The segment covered by this section was divided effective 05-23-05. The standards for the additional segment are under 20.6.4.310 NMAC. The standards for Shuree ponds are in 20.6.4.314 NMAC and the standards for Eagle Nest lake are in 20.6.4.315 NMAC, effective 07-10-12]

20.6.4.701 DRY CIMARRON RIVER: - Perennial portions of the Dry Cimarron river above Oak creek and perennial reaches of Oak creek.

A. Designated uses: coldwater aquatic life, irrigation, livestock watering, wildlife habitat and primary contact.
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: temperature 25°C (77°F) or less, the monthly geometric mean of E. coli bacteria 126 cfu/100 mL or less, single sample 235 cfu/100 mL or less.
(2) TDS 1,200 mg/L or less, sulfate 600 mg/L or less and chloride 40 mg/L or less.
[**NOTE:** The segment covered by this section was divided effective 05-23-05. The standards for the additional segment are under 20.6.4.702 NMAC.]

20.6.4.702 DRY CIMARRON RIVER: - Perennial portions of the Dry Cimarron river below Oak creek, and perennial portions of Long canyon and Carrizozo creeks.

A. Designated uses: coolwater aquatic life, irrigation, livestock watering, wildlife habitat and primary contact.
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: the monthly geometric mean of *E. coli* bacteria 126 cfu/100 mL or less, single sample 235 cfu/100 mL or less.
(2) TDS 1,200 mg/L or less, sulfate 600 mg/L or less and chloride 40 mg/L or less.

20.6.4.900 NMAC provides criteria applicable to existing, attainable or designated uses unless otherwise specified in an AU's specific segment. 20.6.4.13 NMAC lists general criteria that apply to all surface waters of the state at all times, unless a specified standard is provided elsewhere in the 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 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, 2011). 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, 2011).

1.4 Water Quality Monitoring Survey

The 2015-2016 SWQB water quality survey was conducted in the Canadian and Dry Cimarron River watersheds from the Colorado border to the Texas and Oklahoma state lines, respectively. The survey included the Dry Cimarron River and tributaries from its headwaters near Johnson Mesa to the Oklahoma state line; the Cimarron River and tributaries originating above Eagle Nest Lake and in the Valle Vidal unit of the Carson National Forest; Raton Creek and tributaries extending to Sugarite Canyon State Park and Johnson Mesa; the Vermejo River and tributaries originating on the Vermejo Park Ranch; Ocate Creek and the Mora River and tributaries originating in the Carson and Santa Fe National Forests; Conchas River; Ute Creek; the mainstem of the Canadian River all other major tributaries of interest. Additionally, all major lakes and reservoirs in the watershed were monitored.

Rivers 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 from 4-12 times over two years, and nutrient and geomorphology data were collected at least once for each perennial AU. Impaired AUs addressed in this TMDL report are shown on **Figures 1.4 – 1.7**.

Monitoring of surface waters across the State has traditionally occurred on an eight-year rotational watershed approach, meaning a given waterbody is generally surveyed intensively, on average, every eight years. 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. Each assessment unit is represented by a small number of monitoring stations (often only one), each of which receives 4–8 site visits during the survey.

SWQB introduced a new strategy during the 2015-2016 seasons where a larger area is monitored over a longer period of time, with 2-6 water chemistry samples collected at each AU per year (4-12 total samples over the entire survey). Through public outreach, inter-agency coordination, and a scoring system taking into account a variety of factors, a three tier monitoring system − primary, secondary, and tertiary – was developed to prioritize AUs. High ranking priority waters (primary AUs) receive the greatest amount of monitoring, whereas low ranking waters (i.e., tertiary AUs) receive the least. This two-year monitoring allows more data to be collected from the highest priority waters to better capture inter-annual variability primarily due to hydrologic conditions during the sampling events. More detail about the 2015-2016 water quality survey can be found in the survey summary report (NMED/SWQB, 2016).

Figure 1.4 TMDL Assessment Units of the Canadian Headwaters HUC-8

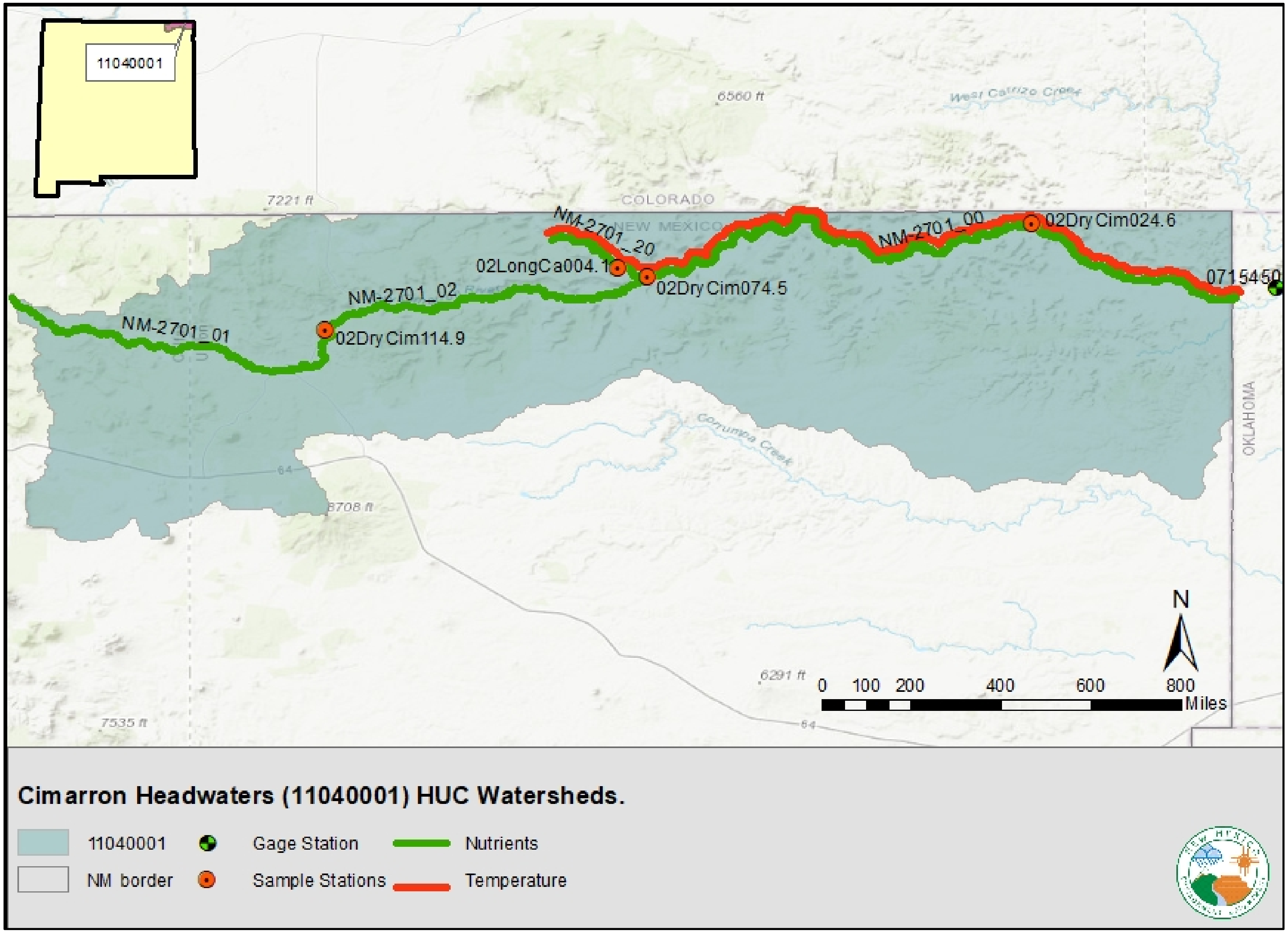


Figure 1.5 TMDL Assessment Units of the Cimarron Headwaters HUC-8

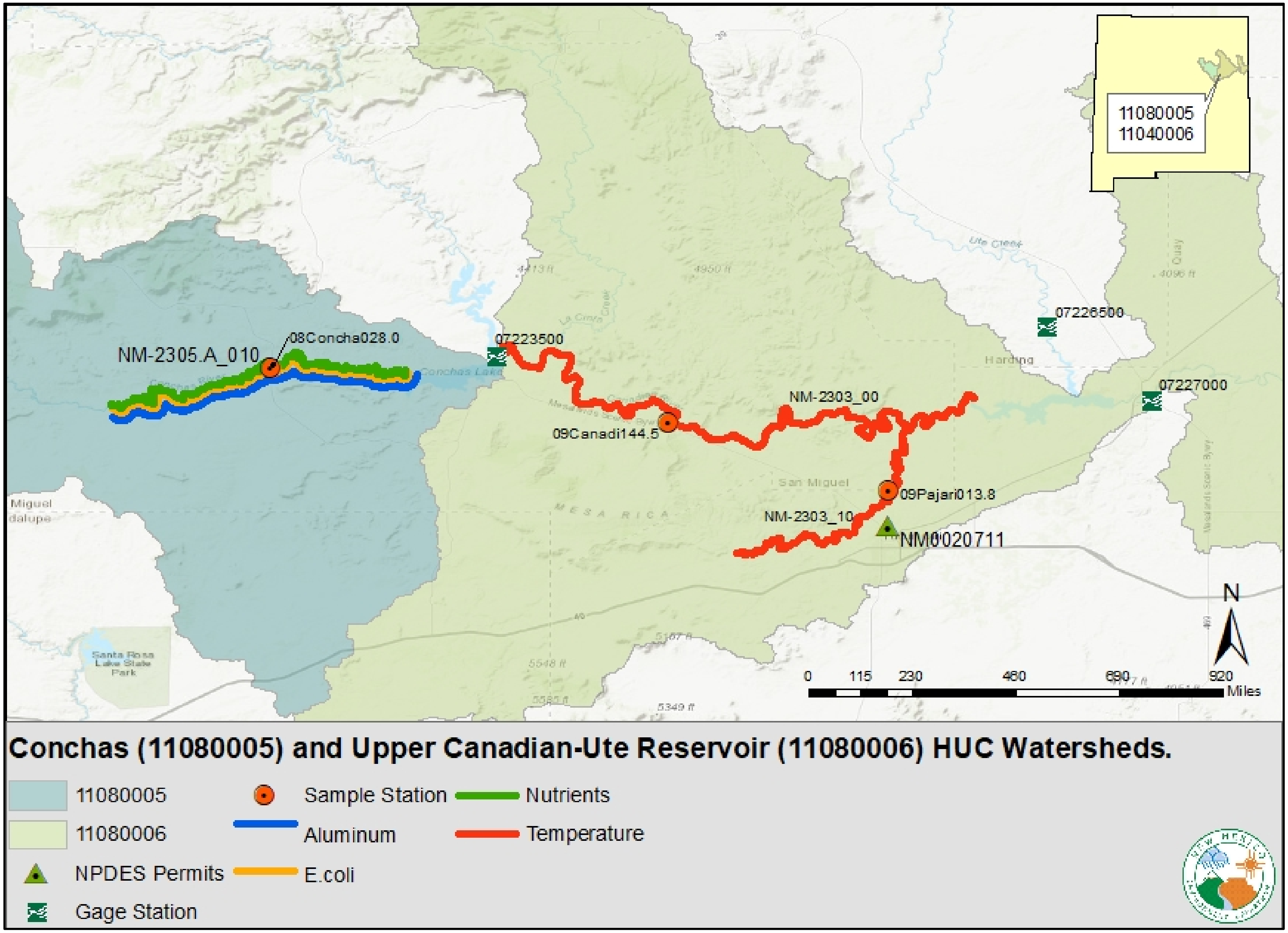


Figure 1.6 TMDL Assessment Units of the Upper Canadian-Ute Reservoir and Conchas HUC-8s

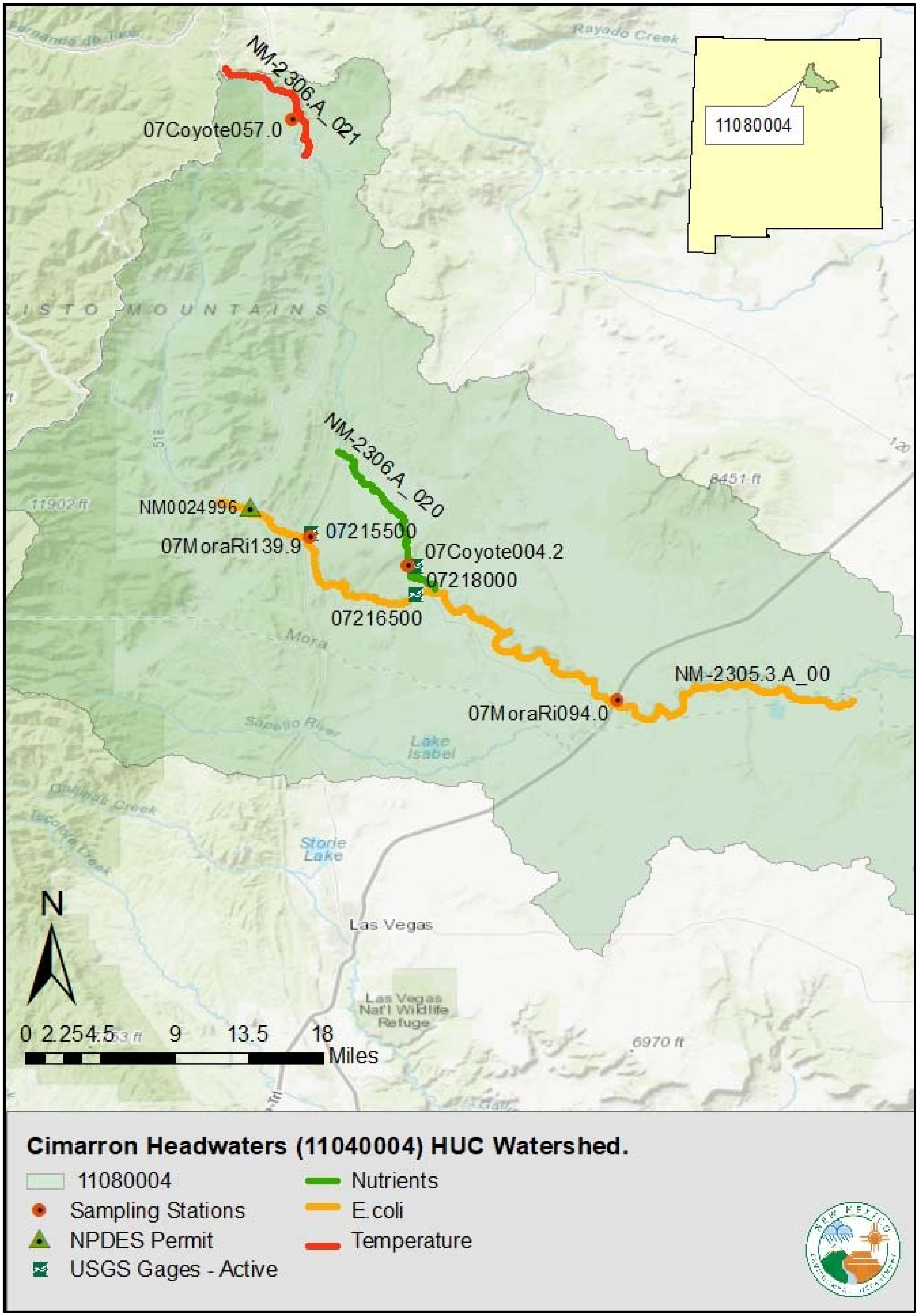


Figure 1.7 TMDL Assessment Units of the Mora HUC-8

1.5 Hydrologic Conditions

There are no active US Geological Service (USGS) flow gages in the New Mexico portion of the Cimarron Headwaters HUC-8. In order to characterize streamflow conditions in which the thermograph and water chemistry data were collected, discharge data were obtained from the closest USGSgage, 07154500 – Cimarron River near Kenton, OK (**Figure 1.8**; the river known as the Cimarron in Oklahoma is called the Dry Cimarron in New Mexico). To further characterize hydrologic conditions during the survey period, precipitation data from a weather station along highway 87 at Capulin are compared to the average year at that station (**Figure 1.9**). Capulin is located near the top of HUC 11040001. The discharge data show that flow in the Dry Cimarron River did not greatly differ from normal during the water quality survey. Precipitation at Capulin was quite a bit above average in 2015 and somewhat below average in 2016.

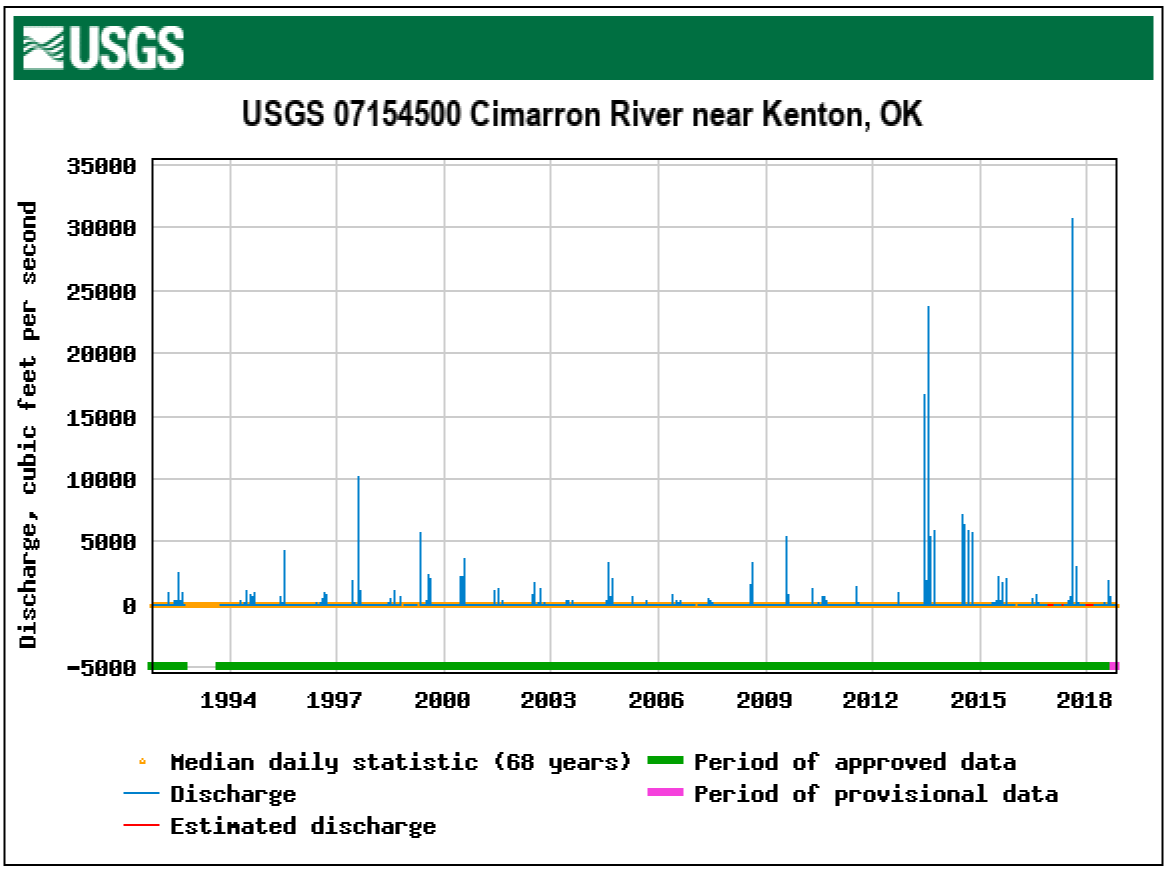


Figure 1.8 Daily discharge 1991-2016 on the Cimarron River (known as the Dry Cimarron River in NM), approximately 4 river miles east of the state line.

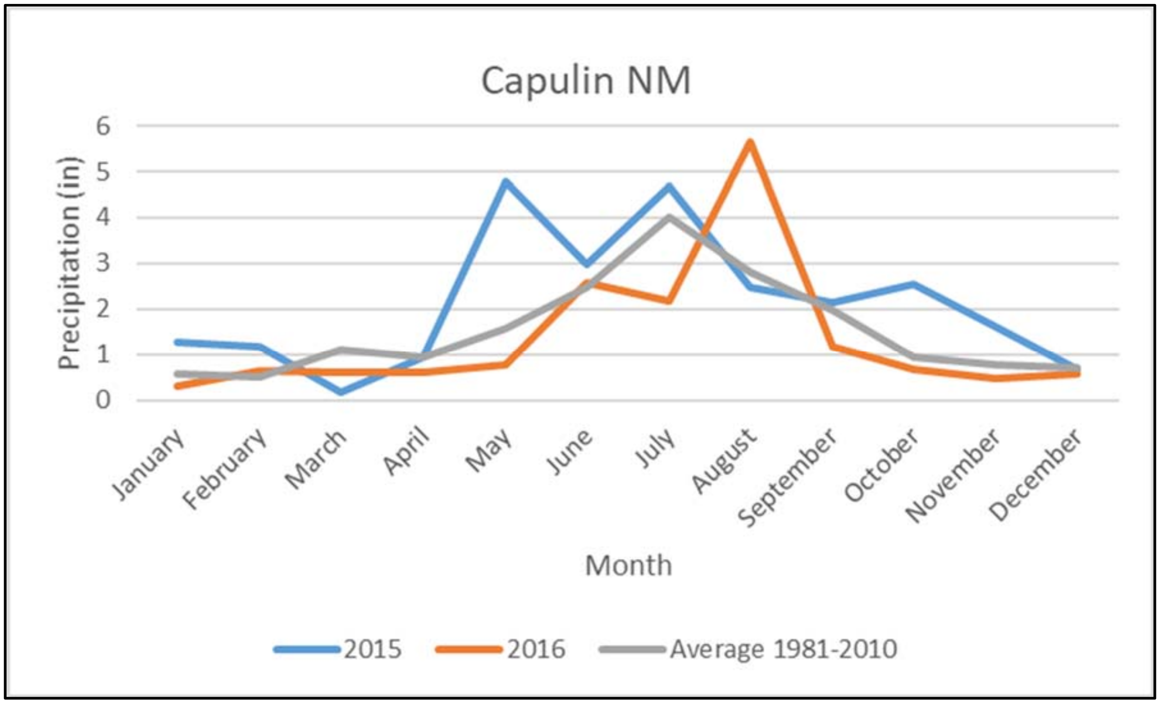


Figure 1.9 Monthly precipitation at Capulin, NM, during the water quality survey, compared to an average year. The annual total precipitation was 25.48 inches in 2015 and 16.21 inches in 2016, compared to the 30 year average annual total of 18.42 inches. Data obtained from U.S. Climate Data, https://www.usclimatedata.com/.

There are few active USGS flow gages in the Canadian basin portion of the TMDL study area. In order to characterize streamflow conditions in which the thermograph and water chemistry data were collected, discharge data were obtained from a U.S. Geological Survey (USGS) gage on the mainstem of the Canadian, below the Mora River but above Conchas Reservoir, 07221500 – Canadian River near Sanchez, NM (**Figure 1.10**). To further characterize hydrologic conditions during the survey period, precipitation data from a weather station at Conchas Dam are compared to the average year at that station (**Figure 1.11**). Conchas Dam is located near the downstream end of the TMDL study area. The discharge data show that flow in the Canadian River during the water quality survey was near average in winter, above average in the summer of 2015 and below average in the summer of 2016. Precipitation at Conchas Dam was quite a bit above average in 2015 and quite a bit below average in 2016.

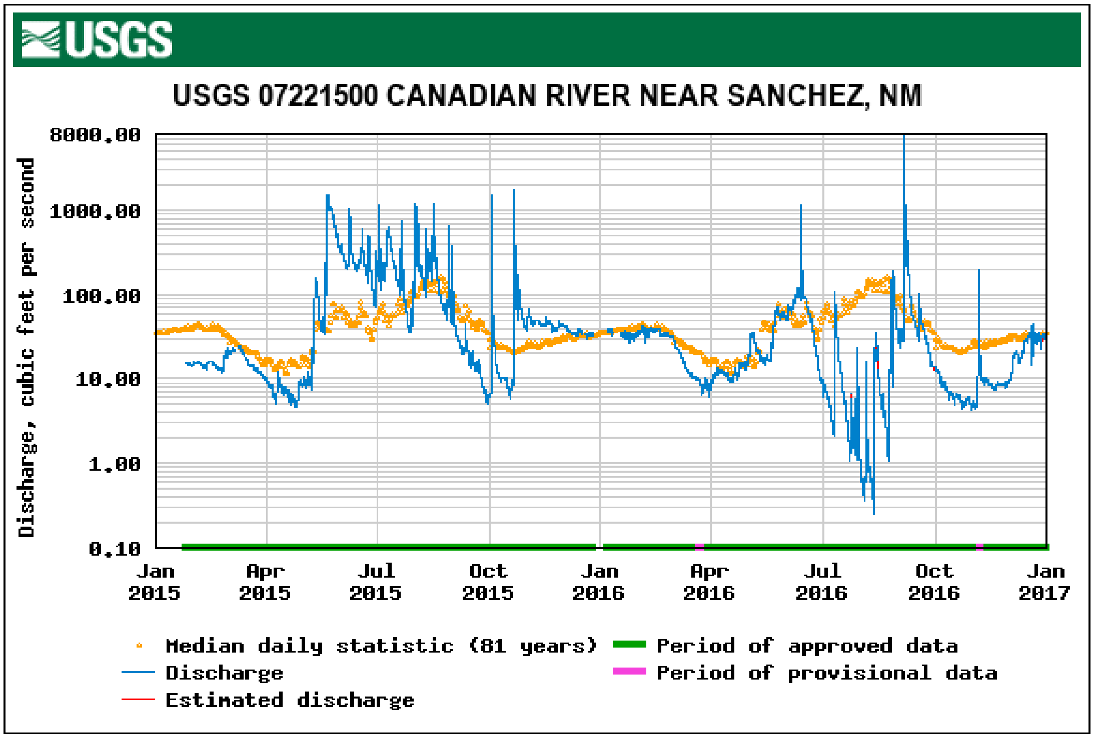


Figure 1.10 Daily discharge on the Canadian River between the Mora River and Conchas Reservoir, for the water quality survey period.

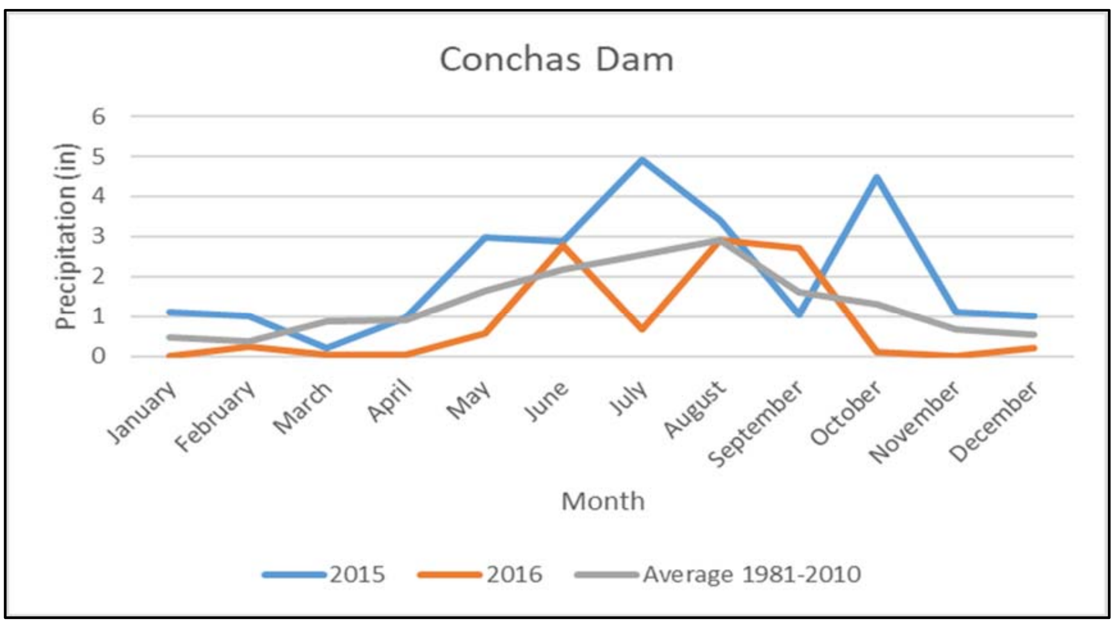


Figure 1.11 Monthly precipitation at Conchas Dam, NM, during the water quality survey, compared to an average year. The annual total precipitation was 25.10 inches in 2015 and 10.28 inches in 2016, compared to the 30-year average annual total of 16.06 inches. Data obtained from U.S. Climate Data, https://www.usclimatedata.com/.

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 suggest 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 Canadian and Dry Cimarron basin were within the applicable pH range during all of the 2015-2016 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 exceedence 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 Assessment Protocol (NMED SWQB, 2015) says that for any one chemical/physical pollutant, there shall be no more than one exceedence of the acute criterion, and no more than one exceedance of the chronic criterion in three years. Exceedences of the WQS were identified by assessment of the data from the 2015-2016 SWQB Canadian River and Dry Cimarron intensive water quality surveys, as shown on **Table 2.1**. Consequently, this AU was listed on the 2018-2020 Integrated CWA §303(d)/§305(b) List (NMED/SWQB, 2018a) for aluminum. Results of laboratory analyses of the samples are shown in Appendix A.

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

Assessment Unit	Exceedances (chronic)	Exceedances (acute)
Conchas River (Conchas Reservoir to Salitre Creek)	2/5	1/5

2.2 Flow

According to the New Mexico Water Quality Standards, the low flow critical condition for numeric 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 aluminum TMDLs were obtained using a regression model. Because this stream 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 NM (i.e., statewide and mountainous regions above 7,500 ft in elevation). The average elevation of the Conchas River above Conchas Reservoir is below 7,500 ft, so the statewide regression equation was used. The following statewide regression equation (Equation 6.2) is based on data from 50 streamflow-gaging stations that had non-zero 4Q3 low-flow frequency. (Waltemeyer 2002):

Equation 6.3

$$4Q3 = 1.2856 \times 10^{-4} DA^{0.42} {P_w}^{3.16}$$

Where:

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

The 4Q3 value calculated using Waltemeyer's method is presented in **Table 2.2**. Parameters used in the calculation were determined using an online GIS application developed by the USGS, called StreamStats. The critical flow was converted from 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 is the goal of SWQB efforts.

Table 2.2 Calculation of 4Q3 for Total Recoverable Aluminum TMDLs

Assessment Unit	Average Elevation (ft)	Drainage Area (mi^2)	Mean Winter Precipitation (in)	Average Basin Slope (ft/ft)	4Q3 (cfs)	4Q3 (MGD)
Conchas River (Conchas Reservoir to Salitre Creek)	5590	514	4.4	NA	.19	.12

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. The TMDL is calculated based on simple dilution using critical flow, the numeric target, and a conversion factor to correct the units of measure.

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

A TMDL is presented on **Table 2.3** for the critical low flow condition. Chronic aluminum criteria were calculated at 115.5 mg/l, the average hardness value that was measured during the two survey sampling events that resulted in exceedences of the WQS.

Table 2.3 Calculation of Target Loads

Assessment Unit	Chronic TR Al criterion (mg/l)	Flow (MGD)	Conversion Factor	TMDL (lbs/day)
Conchas River (Conchas Reservoir to Salitre Creek)	1.67	0.12	8.34	1.67

The TMDL is a planning tool to be used to achieve water quality standards. Since flows vary throughout the year in these systems the target load will vary based on the changing flow. Management of the load to improve stream water quality and meet water quality criteria should be a goal to be attained. 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*

2.4 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.

- *Explicit Margin of Safety*
  An explicit MOS identified using a duration curve framework is basically unallocated assimilative capacity intended to account for uncertainty (e.g., loads from tributary streams, effectiveness of controls, etc). As new information becomes available, this unallocated capacity may be attributed to nonpoint sources including tributary streams (which could then be added to the load allocation); or it may be attributed to point sources (and become part of the waste load allocations).

An explicit MOS of 10% was assigned to the aluminum impaired AU, to account for the inherent error in all flow measurements.

2.5 Waste Load Allocation

There are no active National Pollutant Discharge Elimination System (NPDES) permits that discharge to Conchas River (Conchas Reservoir to Salitre 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 current 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. BMPs and other controls are designed to prevent to the maximum extent practicable an increase in sediment load and flow velocity during and after construction compared to pre-construction conditions to the water body, or an increase in a sediment-related parameter, such as total suspended solids, turbidity, siltation, stream bottom deposits, etc., in order to assure that waste load allocations and/or applicable water quality standards, including the antidegradation policy, are met. This requirement applies both during and after construction operations.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the current NPDES Multi-Sector General Permit (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. 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. Therefore the WLA for this TMDL is zero.

2.6 Load Allocation

In order to calculate the LA, the WLA and the MOS were subtracted from the target capacity (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 2.4 for details).

Table 2.4 TMDL Allocations for Total Recoverable Aluminum

Assessment Unit	WLA (lbs/day)	MOS (lbs/day)	LA (lbs/day)	TMDL (lbs/day)
Conchas River (Conchas Reservoir to Salitre Creek)	0	0.17	1.50	1.67

The extensive data collection and analyses 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. The target load for TR Al is the TMDL minus the MOS, in this case equal to the LA. The load reduction that would be needed in order to achieve the target loading is the difference between the average measured load and the target load, divided by the measured load.

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

Assessment Unit	Target Load (lbs/day)	Measured Load (lbs/day)	Load Reduction
Conchas River (Conchas Reservoir to Salitre Creek)	1.50	10.0	85%

2.7 Probable Pollutant Sources

SWQB fieldwork includes an assessment of the probable sources of impairment in the AU drainage area (Appendix B). Probable Source Sheets are filled out by SWQB staff during watershed surveys and watershed restoration activities. The list of probable sources is not intended to single out any particular land owner 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 source summary for total recoverable aluminum

Assessment Unit	Probable Sources
Conchas River (Conchas Reservoir to Salitre Creek)	Rangeland grazing; Stream channel incision

Aluminum is the third most common element in the Earth's crust, and the most common metal. Land disturbance in the watershed likely plays a role in the magnitude of soil erosion and transport. 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 stream. However, there was not a strong relationship between the total recoverable aluminum and total suspended solids (TSS) concentrations in the AU being evaluated.

Aluminum is present in natural waters in a complex of chemical forms. Aqueous Al is comprised of inorganic Al hydroxy species, of which gibbsite is the most abundant in the pH range encountered during the 2015-2016 survey, although the $AlOH_4$ ion increases in prominence at the higher pHs recorded by SWQB in the Conchas

River above Conchas Reservoir. There is an exchangeable fraction of Al with soils, sediments, and precipitated organic material. 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). Total aluminum reaches a minimum concentration between pH 6 and 7. At pH values greater than 7, aluminum concentration would be expected to increase with increasing pH. However, the opposite correlation appears to be the case in the TMDL AU during the 2015-2016 survey. This may indicate that a large proportion of the total recoverable aluminum is not in dissolved form. In the Conchas River above Conchas Reservoir, which has a designated marginal warmwater Aquatic Life Use, pH ranged as high as 9.22 during the survey.

2.8 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 would expect to see higher aluminum concentrations during spring sampling events in mountainous AUs. Exceedances were documented in the Conchas River above Conchas Reservoir, which is located at low elevation and has relatively high surface disturbance, only during late summer sampling events of both survey years, possibly indicating that stormwater flow over disturbed ground is the primary mechanism of aluminum delivery to the surface water.

2.9 Future Growth

Growth estimates by county and Water Planning Region (WPR) are available from the New Mexico Bureau of Business and Economic Research (BBER, 2008, available at http://bber.unm.edu/data). These estimates project growth to the year 2060. The Conchas River study falls within the Mora/San Miguel/Guadalupe WPR. BBER projects continuing slow growth for the Mora/San Miguel/Guadalupe WPR, as detailed on **Table 2.7**.

Table 2.7 TMDL Study Area Water Planning Region Population Estimates

WPR	2015*	2030	2040	2050	2060	% Increase (2015-2060)
Mora/San Miguel/Guadalupe	44,545	48,488	50,894	52,855	54,681	22.8

*most recent estimate available

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 fecal 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 *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.

Bacteria data collected for the impaired AUs of the Canadian and Dry Cimarron basins 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 from the 2015-2016 SWQB water quality survey identified exceedences of the New Mexico water quality standards for *E. coli* bacteria. As a result, these AUs are listed on the 2018-2020 Integrated CWA §303(d)/ §305(b) List with *E. coli* as an impairment of the primary contact designated use (NMED/SWQB 2018a).

Table 3.1 Exceedences of E. coli documented during the 2015-2016 SWQB survey.

Assessment Unit	Water Quality Criterion (single sample, cfu/100mL)	Number of Exceedences
Doggett Creek (Raton Creek to headwaters)	940	2/20
East Fork Chicorica Creek (Chicorica Creek to headwaters)	940	2/4
Tinaja Creek (West Fork Tinaja Creek to headwaters)	940	2/5
Mora River (USGS gage east of Shoemaker to HWY 434)	410	3/15
Conchas River (Conchas Reservoir to Salitre Creek)	410	2/6

The TMDL for Doggett Creek is written here as a protective limit for the receiving water body, Raton Creek (Chicorica Creek to headwaters). The same watershed approach is taken in Section 8, to address plant nutrient impairments.

3.1 Target Loading Capacity

For this TMDL document, target values for *E. coli* bacteria are based on achievement of the monthly geometric mean numeric criteria associated with the primary contact designated use.

3.2 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. According to the New Mexico Water Quality Standards, the low flow critical condition is defined as the 4-day, 3-year low-flow frequency (4Q3, 20.6.4.11(B)(2) NMAC), for numeric criteria set in 20.6.4.97 through 20.6.4.900 NMAC and Subsection F of 20.6.4.13 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 for all impaired AUs, except the Mora River, were obtained using a regression model. Because the 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 NM (i.e., statewide and mountainous regions above 7,500 ft in elevation). The average elevation of the E. Fork Chicorica Cr. (Chicorica Cr. to headwaters) watershed is above 7,500 ft, so the mountainous regions regression equation was used. The average elevation of Raton Cr. (Chicorica Cr. to headwaters), Tinaja Cr. (W. Fork Tinaja Cr. to headwaters), and the Conchas River above Conchas Reservoir are below 7,500 ft, so the statewide 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)

The following statewide regression equation (Equation 3.2) is based on data from 50 streamflow-gaging stations that had non-zero 4Q3 low-flow frequency (Waltemeyer, 2002):

Equation 3.2 $$4Q3 = 1.2856 \times 10^{-4} DA^{0.42} {P_w}^{3.16}$$

Where:

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

The 4Q3 values calculated using Waltemeyer's method are presented in **Table 3.2**. Parameters used in the calculation were determined using StreamStats, an online GIS application developed by the US Geological Survey. The critical flow was converted from 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 is the goal of SWQB efforts.

For Raton Creek, the calculated 4Q3 is added to the NPDES permitted design flow to arrive at the TMDL critical flow value. The Raton WWTP (NPDES Permit NM0020273), with a permitted design flow of 0.9 MGD, discharges into Doggett Creek. The Raton Water Filtration Facility (NPDES Permit NM0029891), with a permitted design flow of 0.08 MGD, also flows into Raton Creek above Chicorica Creek. The combined permitted flow was added to the calculated 4Q3 low flow of 0.18 MGD, to arrive at a critical TMDL flow value of 1.16 MGD.

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

Assessment Unit	Average Elevation (ft)	Drainage Area (mi^2)	Mean Winter Precipitation (in)	Average Basin Slope (ft/ft)	4Q3 (cfs)	4Q3 (MGD)
Raton Creek (Chicorica Creek to headwaters)	7150	45	6.85	n/a	0.28	0.18
E. Fork Chicorica Creek (Chicorica Creek to headwaters)	7800	24	7.54	0.19	0.1	0.06
Tinaja Creek (W. Fork Tinaja Creek to headwaters)	6970	50	5.27	n/a	0.13	0.08
Conchas River (Conchas Reservoir to Salitre Creek)	5590	514	4.4	n/a	0.19	0.12

n/a – not applicable

The Mora River is considered a flow-regulated water body, and the Waltenmeyer 4Q3 equation is not valid for such streams (Waltemeyer, 2002). The USGS SWToolbox software was used to calculate 4Q3 values for flow at the USGS 07216500 gage on the Mora River near Golondrinas and the USGS 07218000 gage on the tributary Coyote Creek near Golondrinas. These values were added to each other and to a Waltenmeyer equation derived 4Q3 for the tributary Wolf Creek, to generate a 4Q3 value, as show on **Table 3.2**. Gage and tributary locations are show on **Figure 1.6**. The calculated 4Q3 is added to the NPDES permitted design flow to arrive at the TMDL critical flow value.

Table 3.3 Derivation of TMDL critical flow for the Mora River (USGS gage E. of Showmaker to Hwy 434) AU

USGS 07216500 4Q3 (cfs)	USGS 07218000 4Q3 (cfs)	Wolf Creek 4Q3 (cfs)	Watershed 4Q3 (cfs)	Watershed 4Q3 (MGD)	Permit Design Flow (MGD)	Critical Flow (MGD)
1.02	0.46	0.12	1.60	1.03	.052	1.082

3.3 TMDL Calculations

Bacteria standards are expressed as colony forming units (cfu) per unit volume. TMDLs for bacteria (**Table 3.4**) were calculated based on flow values (**Tables 3.2-3.3**), water quality standards, and a conversion factor, using Equation 3.3. The monthly geometric mean criterion is utilized in TMDL calculations to provide an implicit Margin of Safety. If the single sample criterion was used and achieved as a target, the geometric mean criterion might still not be achieved.

Equation 3.3 $C\ as \frac{MPN}{100mL} * 1000\frac{mL}{L} * \frac{L}{0.264\ gallons} * Q\ in\ 1{,}000{,}000\frac{gallons}{day} = MPN/day$

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

Table 3.4 Calculation of TMDLs

Assessment Unit	Geometric Mean *E. coli* criterion (cfu/100 mL)	Critical Flow (MGD)	Conversion Factor	TMDL (cfu/day)
Raton Creek (Chicorica Creek to headwaters)	126	1.16	3.79×10^7	5.54×10^9
E. Fork Chicorica Creek (Chicorica Creek to headwaters)	206	0.06	3.79×10^7	5.04×10^8
Tinaja Creek (W. Fork Tinaja Creek to headwaters)	206	0.08	3.79×10^7	6.56×10^8
Mora River (USGS gage E. of Showmaker to Hwy 434)	126	1.08	3.79×10^7	5.17×10^9
Conchas River (Conchas Reservoir to Salitre Creek)	126	0.12	3.79×10^7	5.86×10^8

3.4 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 measurements and estimations; a conservative MOS for this element is 10%.

3.5 Waste Load Allocation

There are no National Pollutant Discharge Elimination System (NPDES) individual permits that discharge to the E. Fork Chicorica, Tinaja, or Conchas River watersheds. However, the City of Raton WWTP (NM0020273) discharges into Doggett Creek thence to Raton Creek, the City of Raton Water Filtration Facility (NM0029891) discharges to Raton Creek, and the Mora Mutual Domestic Water and Sewage Works (NM0024996) discharges to the Mora River. *E.coli* exceedences were documented downstream of both of the Raton and Mora WWTPs. Further details about the NPDES permits and WLA implementation is presented in **Section 7.1** and monitoring data is available in **Appendix A**.

Waste load allocations for the NPDES permits were calculated based on the permitted design flow and the geometric mean water quality standard for *E. coli*, using the following equation:

WQS criterion x Design Flow x 3.79×10^7 (a unit conversion factor)

Table 3.5 Calculation of *E. coli* Waste Load Allocations

Facility	*E. coli* Geometric Mean Criterion (cfu/100mL)	Design Flow (MGD)	Conversion Factor	Waste Load Allocation (cfu/day)
NM0020273– City of Raton WWTP	126	0.9	3.79×10^7	4.30×10^9
NM0029891- City of Raton Water Filtration Facility	126	0.08	3.79×10^7	0*
NM0024996 - Mora Mutual Domestic Water & Sewerage	126	0.052	3.79×10^7	2.48×10^8

*See Section 7.1

Stormwater discharges from construction activities are transient because they occur 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 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 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 to assure that waste load allocations and/or applicable water quality standards, including the antidegradation policy, are met. Compliance with a SWPPP that meets the requirements of the CGP is generally assumed to be consistent with this TMDL.

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 and enforcement is complex as permittees 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.

3.6 Load Allocation

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

$$WLA + LA + MOS = TMDL$$

The MOS is 10% of the TMDL shown on **Table 3.4**. Results of the LA calculations are presented in Table 3.6. 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 any flow condition.

Table 3.6 Load allocations for E. coli

Assessment Unit	WLA (cfu/day)	LA (cfu/day)	MOS (10%) (cfu/day)	TMDL (cfu/day)
Raton Creek (Chicorica Creek to headwaters)	4.30×10^9	6.86×10^8	5.54×10^8	5.54×10^9
E. Fork Chicorica Cr. (Chicorica Cr. to headwaters)	0	4.54×10^8	5.04×10^7	5.04×10^8
Tinaja Cr. (W. Fork Tinaja Cr. to headwaters)	0	5.90×10^8	6.56×10^7	6.56×10^8
Mora R. (USGS gage E. of Showmaker to Hwy 434)	2.48×10^8	4.41×10^9	5.17×10^8	5.17×10^9
Conchas River (Conchas Reservoir to Salitre Creek)	0	5.27×10^8	5.86×10^7	5.86×10^8

The target load is the TMDL minus the MOS, or the WLA plus the LA. The percent load reduction needed to achieve the WQS for most pollutants, is calculated as the average measured load minus the target load, divided by the measured load. In the case of *E. coli*, the impairment determinations were based on exceedences 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 Title 40, Part 130.7 of the Code of Federal Regulations 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 exceedences in the TMDL report, the "percent reduction" value can be calculated in multiple ways and as a result is often misinterpreted.

3.7 Identification and Description of Pollutant Source(s)

SWQB fieldwork includes an assessment of the probable sources of impairment. Probable source sheets are filled out by SWQB staff during watershed surveys and watershed restoration activities. The draft probable source list was reviewed and modified as necessary with watershed group/stakeholder input during the TMDL public meeting and comment period. The probable source documentation process is fully described in Appendix B. Although this procedure includes subjective and qualitative elements, SWQB has concluded that it provides the best available information for the identification of probable sources of impairment in a watershed. The list of probable sources is not intended to single out any individual land owner or particular land management activity and generally includes several sources per impairment. Pollutant sources that may contribute to each segment were determined by field reconnaissance and evaluation (**Table 3.8**). Probable sources of bacteria impairments will be evaluated, refined, and changed as necessary through the Watershed Based Plans.

In addition to the initial loading, several ambient parameters have been documented to influence coliform bacterial survival (or mortality) and, potentially, regrowth, in fresh water 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.

Table 3.7 Probable Source Summary for E. coli

Doggett Cr. (Raton Cr. to headwaters)	
Bridges/culverts/RR crossings Channelization Gravel or dirt roads Municipal point source discharge On-site treatment systems Paved roads	Pavement/impervious surface Residences/buildings Site clearance (land development) Urban runoff/storm sewers Wildlife other than waterfowl
E. Fork Chicorica Cr. (Chicorica Cr. to headwaters)	
Bridges/culverts/RR crossings Forest fire runoff Gravel or dirt roads Highway/road/bridge runoff Livestock grazing or feeding Low water crossing	Paved roads Pavement/impervious surface Rangeland grazing Residences/buildings Riprap/wall dike/jetty jack Wildlife other than waterfowl
Tinaja Cr. (W. Fork Tinaja Cr. to headwaters)	
Stream channel incision Mass wasting Rangeland grazing	Bridges/culverts/RR crossings Gravel or dirt roads
Mora R. (USGS gage E. of Showmaker to Hwy 434)	
Crop production (dryland) Dams/diversions Gravel or dirt roads Irrigated crop production On-site treatment systems	Paved roads Rangeland grazing Residences/buildings Waterfowl
Conchas River (Conchas Reservoir to Salitre Creek)	
Rangeland grazing Stream channel incision	Waterfowl

3.8 Linkage of Water Quality and Pollutant Sources

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. Bacterial concentrations may become elevated when bacteria-laden sediment is re-suspended during storm events or by subsequent livestock trampling. Survival of bacteria in water bodies is influenced by a number of variables including temperature and sediment size and quantity. Bacterial growth also increases as water temperature increases (Howell et al, 1996).

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 exceedences, a BST dataset would likely be useful to better identify the sources of *E. coli* impacting the stream.

3.9 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. Data used in the calculation of these TMDLs were collected during the spring, summer, and fall of 2015-2016 in order to ensure coverage of potential seasonal variation in the system. Exceedence of the WQS did not correspond with any particular flow level. Exceedences occurred during the all survey months but did seem to be higher in June through September.

3.10 Future Growth

Growth estimates by county and Water Planning Region (WPR) are available from the New Mexico Bureau of Business and Economic Research (BBER, 2008, available at http://bber.unm.edu/data). These estimates project growth to the year 2060. The Doggett Creek (Raton Creek to headwaters), East Fork Chicorica Creek (Chicorica Creek to headwaters), and Tinaja Creek (West Fork Tinaja Creek to headwaters) TMDL study areas fall within the Colfax WPR. The Mora River (USGS gage east of Shoemaker to HWY 434) and Conchas River (Conchas Reservoir to Salitre Creek) TMDL study areas fall within the Mora/San Miguel/Guadalupe WPR. As detailed on **Table 3.8**, BBER projects continuing slow growth for the Colfax and Mora/SanMiguel/Guadalupe WPRs.

Table 3.8 TMDL Study Area Water Planning Region Population Estimates

WPR	2015*	2030	2040	2050	2060	% Increase (2015-2060)
Colfax	15,323	16,480	16,976	17,484	18,129	18.3
Mora/San Miguel/Guadalupe	44,545	48,488	50,894	52,855	54,681	22.8

*most recent estimate available

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

Nutrient assessments were conducted on data collected during the 2015-2016 Canadian River water quality survey. Detailed assessment of various water quality parameters indicated plant nutrient impairment in nine assessment units. The nutrient impairments are addressed through the four watershed TMDLs listed in **Table 4.1**. The Cimarron River in Oklahoma is downstream of the Dry Cimarron River in New Mexico. The Oklahoma portion is impaired for dissolved oxygen, but the State of Oklahoma does not have nutrient criteria for this waterbody and is therefore not listed as impaired for plant nutrients.

A previous TMDL for plant nutrients was developed for Pajarito Creek (Canadian River to headwaters) that included a WLA for the Tucumcari WWTP (NM0020711). A revision of that TMDL is planned before the end of the current permit term (September 30, 2020). The Maxwell WWTP (NM0029149) discharges to Canadian River (Cimarron River to Chicorica Creek), however, no nutrient WLA is assigned as the facility has reported no discharge since 2006 and may not renew their NPDES permit (June 30, 2019 expiration).

Table 4.1 Nutrient impaired watersheds and assessment units

AU_ID	Assessment Unit	WQS Segment	HUC
Conchas River (Conchas Reservoir to Salitre Creek)			
NM-2305.A_010	Conchas River (Conchas Reservoir to Salitre Creek)	20.6.4.305	11080005
Coyote Creek (Mora River to headwaters)			
NM-2306.A_020	Coyote Creek (Mora River to Amola Ridge)	20.6.4.309	11080004
NM-2306.A_023	Coyote Creek (Amola Ridge to Williams Canyon) *	20.6.4.309	11080004
NM-2306.A_022	Coyote Creek (Williams Canyon to Black Lake)	20.6.4.309	11080004
NM-2306.A_021	Coyote Creek (Black Lake to headwaters) *	20.6.4.309	11080004
Dry Cimarron River (Perennial reaches OK boundary to headwaters)			
NM-2701_00	Dry Cimarron River (Perennial reaches OK bnd to Long Cyn)	20.6.4.702	11040001
NM-2701_01	Dry Cimarron River (Oak Creek to headwaters)	20.6.4.701	11040001
NM-2701_02	Dry Cimarron River (Long Canyon to Oak Creek)	20.6.4.702	11040001
NM-2701_20	Long Canyon (Perennial reaches abv Dry Cimarron)	20.6.4.702	11040001
Raton Creek (Chicorica Creek to headwaters)			
NM-2305.A_255	Doggett Creek (Raton Creek to headwaters)	20.6.4.99	11080001
NM-2305.A_253	Raton Creek (Chicorica Creek to headwaters)	20.6.4.305	11080001

**unimpaired assessment unit*

4.1 Target Loading Capacity

There are two potential causes of nutrient enrichment in a given stream: excessive phosphorus and/or nitrogen. 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 as the sum of nitrate+nitrite (N+N), and Total Kjeldahl Nitrogen (TKN). 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 (N+N) is appropriate for estimating total nitrogen (APHA 1989). While not an EPA-approved method, Method SM4500-N for Total Nitrogen using a persulfate digest, is an approved method in the SWQB QAPP (NMED/SWQB 2019) and is used in cases where a lower detection limit is needed.

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 (USEPA 2012).

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. Therefore, SWQB, with the assistance from EPA and the USGS, developed nutrient-related thresholds, or *narrative translators*, to address both cause (TN and TP) and response variables (dissolved oxygen [DO], pH, and periphyton chlorophyll *a*). Water quality assessments for nutrients are based on quantitative measurements of these causal and response indicators. If these measurements exceed the numeric nutrient threshold values, indicate excessive primary production, and/or demonstrate an unhealthy biological community, the reach is considered impaired (NMED/SWQB 2018a).

The applicable threshold values for cause and response variables for three of the four watershed TMDLs are in the Flat TN site class (0.65 mg/L) and the Flat-moderate TP site class (0.061 mg/L), whereas Coyote Creek is in the Moderate TN site class (0.37 mg/L) and the Flat-moderate TP site class (0.061 mg/L). These threshold values were used for water quality assessments and as a starting point for TMDL development.

4.2 Flow

40 CFR 130.7(c)(1) requires states to calculate a TMDL using the critical conditions for stream flow. The presence of plant nutrients in a stream can vary as a function of flow, however, higher nutrient concentrations typically occur during low-flow conditions because there is reduced stream capacity to assimilate nutrients. In other words, as flow decreases, the stream cannot dilute its constituents causing the concentration of plant nutrients to increase. Higher flows typically do not represent impairment as high flows can quickly move the TN and TP through the assessment unit not allowing for the growth of nuisance algae.

A climatic year starting April 1 of the prior year and ending March 31 is often used when examining critical low flow conditions in the United States. This choice reduces the likelihood of splitting low flow periods - typically found in the summer or fall - across different years and thereby affecting the results of Log Pearson Type III analysis of series of annual low flows. A different climatic year or shorter season may be used if low flow periods occur at other times of the year or overlap the boundaries of the climatic year.

When available, USGS gages are used to estimate flow. The 4Q3 flow for Coyote Creek (07218000) was estimated using gage data and DFLOW software, Version 3.1b (USEPA 2006). DFLOW 3.1b is a Windows-based tool developed to estimate user selected design stream flows for low flow analysis by utilizing algorithms based on Log Pearson Type III distribution.

It is often necessary to estimate a critical flow for a portion of a watershed where there is no active USGS flow gage. 4Q3 derivations for ungauged streams were based on analysis methods described by Waltemeyer (2002). 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 7,500 feet in elevation). The following statewide regression equation (**Equation 4.1**) is based on data from 50 streamflow-gaging stations that had non-zero 4Q3 low-flow frequency (Waltemeyer, 2002). Parameters used in the calculation were determined using StreamStats, an online GIS application developed by the US Geological Survey. The critical flow was converted from cfs to million gallons per day (MGD) using a conversion factor of 0.646. Flows used for TMDL development are listed in **Table 4.2.**

Equation 4.1

$$4Q3 = 1.2856 \times 10^{-4} DA^{0.42} {P_w}^{3.16}$$

Where:

4Q3 = Four-day, three-year low-flow frequency (cfs)

DA = Drainage area (mi^2)

P_w = Average basin mean winter precipitation (inches)

Table 4.2 Flow summaries for nutrient-impaired watersheds

Watershed	Flow Method	Average Elevation (ft)	DA (mi^2)	P_w (in)	4Q3
Conchas River (Conchas Reservoir to Salitre Creek)	Waltemeyer-statewide	5590	514	4.4	0.19 cfs 0.12 mgd
Coyote Creek (Mora River to headwaters)	DFLOW 07218000 [a]	n/a	n/a	n/a	0.46 cfs 0.30 mgd
Dry Cimarron River (Perennial reaches OK boundary to headwaters)	Waltemeyer - statewide	5840	905	4.87	0.33 cfs 0.21 mgd
Raton Creek (Chicorica Creek to headwaters)	Waltemeyer-statewide	7150	45	6.85	0.28 cfs 0.18 mgd

(a) period of record 1929-2018

It is important to remember that in this case, the TMDL itself is a value calculated at a defined critical flow condition and is calculated as part of the 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 also vary.

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. 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 4.3**.

Critical flow (4Q3) x WQS x Conversion Factor = TMDL **(Eq. 4.2)**

Table 4.3 Daily target loads for TP & TN

TMDL Watershed	Parameter	Critical Flow (mgd)[(a)]	In-Stream Target (mg/L)	Conversion Factor	TMDL (lbs/day)
Conchas River (Conchas Reservoir to Salitre Creek)	Total Phosphorus Total Nitrogen	0.12	0.061 0.65	8.34	0.06 0.65
Coyote Creek (Mora River to headwaters)	Total Phosphorus Total Nitrogen	0.30	0.061 0.37	8.34	0.15 0.93
Dry Cimarron River (Perennial reaches OK boundary to headwaters)	Total Phosphorus Total Nitrogen	0.33	0.061 0.65	8.34	0.17 1.79
Raton Creek (Chicorica Creek to headwaters)	Total Phosphorus Total Nitrogen	1.16 [(b)]	0.061 0.65	8.34	0.59 6.29

Notes: *(a)* See Section 4.2 for details about critical flow calculations.
(b) The design flows of NM0020273 (0.9 mgd) and NM0029891 (0.08 mgd) were added to the calculated 4Q3.

This total TMDL for the Raton Creek watershed is then allocated as follows: first the MOS is subtracted as described in Section 4.4, then the Waste Load Allocation is subtracted as described in Section 4.5.1, and the remainder is the Load Allocation as described in Section 4.5.2 and Equation 4.3.

Table 4.4 Plant Nutrient TMDLs

Assessment Unit	Parameter	MOS (lbs/day)	LA (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)
Conchas River (Conchas Reservoir to Salitre Creek)	Total Phosphorus Total Nitrogen	0.01 0.07	0.05 0.59	0 0	0.06 0.65
Coyote Creek (Mora River to headwaters)	Total Phosphorus Total Nitrogen	0.02 0.09	0.14 0.83	0 0	0.15 0.93
Dry Cimarron River (Perennial reaches OK boundary to headwaters)	Total Phosphorus Total Nitrogen	0.01 0.11	0.1 1.02	0 0	0.17 1.79
Raton Creek (Chicorica Creek to headwaters)	Total Phosphorus Total Nitrogen	0.06 0.63	0.07 0.78	0.46 [(a)] 4.88 [(a)]	0.59 6.29

Notes: *(a)* WLA for NM0020273. See Secton 4.5.1.

4.4 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 these nutrient TMDLs, 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*
  - Uncertainty exists in sampling nonpoint sources of pollution. A conservative MOS for this element is therefore **5 %**.
  - There is inherent error in all flow values, both measured and calculated; a conservative MOS for this element in gaged streams is **5 %**.

4.5 Waste Load Allocations and Load Allocations

4.5.1 Waste Load Allocation

There are no National Pollutant Discharge Elimination System (NPDES) individual permits that discharge to the Conchas River, Coyote Creek, or Dry Cimarron River watersheds. However, the City of Raton WWTP (NM0020273) discharges into Doggett Creek thence to Raton Creek and the City of Raton WTP (NM0029891) discharges to Raton Creek. Phased WLAs for NM0020273 are listed in **Table 4.5**; no WLA was assigned for NM0029891. The EPA Technical Support Document for Water Quality Based Toxics Control (EPA 1991) strongly recommends that the WLA is not directly implemented in the permit as it is an overly conservative estimate, but the document provides a methodology for translation of the WLA into appropriate permit limitations. See Chapter 7.4.3 in the 1991 TSD for an example calculation. Per Chapter 5.3.1 of the TSD:

> *"Direct use of a WLA as a permit limit creates a significant risk that the WLA will be enforced incorrectly, since effluent variability and the probability basis for the limit are not considered specifically. For example, the use of a steady state WLA typically establishes a level of effluent quality with the assumption that it is a value never to be exceeded. The same value used directly as a permit limit could allow the WLA to be exceeded without observing permit violations if compliance monitoring was infrequent. Confusion can also result in translating a longer duration WLA requirement (e.g. for chronic protection) into maximum daily and average monthly permit limits. The permit writer must ensure that permit limits are derived to implement a WLA requirement correctly."*

Further discussion of these permits as well as nutrient TMDL implementation are discussed in **Section 7.1**.

Table 4.5 Wasteload Allocation for NM0020273

Phase	Parameter	Target limit (mg/L)	WLA (lbs/day)
0 (Current permit)	Total Phosphorus Total Nitrogen	3.0 [a] 10.0 [a]	14 [a] 46.7 [a]
1st	Total Phosphorus Total Nitrogen	3.0 [b] 9.4 [b]	13.3 [b] 41.5 [b]
2nd	Total Phosphorus Total Nitrogen	TBD [c]	TBD [c]
nth	Total Phosphorus Total Nitrogen	0.061 [d] 0.65 [d]	0.46 [e] 4.88 [e]

TBD = to be determined.

[a] The 2015 permit effluent limits were based on the 85th percentile of 2009-2014 concentration data. The loading limit was based on the maximum 30-day average flow (0.56 mgd) from the previous two years of data. See fact sheet for NPDES permit issued in 2015.

[b] Targets and WLA based on 85^{th} percentile of DMR chemistry data and maximum 30-day flow (0.53 mgd) for the July 2015-March 2019 time period.

[c] To be evaluated next permit cycle. See Section 7.1.

[d] Targets based on in-stream nutrient targets discussed in Section 4.1.

[e] TMDL calculated using Equation 4.2 and 0.9 mgd design flow.

There are no Municipal Separate Storm Sewer System (MS4) permits in these AUs. However, excess nutrient loading may be a component of some storm water discharges covered under general NPDES permits. There may be storm water discharges from construction activities covered under the NPDES Construction General Permit (CGP). Permitted sites require preparation of a SWPPP that includes identification and control of all 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 to assure that WLAs or applicable water quality standards, including the antidegradation policy, are met. Compliance with a SWPPP that meets the requirements of the CGP is generally assumed to be consistent with this TMDL.

Storm water discharges from active industrial facilities are generally covered under the current NPDES Multi-Sector General Permit (MSGP). This permit also requires preparation of an SWPPP, which includes specific requirements to limit (or eliminate) pollutant loading associated with the industrial activities in order to minimize impacts to water quality. Compliance with a SWPPP that meets the requirements of the MSGP is generally assumed to be consistent with this TMDL.

It is not possible to calculate individual WLAs for facilities covered by these General Permits at this time using available tools. Loads that are in compliance with the General Permits are therefore currently included as part of the LA.

4.5.2 Load Allocation

The load allocation (LA) accounts for the non-point sources (NPS) of pollution in the respective watersheds. Nonpoint sources include all other categories not classified as point sources (i.e., WLAs). In order to calculate the LA, the WLAs and MOS were subtracted from the TMDL using **Equation 4.3**:

$$TMDL = \Sigma\ WLA + \Sigma\ LA + MOS \qquad \textbf{(Eq. 4.3)}$$

therefore,

$$\Sigma\ LA = TMDL - MOS - \Sigma\ WLA$$

4.5.3 Load Reductions

The load reductions necessary to meet the target loads were calculated as the difference between the calculated daily target load (**Table 4.5**) and the measured load as shown in **Table 4.6**.

Table 4.6 Calculation of load reduction for TP and TN

TMDL Watershed	Parameter	Target Load[(a)] (lbs/day)	Measured Load[(b)] (lbs/day)	Load Reduction (lbs/day)	Percent Reduction[(c)]
Conchas River (Conchas Reservoir to Salitre Creek)	Total Phosphorus	0.05	0.50	0.45	89%
	Total Nitrogen	0.59	5.20	4.61	89%
Coyote Creek (Mora River to headwaters)	Total Phosphorus	0.14	32.89	32.75	100%
	Total Nitrogen	0.83	348.28	347.45	100%
Dry Cimarron River (Perennial reaches OK boundary to headwaters)	Total Phosphorus	0.10	0.73	0.63	87%
	Total Nitrogen	1.02	6.91	5.89	85%
Raton Creek (Chicorica Creek to headwaters)	Total Phosphorus	0.53	5.70	5.18	91%
	Total Nitrogen	5.66	11.73	6.07	52%

Notes: *(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 exceedance values (Appendix D) and the mean measured flow at exceedances.

(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.

4.5 Identification and Description of Pollutant Sources

SWQB fieldwork includes an assessment of the probable sources of impairment (**Appendix A**). The approach for identifying "Probable Sources of Impairment" was modified by SWQB to include additional input from a variety of stakeholders including landowners, watershed groups, and local, state, tribal and federal agencies. Probable Source Sheets are filled out by SWQB staff during watershed surveys and watershed restoration activities. The draft probable source list (**Table 4.7**) will be reviewed and modified, as necessary, with watershed group/ stakeholder input during the TMDL public meeting and comment period.

Table 4.7 Pollutant source summary for plant nutrients

TMDL Watershed	NPDES permits	Probable Sources
Conchas River (Conchas Reservoir to Salitre Creek)	None	Bridges/culverts/RR crossings, gravel or dirt roads, low water crossing, on-site treatment systems (septic), rangeland grazing, residences/buildings, stream channel incision, waterfowl, wildlife other than waterfowl
Coyote Creek (Mora River to headwaters)	None	Angling pressure, campgrounds, channelization, crop production, dams/diversions, fish stocking, flow alterations, gravel or dirt roads, highways/road/bridge runoff, hiking trails, irrigated crop production, legacy logging, on-site treatment systems (septic), rangeland grazing, residences/buildings, site clearance (land development), stream channel incision, waterfowl, wildlife other than waterfowl
Dry Cimarron River (Perennial reaches OK boundary to headwaters)	None	Bridges/culverts/RR crossings, channelization, crop production, dams/diversions, dumping/garbage/trash/litter, flow alterations, gravel/dirt roads, irrigated crop production, legacy logging, low water crossing, mass wasting, on-site treatment systems (septic), paved roads, rangeland grazing, recent bankfull/overbank flows, residences/buildings, stream channel incision, storm runoff due to construction, waterfowl, wildlife other than waterfowl.
Raton Creek (Chicorica Creek to headwaters)	NM0020273 NM0029891	Bridges/culverts/RR crossings, channelization, crop production, dams/diversions, dumping/garbage/trash/litter, flow alterations, gravel/dirt roads, highway/road/bridge runoff, hiking trails, inappropriate waste disposal, irrigated crop production, legacy logging, low water crossing, mass wasting, municipal point source discharge, on-site treatment systems (septic), paved roads, pavement/impervious surfaces, rangeland grazing, recent bankfull/overbank flows, residences/buildings, site clearance, stream channel incision, urban runoff/storm sewers, waste from pets, waterfowl, watershed runoff following forest fire, wildlife other than waterfowl.

The Probable Source Identification Sheets in **Appendix A** provide an approach for a visual analysis of a pollutant source along an impaired reach. Although this procedure is qualitative, SWQB feels that it provides the best available information for the identification of probable sources of impairment in a watershed. 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 impairment. Probable sources of impairment along each reach as determined by field reconnaissance and assessment are listed in **Table 4.8**. Probable sources of nutrients will be evaluated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

4.6 Linkage between Water Quality and Pollutant Sources

The source assessment phase of TMDL development identifies sources of nutrients that may contribute to both elevated nutrient concentrations and the stimulation of algal growth in a waterbody (**Figure 4.3**). Where data gaps exist or the level of uncertainty in the characterization of sources is large, the recommended approach to TMDL assignments requires the development of allocations based on estimates utilizing the best available information.

Figure 4.3: Canadian River at NM 120, October 13, 2016

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 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 4.4**).

As noted above, 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 4.4**). The relationship between nuisance algal growth and nutrient enrichment in stream systems has been well documented in the literature (Welch 1992; Van Nieuwenhuyse and Jones 1996; Dodds *et al.* 1997; Chetelat *et al.* 1999). Unfortunately, the magnitude of nutrient concentration that constitutes an "excess" is difficult to determine and varies by ecoregion. The recommended level of total phosphorus to avoid algal blooms in nitrogen-limited ecosystems is 0.01 to 0.1 mg/L and 0.1 mg/L to 1 mg/L of total nitrogen. The upper end of these ranges also support less biological diversity (NOAA/USEPA 1988).

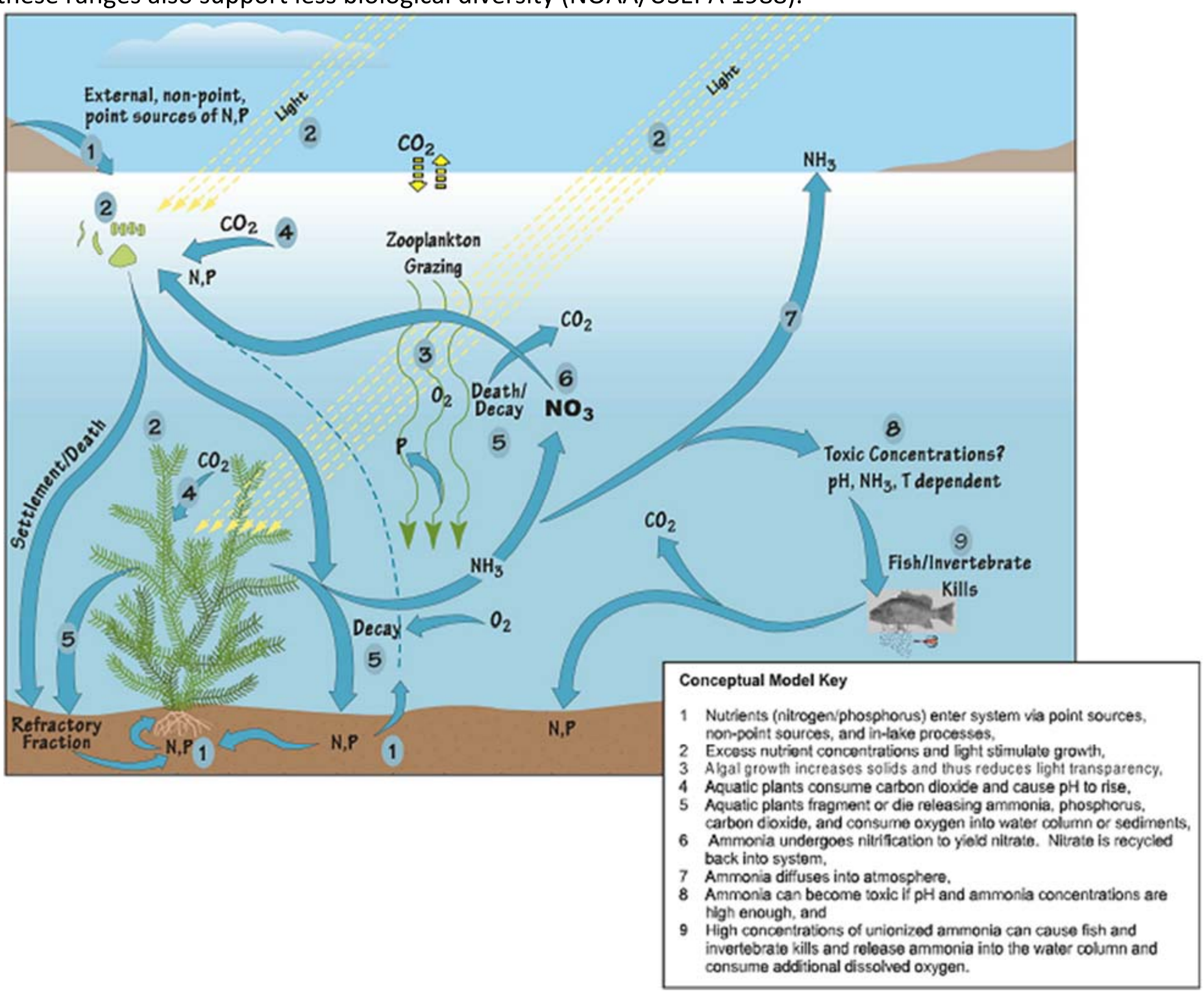


Figure 4.4 Nutrient conceptual model (USEPA 1999)

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 geographically occurring nutrient source is atmospheric deposition, which adds nutrients directly to the waterbody through dryfall and rainfall. 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.

Water pollution caused by on-site septic systems is a widespread problem in New Mexico (McQuillan 2004). Septic system effluents have contaminated more water supply wells, and more acre-feet of ground water, than all other sources in the state combined. Groundwater contaminated by septic system effluent can discharge into streams gaining from groundwater inflow. Nutrients such as phosphorous and nitrogen released into gaining streams from aquifers contaminated by septic systems can contribute to eutrophic conditions.

4.7 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 this TMDL were collected during the spring, summer, and fall to ensure coverage of any potential seasonal variation in the system. Exceedences were observed during all seasons, which captured flow alterations related to snowmelt, the growing season, and summer monsoonal rains. 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. Flow considerations are discussed in Section 4.2.

4.8 Future Growth

Growth estimates by county and Water Planning Region (WPR) are available from the New Mexico Bureau of Business and Economic Research (http://bber.unm.edu/data). These estimates project growth to the year 2060. The nutrient TMDLs fall within the Northeast New Mexico, Colfax and Mora/San Miguel/Guadalupe WPRs, as detailed on **Table 4.9**. BBER projects continuing slow growth for the Colfax and Mora/SanMiguel/Guadalupe WPRs, and "relatively very slow" growth in the Northeast New Mexico WPR, with slight negative growth in the 2050-2060 decade.

Table 4.8 TMDL Study Area Water Planning Region Population Estimates

WPR	2015*	2030	2040	2050	2060	% Increase (2015-2060)
Northeast New Mexico	84,987	88,338	89,654	89,772	89,216	5.0
Colfax	15,323	16,480	16,976	17,484	18,129	18.3
Mora/San Miguel/Guadalupe	44,545	48,488	50,894	52,855	54,681	22.8

**most recent estimate available*

Estimates of future growth are not anticipated to lead to a significant increase in nutrients that cannot be controlled with BMPs. However, it is imperative that BMPs continue to be utilized to improve road conditions and grazing allotments and adhere to SWPPP requirements related to construction and industrial activities covered under the general permit. Any future growth would be considered part of the existing load allocation, assuming persistence of the hydrologic conditions used to develop these TMDLs.

5.0 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 geographical 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).

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 ALU was approved by the WQCC in October 2010, to support aquatic life whose physiologic tolerances are intermediate between those of warm 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.

5.1 Target Loading Capacity

For this TMDL document, target values for temperature are based on the reduction in thermal loading necessary to achieve numeric criteria. Increases in thermal loading in a given AU can often be correlated to changes in shade and/or canopy cover. Temperature criteria for aquatic life uses in New Mexico are shown on **Table 5.1**. New Mexico's aquatic life temperature criteria are expressed as 4T3, 6T3 and T_{MAX}. 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 5.1 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

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

$$WLA + LA + MOS = TMDL$$

The Dry Cimarron River in New Mexico becomes the Cimarron River when it crosses the state border into Oklahoma. The State of Oklahoma does not have temperature criteria for this waterbody.

Assessment of the Canadian/ Dry Cimarron watershed thermograph data determined that some of the AUs exceeded the $\mathbf{T_{MAX}}$ for their designated Aquatic Life Use (ALU).

Table 5.2 Canadian/ Dry Cimarron temperature impaired AUs

AU Name	AU ID	Designated ALU	T_{MAX} Criterion (°C)	Date of Measured T_{MAX}	Measured T_{MAX} (°C)
Canadian River (Ute Reservoir to Conchas Reservoir)	NM-2303_00	Marginal Warmwater	32.2	7/25/2016	37.12
Coyote Creek (Black Lake to headwaters)	NM-2306.A_021	High Quality Coldwater	23	6/19/2016	30.09
Dry Cimarron R (Perennial reaches OK bnd to Long Canyon)	NM-2701_00	Coolwater	29	8/5/2015	31.18
Long Canyon (Perennial reaches abv Dry Cimarron)	NM-2701_20	Coolwater	29	7/25/2015	33.24
Pajarito Creek (Perennial part Canadian River to Vigil Canyon)	NM-2303_10	Marginal Warmwater	29	6/28/2015	36.57

5.2 Flow

40 C.F.R. § 130.7(c)(1) requires states to calculate a TMDL using critical conditions for stream flow. The highest in-stream water temperatures typically occur during the hottest times of the year when the daytime is at its longest and solar radiation is at its highest. For New Mexico, the beginning of summer (before the monsoon season) is generally the hottest time of the year and coincides with the dry season, and consequently the lowest stream flows. The critical flow condition used to calculate these temperature TMDLs is the 4Q3, which is the minimum average four consecutive day flow that occurs with a frequency of once every three years. When available, USGS gages are used to estimate flow. Where continuous gage data is not available, the 4Q3

flows were obtained using a 4-day, 3-year low-flow frequency (4Q3) regression model developed by Waltemeyer (2002). 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 7,500 ft in elevation). The following statewide regression equation is based on data from 50 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 = 1.2856 \times 10^{-4} DA^{0.42} Pw^{3.16}$$

Where:

4Q3 = Four-day, three-year low-flow frequency (cfs)
DA = drainage area (mi^2)
Pw = average basin mean winter precipitation (inches)

Waltemeyer's equation for mountainous regions above 7500 feet is:

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

Where:

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

The 4Q3 flow for the Canadian River (Ute Reservoir to Conchas Reservoir) is based on USGS gage data from an inactive gage below Conchas Dam. The gage, named Canadian River below Conchas Dam, NM (USGS Gage 07224500), is located in the AU and has a period of record from 1943 to 1972. Conchas Dam was completed in 1939 so using this gage data as an estimate of current flow seems reasonable since streamflow is dependent on releases from the dam. The 4Q3 for this AU was estimated using the USGS A193 calculation for Log Pearson Type III distribution through DFLOW software (USEPA, 2015). DFLOW is a Windows-based tool developed to estimate user selected design stream flows for flow frequency analysis.

Table 5.3 Critical flow values for Canadian/ Dry Cimarron temperature TMDLs

Assessment Unit	4Q3 (cfs)
Canadian River (Ute Reservoir to Conchas Reservoir)	0.98
Coyote Creek (Black Lake to headwaters)	0.31
Dry Cimarron River (Perennial reaches OK bnd to Long Canyon)	0.33
Long Canyon (Perennial reaches abv Dry Cimarron)	0.17
Pajarito Creek (Perennial part Canadian R to Vigil Canyon)	0.2

No gage data was available for the remaining TMDL AUs. Critical flow was estimated using the Waltemeyer mountainous regions equation for Coyote Creek (Black Lake to headwaters), and the statewide equation for Dry Cimarron River (Perennial reaches OK bnd to Long Canyon), Long Canyon (Perennial reaches abv Dry Cimarron), and Pajarito Creek (Perennial part Canadian R to Vigil Canyon). Values for the parameters used in the calculation were obtained using the USGS StreamStats web application (USGS, 2016).

It is important to remember that 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.

5.3 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 site-specific criteria and 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 convert units used by SWQB for temperature (in Celsius) and flow (in cfs) to units needed to balance the thermal energy equation. Substituting the appropriate unit conversion factors, the equation used for temperature is the following:

WQS (°C) x Flow (cfs) x 1.023E+7 = TMDL (kJ/day)

Details of the derivation of the TMDL equation are presented in Appendix C. **Table 5.4** shows the TMDL calculation values for each impaired AU.

Table 5.4 Temperature TMDL calculations based on WQS T_{MAX}

Assessment Unit Name	WQS T_{MAX} (°C)	4Q3 critical flow (cfs)	Conversion factor	TMDL (kJ/day)
Canadian River (Ute Reservoir to Conchas Reservoir)	32.2	0.98	1.023×10^7	3.23×10^8
Coyote Creek (Black Lake to headwaters)	23	0.31	1.023×10^7	7.29×10^7
Dry Cimarron R (Perennial reaches OK bnd to Long Canyon)	29	0.33	1.023×10^7	9.79×10^7
Long Canyon (Perennial reaches abv Dry Cimarron)	29	0.17	1.023×10^7	5.04×10^7
Pajarito Creek (Perennial part Canadian R to Vigil Canyon)	29	0.20	1.023×10^7	5.93×10^7

5.4 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.

For this temperature TMDL, data from the warmest time of the year were used as a conservative assumption, in order to capture the seasonality of temperature exceedences. Because of the uncertainty in determining critical low flow, an explicit MOS of 10%, is assigned to this TMDL. **Table 5.5** shows the MOS values for each AU.

Table 5.5 Explicit MOS for Temperature impairments.

Assessment Unit	MOS (10%) (kJ/day)
Canadian River (Ute Reservoir to Conchas Reservoir)	3.23×10^{7}
Coyote Creek (Black Lake to headwaters)	7.29×10^{6}
Dry Cimarron R (Perennial reaches OK bnd to Long Canyon)	9.79×10^{6}
Long Canyon (Perennial reaches abv Dry Cimarron)	5.04×10^{6}
Pajarito Creek (Perennial part Canadian R to Vigil Canyon)	5.93×10^{6}

5.5 Waste Load Allocation

There are no National Pollutant Discharge Elimination System (NPDES) individual permits that discharge to the Dry Cimarron river, Long Canyon, Coyote Creek, or Canadian River watersheds. The City of Tucumcari WWTP (NM0020711) discharges to Pajarito Creek but no WLA was assigned to this permit. Further discussion of permits and permit implementation are discussed in **Section 7.1**.

There are no Municipal Separate Storm Sewer System (MS4) permits in these AUs. However, excess nutrient loading may be a component of some storm water discharges covered under general NPDES permits. There may be storm water discharges from construction activities covered under the NPDES Construction General Permit (CGP). Permitted sites require preparation of a SWPPP that includes identification and control of all 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 to assure that WLAs or applicable water quality standards, including the antidegradation policy, are met. Compliance with a SWPPP that meets the requirements of the CGP is generally assumed to be consistent with this TMDL.

5.6 Load Allocation

Load Allocation (LA) is pollution from any non-point 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 5.6 TMDL allocation summary.

Assessment Unit	MOS	WLA	LA	TMDL
Canadian River (Ute Reservoir to Conchas Reservoir)	3.23×10^7	0	2.91×10^8	3.23×10^8
Coyote Creek (Black Lake to headwaters)	7.29×10^6	0	6.56×10^7	7.29×10^7
Dry Cimarron R (Perennial reaches OK bnd to Long Canyon)	9.79×10^6	0	8.81×10^7	9.79×10^7
Long Canyon (Perennial reaches abv Dry Cimarron)	5.04×10^6	0	4.54×10^7	5.04×10^7
Pajarito Creek (Perennial prt Canadian R to Vigil Canyon)	5.93×10^6	0	5.34×10^7	5.93×10^7

The load reductions necessary to meet the target loads were calculated as the difference between the calculated daily target load (**Table 5.6**) and the measured load as shown in **Table 5.7**.

Table 5.7 Calculation of temperature load reduction

Assessment Unit	Measured flow/Date (cfs)	T_{MAX}/Date (°C)	Measured load [(b)]	Target Load [(a)]	Percent reduction [(c)]
Canadian River (Ute Reservoir to Conchas Reservoir)	0.2/ 7-14-2016	37.12/ 7-25-2016	7.59×10^7	2.91×10^8	5%*
Coyote Creek (Black Lake to headwaters)	0.6/ 6-29-2016	30.09/ 6-19-2016	1.85×10^8	6.56×10^7	64%
Dry Cimarron R (Perennial reaches OK bnd to Long Canyon)	1.34/ 2015-2016**	31.18/ 7-25-2015	4.27×10^8	8.81×10^7	79%
Long Canyon (Perennial reaches abv Dry Cimarron)	0.14/ 2015-2016**	33.24/ 7-25-2015	4.76×10^7	4.54×10^7	5%
Pajarito Creek (Perennial prt Canadian R to Vigil Canyon)	0.5/ 6-25-2015	36.57/ 6-28-2015	1.87×10^8	5.34×10^7	71%

Notes: *(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 maximum measured exceedance value (Appendix D) and the mean measured flow at exceedances.

(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.

*estimated

**No measured flow data available at or near the date of maximum temperature exceedance, so the average measured flows at the thermograph site for the 2015-2016 field season was used.

5.7 Identification and Description of Pollutant Source(s)

SWQB fieldwork includes an assessment of the probable sources of impairment (Appendix A). Probable Source Sheets are filled out by SWQB staff during watershed surveys and watershed restoration activities. The list of "Probable Sources" is not intended to single out any single land owner or particular land management activity and generally includes several sources per pollutant. **Table 5.8** displays probable pollutant sources that have the possibility to contribute to increased temperature as determined by field reconnaissance and knowledge of watershed activities.

Table 5.8 Probable Source summary for AU temperature impairments within the Canadian/Dry Cimarron watershed.

Assessment Unit	Probable Source
Canadian River (Ute Reservoir to Conchas Reservoir)	Dams/diversions, drought-related impacts, exotic species, on-site treatment systems, paved roads, rangeland grazing, residences/buildings, waterfowl, wildlife
Coyote Creek (Black Lake to headwaters)	Crop production (dryland), deams/diversions, gravel or dirt roads, irrigated crop production, on-site treatment systems, paved roads, rangeland grazing, residences/buildings, waterfowl
Dry Cimarron R (Perennial reaches OK bnd to Long Canyon)	Channel incision, crop production (dryland), dams/diversions, gravel or dirt roads, irrigated crop production, litter, low water crossing, mass wasting, on-site treatment systems, paved/unpaved roads, rangeland grazing, residences/buildings, waterfowl, wildlife
Long Canyon (Perennial reaches abv Dry Cimarron)	Channel incision, channelization, crop production dry and irrigated, dams/diversions, flow alteration, mass wasting, on-site treatment systems, paved/unpaved roads, rangeland grazing, residence/buildings, wildlife
Pajarito Creek (Perennial prt Canadian R to Vigil Canyon)	Crop production dry land/irrigation, dams/diversions, drought-related impacts, flow alterations, irrigation, livestock operation, litter, rangeland grazing, residences/buildings, riprap, roads paved/unpaved, site clearance, waterfowl, wildlife

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 will be further evaluated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

5.8 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.

The warmest stream temperatures correspond to prolonged solar radiation exposure, warmer air temperature, and low flow conditions. These conditions occur during late summer and early fall and promote the warmest seasonal instream temperatures. It is assumed that if critical conditions are met, coverage of any potential seasonal variation will also be met.

5.9 Future Growth

Growth estimates by county and Water Planning Region (WPR) are available from the New Mexico Bureau of Business and Economic Research (http://bber.unm.edu/data). These estimates project growth to the year 2060. The Coyote Creek (Black Lake to headwaters) AU falls within the Colfax WPR, and the remaining temperature TMDL AUs fall within the Northeast New Mexico WPR. BBER projects continuing slow growth for the Colfax WPR, and "relatively very slow" growth in the Northeast New Mexico WPR, with slight negative growth in the 2050-2060 decade.

Table 5.8 TMDL Study Area Water Planning Region Population Estimates

WPR	2015*	2030	2040	2050	2060	% Increase (2015-2060)
Northeast New Mexico	84,987	88,338	89,654	89,772	89,216	5.0
Colfax	15,323	16,480	16,976	17,484	18,129	18.3

**most recent estimate available*

Estimates of future growth are not anticipated to lead to a significant increase in temperature that cannot be controlled with BMPs. However, BMPs should continue to be utilized to improve road conditions and grazing allotments and adhere to SWPPP requirements related to construction and industrial activities covered under the general permit. Any future growth would be considered part of the existing load allocation, assuming persistence of the hydrologic conditions used to develop these TMDLs.

6.0 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. 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 years. The next scheduled monitoring date for the Canadian River watershed is 2023-2024.

The SWQB maintains current quality assurance and quality control plans to cover all monitoring activities. This document, called the Quality Assurance Project Plan (NMED/SWQB, 2018b), 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). Short-term efforts were directed toward those waters that are on the USEPA TMDL consent decree list (U.S. District Court for the District of New Mexico 1997), however NMED/SWQB completed the final remaining TMDL on the consent decree in December 2006 and USEPA approved this TMDL in August 2007. The U.S. District Court terminated the Consent Decree on April 21, 2009.

Once assessment monitoring is completed, those reaches showing impacts and requiring a TMDL will be targeted for more intensive monitoring. The methods of data acquisition include fixed-station monitoring, intensive surveys of priority assessment units (including biological assessments), and compliance monitoring of industrial, federal, and municipal dischargers, as specified in the SWQB 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.

7.0 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.

7.1 Point Sources – NPDES permitting

There are four individual NPDES permits that discharge to the assessment units addressed in this document.

Table 7.1 Individual NPDES permits

NPDES permit/ expiration date	Assessment Unit	Impairment	WLA	Current permit limit
NM0024996 - Mora Mutual Domestic Water & Sewerage (September 30, 2022)	Mora River (USGS gage east of Shoemaker to Hwy 434)	*E.coli*	2.48×10^{8} cfu/day	126 MPN/100mL 30-day average and 410 MPN/100 mL daily maximum
NM0029891 - City of Raton Water Filtration Facility (August 31, 2021)	Raton Creek (Chicorica Creek to headwaters)	Plant nutrients	Zero	None
NM0020273 – City of Raton WWTP (June 30, 2020)	Raton Creek (Chicorica Creek to headwaters)	Plant nutrients *E.coli*	Phased TMDL. See Table 4.5 4.30×10^{9} cfu/day	TN 10mg/L and 46.7 lbs/day (30-day avg) TP 3mg/L and 14 lbs/day (30-day avg) 126 MPN/100mL 30-day average and 410 MPN/100 mL daily maximum
NM0020711 – City of Tucumcari WWTP (September 30, 2020)	Pajarito Creek (Perennial portions Canadian River to Vigil Canyon)	Temperature	Zero	None

7.1.1 *E. coli*

The Mora WWTP (NM0024996) discharges into the Mora River (USGS gage east of Shoemaker to Hwy 434) assessment unit and has 126 MPN/100mL 30-day average and 410 MPN/100mL daily maximum *E.coli* permit limits. Monthly DMR *E.coli* results reported by the WWTP indicate 0 MPN/100 mL for the beginning of the current permit term in October 2017 through June 2018. However, nine *E.coli* samples collected by MASS staff during the March 2015-November 2016 time period indicate five samples greater than 2419.6 MPN/100 mL and the remaining four results were 16.1, 98.4, 203.54, and 1299.65 MPN/100mL, respectively. In summary, six of the nine effluent samples collected by MASS staff exceeded the 410 MPN/100mL daily maximum permit limit. The WLA assigned to the Mora WWTP in Section 3.0 is based on the *E.coli* WQS already used in the current permit, therefore the assigned WLA does not assume the need for permit modifications during the next permit term.

The Mora National Fish Hatchery (NM0030031) previously discharged to the Mora River (USGS gage east of Shoemaker to Hwy 434) assessment unit. However, the permittee notified SWQB and EPA Region 6 on January 12, 2018 that they would not be seeking renewal for their permit expiring July 31, 2018. The letter indicated that their annual average fish production of 2,786 pounds is less than the 20,000 pound fish production that requires a NPDES permit as stated in 40 CFR 122.24 Appendix C. Therefore, no WLA was assigned to this terminated permit.

The Raton WWTP (NM0020273) discharges into the Doggett Creek (Raton Creek to headwaters) assessment unit and then into Raton Creek and has a 126 MPN/100mL 30-day average and 410 MPN/100mL daily maximum *E.coli* permit limits. Monthly DMR *E.coli* results reported by the WWTP for the July 2015-June 2018 period indicate two samples (648.8 and 2419.8 MPN/100mL, respectively) that exceeded the 410 MPN/100mL permit limit. Eleven *E.coli* samples collected by MASS staff during the March 2015-October 2016 period averaged 144.9 MPN/100mL with no exceedences of the 410 MPN/100mL *E.coli* daily maximum permit limit. The WLA assigned to the Raton WWTP in Section 3.0 is based on the *E.coli* WQS already used in the current permit, therefore the assigned WLA does not assume the need for permit modifications during the current permit term. The current permit does not include loading limits for E. coli. WLA loading limits of 4.3×10^{9} cfu/day for the 30-day average should be added in the next permit renewal.

7.1.2 Plant nutrients

A previous TMDL for plant nutrients was developed for Pajarito Creek (Canadian River to headwaters) that included a WLA for the Tucumcari WWTP (NM0020711). A revision of that TMDL is planned before the end of the current permit term (September 30, 2020). The Maxwell WWTP (NM0029149) discharges to Canadian River (Cimarron River to Chicorica Creek), however, no nutrient WLA is assigned as the facility has reported no discharge since 2006 and may not renew their NPDES permit (June 30, 2019 expiration).

The Raton Water Filtration Facility (NM0029891) discharges into the Raton Creek (Chicorica Creek to headwaters) assessment unit and has no permit limit for either total nitrogen or total phosphorus. No plant nutrient data from either DMR documents or MASS staff are available for this facility. The reasonable potential analysis conducted during the 2015 permit renewal process indicated that the facility discharge has no reasonable potential to exceed the applicable WQS for nitrite+nitrate. The facility has reported “no discharge” since at least January 2010. The Raton WTP is not expected to cause or contribute to the plant nutrient impairment, therefore no WLA is assigned. The permit expires in August 2021.

The Raton WWTP (NM0020273) discharges into the Doggett Creek (Raton Creek to headwaters) assessment unit and then into Raton Creek. The Raton WWTP has both total nitrogen and total phosphorus permit limits: total nitrogen 10mg/L and 46.7 lbs/day (30-day average) and total phosphorus 3mg/L and 14 lbs/day (30-day average). Thirty-six monthly DMR samples were collected for the July 2015-June 2018 period and during that time, two total nitrogen samples exceeded the 10 mg/L permit limit and two total phosphorus samples exceeded the 3 mg/L permit limit. No samples exceeded either 30-day average loading permit limit. The permit expires in June 2020.

If the TS 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 for the facility modifications necessary to meet new water quality-based requirements. The target threshold values for the WWTP discharging to Raton Creek of 0.65 mg/L TN and 0.061 mg/L TP are not achievable with current technology. NMED-SWQB proposes a multiphase approach that will provide incremental progress towards the highest attainable condition (see Table 4.5). Phase 0 is the current permit limits. Phase 1 is a reduction from the current permit limits and is based on the 85th percentile of what the facility is currently achieving. Phase 2 through the final phase (n), will be re-evaluated as additional data about the receiving waters and the facility's capabilities is collected and technology improves. In any case, the WLAs should be translated into discrete permrit limits using the approach in EPA's Technical Support Document. The TSD specifically states that implementing a WLA directly as limitations in a permit is overly conservative. The compliance schedule for the next Permit renewal should be set for the facility to meet Phase 1 (a reduction from 10 mg/L TN to 9.1 mg/L and 3 mg/L TP to 2.8) at the end of that permit cycle with the current phase 0 limits retained for the balance of the permit cycle.

7.1.3 Temperature

The Tucumcari WWTP (NM0020711) discharges into the Pajarito Creek (Perennial portions Canadian River to Vigil Canyon) assessment unit and has no permit limit for temperature. Five effluent field temperatures collected by MASS staff during the May 2015-September 2016 period averaged 23.85ºC with a maximum effluent temperature in June 2016 of 27.42 ºC. None of the five effluent temperature samples exceeded the 32.2 ºC temperature WQS. Data indicate that the WWTP is not contributing to the elevated temperature in the assessment unit, therefore, the WLA for this reach is zero.

There are no other individual NPDES permits that discharge to assessment units addressed in this document.

7.2 Nonpoint Sources

7.2.1 WBP and BMP Coordination

Public awareness and involvement will be crucial to the successful implementation of these plans and improved water quality. A 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 non-point source pollution can be found online at: *https://www.epa.gov/polluted-runoff-nonpoint-source-pollution*.

SWQB staff will continue to provide technical assistance such as selection and application of BMPs needed to meet WBP goals. Stakeholder public outreach and involvement in the implementation of this TMDL will be ongoing.

7.2.2 Temperature modeling

Introduction

Fresh water systems have interrelated biotic and abiotic parameters that drive the temperature of the waterbody. These parameters can be generalized into simple categories that include: vegetation and land cover, channel morphology, and hydrology. Together these parameters affect stream heat transfer and stream mass transfer processes to varying degrees. Stream parameters can exhibit considerable spatial variability within a system, such as: channel width, spatial and seasonal variability, meteorological measurements and microclimates, and solar irradiance.

Due to the complexity of what can drive these systems, temperature modeling techniques can facilitate the computation and prediction of the extent to which different parameters can affect a fresh water system. Temperature models can also provide information and identify the sensitivity of the parameters that affect temperature further an understanding towards TMDL implementation.

This section provides information about the temperature model used for implementation of the impaired AU's mentioned in this TMDL. This assessment was completed to support the TMDL and implement the water quality standard for temperature. The specific required components of the TMDL are provided in Section 5 of the TMDL document.

The model temperature analysis (once calibrated) focused mainly on changes in the riparian shade percentage (which is a function of the sites' landscape and stream dynamics). This temperature model analysis focused only on measured percent effective shade to reduce surface waters case scenario. Percent effective shade was a parameter chosen as a first-step analysis for TMDL implementation since it is the most straightforward stream parameter to monitor and calculate and is easily translated into quantifiable water quality management. Other parameter qualifiers where not included in the analysis and should be further researched for restoration and management purposes, such as: shade geometry and density, riparian conditions, stream's orientation, ecoregion and riparian species assessment. A more thorough ecosystem evaluation as well as possible further modeling of alternate river morphological conditions would be recommended for BMP /restoration TMDL implementation analysis.

Model Assumptions

A series of assumptions are associated with the SSTEMP run conditions. Running the model outside of these assumptions will often result in inaccuracies or model instability. For a complete list of assumptions and model deficiencies, please see the SSTEMP user manual (Bartholow 2004). The assumptions used in the development of SSTEMP that are most relevant to the development of the present TMDL are listed below:

- Water in the system is instantaneously and thoroughly mixed at all times; there is no lateral temperature distribution across channel OR vertical gradients in pools.
- Stream geometry is characterized by mean conditions.
- Solar radiation and other meteorological and hydrological variables are 24-hour means.
- Distribution of lateral inflow is uniformly apportioned throughout the segment length
- Manning's n and travel time do not vary as functions of flow.
- Modeled/representative time periods must be long enough for water to flow the full length of the segment.
- SSTEMP is not able to model cumulative effects; for example, adding or deleting vegetation mathematically is not necessarily equivalent to on-the-ground needs of the riparian system.

Methods

The calibration for this stream temperature model assessment utilized both in situ habitat data in accordance of SWQB SOP 5.0 ((NMED/SWQB 2016) and remotely sensed spatial data (see Appendix D) to determine the modeling of hydrologic and thermal processes of the temperature impaired AU.

For this TMDL we utilized two complementary modeling tools:

- WinXSPRO, A Channel Cross Section Analyzer, Version 3.0. (https://www.fs.fed.us/biology/nsaec/products-tools.html) and;
- Stream Segment Temperature Model (SSTEMP) Version 2.0 (https://www.sciencebase.gov/catalog/item/53ea4091e4b008eaa4f4c457).

WinXSPRO is a software tool that is designed to analyze stream channel cross section input data for geometric, hydraulic and sediment transport for a single transect (Thomas el at 2005). The analysis options that this software provides are: stage-to-discharge relationships, inundation scenarios, changes in channel morphology and computing sediment transport rates (Thomas *et al*. 2005). For this TMDL we utilized WinXSPRO to determine the for the stage-to-discharge relationships, to ultimately determine two variables need for the second stage of the model. See Appendix D for variable determination and their methodologies.

For the second stage of the model we utilized SSTEMP. This software is supported by the USGS and it is was used to evaluate the effects of changing riparian shade within the impaired streams presented in this TMDL (Bartholow 2004). SSTEMP also has the capability to analyze and evaluate alternative physical factors that can affect the temperature budget of a stream, these include: reservoir release proposals, the physical features of a stream and different stream withdrawals and returns on instream temperature (Bartholow 2004). The analysis is designed to evaluate single stream segments for day time period (Bartholow 2004). See Appendix D for variable determination and their methodologies.

Results

The first step of the model analysis involved obtaining the wetted width-discharge/flow relationship called for 2 variables called "width A and B" needed for the SSTEMP model. The width-flow relationship was obtained in a stepwise methodology using Winxspro. Winxspro modeled the cross-section flow at different stages. Then one can utilize SSTEMP methodology to obtain the width flow relationships (Bartholow 2004).

- Width's A and B Term- a regression analysis can be used to develop this relationship by transforming the natural log (flow) and width to natural log (width). The resulting regression line's slope will be the B term and A term will be the exponentiated:

$$B = \text{Slope};\ A = e^{(\text{constant from regression/y-intercept})}$$

The following is an example of the regression equation developed for one of the AU's in order to determine Width A and B, see **Figure 7.1**.

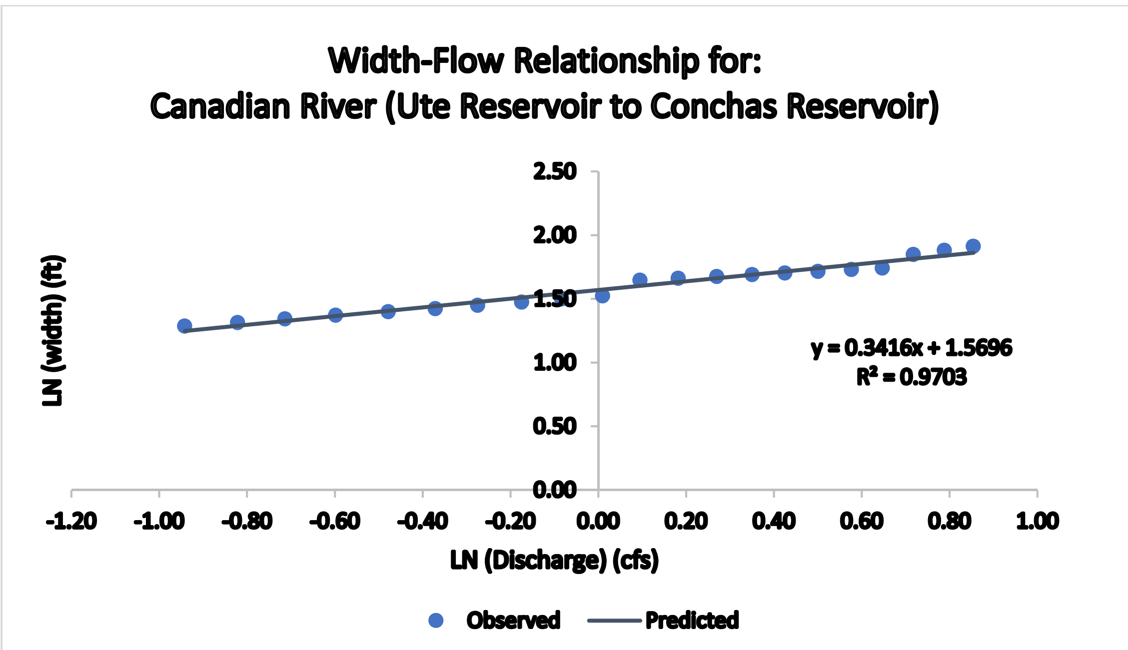


Figure 7.1 Width-flow relationship example for obtaining Width A and B terms.

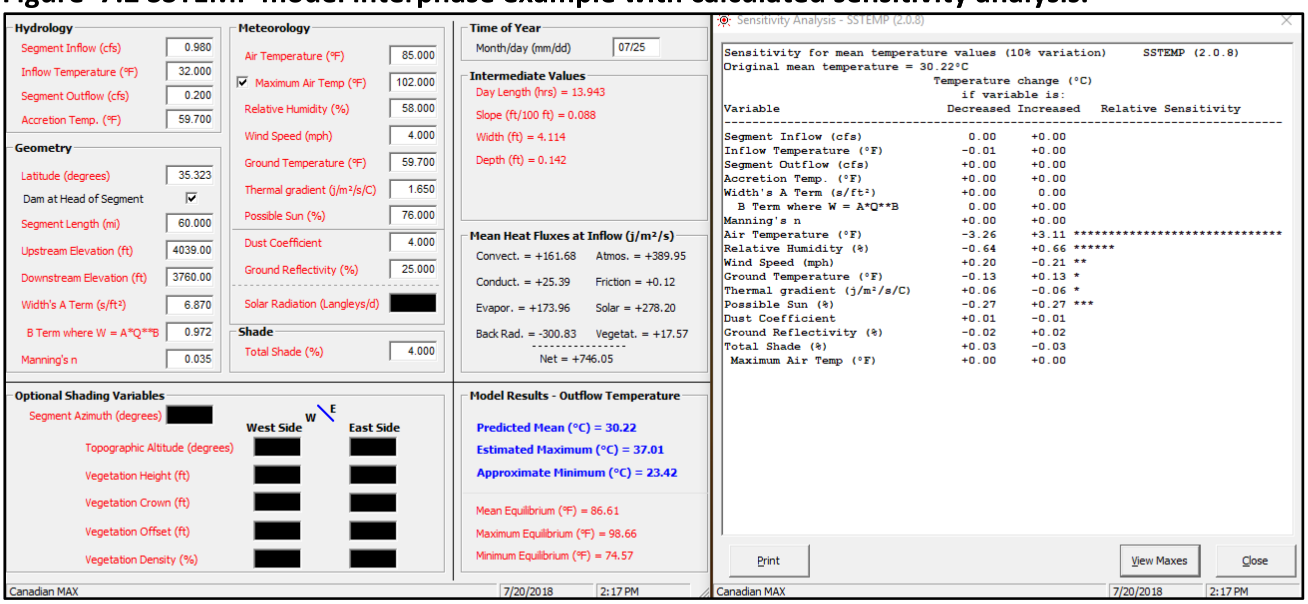
Width A and B term calculations were obtained for all impairments. **Table 7.1** shows the results for Width A and B calculations and weather in situ data was available for the analysis, otherwise remote sensing was utilized for morphology measurements.

Table 7.1 Width A and B term calculation results

Assessment Unit	Width A	Width B
Canadian River (Ute Reservoir to Concha's Reservoir)	6.88	0.97
Coyote Creek (Black Lake to headwaters)	1.71	0.38
Dry Cimarron River (Perennial reaches OK bnd to Long Canyon)	4.06	0.35
Long Canyon (Perennial reaches abv Dry Cimarron)	4.79	0.25
Pajarito Creek (Perennial part Canadian R to Vigil Canyon)	3.12	0.54

The Width A and B term values were entered to the SSTEMP model interphase, as well as other needed variables see **Figure 7.2**. The "Relative Sensitivity" schematic graph that accompanies the display gives an indication of which variables most strongly influence the results (Bartholow 2004). The remaining variable were obtained through various methods further explained in Appendix D.

Figure 7.2 SSTEMP model interphase example with calculated sensitivity analysis.



The SSTEMP model was calibrated to the original T_{MAX} conditions, then the shade variable was manipulated to meet temperatures at standard and Load Allocation conditions (WQS-MOS) . All variable calibration values can be found in Appendix D.   The results for the percent effective shade are in **Table 7.2**.

Table 7.2 SSTEMP model results for AU's with temperature impairments.

	Temperature standard	Thermograph T_{MAX} in situ	Calibration Value	Model Output					
Assessment Unit	**WQS (°C)**	**T_{MAX} (°C) field**	**Modeled T_{MAX}**	**Mean % shade (at T_{MAX})**	**WQS (°C)**	**Mean % shade (at WQS)**	**LA (°C)***	**Mean % shade (at LA)**
Canadian River (Ute Reservoir to Concha's Reservoir)	32.2	37.12	37.01	4	32.18	55	28.98	75
Coyote Creek (Black Lake to headwaters)	23	30.09	30.26	10	22.87	59	20.7	72
Dry Cimarron River (Perennial reaches OK bnd to Long Canyon)	29	31.18	31.53	6.2	28.97	31	26.1	56
Long Canyon (Perennial reaches abv Dry Cimarron)	29	33.24	33.32	2	28.89	42	26.1	65
Pajarito Creek (Perennial part Canadian R to Vigil Canyon)	29	36.57	36.07	2	28.88	59	26.1	78

* WQS - MOS

7.3 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 by applicants 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: *http://www.nmenv.state.nm.us/swqb/*.

There is currently no approved WBP or active watershed group working on Tecolote Creek. SWQB staff will continue to conduct outreach related to the CWA Section 319(h) funding program which could lead to the formation of a watershed group in the area.

7.4 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 land owners in the basin. The USDA Forest Service aligns their mission to protect lands they manage with the TMDL process, and are another source of assistance. The Bureau of Land Management (BLM) has several programs in place to provide assistance to improve unpaved roads and grazing allotments.

SWQB annually makes available CWA Section 604(b) funds through a Request for Quotes (RFQ) process. 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. 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. 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 New Mexico Legislature appropriated $2.3 million in state funds for the River Stewardship Program during the 2014 Legislative Session, $1 million during the 2015 Special Session, and $1.5 million during the 2016 Legislative Session. The River Stewardship Program has the overall goal of addressing the root causes of poor water quality and stream habitat. Objectives of the River Stewardship Program 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 CWA grants." A competitive request for proposals was conducted for 2014 funding and twelve projects located throughout the state were selected. Responsibility for the program is assigned to NMED, and SWQB staff administer the projects. SWQB issued a competitive request for proposals for the 2015-2016 funding in early 2016. Submitted project proposals have been reviewed, funding has been approved, and contracts are currently in development.

Information on additional watershed restoration funding resources is available on the SWQB website at- https://www.env.nm.gov/swqb/Watershed_Protection/FundingSourcesforWatershedProtection.pdf

8.0 APPLICABLE REGULATIONS AND REASONABLE ASSURANCES

New Mexico's Water Quality Act, NMSA 1978 §§ 74-6-1 to -17 (Act), authorizes the WQCC to "promulgate and publish regulation 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. Several statutory provisions on nuisance law could also be applied to NPS water pollution. The Act also states in Section 74-6-12(a):

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

In addition, the State of New Mexico Surface Water Quality Standards (20.6.4.6.C NMAC) states:

> *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.

9.0 PUBLIC PARTICIPATION

Public participation was solicited in development of this TMDL. The draft TMDL was first made available for a 30-day comment period beginning June 5, 2019 and ending on July 5, 2019. The draft document notice of availability was advertised via email distribution lists and webpage postings. A public meeting was held on June 13, 2019, at the Raton City Council chambers from 5:30 to 7:30 pm. A response to comments will be added to the TMDL document as Appendix E.

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

Table A1: TR aluminum data

Asterisk (*) indicates exceedance of the applicable crierion.

Conchas River (Conchas Reservoir to headwaters)				
Site ID	**Date**	**TR Al results (mg/L)**	**Hardness (mg/L)**	**Flow (cfs)**
08Concha028.0	9/1/15	* 2.2	130	NA
08Concha028.0	10/1/15	1.4	158	0.1
08Concha028.0	4/28/16	1.4	220	0.5
08Concha028.0	6/29/16	1.5	220	0.5
08Concha028.0	9/21/16	* 4.4	101	0.8

Table A2: E.coli data

Asterisk (*) indicates exceedance of the applicable criterion. MDP is a missing data point. MPN is the most probable number of colony forming units, and is equivalent to cfu in the NM WQS.

Doggett Creek (Raton Creek to headwaters)				
Date	**E.coli results (MPN/100mL)**			**Flow (cfs)**
	04Dogget002.3 (Above WWTP)	**WWTP Effluent**	**04Dogget002.2 (Below WWTP)**	
3/23/2015	686.7	38.8	61.6	1
4/22/2015	14.8	7.4	25.3	1.5
7/15/2015	14.6	178.2	866.4	1
10/20/2015	344.8	74.9	95.9	MDP
5/4/2016	6.3	4.1	52.0	<1
6/2/2016	1.0	7.4	74.9	MDP
7/13/2016	12.2	73.3	* 1732.9	0.75
8/16/2016	31.7	3.0	93.3	MDP
9/14/2016	25.0	7.4	67.7	MDP
10/26/2016	84.2	10.8	* 2419.6	MDP

East Fork Chicorica Creek (Chicorica Creek to headwaters)			
Site ID	**Date**	**E.coli results (MPN/100mL)**	**Flow (cfs)**
04EFChic001.0	3/24/2015	517.2	5
04EFChic001.0	4/22/2015	* 2419.6	0.7
04EFChic001.0	5/4/2016	113.4	10.8
04EFChic001.0	6/2/2016	* 2419.6	0.9

Mora River (USGS gage east of Shoemaker to HWY 434)			
Date	**E.coli results (MPN/100mL)**		**Flow (cfs)**
	07MoraRi139.9 (at La Cueva)	**07MoraRi094.0 (at Watrous)**	
3/20/15	123.2	2.0	27
5/7/15	23.3	MDP	MDP
7/14/15	47.1	MDP	70
7/23/15	MDP	167.0	29
8/5/15	MDP	325.5	100
9/24/15	MDP	44.8	6.5
5/18/16	* 461.1	MDP	73
6/23/16	53.8	MDP	MDP
7/27/16	MDP	* 435.2	18
8/11/16	49.6	MDP	21
9/1/16	MDP	* 866.4	24.7
9/28/16	MDP	58.3	14
9/29/16	51.2	MDP	19
10/13/16	12.1	MDP	13

Conchas River (Conchas Reservoir to Salitre Creek)			
Site ID	**Date**	**E.coli results (cfu/100mL)**	**Flow (cfs)**
08Concha028.0	6/25/15	* 2419.6	.1
08Concha028.0	9/1/15	1.0	>1.0
08Concha028.0	10/1/15	7.5	0.5
08Concha028.0	5/24/16	178.9	0.5
08Concha028.0	6/29/16	* 1299.7	0.78
08Concha028.0	9/21/16	37.3	.25

Tinaja Creek (West Fork Tinaja Creek to headwaters)			
Site ID	**Date**	**E.coli results (MPN/100mL)**	**Flow (cfs)**
04Tinaja010.1	9/23/2015	* 2419.6	2
04Tinaja010.1	10/6/2015	40.4	1
04Tinaja010.1	5/4/2016	435.2	2
04Tinaja010.1	9/14/2016	* 2419.6	0.4
04Tinaja010.1	10/26/2016	12.1	0.2

Table A3: Plant nutrients data

Asterisk (*) indicates exceedance of applicable causal threshold, and double asterisk (**) indicates that results exceed both the causal and upper thresholds.

Conchas River (Conchas Reservoir to Salitre Creek)						
Site ID	**Date**	**Total Persulfate Nitrogen (mg/L)**	**Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N**	**Kjeldahl nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Flow (cfs)**
08Concha028.0	2015-06-25 17:00:00.0	n/a	<0.1	0.65	0.06	0.25
08Concha028.0	2015-09-01 19:00:00.0	n/a	<0.1	** 0.87	** 0.129	low
08Concha028.0	2015-10-01 10:50:00.0	n/a	<0.1	* 0.7	** 0.097	0.1
08Concha028.0	2016-04-28 09:58:00.0	* 0.701	<0.1	0.53	0.032	0.5
08Concha028.0	2016-05-24 11:06:00.0	** 0.899	<0.1	0.5	0.06	>1
08Concha028.0	2016-06-29 12:39:00.0	n/a	<0.1	** 2.99	** 0.276	0.5
08Concha028.0	2016-09-21 10:13:00.0	* 0.732	<0.1	* 0.71	** 0.147	0.78
Delta DO = 6.68 mg/L, start date and time 2015-09-01 19:00:00						

Coyote Creek (Mora River to Amola Ridge)						
Site ID	**Date**	**Total Persulfate Nitrogen (mg/L)**	**Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N**	**Kjeldahl nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Flow (cfs)**
07Coyote004.2	2015-06-17 13:00:00	n/a	<0.1	** 0.56	0.052	high
07Coyote004.2	2015-08-05 12:04:00	n/a	<0.1	** 0.78	* 0.068	58
07Coyote004.2	2015-09-24 12:03:00	n/a	<0.1	<0.5	0.049	1.2
07Coyote004.2	2015-10-14 11:00:00	n/a	<0.1	<0.5	0.038	1.5
07Coyote004.2	2016-05-19 08:00:00	0.253	<0.1	<0.5	0.048	1.4
07Coyote004.2	2016-07-27 13:08:00	n/a	<0.1	<0.5	0.053	moderate
07Coyote004.2	2016-09-28 11:54:00	0.194	<0.1	<0.5	0.056	7.1
Delta DO = 8.78 mg/L, start date and time 2016-07-27 13:00:00						

Doggett Creek (Raton Creek to headwaters)						
Site ID	**Date**	**Total Persulfate Nitrogen (mg/L)**	**Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N**	**Kjeldahl nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Flow (cfs)**
04Dogget002.2	2015-03-23 15:00:00.0	n/a	** 4.11	** 1.92	** 2.18	1
04Dogget002.2	2015-04-22 08:20:00.0	n/a	** 4.09	** 1.58	** 2.1	1.5
04Dogget002.2	2015-05-13 10:40:00.0	n/a	** 2.77	** 1.79	** 2.68	0.5
04Dogget002.2	2015-07-15 14:50:00.0	n/a	** 3.7	** 1.77	** 2.62	1
04Dogget002.2	2015-08-27 08:15:00.0	n/a	** 5.76	** 1.56	** 1.63	moderate
04Dogget002.2	2015-10-20 08:45:00	n/a	** 4.05	** 1.12	n/a	moderate
04Dogget002.2	2016-05-04 23:59:00.0	n/a	** 3.34	** 1.72	** 1.66	<1
04Dogget002.2	2016-06-02 08:19:00.0	n/a	** 3.21	** 1.79	** 4.36	moderate
04Dogget002.2	2016-07-13 08:55:00.0	n/a	** 2.96	** 1.63	** 3.59	0.75
04Dogget002.2	2016-08-16 13:02:00.0	n/a	** 6.8	** 1.16	** 3.73	moderate
04Dogget002.2	2016-09-14 08:35:00.0	n/a	** 4.02	** 1.31	** 1.96	moderate
04Dogget002.2	2016-10-26 08:33:00.0	** 5	** 3.15	** 2.1	** 1.6	moderate
Delta DO = 13.41 mg/L, start date and time 2016-05-12 14:15:00						

Dry Cimarron (Perennial reaches OK boundary to Long Canyon)						
Site ID	**Date**	**Total Persulfate Nitrogen (mg/L)**	**Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N**	**Kjeldahl nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Flow (cfs)**
02DryCim024.6	2015-03-24 11:45:00	n/a	<0.1	* 0.69	n/a	1.5
02DryCim024.6	2015-04-22 11:20:00.0	n/a	<0.1	0.61	0.047	0.2
02DryCim024.6	2015-05-12 19:30:00.0	n/a	<0.1	0.58	n/a	0.3
02DryCim024.6	2015-06-23 14:30:00.0	n/a	<0.1	* 0.7	** 0.077	moderate
02DryCim024.6	2015-10-07 10:30:00.0	n/a	<0.1	* 0.75	** 0.088	moderate
02DryCim024.6	2016-05-03 14:21:00.0	n/a	<0.1	<0.5	0.053	5.6
02DryCim024.6	2016-06-01 17:45:00.0	n/a	<0.1	0.6	0.05	moderate
02DryCim024.6	2016-07-12 15:56:00.0	n/a	<0.1	* 0.69	0.033	low
02DryCim024.6	2016-08-16 15:39:00.0	n/a	<0.1	* 0.66	** 0.076	0.25
02DryCim024.6	2016-09-13 15:30:00.0	n/a	<0.1	** 1.35	** 0.285	0.2
02DryCim024.6	2016-10-26 15:29:00.0	* 0.78	<0.1	* 0.79	** 0.074	no flow
Delta DO = 19.42 mg/L, state date and time 2016-06-01 18:30:00						

Dry Cimarron River (Long Canyon to Oak Creek)						
Site ID	**Date**	**Total Persulfate Nitrogen (mg/L)**	**Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N**	**Kjeldahl nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Flow (cfs)**
02DryCim074.5	2015-03-24 12:45:00	n/a	<0.1	0.6	n/a	1
02DryCim074.5	2015-04-22 12:30:00.0	n/a	<0.1	<0.5	0.046	0.2
02DryCim074.5	2015-05-12 19:00:00	n/a	<0.1	<0.5	n/a	2.5
02DryCim074.5	2015-10-07 11:40:00.0	n/a	<0.1	<0.5	** 0.073	moderate
02DryCim074.5	2016-05-03 15:51:00.0	n/a	<0.1	0.51	** 0.085	2
02DryCim074.5	2016-06-01 19:11:00.0	n/a	<0.1	<0.5	0.061	moderate
02DryCim074.5	2016-07-12 14:10:00.0	n/a	<0.1	0.53	0.043	0.5
02DryCim074.5	2016-09-13 16:38:00.0	n/a	<0.1	<0.5	** 0.085	0.3
02DryCim074.5	2016-10-26 14:21:00.0	0.234	<0.1	<0.5	0.06	1
Delta DO = 4.14 mg/L, start date and time 2015-06-23 17:30:00						

Dry Cimarron River (Oak Creek to headwaters)						
Site ID	**Date**	**Total Persulfate Nitrogen (mg/L)**	**Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N**	**Kjeldahl nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Flow (cfs)**
02DryCim114.9	2015-04-22 13:00:00.0	n/a	0.32	<0.5	0.055	0.6
02DryCim114.9	2015-05-12 17:30:00	n/a	0.2	<0.5	n/a	3
02DryCim114.9	2015-10-07 12:55:00.0	n/a	0.59	<0.5	0.051	moderate
02DryCim114.9	2016-05-03 17:13:00.0	n/a	0.37	<0.5	0.058	4
02DryCim114.9	2016-06-01 20:04:00.0	n/a	0.15	<0.5	0.06	moderate
02DryCim114.9	2016-07-12 16:54:00.0	n/a	0.4	0.54	** 0.111	2.5
02DryCim114.9	2016-09-13 17:50:00.0	n/a	0.47	<0.5	** 0.11	1
02DryCim114.9	2016-10-26 17:40:00.0	* 0.789	0.51	<0.5	* 0.065	1.4
Delta DO = 6.52 mg/L, start date and time 2016-06-01 20:30:00						

Long Canyon (Perennial reaches above Dry Cimarron)						
Site ID	**Date**	**Total Persulfate Nitrogen (mg/L)**	**Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N**	**Kjeldahl nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Flow (cfs)**
02LongCa004.1	2015-03-24 13:00:00	n/a	** 1.58	** 0.91	n/a	0.1
02LongCa004.1	2015-04-22 12:35:00	n/a	0.55	** 1.22	** 0.174	0.1
02LongCa004.1	2015-05-12 18:00:00	n/a	0.1	* 0.76	n/a	moderate
02LongCa004.1	2015-06-23 16:45:00	n/a	0.1	0.65	0.056	moderate
02LongCa004.1	2015-10-07 12:10:00	n/a	** 2.58	0.57	0.023	moderate
02LongCa004.1	2016-05-03 16:10:00	n/a	** 2.56	<0.5	0.022	<1
02LongCa004.1	2016-06-01 19:27:00	n/a	0.1	0.62	0.03	moderate
02LongCa004.1	2016-07-12 13:45:00	n/a	0.1	** 1.23	** 0.148	0.2
02LongCa004.1	2016-09-13 17:05:00	n/a	** 3.01	** 0.94	** 0.126	0.1
02LongCa004.1	2016-10-26 16:56:00	** 5.97	** 5.69	<0.5	0.044	0.3
Delta DO = NA. Listing based on exceedences of upper threshold and downstream Non Support determination. This AU will be covered in the lower AU TMDL						

Raton Creek (Chicorica Creek to headwaters)						
Site ID	**Date**	**Total Persulfate Nitrogen (mg/L)**	**Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N**	**Kjeldahl nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Flow (cfs)**
04RatonC005.1	2015-03-23 16:00:00		0.3	** 1.14	** 0.92	1.5
04RatonC005.1	2015-04-22 15:19:00.0		0.39	* 0.81	** 0.692	1
04RatonC005.1	2015-05-13 11:30:00		<0.1	** 0.98	** 1.14	0.5
04RatonC005.1	2015-10-20 12:20:00		0.6	<0.5	** 0.366	moderate
04RatonC005.1	2016-05-04 13:14:00.0		0.45	** 0.88	** 0.376	1.5
04RatonC005.1	2016-08-17 08:23:00.0		0.28	0.55	** 0.91	0.4
04RatonC005.1	2016-09-14 09:38:00.0		0.51	0.64	** 0.502	0.45
04RatonC005.1	2016-10-26 09:17:00.0	0.645	0.12	0.53	** 0.252	0.4
Delta DO = 11.24 mg/L, state date and time 2016-05-12 14:45:00						

Table A4: Temperature data

See Appendix (C) for thermograph and SSTEMP input data

APPENDIX B
SOURCE DOCUMENTATION

“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. Data on Probable Sources is routinely gathered by Monitoring and Assessment Section staff and Watershed Protection Section staff during water quality surveys and watershed restoration projects and is housed in the Assessment Database (ADB version 2). ADB was developed by USEPA to help states manage information on surface water impairment and to generate §303(d)/§305(b) reports and statistics. 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.

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.

The approach for identifying “Probable Sources of Impairment” was recently modified by SWQB. Any new impairment listing will be assigned a Probable Source of “Source Unknown.” Probable Source Sheets will continue to be filled out during watershed surveys and watershed restoration activities by SWQB staff. Information gathered from the Probable Source Sheets will be used to generate a draft Probable Source list in consequent TMDL planning documents. 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 final Probable Source list in the approved TMDL will be used to update the subsequent Integrated List.

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.

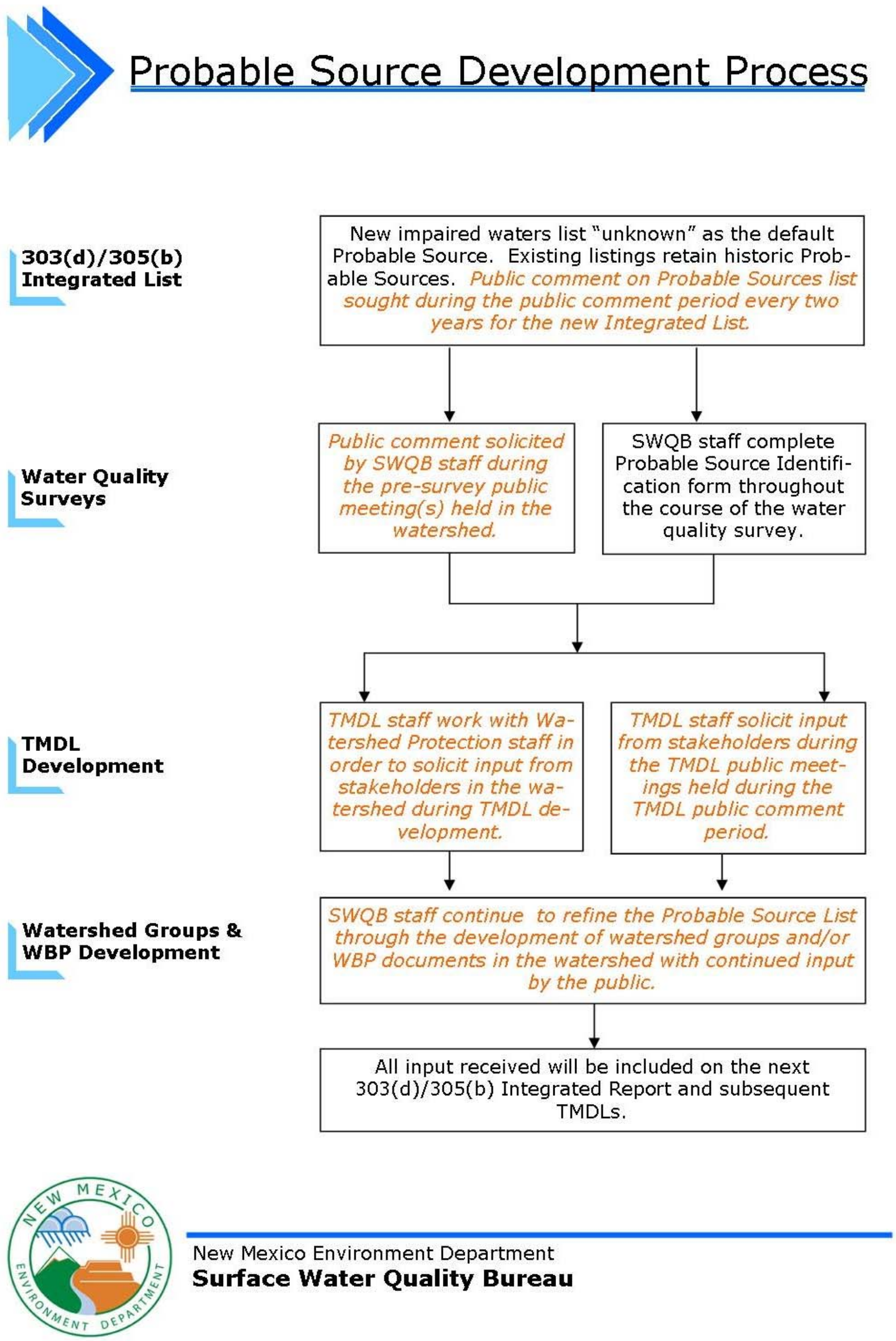

Figure B1. Probable Source Development Process and Public Participation Flowchart

Probable Source(s) & Site Condition Class Field Form

Station ID:	Station Name/Description:	
AU ID:	AU Description:	
Field Crew:	Comments:	
Date:	Watershed protection staff reviewer:	Date of WPS review:

Score the proximity, intensity and/or certainty of occurrence of the following activities in the AU upstream of the site. Consult with the appropriate staff at NMED and other agencies to score "*" cells if needed.

Activity Checklist

Hydromodifications				
Channelization	0	1	3	5
Dams/Diversions	0	1	3	5
Draining/Filling Wetlands	0	1	3	5
Dredging	0	1	3	5
Irrigation Return Drains	0	1	3	5
Riprap/Wall/Dike/Jetty Jack -- circle	0	1	3	5
Flow Alteration (from Water Diversions/Dam Ops – circle)	0	1	3	5
Highway/Road/Bridge Runoff	0	1	3	5
Other:	0	1	3	5
Habitat Modification				
Active Exotics Removal	0	1	3	5
Stream Channel Incision	0	1	3	5
Mass Wasting	0	1	3	5
Active Restoration	0	1	3	5
Other:	0	1	3	5
Industrial/ Municipal				
Storm Water Runoff due to Construction	0	1	3	5
Landfill	0	1	3	5
On-Site Treatment Systems (Septic, etc.)	0	1	3	5
Pavement/Impervious Surfaces	0	1	3	5
Inappropriate Waste Disposal	0	1	3	5
Residences/Buildings	0	1	3	5
Site Clearance (Land Development)	0	1	3	5
Urban Runoff/Storm Sewers	0	1	3	5
Power Plants	0	1	3	5
* Industrial Storm Water Discharge (permitted)	0	1	3	5
* Industrial Point Source Discharge	0	1	3	5
* Municipal Point Source Discharge	0	1	3	5
* RCRA/Superfund Site	0	1	3	5
Other:	0	1	3	5
Resource Extraction				
* Abandoned Mines (Inactive)/Tailings	0	1	3	5
* Acid Mine Drainage	0	1	3	5
* Active Mines (Placer/Potash/Other -- circle)	0	1	3	5
* Oil/Gas Activities (Permitted/Legacy – circle)	0	1	3	5
* Active Mine Reclamation	0	1	3	5
Other:	0	1	3	5

Silviculture				
* Logging Ops – Active Harvesting	0	1	3	5
* Logging Ops – Legacy	0	1	3	5
* Fire Suppression (Thinning/Chemicals)	0	1	3	5
Other:	0	1	3	5
Rangeland				
Livestock Grazing or Feeding Operation	0	1	3	5
Rangeland Grazing (dispersed)	0	1	3	5
Other:	0	1	3	5
Roads				
Bridges/Culverts/RR Crossings	0	1	3	5
Low Water Crossing	0	1	3	5
Paved Roads	0	1	3	5
Gravel or Dirt Roads	0	1	3	5
Agriculture				
Crop Production (Cropland or Dry Land)	0	1	3	5
Irrigated Crop Production (Irrigation Equip)	0	1	3	5
* Permitted CAFOs	0	1	3	5
* Permitted Aquaculture	0	1	3	5
Other:	0	1	3	5
Miscellaneous				
Angling Pressure	0	1	3	5
Dumping/Garbage/Trash/Litter	0	1	3	5
Exotic Species (describe in comments)	0	1	3	5
Hiking Trails	0	1	3	5
Campgrounds (Dispersed/Defined – circle)	0	1	3	5
Surface Films/Odors	0	1	3	5
Pesticide Application (Algaecide/Insecticide)	0	1	3	5
Waste From Pets (high concentration)	0	1	3	5
* Fish Stocking	0	1	3	5
Other:	0	1	3	5
Natural Disturbance or Occurrence				
Waterfowl	0	1	3	5
Drought-related Impacts	0	1	3	5
Watershed Runoff Following Forest Fire	0	1	3	5
Recent Bankfull or Overbank Flows	0	1	3	5
Wildlife other than Waterfowl	0	1	3	5
Other Natural Sources (describe in comments)	0	1	3	5

Legend – Proximity Score

Activity not known occur within AU upstream of station (includes unknown)	0	Activity observed or known to be present near station (1 km or less) or is known to occur in moderate frequency/intensity within the AU upstream of station	3
Activity observed or known to be present but not near the station and at low frequency/intensity within AU upstream of station	1	Activity observed or known to be present at station or known to occur in high frequency/intensity within the AU upstream of station	5

Figure B2. Probable Source & Site Condition Field Sheet for SWQB Staff

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 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 * 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)

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) = 1.023 x 107 kJ/(day*C)

Form of TMDL Equation

Eq5. [**ºC**] x [**cfs]** x 1.023 x 107 = TMDL (kJ/day)

Input variables in **bold**, **ºC** = WQC and **cfs** = critical flow

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

APPENDIX D
SSTEMP INPUT DATA

D 1.0 INTRODUCTION

The Stream Segment Temperature (SSTEMP) Model requires the stream system heat flux sources/variable values in order to calculate heat gain and losses to the determine the temperature of the surface water. This appendix section describes the methods for obtaining data for the different variables. The variables were first initially set up for calibrating the model to replicate the T_{MAX} temperature for the exceedance day. Then the SSTEMP stream simulation was utilized to investigate what percentage of shading can affect the stream heating processes in order to reach the standard and the conservative Load Allocation (see section 5.6). This study however, does not does not evaluate simulations for channel geometry and/or different flow regimes and its effect on stream temperatures, or implement riparian delineation and ecoregion study.

This appendix provides site-specific hydrology, geometry, and meteorological data for input into the Stream Segment Temperature (SSTEMP) Model utilizing the Bartholow (2004) manual.

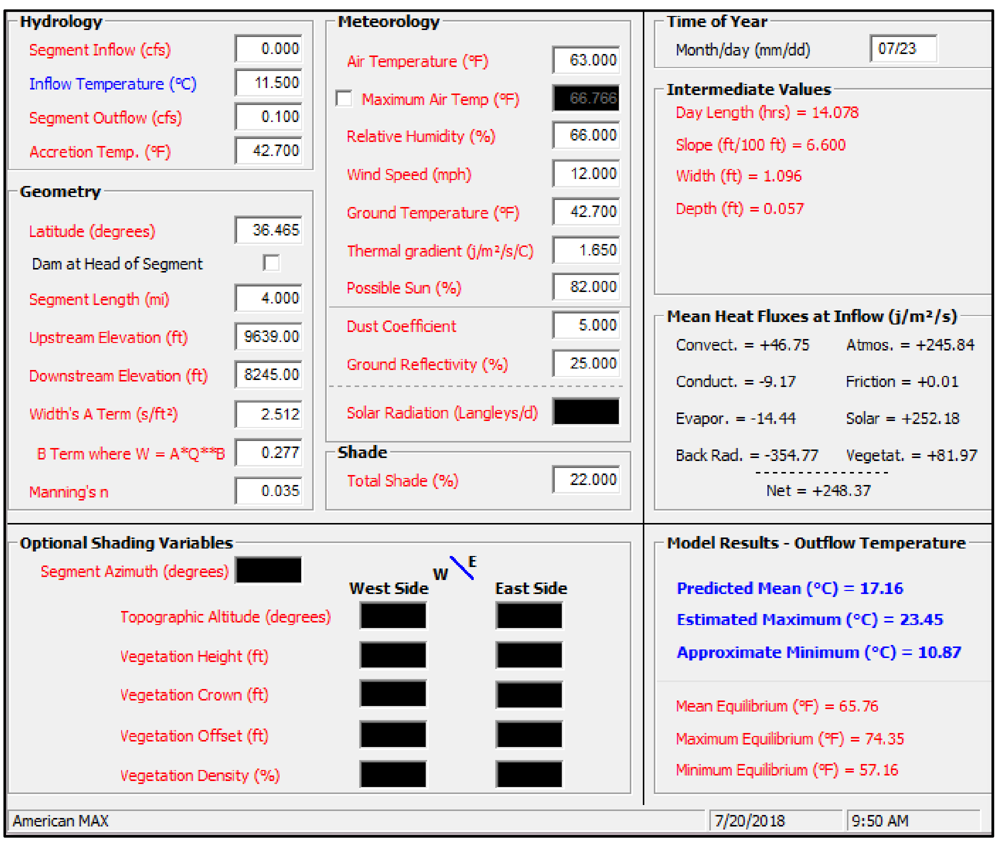

Figure D.1. SSTEMP input window sample.

A two-prong approach was applied to obtain the variable data needed to run SSTEMP: field in situ measurements from the field surveys and through remote sensing data. **Tables D-1 through D-5** of this Appendix provide the data values for each variable and the reference provides the data source.

D 2.0 SSTEMP Variable inputs

The following list defines and describes the different variables and how to obtain them according to Bartholow (2004):

1. **Segment Inflow (cfs or cms)**

This variable is the mean daily flow on top of the stream segment. In order to obtain this variable, different methods were utilized contingent on the available data. The methods included: calculating the 4Q3 flows analysis methods described by Waltemeyer (2002) by utilizing StreamStats (USGS 2018) parameter data; applying the headwaters SSTEMP suggested value of zero (Bartholow 2004); and when gage data is present the 4Q3 value is determined using BASINS Dflow software (US EPA 2015).

2. **Inflow Temperature (° F or ° C)**

This parameter represents the mean daily water temperature at the top of the segment. In order to obtain this variable, different methods were utilized contingent on the available data. The methods included: utilizing NorWeST modeled summer stream temperature (Wenger et al. 2016); Mean daily average of thermograph on top of head waters (NMED 2018); the Instant temperature at station representative station; and Headwaters SSTEMP suggested value (Bartholow 2004).

3. **Accretion Temperature (° F or ° C)**

According to Bartholow (2004); "*the temperature of the lateral inflow, barring tributaries, generally should be the same as groundwater temperature… In turn, groundwater temperature may be approximated by the mean annual air temperature.*" Mean annual air temperature for the coordinates of the AU, was obtained from the PRISM database (PRISM 2018).

4. **Latitude (coordinate)**

Latitude refers to the position of the stream segment on the earth's surface. Latitude was obtained from NMED's Surface Water Quality Information Database (SQUID 2018).

5. **Segment Length (mi or km)**

Segment length AU was obtained from NMED's Surface Water Quality Information Database (SQUID 2018).

6. **Dam at head of Segment**

If there is a Dam and the inflow is supplied by a reservoir the beginning of the AU, the variable box should be checked.

7. **Upstream and Downstream Elevation (ft or m)**

The upstream and downstream elevations were determined using a NorWeST elevation at beginning and end of AU (Wenger et al. 2016).

8. **Width's A and Width's B Term** (seconds/foot^2 or seconds/meter^2)

These variables were obtained utilizing WinXSPRO, A Channel Cross Section Analyzer, Version 3.0. (Thomas et al. 2005). This software provides calculations of mean cross section velocity discharge flows at different wetted widths, based on the morphology of the stream dimension entered into the model.

The numerical value of the relationship of water discharge-to wetted width was calculated by plotting these variables on a log scale and determine Width B with the slope value and the Width A value is the Y- intercept. Bartholow (2002) recommends first transforming the flow and width to natural log, then plot flow (independent variable) against the width (dependent variable), see Figure D2. The regression equation slope is Width B term and A term is determined through equation A.1 according to Bartholow (2002).

Equation A.1 Width A term

$$A = e^{(\text{constant from regression})}$$

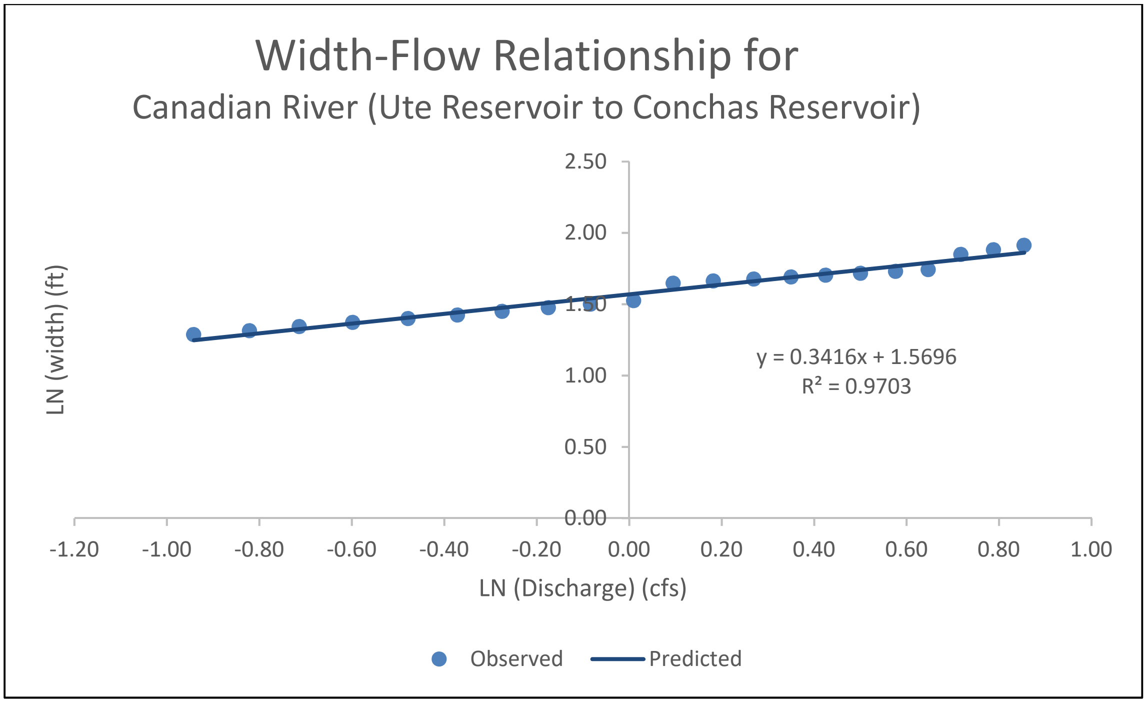

Figure D2. Width-Flow Relationship example. Where the slope of the linear regression is Width B term.

9. Manning's n (sec/mi or sec/km)

This variable is the numerical measurement for the streams' roughness. The value utilized in the model was generally acceptable default value 0.035 (Chow, 1959; Bartholow, 2002; Thomas, 2005).

10. Air Temperature (° F or ° C)

The air temperature daily mean was obtained through PRISM Climate Group (2018). This temperature database approximates the site location better than the nearest weather station.

11. Maximum Air Temperature (° F or ° C)

The air temperature daily max was obtained through PRISM Climate Group (2018). This temperature database approximates the site location better than the nearest weather station.

12. Relative Humidity (%)

This variable value was obtained from the nearest available weather station. For this model Weather Underground (Wunderground 2018) data base was utilized for the average daily humidity.

13. Wind Speed (mi/hr or m/s)

This variable value was obtained from the nearest available weather station. For this model Weather Underground (Wunderground 2018) data base was utilized for the average daily wind speed.

14. **Ground Temperature (° F or ° C)**

According to Bartholow (2004); *"the temperature of the lateral inflow, barring tributaries, generally should be the same as groundwater temperature… In turn, groundwater temperature may be approximated by the mean annual air temperature."* Mean annual air temperature for the coordinates of the AU, was obtained from the PRISM database (PRISM 2018).

15. Thermal Gradient (Joules/Meter^2/Second/° C)

Thermal gradient measures the rate of thermal input from the streambed to the water (Bartholow 2002).
For this model the default value of 1.65 recommended by Bartholow (2002).

16. **Possible Sun (%)**

This variable is an indirect and inverse measure of cloud cover. This model used: Albuquerque "Sunshine – Average Percent of Possible" from Comparative Climatic Data (NCDC 2018)

17. **Dust Coefficient** (**dimensionless**)

This value represents the amount of dust in the air. If you enter a value for the dust coefficient, SSTEMP will calculate the solar radiation. In the absence of measured data, the dust coefficient was set at 5, which is at the low end of the range of summer values provided by Bartholow (2002).

18. **Ground Reflectivity (%)**

This variable represents the short-wave radiation reflected back into the atmosphere (Bartholow 2002).
Bartholow (2002) list the representative values; this model used the values 14 and 25 depending on the calibration needs for each AU.

19. **SHADE (%)**

This model utilized NorWeST modeled summer stream temperature (Wenger et al. 2016) mapping tool to obtain this value.

D 2.1 SSTEMP variable data values and source by Assessment Unit

The following tables A-I describe the variable type, data values, data source and its references:

Table D-1. SSTEMP: Canadian River (Ute Reservoir to Conchas Reservoir) -09Canadi144.5

VARIABLE	DATA	DATA SOURCE	REFERENCE
Segment Inflow (cfs)	0.98	4Q3 Basins (Dflow)	US EPA 2015
Inflow Temperature (C)	34.95	Instant temperature at station 09Canadi144.5, on 07/14/17	NMED 2018
Segment Outflow (cfs)	0.2	Instant flow at station 09Canadi144.5,07/14/16	NMED 2018
Accretion Temp (F)	59.7	Mean annual air temperature	PRISM 2018
Latitude (deg)	35.32349	SQUID	NMED 2018
Dam?	yes	Conchas lake and Ute reservoir	NMED 2018
Segment Length (mi)	60	SQUID	NMED 2018
Upstream Elevation (ft)	4039	NorWeST elevation at beginning of AU	Wenger et al. 2016
Downstream Elevation (ft)	3760	NorWest elevation at end of AU	Wenger et al. 2016
With's A Term (s/sqft)	6.879	WinXSPRO	Hardy et al. 2005
B Term	0.972	WinXSPRO	Hardy et al. 2005
Manning's n	0.035	WinXSPRO Manual / SSTEMP default	USGS 2016 and Hardy et al. 2005
Air Temperature (F)	85	PRISM daily mean	PRISM 2018
Max Air Temp (F)	102	PRISM daily max	PRISM 2018
Relative Humidity	56	Average humidity: Tucumcari/KNMTUCUM3	Wunderground 2018
Wind Speed (mph)	8.5	Wind Speed: Tucumcari/KNMTUCUM3	Wunderground 2018
Ground Temp (F)	59.7	Mean annual air temperature	PRISM 2018
Thermal Gradient (j/sqm/s/C)	1.65	SSTEMP suggested value	Bartholow 2004
Possible Sun %	76	Albuquerque “Sunshine – Average Percent of Possible”	NCDC 2018
Dust Coefficient	5	SSTEMP suggested value	Bartholow 2004
Ground Reflectivity (%)	14	Meadows and field	Bartholow 2004
Total Shade (%)	7	NorWeST modeled summer stream temperature	Wenger et al. 2016
Time of year	7/25/2016	Maximum temperature date of deployed thermograph	NMED 2018

Table D-2. SSTEMP: Coyote Creek (Black Lake to headwaters)- NM-2306.A_021

VARIABLE	DATA	DATA SOURCE	REFERENCE
Segment Inflow (cfs)	0	4Q3 at beginning of AU using StreamStats.	USGS 2018
Inflow Temperature (C)	11	NorWeST temperature at headwaters.	Wenger et al. 2016
Segment Outflow (cfs)	0.31	4Q3 at end of AU using StreamStats	USGS 2016
Accretion Temp (F)	43	Mean annual air temperature	PRISM 2018
Latitude (deg)	36.30567	SQUID	NMED 2018
Dam?	no	SQUID	NMED 2018
Segment Length (mi)	7	SQUID	NMED 2018
Upstream Elevation (ft)	9837	NorWeST elevation at beginning of AU	Wenger et al. 2016
Downstream Elevation (ft)	8544	NorWest elevation at end of AU	Wenger et al. 2016
With's A Term (s/sqft)	1.705	WinXSPRO	Hardy et al. 2005
B Term	0.385	WinXSPRO	Hardy et al. 2005
Manning's n	0.035	WinXSPRO Manual / SSTEMP default	USGS 2016 and Hardy et al. 2005
Air Temperature (F)	61	PRISM daily mean	PRISM 2018
Max Air Temp (F)	81	PRISM daily max	PRISM 2018
Relative Humidity	* 60	Average humidity: Cimarron/KAXX	Wunderground 2018
Wind Speed (mph)	* 5	Wind Speed: Cimarron/KAXX	Wunderground 2018
Ground Temp (F)	43	Mean annual air temperature	PRISM 2018
Thermal Gradient (j/sqm/s/C)	1.65	SSTEMP suggested value	Bartholow 2004
Possible Sun	82	Albuquerque “Sunshine – Average Percent of Possible”	NCDC 2018
Dust Coefficient	5	SSTEMP suggested value	Bartholow 2004
Ground Reflectivity (%)	25	Flat ground, vegetation and grass covered	Bartholow 2004
Total Shade (%)	10	NorWeST modeled summer stream temperature	Wenger et al. 2016
Time of year	6/19/2016	Maximum temperature date of deployed thermograph	NMED 2018

*** Value manipulated to fit calibration temperature: relative humidity was changed from 59 to 60, wind speed was changed from 5 to 4.**

Table D-3. SSTEMP: Dry Cimarron R (Perennial reaches OK bnd to Long Canyon)- NM-2701_00

VARIABLE	DATA	DATA SOURCE	REFERENCE
Segment Inflow (cfs)	0.33	4Q3 at beginning of AU using StreamStats.	USGS 2018
Inflow Temperature (C)	32	NorWeST modeled summer stream temperature.	Wenger et al. 2016
Segment Outflow (cfs)	0.06	Mean of daily mean values USGS 07154500 Cimarron River near Kenton, OK.	USGS 2018 (b)
Accretion Temp (F)	55.2	Mean annual air temperature.	PRISM 2018
Latitude (deg)	36.987226	SQUID	NMED 2018
Dam?	No	SQUID	NMED 2018
Segment Length (mi)	54	SQUID	NMED 2018
Upstream Elevation (ft)	5120	NorWeST elevation at beginning of AU	Wenger et al. 2016
Downstream Elevation (ft)	4340	NorWest elevation at end of AU	Wenger et al. 2016
With's A Term (s/sqft)	4.063	WinXSPRO	Hardy et al. 2005
B Term	0.354	WinXSPRO	Hardy et al. 2005
Manning's n	0.035	WinXSPRO Manual / SSTEMP default	USGS 2016 and Hardy et al. 2005
Air Temperature (F)	74	PRISM daily mean	PRISM 2018
Max Air Temp (F)	88	PRISM daily max	PRISM 2018
Relative Humidity	‡ 46	Average humidity: Folsom/KRTN	Wunderground 2018
Wind Speed (mph)	* 5	Wind Speed: Folsom/KRTN	Wunderground 2018
Ground Temp (F)	55.2	Mean annual air temperature	PRISM 2018
Thermal Gradient (j/sqm/s/C)	1.65	SSTEMP suggested value	Bartholow 2004
Possible Sun	76	Albuquerque "Sunshine – Average Percent of Possible"	NCDC 2018
Dust Coefficient	5	SSTEMP suggested value	Bartholow 2004
Ground Reflectivity (%)	14	meadows and field	Bartholow 2004
Total Shade (%)	6	NorWeST modeled summer stream temperature	Wenger et al. 2016
Time of year	8/5/2015	Maximum temperature date of deployed thermograph	NMED 2018

*** Value manipulated to fit calibration temperature: wind speed was changed from 13 to 5.**

‡ Altitude corrected: humidity

Ta = To + Ct * (Z - Zo); where Ta = air temperature at elevation E (°C), To = air temperature at elevation Eo (°C), Z = mean elevation of segment (m), Zo = elevation of station (m), Ct = moist-air adiabatic lapse rate (-0.00656 °C/m)

Table D-4. SSTEMP: Long Canyon (Perennial reaches abv Dry Cimarron)- NM-2701_20

VARIABLE	DATA	DATA SOURCE	REFERENCE
Segment Inflow (cfs)	0.15	4Q3 at beginning of AU using StreamStats.	USGS 2018
Inflow Temperature (C)	25	Mean daily average of thermograph located at the top of AU.	NMED 2018
Segment Outflow (cfs)	0.17	4Q3 at end of AU using StreamStats.	USGS 2018
Accretion Temp (F)	44.4	Mean annual air temperature	PRISM 2018
Latitude (deg)	36.945	SQUID	NMED 2018
Dam?	no	4Q3 using StreamStats at end of AU	USGS 2018
Segment Length (mi)	8	SQUID	NMED 2018
Upstream Elevation (ft)	5324	NorWeST elevation at beginning of AU	Wenger et al. 2016
Downstream Elevation (ft)	5133	NorWest elevation at end of AU	Wenger et al. 2016
With's A Term (s/sqft)	4.788	WinXSPRO	Hardy et al. 2005
B Term	0.246	WinXSPRO	Hardy et al. 2005
Manning's n	0.035	WinXSPRO Manual / SSTEMP default	USGS 2016 and Hardy et al. 2005
Air Temperature (F)	74	PRISM daily mean	PRISM 2018
Max Air Temp (F)	88	PRISM daily max	PRISM 2018
Relative Humidity	55 ‡	Average humidity: Folsom/KRTN	Wunderground 2018
Wind Speed (mph)	* 4	Wind Speed: Folsom/KRTN	Wunderground 2018
Ground Temp (F)	44.4	Mean annual air temperature	PRISM 2018
Thermal Gradient (j/sqm/s/C)	1.65	SSTEMP suggested value	Bartholow 2004
Possible Sun	76	Albuquerque “Sunshine – Average Percent of Possible”	NCDC 2018
Dust Coefficient	* 4	SSTEMP suggested value	Bartholow 2004
Ground Reflectivity (%)	25	Flat ground, vegetation and grass covered	Bartholow 2004
Total Shade (%)	2	NorWeST modeled summer stream temperature	Wenger et al. 2016
Time of year	8/5/2015	Maximum temperature date of deployed thermograph	NMED 2018

*** Value manipulated to fit calibration temperature: wind speed was changed from 7 to 4; dust coefficient 5 to 4**

‡ Altitude corrected: for humidity

Ta = To + Ct * (Z - Zo); where Ta = air temperature at elevation E (°C), To = air temperature at elevation Eo (°C), Z = mean elevation of segment (m), Zo = elevation of station (m), Ct = moist-air adiabatic lapse rate (-0.00656 °C/m)

Table D-5. SSTEMP: Pajarito Creek (Perennial prt Canadian R to Vigil Canyon)-NM-2303_10

VARIABLE	DATA	DATA SOURCE	REFERENCE
Segment Inflow (cfs)	0	Headwaters SSTEMP suggested value	Bartholow 2004
Inflow Temperature (C)	24	NorWeST modeled summer stream temperature.	Wenger et al. 2016
Segment Outflow (cfs)	0.2	4Q3 using StreamStats at end of AU	USGS 2018
Accretion Temp (F)	59.5	Mean annual air temperature	PRISM 2018
Latitude (deg)	35.24105	SQUID	NMED 2018
Dam?	No	SQUID	NMED 2018
Segment Length (mi)	27	SQUID	NMED 2018
Upstream Elevation (ft)	4120	NorWeST elevation at beginning of AU	Wenger et al. 2016
Downstream Elevation (ft)	3795	NorWest elevation at end of AU	Wenger et al. 2016
With's A Term (s/sqft)	3.121	WinXSPRO	Hardy et al. 2005
B Term	0.5443	WinXSPRO	Hardy et al. 2005
Manning's n	0.035	WinXSPRO Manual / SSTEMP default	USGS 2016 and Hardy et al. 2005
Air Temperature (F)	80	PRISM daily mean	PRISM 2018
Max Air Temp (F)	96	PRISM daily max	PRISM 2018
Relative Humidity	43	Average humidity; station- airport/KTCC airport/KTCC	Wunderground 2018
Wind Speed (mph)	8	Wind Speed; station- airport/KTCC	Wunderground 2018
Ground Temp (F)	59.5	Mean annual air temperature	PRISM 2018
Thermal Gradient (j/sqm/s/C)	1.65	SSTEMP suggested value	Bartholow 2004
Possible Sun	0.76	Albuquerque "Sunshine – Average Percent of Possible"	NCDC 2018
Dust Coefficient	5	SSTEMP suggested value	Bartholow 2004
Ground Reflectivity (%)	25	Flat ground, vegetation and grass covered	Bartholow 2004
Total Shade (%)	2	NorWeST modeled summer stream temperature	Wenger et al. 2016
Time of year	6/28/2015	Maximum temperature date of deployed thermograph	NMED 2018

D 6.0 REFERENCES

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APPENDIX E
RESPONSE TO COMMENTS