Rio Guadalupe

Stream Inventory Report
Santa Fe National Forest
Surveyed: June – July 2004
Forest Fisheries Crew

Report By
Tara Anderson, Fisheries Technician
Dylan Hoffman, Fisheries Technician
Chuck Dentino, Fisheries Biologist

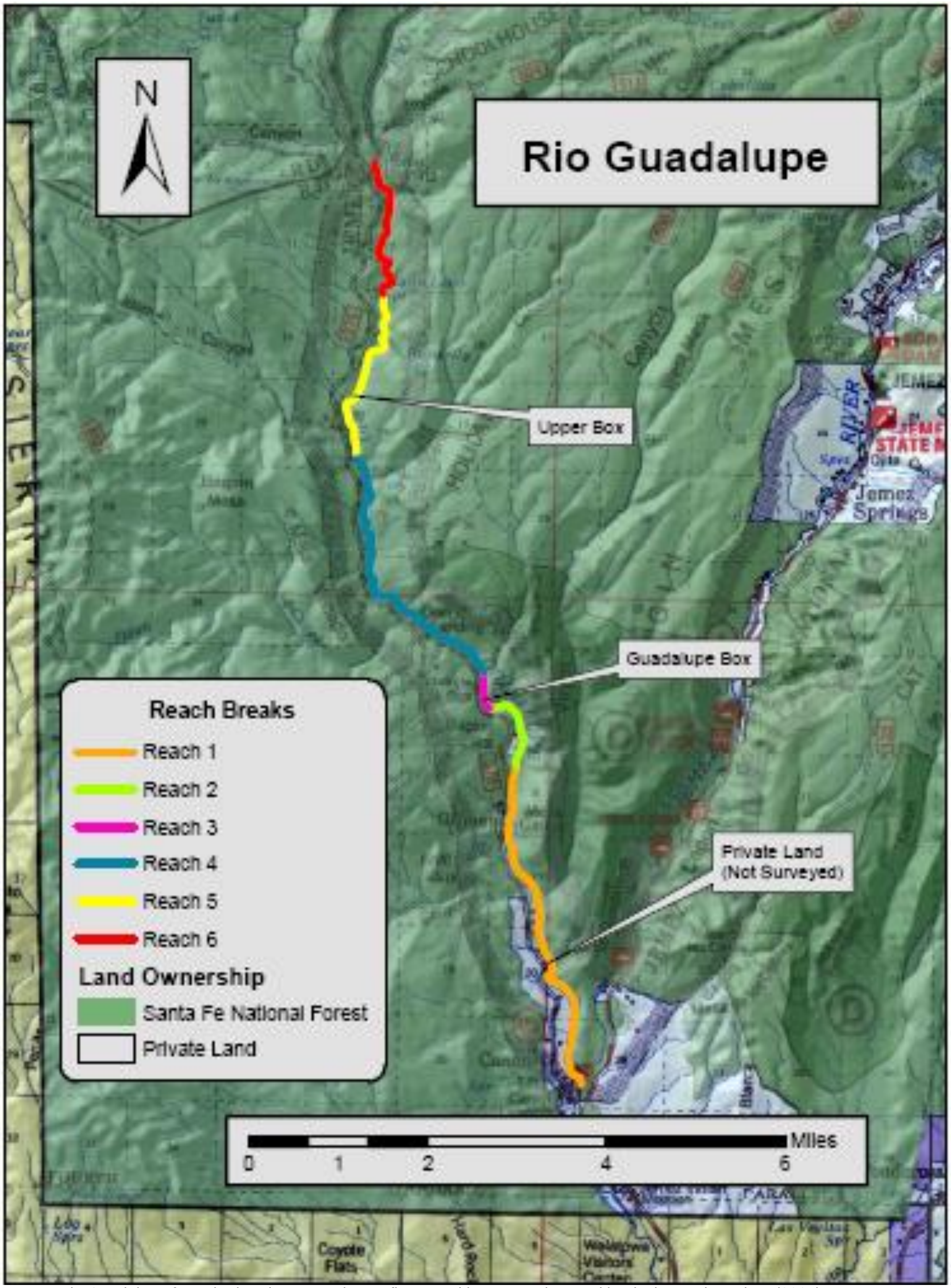
Reviewed By
Sean Ferrell
Forest Fisheries Biologist

Santa Fe National Forest
February 2006

Versions of this document were reviewed, edited and approved by the following individual:

- Bill Britton, Forest Biologist, USDA Forest Service, Santa Fe National Forest

Table of Contents



Map 1. Rio Guadalupe from the headwaters to its confluence with Jemez River and its designated reaches (2004).

This document is a specialist report. It is meant to assist managers in understanding current conditions of a stream corridor and possibly how those conditions have developed over a period of time. Recommendations are drawn up emphasizing the aquatic resource, although the accomplishment of multiple use is considered within those recommendations.

Readers should note that there is some amount of repetition in this document. The author assumes that readers may only read certain sections; therefore, points or observations may be repeated. A glossary is provided at the end of document to help the reader think like a fish biologist. In addition, appendices provide greater detail on certain data points.

INTRODUCTION

Rio Guadalupe 2004 Stream Survey

Rio Guadalupe is a tributary to the Jemez River and part of the Middle Rio Grande River system. The confluence of Rio Cebolla and Rio de Las Vacas form the Rio Guadalupe at Porter Landing (Township 19 North, Range 1 East, Section 1, elevation 7,200'). From Porter Landing the river flows through series of box canyons and valley confinement until it reaches the wider, lower gradient valley type for the last 5 miles before reaching the confluence with the Jemez River (T17N, R2E, Sec. 28, elev. 5,700'). The Rio Guadalupe travels 13.4 miles from Porter before joining the Jemez River downstream of Gilman, NM. The Santa Fe National Forest Fisheries Program conducted a stream inventory on the entire Rio Guadalupe located on public land during the summer of 2004. A total of 9.4 miles of stream was surveyed from above the Forest Service boundary located above the Gilman community (T17N, R2E, Sec 8, elev. 5,920') to its origin at the confluence of Rio de las Vacas and Rio Cebolla.

The USDA Forest Service Region 3 stream survey protocol is a modified version of the Hankins/Reeves survey used in the Pacific Northwest Region. Under this protocol, streams are surveyed from the mouth upstream and the river is separated into riffle, pool, side channel, dry channel, culvert, and falls habitat types by specific attributes (USFS 2002). Different habitat types require specific measurements relevant to evaluating the habitat (Appendix A, Table 1). In addition to the habitats located in the primary stream, tributary mouths are also surveyed and classified as a seep, spring, or stream (Appendix C). All habitat types are assigned a Natural Sequence Order number (NSO) in the order that they are surveyed. The stream, as a collection of NSOs, is further organized by homogeneous sections and grouped into a sequence of reaches. Each reach is assigned a number in the order that it is surveyed and analyzed separately, as well as together for a holistic overview of the system.

A matrix of factors and indicators was developed to relate stream habitat information into an easily understood habitat condition classification of properly functioning, at risk, or not properly functioning. The matrix originally was developed in the Pacific Northwest by US Fish & Wildlife Service and National Marine Fisheries Service, but was modified for mountain streams in the intermountain west and relates to regulations determined by New Mexico Environment Department (NMED). The matrix was further refined to incorporate geology of streams historically occupied by Rio Grande cutthroat trout (see Table 1).

Table 1. Matrix of factors and indicators of habitat condition for historic and currently occupied Rio Grande cutthroat trout (RGCT) streams as related to R3 Stream Habitat Inventory.

FACTORS	INDICATORS	Properly Functioning	At Risk	Not Properly Functioning
Water Quality	***Temperature – State of New Mexico Standards***	<20°C (68°F) (3 day avg. max)	≥20°C (68°F) <23°C (73.4°F) (3 day avg. max)	≥23°C (73.4°F) (3 day avg. max)
	Temperature – Salmonid Development	≤17.8°C (64°F) (7 day avg. max)	>17.8° (64°F) < 21.1° (70°F) (7 day avg. max)	≥21.1°C (70°F) (7 day avg. max)
Habitat Characteristics	**Sediment**	<20% fines (sand, silt, clay) in riffle habitat. Fine sediment within range of expected natural streambed conditions		≥20% fines (sand, silt, clay) in riffle habitat. Fine sediment outside of expected natural streambed conditions.
	Large Woody Debris[1]	>30 pieces per mile, >12" diameter, >35 feet in length	20-30 pieces per mile, >12" diameter, >35 feet in length	<20 pieces per mile, >12" diameter, >35 feet in length
	Pool Development[2]	≥30% pool habitat by area[3]		<30% pool habitat by area[3]
	Pool Quality[4]	Average residual pool depth ≥1 foot		Average residual pool depth <1 foot
Channel Condition and Dynamics	**Width Depth Ratios by Channel Type** *(utilize Rosgen type and range given if applicable)*	Width/depth ratios and channel types within natural ranges and site potential		Width/depth ratios and channel types are well outside of historic ranges and/or site potential
		Expected range of bankfull width/depth ratios and channel type	**Rosgen Type** A, E, G B, C, F D	**W/D Ratio** <12 12-30 >40
	Streambank Condition[5]	<10% unstable banks (lineal streambank distance)	10-20% unstable banks (lineal streambank distance)	>20% unstable banks (lineal streambank distance)

[1] Large Woody Debris numeric are not applicable in meadow reaches. For this survey a meadow reach can be defined as an area where there is no natural local recruitment of LWD.
[2] Pool Development numeric are applicable to 3rd order or larger streams.
[3] Area is defined by habitat length.
[4] All pool habitats in the Rio Guadalupe survey have a residual depth of greater than or equal to 1 foot. Exclusive quality pools are related to a surveyor error and this parameter is excluded from analysis.
[5] Streambank Condition numeric are not applicable in reaches with > 4% gradient

Global positioning system (GPS) units are utilized for survey data collection. Trimble GeoExplorer 3 units are used to identify specific features throughout the survey (Appendix A, Table 2). The GPS feature locations are then transferred into a geographical information system (GIS) layer and used to provide graphical representations and spatial analysis of river attributes.

The primary objectives of the Region 3 Hankins/Reeves survey include the compilation of historical information and in-stream habitat data to assist in proper management decisions of the surveyed stream and its watershed. The historical information provides a background of land use and management techniques collected from the Forest Service and a variety of other sources. Previous land use and management practices reflect on the current condition of environmental systems. Historical information helps explain the current condition of the river and is incorporated into the survey. Understanding events that formed the habitat condition enhances decision-maker options.

In-stream survey data is collected to provide an overview of the current condition of a stream. Survey data produces a "snapshot" in time of the stream's habitat condition and the factors affecting it. Survey information can be used to identify both degraded sections as well as ideal areas to be used as a reference or model for other similar sections of stream. By combining the historical and current information pertaining to a stream, management options can be more clearly identified, which is the goal of this document.

Photo 1. NOS 196, P61. The Rio Guadalupe Stream Inventory Reach 5 (14-June-04).

BASIN SUMMARY

Table 2. Stream Summary Table for the Rio Guadalupe.

LOCATION:		
County:	Sandoval County	
Forest:	Santa Fe National Forest	
District:	Jemez Ranger District	
Drainage:	Rio Guadalupe	
Tributary to:	Jemez River	
Survey Began at:	T17N, R2E, Sec. 8, elevation 5,920 ft	
WATERSHED:		
5th HUC Code[1]:	1302020201	
Guadalupe Watershed Area:	171,194 acres	268 square miles
Stream Order:	5	
Stream Length:	70,752 feet[2]	13.4 miles[2]
AQUATIC BIOTA:		
Fish Species: Rio Grande cutthroat trout[3] *(Oncorhynchus clarki virginalis),* rainbow trout (*Oncorhynchus mykiss)*, brown trout (*Salmo trutta),* Rio Grade sucker *(Catostomus plebeius),* Rio Grande chub *(Gila Pandora),* Longnose Dace (*Rhinichthys cataractae),* Fathead Minnow (*Pimephales promelas*).		

[1] Hydrologic Unit Code used to identify watersheds.
[2] Stream length includes both surveyed and un-surveyed private land.
[3] Listed as a Sensitive Species by the Santa Fe National Forest (1999)

EXECUTIVE SUMMARY

Rio Guadalupe is a 5th order stream originating from the confluence the confluence of the Rio de las Vacas and the Rio Cebolla (T19N, R1E, Sec. 1, elev. 7,200'),on the Jemez Ranger District of the Santa Fe National Forest (Forest). The stream survey covered a 9.4 -mile stretch, from the headwaters to just above the Forest Service boundary at Gilman (T17N, R2E, Sec. 8, elev. 5,920'). Fisheries populations are present from the beginning of the survey to the end of the survey. The Guadalupe Headwaters contain the Rio de las Vacs which drains out of the San Pedro Park Wilderness and the Rio Cebolla which drains the land to the west of the Valle Caldera National Preserve. The watershed encompasses 171,194 acres (268 square miles), owned by the Forest, New Mexico Department of Game and Fish (NMGF), Valle Caldera National Preserve, and private landowners.

Rio Guadalupe is divided into 6 reaches, each containing relatively homogeneous habitat characteristics. Reach divisions are based on stream and valley morphology and land ownership boundaries. Reaches are numbered sequentially as the survey progresses upstream (see Table 3). The average gradient of the Rio Guadalupe is 2.1% or 111.7 feet per mile. When evaluated by reach divisions, the gradient ranges from 1.0% in Reach 1 to 6.0% in Reach 3 (see Table 9).

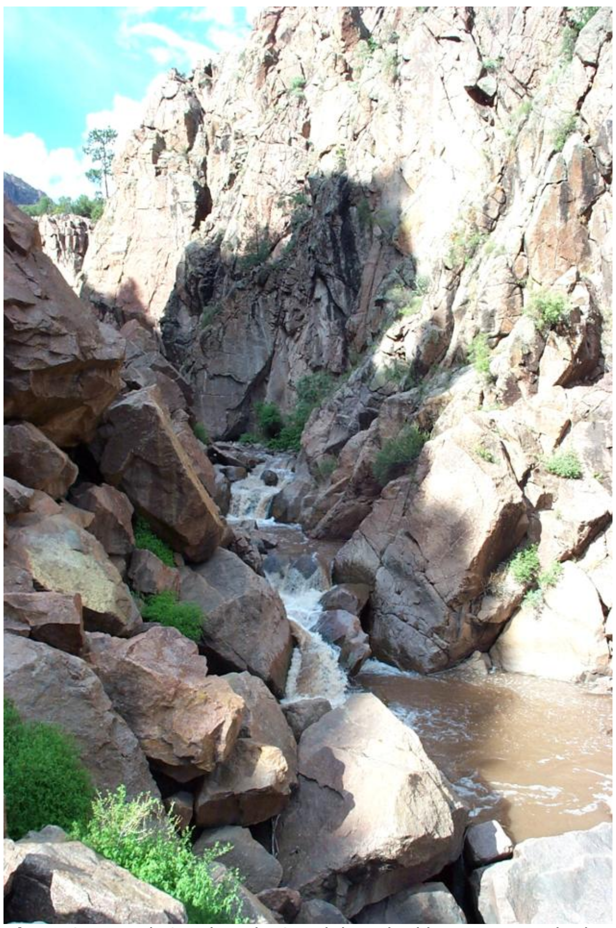


Photo 2. Reach 3. The Rio Guadalupe looking upstream in the Guadalupe Box (17-Dec.-2002).

Rio Guadalupe originates in the Jemez Mountains, which were formed by uplift and volcanic activity. The Rio Guadalupe flows through confined valleys and deep bedrock canyons. Geoloically, the Rio Guadalupe flows through areas associated with the Nacimiento Uplift. The eastern portion of the drainage contains bandelier tuff and volcanic ash deposits. The central portion contains limestone, sandstone and mudstone, with shale interwoven. The western portion contains areas of pre-Cambrian granite, sandstone, grading into basalt flows to the north (USDA, 2004b).

Stream flow in the Rio Guadalupe fluctuates between the high flow events in the spring and lesser events in the late summer during the monsoon season to low flow in the mid summer. Spring high flow events originate from snow runoff and vary with the previous winter's snow pack. The snow pack for 2004 (Feb 1, March 1, April 1, and May 1 average) was at 76% of the average (Snotel, 2004). The Snotel site is located at in the upper part of the Rio Guadalupe Watershed in the Clear Creek Drainage and is more representative of runoff from the Vacas portion of the watershed south of the San Pedro Parks Wilderness. Rainfall comes in short duration high intensity storms during the summer resulting in a flashy system. Rainfall can affect the quality of the water as the result of surface erosion during high-intensity storms. About ½ of the precipitation comes during the winter months (Snotel 2004b).

Table 3. Description and length of reaches on the Rio Guadalupe.

Reach	River Miles	Landmark at Beginning and End	Land Owner
1	0.0 to 4.0	Confluence with the Jemez River to a dry arroyo on the right bank above private property. Not Surveyed	Private
2	4.0 to 5.0	Private property to the USGS station at the mouth of the Guadalupe Box	SFNF
3	5.0 to 5.5	USGS station at the mouth of the Guadalupe Box to change in gradient and valley confinement at the head of the Guadalupe box	SFNF
4	5.5 to 9.2	Head of the Guadalupe Box to the bottom of the upper box canyon.	SFNF
5	9.2 to 11.4	Lower end of the upper box canyon to the top of the box canyon just below Llano Loco spring.	SFNF
6	11.4 to13.43	The top of the box canyon just below Llano Loco spring to the confluence of the Rio de las Vacas and the Rio Cebolla at Porter Landing.	SFNF

Water quality in the Rio Guadalupe has received special attention because of its listing as impaired by the New Mexico Environment Department. Water quality limited waters list (303 (d) list of waters that do not attain the State water quality standards) is revised and published every 2 years. The entire reach of the Rio Guadalupe from its mouth on the Jemez River to the headwaters at the confluence of Rio de las Vacas and Rio Cebolla is limited due to conductivity, fecal coliform, turbidity, stream bottom deposits and aluminum.

The 2004 survey was accompanied by temperature analysis at 3 thermograph or temperature recording sites. The thermograph sites were distributed from the mouth to the head. The stream temperatures were analyzed and classified by both Forest and New Mexico Environment Department (NMED) Standards. The Forest and NMED temperature standards classify coldwater fisheries habitat as properly functioning, at risk, or not properly functioning. Water temperatures at the temperature stations are classified as **at risk** at 1 of the 3 sites by NMED standards. Temperatures are classified as **not properly functioning** 2 of the 3 sites by NMED standards and at all of the 3 sites by Forest standards. Stream habitat conditions generally noted a lack of pool habitat. This could be a limiting factor to overall stream productivity and could be further complicated by the lack of large wood structure in the stream.

Habitat Characteristics

The 9.4 surveyed miles (49,685 feet) of the Rio Guadalupe is divided into 255 Natural Sequence Order Habitat Units (NSOs). The 78 pool habitats comprise 8.2% of the stream habitat length. There are 137 NSOs that are riffle habitat, which comprises the majority of habitat in the Rio Guadalupe (see Table 4). Other habitat types in the Rio Guadalupe are tributaries, falls, and side channels. Tributaries to the Rio Guadalupe are not considered stream habitat and are excluded from length and habitat analyses.

Table 4. Stream summary information for the Rio Guadalupe Habitat Survey 2004.

ENTIRE STREAM		Stream Length Surveyed: 49,685 feet 9.4 miles			
Habitat Type	**Total Number**	**Total Feet of Stream Habitat**	**% Stream Length***	**% Stream Habitat****	**Properly Functioning Indicators**
Pool	78	4288.0	8.6	8.2	>30%
Riffle	137	44940.0	90.4	85.9	-
Culvert	0	0	0	0	-
Tributary	7	-	-	-	-
Falls	16	457.7	1.0	0.9	-
Side Channel	17	2619.5	NA	5.0	-
Total	255	52,305.2	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, the Rio Guadalupe contains not properly functioning, at risk and properly functioning characteristics (see Table 5). The parameters that are **not properly functioning** include stream temperature by NMED standards and Forest standards, density of large woody debris (LWD), and pool development. Temperature is **at risk** at one of the three stations by NMED. **Properly functioning** characteristics include riffle sediment content, pool quality, stream bank condition, and width-to-depth ratio.

Table 5. Stream habitat conditions as evaluated by the matrix of factors and indicators of habitat condition for historic and currently occupied Rio Grande cutthroat trout streams.

Factors	Indicators	Rio Guadalupe Conditions
Water Quality	Temperature 3-Day Average	**Site 1) Headwaters**
		Site 2) Holiday Mesa Road Crossing
		Site 3) USGS Station
		Site 4) Mouth (LOST)
Salmonid Development	Temperature 7-Day Average	**Sites (1-3) Not Functioning Properly**
Habitat Characteristics	Riffle Sediment	**Properly Functioning**
	Large Woody Debris	**Not Properly Functioning**
	Pool Development	**Not Properly Functioning**
	Pool Quality	**Properly Functioning**
Channel Condition and Dynamics	Stream Bank Condition	**Properly Functioning**
	Width-to-Depth Ratio	**Properly Functioning**

Red= Not Properly Functioning Yellow = At Risk

The riffle habitat in the Rio Guadalupe is the dominant habitat, comprising 85.9% of all stream habitat types. The high relative quantity of riffle habitat reflects the lack of pool habitat. Sediment content in riffle habitat (18.2%) was determined to be **properly functioning** (see Table 6). The dominant substrate type is cobble followed by boulder.

Table 6. Summary of habitat and substrate composition in the Rio Guadalupe

Habitat Summary					
	# of Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth
Entire River	137	328	19.6	1.2	2.4

Substrate Summary						
	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Total (%)
Entire River	18.2	20.3	29.9	23.9	7.7	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool habitat is important over wintering, resting, and feeding habitat for fish. Pool habitat is evaluated by both quality or residual depth and area of pool habitat (by length). Pool quality is **properly functioning** in the Rio Guadalupe with 97% of the pool habitats with at least a 1-foot residual depth. Residual depth is calculated by subtracting the maximum depth from the pool tail crest depth to determine the depth of water that would remain in the habitat if flow ceased. The average residual pool depth is over twice the properly functioning indicator (see Table 7). The relative quantity of pool habitat (8.3%) is **not properly functioning** (see Table 7). Making certain there is adequate pool habitat in the Rio Guadalupe should be a priority in the river's management.

Table 7. Summary of pool habitat and relative substrate in the Rio Guadalupe.

Pool Habitat Summary											
Area	Number of Pool Habitats	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools per Mile	Number of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	Number of Pools w/ Max. Depth >3'	Number of Pools w/ Max. Depth >3'/Mile
Entire River	78	55.0	18.5	3.5	1.0	2.6	8.3	76	8.1	54	5.7
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary						
Area	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	% Total
Entire River	24.0	20.9	21.5	18.6	15.0	100.0

Large woody debris (LWD) is related to habitat complexity and the health of fish populations in stream habitats (Fausch and Northcote 1992). LWD density is **not properly functioning** in the Rio Guadalupe. The LWD density is 3.6 piece per mile, far below the standard (see Table 8). The Rio Guadalupe had 34 pieces of wood classified as medium and large sizes. Wood classified as medium LWD must be greater than 12 inches in diameter at a length of 35 feet from the large end. Large pieces of LWD have a diameter of greater than 20 inches at a length of 35 feet from the large end. Increasing the LWD density should be a focus in the management of the Rio Guadalupe. Increasing LWD may also improve other degraded factors in the stream habitat including pool development. Bank stability (0.1%) is **properly functioning** when analyzed by the length of the entire surveyed section of stream. Although the length of bank instability is **properly functioning**, several areas could use mitigation. Areas of instability in need of management are primarily near the Holiday Mesa Road crossing and at recreation sites.

Table 8. Selected habitat charicterisics in the Rio Guadalupe.

Area	Pool:Riffle Ratio	Avg. Riffle Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
Entire River	1: 1.8	16.3	3.6	180'	0.1%
Properly Functioning Indicators	-	-	>30	-	<10

Red= Not Properly Functioning Yellow = At Risk

Reach by Reach Comparison

The 5 reaches of the Rio Guadalupe contain different combinations of properly functioning, at risk, and not properly functioning characteristics. Pool habitat, LWD density, bankfull width-to-depth ratio and unstable banks are parameters that are outside of properly functioning classification in at least one reach. None of the surveyed reaches are properly functioning in all categories (seeTable 9).

Table 9. Reach characteristic summaries for the Rio Guadalupe 2004.

Reach	Total Length (mi)	Gradient (%)	Rosgen Channel Type	Pool Habitat (%)	Riffle Habitat (%)	Side Channel Habitat (%)	Dominant Substrate in Pools	Dominant Substrate in Riffles	LWD Per Mile	Bankfull Width to Depth	Unstable Banks (%)
1	4.0	0.3	Private Land Not Surveyed								
2	1.0	2.3	B3	2.0	81.8	16.2	Cobble	Cobble	0	16:1	1.0
3	0.5	6.1	A2	18.7	77.5	0	Cobble	Boulder	0	25:1	Not Surveyed
4	3.7	2.4	B3	5.0	90.2	4.8	Gravel	Cobble	1.1	14:1	0.6
5	2.2	2.6	F3b	16.2	78.9	1.8	Sand	Cobble	11.4	21:1	0
6	2.0	2.2	B3	6.8	90.0	3.5	Sand	Cobble	2.5	31:1	0.1
Entire River	13.4	2.1	-	8.3	87.1	3.7	Sand	Cobble	3.6	-	0.1
Properly Functioning Indicators	-	-	-	>30	-	-	-	-	>30	A,E,G: <12 B,C,F: 12-30 D: >40	<10

Red= Not Properly Functioning Yellow = At Risk

[1]Pool development applicable only to 3rd order streams and higher.

²Streambank condition analysis is excluded in reaches with >4% gradient.

The length of pool habitat is of concern in every reach of the Rio Guadalupe. The relative quantity of pool habitat in reaches that are **not properly functioning** in the Rio Guadalupe range from 2.0 % in Reaches 2 and to 18.7% in Reach 3 (seeTable 9).

LWD density in the Rio Guadalupe is **not properly functioning** in all of the reaches. The reaches that are **not properly functioning** range from no wood in Reach 2 and 3 to 11.4 pieces per mile in Reach 5. Increasing the low densities of LWD should be a focus in the management of the Rio Guadalupe.

Bankfull width-to-depth ratios are **properly functioning** in reaches 3 of the 5 reaches. Bankfull width-to-depth ratio in each reach is compared to the expected range for its related Rosgen stream type. Reaches 3 and 6 exceed the expected range. Bankfull measurements for reach 3 were taken in an area that was lower gradient and less confined and not characteristic of the whole reach. Redoing the measurements in a higher gradient and more confined channel may result in a properly functioning condition for the bankfull width-to-depth ratio.

Photo 3. Reach 6, NSO 219, R117. The Rio Guadalupe with one of the few pieces of LWD (21-July-2004).

Al l of the 5 reaches have **properly functioning** bank condition. The **properly functioning** reaches range from no bank instability in Reach 5 to 5.1 % in Reach 4 (see Table 9).

Tributaries

Seven (7) tributaries in the form of seep, spring, and stream habitats contributed surface flow to the Rio Guadalupe during the survey. A majority of tributaries are found in the upper reaches. None of the tributaries altered the habitat enough to create a reach break.

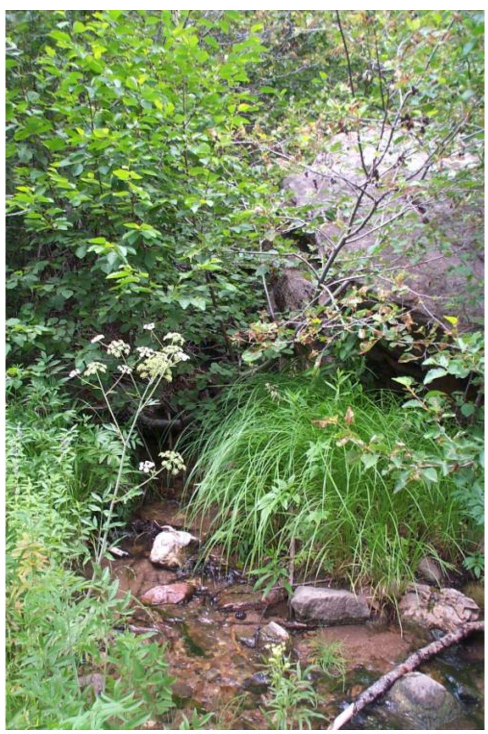


Photo 4. Lano Loca Spring entering in NSO 210, T6 near the end of Reach 5 (21-July-2004).

Table 10. Summary of all tributaries contributing to the main flow of the Rio Guadalupe.

Location		Bank	Habitat Type	Name	Percent Flow*	Time	Tributary Temp (°F)	Stream Temp (°F)		Comments
Reach	Tributary Number							Below Tributary	Above Tributary	
4	1	Right	Spring	NA	NA	1033	60	60	63	Smelled like sulfur
5	2	Left	Stream	Joaquin Canyon	5	1123	60	60	59	Has a waterfall barrier 150' upstream.
5	3	Right	Seep	NA	NA	NA	NA	NA	NA	Seep from bedrock wall
5	4	Right	Spring	Butterfly Springs	10	1350	62	70	66	Butterfly Springs goes through 3 NSO units. Temp. was taken in main spring. Other unmeasured sources may attribute to increased temp. below
5	5	Right	NA	NA	<5	1125	58	68	69	NA
5	6	Right	NA	NA	NA	NA	60	67	67	Tributary below Llano Loco Spring
6	7	Left	Stream	Llano Loco Spring	NA	1400	60	72	74	Llano Loco Spring

*Percent flow is a visual estimate by the surveyors and therefore should not be considered an exact measurement.

Stream Flow

The Rio Guadalupe begins at the confluence of Rio de las Vacas and Rio Cebolla at Porter Landing. Rio de las Vacas drains out of the San Pedro Park Wilderness and the Rio Cebolla drains a small part of the Valle Caldera National Preserve and land east to the Rio de las Vacas drainage. All of the smaller watersheds that comprise the Rio Guadalupe originate in the Jemez Mountains. The snow pack of the mountain basins governs the flow of the Guadalupe and its tributaries. Peak stream flow of the Rio Guadalupe occurs between late April and May. Smaller high flow events take place after late summer monsoon events. Stream flow during the 2004 Stream Inventory was lower than typical years due to drought conditions in Northern New Mexico.

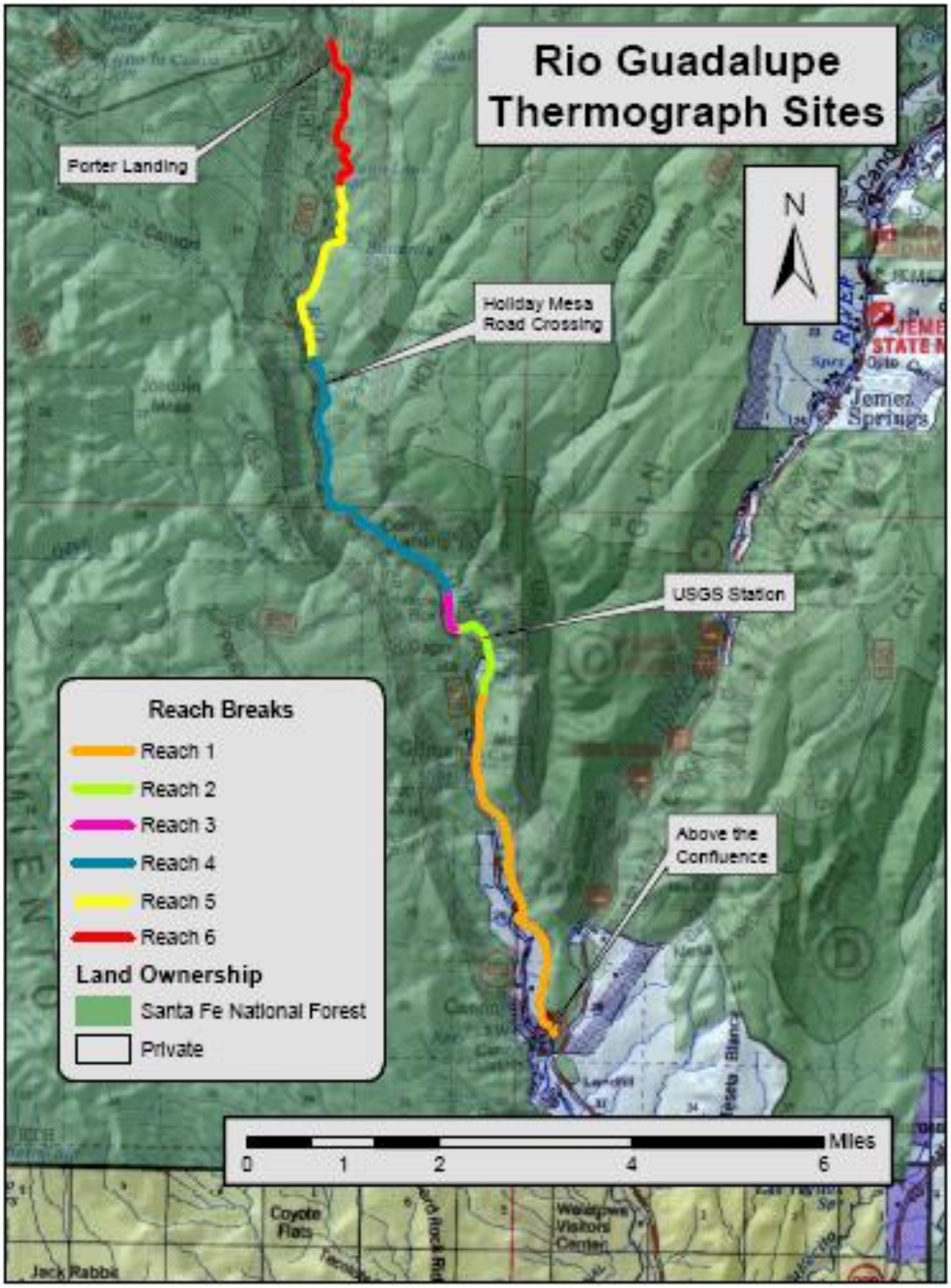
Flow was measured utilizing Swoffer brand flow meter on July 14th 2004 in Reach 2, River Mile 4.1. The flow measurement location is at the beginning of the survey above the Forest Service boundary. The flow measurement location was in a straight section of riffle with as few flow restricting obstacles (boulders, logs, etc.) as possible. A transect was created and divided into 12 equally spaced sections. At each section, flow was taken at 60% of the depth in twenty-second intervals. The average flow is recorded from each section and related to area to calculate the stream flow. The Rio Guadalupe flow on June 14th was 11.7 cubic feet per second (cfs).

Photo 5. Stream flow station at the start of Reach 2 (14-June-2004).

Water Quality

Water temperature is a key component of water quality in a stream environment. Combinations of multiple factors determine water temperature regimes in stream habitats. Solar radiation, air temperature, riparian vegetation cover, ground water, stream discharge, channel shape, stream orientation, and climate are some of the environmental factors that influence water temperature. Many chemical and biological processes depend on specific temperatures. Temperature can help determine the suitability of waters for aquatic species such as Rio Grande cutthroat trout (RGCT).

Fish growth, health, and reproduction are affected by water temperature. Fish are very sensitive to water temperature due to temperature specific enzymes. As water temperature increases, so does fish performance. Although fish have increased performance with temperature, they also approach a lethal limit. No lethal temperature information is currently available for RGCT. Another high elevation, arid cutthroat subspecies Lahontan cutthroat trout (*Oncorhynchus clarki henshawi)* indicated an upper limit for growth and long-term survival is somewhere between 71.6 and 73.4°F. These temperature limits were based on optimal conditions with high food availability and good water quality, not taking into account the other stressors that may exist in stream environments. It is possible that the actual lethal limits are lower due to water chemistry and other environmental factors (Dunham 1999).



Map 2. Thermograph locations in the 2004 Rio Guadalupe Stream Inventory. Temperatures were taken at these sites every 4 hours between June 1st and September 30th.

Cutthroat trout reproduction is affected by temperature. Smith et al (1983) compared egg quality of cutthroat trout in a variety of water temperatures. Eggs in cold water were expelled easily and were in good condition. In warm water the eggs were expelled with difficulty, were cloudy or opaque and often broken. Eggs spawned from two-year-old adults exhibited 74% viability in coldwater while in warm water only 6.9%.

Photo 6. Reach 3, NSO 24, P4. Theromgraph site at the USGS gauge site (15-June-2004).

Forest standards (noted as SFNF in Table 11) are based on seven-day average maximum temperatures and are stricter than the NMED standards. While it is stricter, the Forest standard is more in line with approaches taken by U.S. Fish and Wildlife Service and NOAA Fisheries across the western United States. It also allows the SFNF to be more pro-active in improving watershed conditions for native fish as well as ameliorating impairments to water quality before a stream is listed as impaired on the 303(d) list.

NMED standards are based on maximum temperatures (see Table 11). Forest temperature standards are derived from research done on inland cutthroat trout and salmonid development. NMED standards are based on the Clean Water Act and Total Maximum Daily Loads mandate for water quality standards but are defined by needs for a successful coldwater fishery. Data between June 1st and September 30th is used for maximum water temperature standards analysis to identify high temperatures that occur in summer months (see Table 1).

Water temperature in the Rio Guadalupe was monitored between June 1st and October 1st, 2004. Tidbit thermographs, small temperature recording devices, were strategically placed at 4 locations in the Rio Guadalupe. Thermographs recorded temperatures at 4-hour intervals for the duration of their time in the river, providing over 725 temperatures for each site. Data collected by thermographs was exported to Microsoft Access and Excel 2000 for analysis and comparison to water quality standards.

Four temperature monitoring stations were established on the Rio Guadalupe. The first station was placed at the mouth of the Rio Guadalupe above the confluence with the Jemez River (River Mile 0.0). We were unable to locate this Tidbit during retrieval thus, **no data was collected at this site**. The next station was located at USGS gauging station below the box canyon and at the end of reach 2 (RM 5.0). The third station, was located at the Holiday Mesa Road 656 crossing below Butterfly Springs (RM 8.9). The uppermost temperature station was placed at Porter Landing just below the confluence of the Rio de las Vacas and the Rio Cebolla (RM 13.3). The Holiday Mesa station was moved mid way during the monitoring period to deeper water due to drought conditions.

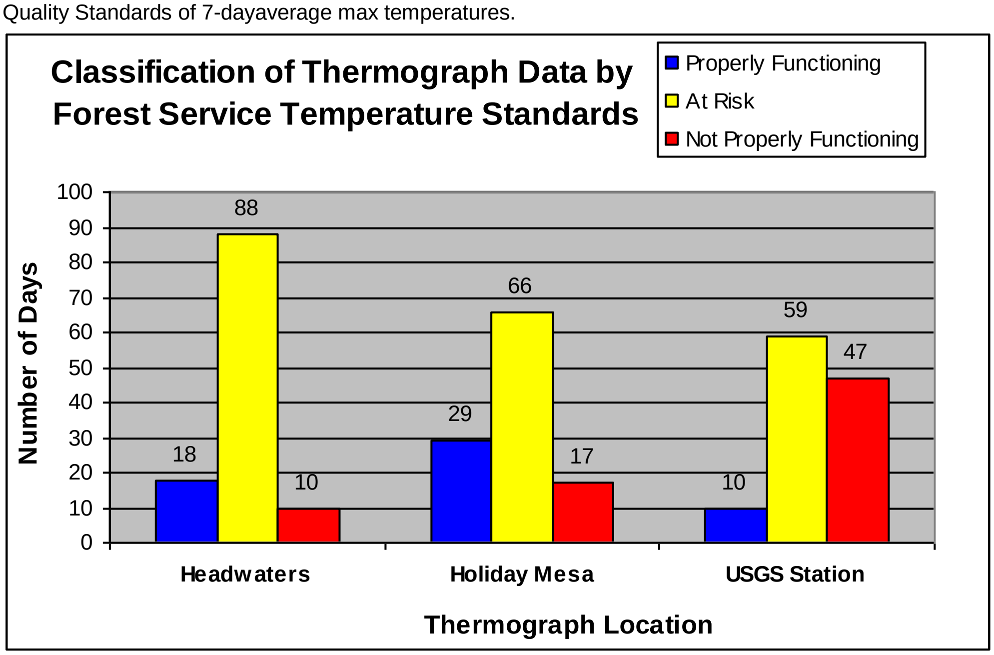
Table 11. Santa Fe National Forest and New Mexico Environment Department Water Quality Temperature Standards 2004.

Water Temperature Standards	**Properly Functioning**	**At Risk**	**Not Properly Functioning**
SFNF 7-day Average Maximum	≤ 64°F	64 to 70°F	> 70°F
	Fully Support		**Not Fully Support**
NMED High Quality Coldwater Fishery	<73.4°F at one time; or = 68°F for 4 consecutive hours over 4 consecutive days		≥ 73.4°F at one time; or > 68°F for 4 consecutive hours over 4 consecutive days

Data collected from the three (3) thermograph stations is compared to Forest and New Mexico Environment Department (NMED) Water Quality Standards for temperature.

When Forest standards are applied to the thermograph data, all three of the stations are **not properly functioning**. All of the sites had more at risk days than days properly functioning The Holiday Mesa Station had the least days of at risk and not properly functioning (see Figure 3).

Figure 1. A comparison of at risk and properly functioning days at the thermograph sites on the Rio Guadalupe between June 1st and September 30th, 2004. Classification based on SFNF Water Quality Standards of 7-dayaverage max temperatures.



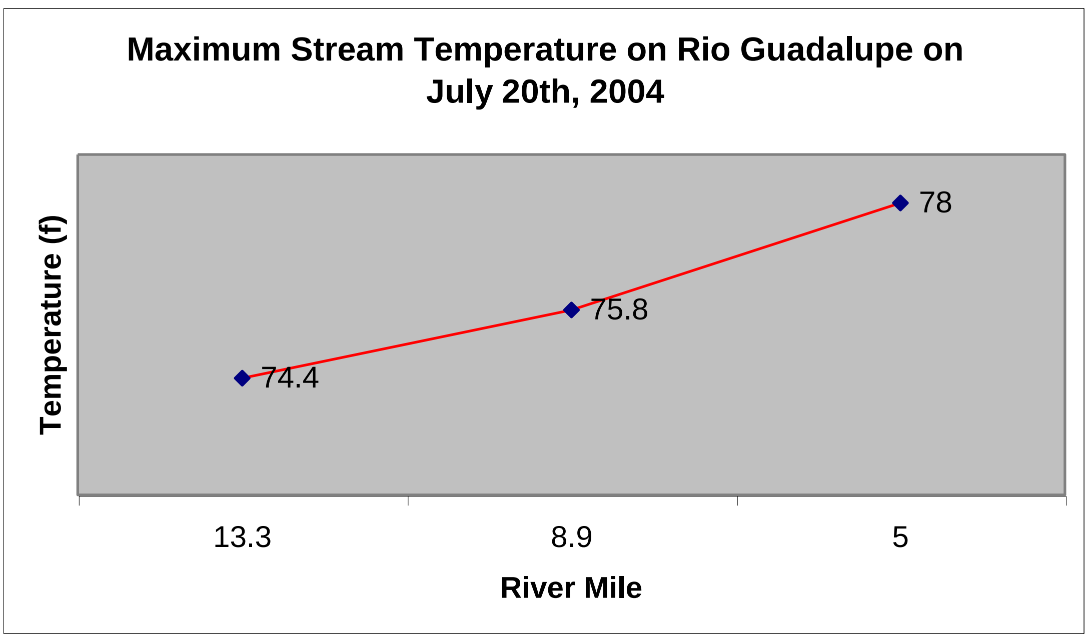
All of the stations recorded **not fully supporting** conditions for high quality cold water fisheries when classified by NMED standards. Though the thermographs were collecting data every four hours (instead of once every hour as required by NMED protocol) the 73.4ºF maximum was exceeded resulting in not fully supporting conditions (see Figure 3).

The **NPF and NFS** classification of multiple sites by both the Forest and NMED water quality standards implies that water temperature should be a management consideration for the Rio Guadalupe. Temperature mitigating strategies should be applied to protect the integrity of the coldwater fishery. Increasing LWD and pool development to create a narrower and deeper channel along with planting native riparian vegetation and protecting bank stability in high use areas are means of decreasing water temperatures on the Rio Guadalupe.

Utilizing the rate at which water temperatures increase, areas can be identified that are in the most need of temperature mitigation. The most rapid temperature increase is between the Holiday Mesa (River Mile 8.9) and the USGS station (RM 5.0). This area receives high recreational use leaving some areas with trampled riparian vegetation, decreased bank stability, and other effects of a recreation area. Another factor that could be influencing stream temperature between Holiday Mesa Road and the USGS station is the change in riparian overstory that provides shade cover. Above the Holiday Mesa Road large ponderosa pine and fir trees shade the stream. Below that the vegetation changes to more of oak and juniper overstory, which provides less protection from thermal heating and evaporation.

Diurnal or daily high to low temperature fluctuations are analyzed from the thermograph stations. On July 20th, 2004, a particularly warm day, diurnal fluctuations ranged from 12.4°F at the Holiday Mesa Site to 12.0° F at the USGS Station.

Figure 3. Maximum temperatures at the three thermograph sites on the Rio Guadalupe on a particularly warm day. The sites are listed from the highest (Mouth) to the lowest (USGS Station) and demonstrate the change of temperature with distance.



In 1999 the New Mexico Environmental Department (NMED) conducted a TMDL Study on the Rio Guadalupe Watershed to determine if it is meeting its standards as a coldwater fishery and it beneficial uses. Beneficial uses identified for the Rio Guadalupe are: domestic water supply, fish culture, high quality coldwater fishery (Rio Grande cutthroat trout, Rio Grande chub, Rio Grande sucker, longnose dace, rainbow trout, and brown trout.), irrigation, wildlife habitat, livestock watering, and secondary contact.

Water quality limited waters list (303 (d) list of waters that do not attain the State water quality standards) is revised and published every 2 years. The upper reach of Rio Cebolla, from Fenton Lake to its headwaters, is listed for stream bottom deposits and temperature. The lower reach of the Rio Cebolla, from Fenton to confluence with Rio de las Vacas, is limited due to stream bottom deposits.

The upper reach of Rio de las Vacas, from Rito Peñas Negras to headwaters, is limited due to temperature, stream bottom deposits, and total organic carbon. The lower reach of the Rio de las Vacas from Rito de las Palomas to confluence with Rio Cebolla is limited due to temperature and total organic carbon.

The entire reach of the Rio Guadalupe from its mouth on the Jemez River to the Rio de las Vacas and Rio Cebolla is limited due to conductivity, fecal coliform, turbidity, stream bottom deposits and aluminum (USDA, 2004b).

Riparian and Upland Vegetation

Outside of the bedrock canyon, riparian vegetation is located on both banks of streams. Riparian areas serve many important functions including water purification and storage, erosion reduction and more. Riparian vegetation removes toxins from the water column and improves water quality. Riparian vegetation also stores water in the stream banks increasing available water and stream flow duration. Streamside vegetation also improves streambank stability reducing erosion and its associated fine sediment inputs (Brodie 1996). Riparian vegetation is important in maintaining a healthy fish population in the Rio Guadalupe.

Rio Guadalupe riparian vegetation includes a variety of native and nonnative species. Native riparian vegetation includes alder, willow and cottonwood species (see Photo 7). Non-native or introduced riparian vegetation species include tamarisk and Russian olive near the Gilman Sawmill site site.

Vegetation varies by elevation and aspect. The potential for high intensity wildfire is high in many parts of the watershed due to high stand densities, ladder fuels and abundant down woody material in the uplands.

Photo 2. Reach 2, NSO 19, S1. Riparian vegetation in lower Rio Guadalupe. Notice the strong willow component and lack of over story shade cover (15-June-2004).

Englemann spruce (*Picea engelmannii*), blue spruce (*Picea pungens*), and aspen (*Populus tremuloides*) are common in high elevations of San Pedro Parks (headwaters of Rio de las Vacas). White fir (*Abies concolor*), Douglas-fir (*Pseudotsuga menziesii*), aspen, blue spruce, Ponderosa pine (*Pinus ponderosa)* dominate in the upper-mid elevations (Rio de las Vacas and Rio Cebolla). A ponderosa pine dominated overstory with understories of ponderosa pine, Douglas-fir, gambel oak (Quercus gambelii), Rocky Mountain juniper (*Juniperus scorpulorum*) and some white fir are at lower-mid elevations along the upper half of Rio Guadalupe. Pinyon pine (*Pinus edulis*) and one-seeded juniper (*Juniperus momosperma*) dominate the lower elevations on the outskirts of the riparian area from Dear Creak Landing to the mouth. Narrowleaf (*Populus augustfolia)* and Rio Grande cottonwoods (*Populus fremontii*), willow (*Salix spp*.), and alder (*Alnus tenuifolia*) dominate the river bottoms from about 6,500 feet elevation, from Gilman through the private land to the mouth (USDA, 2004b).

Beaver Activity

No information on historical beaver populations could be found for the Rio Guadalupe, though they are presumed to have inhabited the area where conditions would allow. This assumption is made due to the fact that beavers historically and currently occupy the Rio Cebolla at its confluence with the Rio de las Vacas and the Jemez River at its conflunce with the Rio Guadalupe. No beaver activity was observed during the survey. Improvements in cottonwood and willow vegetation along the banks of the lower Rio Guadalupe (private) and above the Guadalupe Box may be all that is needed to provide suitable habitat.

Beavers have many influences on stream systems, surrounding riparian vegetation, and fisheries populations. Beaver caused stream impacts are considered to be generally beneficial to trout habitat and an asset to stream systems.

Beaver activity and its associated ponds have many affects on stream water quality, most of which are considered beneficial to trout habitat. The decreased stream velocity that occurs in pool habitat, such as beaver dams, decreases the water's ability to carry sediment suspended in the water column. Suspended sediment tends to settle into a pond's substrate, creating a sink for stream sediment and reducing turbidity. Sediment transport has been reduced by as much as 90% in studied streams (Olson and Wayne 1994).

Photo 8. Beaver activity on the Rio Cebolla (4-1-2004).

Nitrogen and phosphorus containing sediments also settle, making beaver ponds a nutrient sink for a stream system. The storage of nutrient laden soil in sediment reduces eutrophication in nutrient rich systems. In low nutrient systems, such as headwater streams, the nutrient storage in pond sediment creates a time-release system increasing productivity. After the beaver leaves an area and the pond drains, the nutrient rich soil is utilized by riparian vegetation to produce dense riparian areas.

Decreased water velocity caused by beaver ponds alters the carbon cycle of streams. Reduced water velocity combined with increased water temperatures allows macroinvertebrates and bacteria to break down organic matter (leaves and wood) at a faster rate, creating dense macroinvertebrate populations. The breakdown converts organic matter to sediment and in some cases methane gas. The increased bacterial action reduces dissolved oxygen levels within the ponds and immediately downstream. The decreased velocity combined with increased width and overall surface area of the beaver ponds increases stream temperatures. The reduced concentration of dissolved oxygen and increased temperatures usually does not reach levels of concern for trout in Rocky Mountain streams (Gard 1961).

Beaver activity also has an affect on the riparian vegetation within proximity of the ponds, as well as the water table. Beaver activity increases the surface area of ponds by several hundred times, which is highly influential on the surrounding riparian vegetation. The increased surface area allows for storage of water in the banks and floodplain. The storage of water in the soil and floodplain increases the water table and stores water for times of low flow. During late summer low flow conditions water stored in the banks provides cool water to moderate flow and extreme temperatures (Parker et al. 1985).

While storing water, beaver dams also reduce extreme flows and related disturbance. The dams moderate flow during flood periods. This moderation reduces bank erosion related to flood events, improving bank stability in downstream areas (Olson 1994).

Beavers consume large quantities of riparian vegetation or woody supplies in their diet, as well as for the construction and maintenance of their habitat. Consumption rates for beaver populations are higher than the regeneration rates of riparian vegetation. Beaver tend to occupy an area until the surrounding supplies are consumed and then move on to a new section of river within or outside of the watershed. Once a beaver leaves, high nutrient content in the area allows for fast regeneration of consumed riparian vegetation. Over time, the area will regenerate and be ready for a beaver to return in future years (DeByle 1985).

Beavers generally improve trout habitat. Cutthroat trout in Rocky Mountain streams tend to be most abundant in streams with beaver ponds. Beavers do several things for fisheries habitat: Provide a food source, moderate stream temperatures, as well as increase habitat volume and over wintering habitat. Trout biomass and individual size increases with the presence of beaver dams. One possible explanation is high density of macroinvertebrates involved in the decomposition of organic matter and consumption of bacteria. Macroinvertebrates are a key food source for many trout, including RGCT. Increased pool volume, a vital habitat feature for trout, could also contribute to the correlation of healthy fish populations and beaver ponds. Over wintering habitat is also provided by the deep pools created by some ponds. The deeper pools become a refuge for fish when riffle habitat is frozen and can determine the carrying capacity of a stream. Flow and water temperature moderating affects that are caused by increased water tables provide cool water to the stream during low flow conditions. This could further increase the fish population carrying capacity of the stream (Olson 1994).

Fisheries

As with most of the rivers in New Mexico, extensive stocking practices with non-native German brown trout and rainbow trout species has led to a drastic change in species assemblages. Historically Rio Grande cutthroat trout was the only trout species found in the Guadalupe Watershed. They would also be found with the other native fish, which include the Rio Grande sucker, Rio Grande chub, Longnose dace, and Fathead Minnow. A 1962 NMGF report indicated the presence of Speckled dace, but the historical range on this species never has shown it to occur in the Rio Grande drainage and it is believed that they may have been mistook for the native Longnose dace (Hatch 1990).

Photo 9. Native Rio Grande cuttroat trout from Rio de las Vacas.

Currently, there are very small populations of native cutthroat in the upper watershed (Rio de las Vacas and Rio Cebolla). While unreported in the last decade, it is possible that individual RGCT may persist in section of Rio Guadalupe, it is likely that they are not resident fish and have been washed down from the upper watershed. Brown trout are the dominant fish in Rio Guadalupe. Over 4 million rainbow trout had been stocked between 1929 and 1990 (see Appendix B), and they have proven to have low survivability in the wild living amongst brown trout. A 2003 survey found no rainbows in the Rio Guadalupe near Porter Landing. No fathead minnows were found during the 2003 survey, but one minnow was observed during a 2004 survey in the Rio de las Vacas just upstream of Porter Landing.

Exotic trout species have been stocked in the watershed since as early as 1929 according to New Mexico Game and Fish (NMGF) records. Between 1929 and 1998 the Rio Guadalupe was stocked with rainbow and brown trout (FS Fisheries Files; see Appendix B). The large number of exotic trout stocked in the Rio Guadalupe placed pressure on native trout that led to their extirpation. The exotic trout displaced the native population through competition for resources, hybridization and predation. Brown trout is a piscivore, consuming fish like RGCT. Brown trout also compete with native fish for food and living space in the river. A characteristic such as higher temperature tolerance (80.6°F) (Sublette et al. 1990) increases the brown trout's success over native trout in water where temperature is an issue. Rainbow trout freely hybridize with RGCT and threaten genetic purity of native populations (Sublette et al. 1990). Conflicts with exotic trout species are one factor that has defined the RGCT as a sensitive species for the Forest Service.

Along with the years of intense stocking of non-native, there were also efforts to reduce native non-game fish in order to improve the non-native sport fishery. In September 1962, the NMGF treated Rio Guadalupe, Rio de las Vacas, and Rio Cebolla with rotenone "for the control of non-game fish. The Rio Grande mountain sucker and the Rio Grande chub were the predominant non-game species present. Brown and rainbow trout were the only game fish observed" (Olsen, H., 1962).

Photo 10. Native Rio Grande chub found dead in reach 2 (7/15/2004).

The latest survey conducted by the NMGF indicates the lack of native cutthroat in Rio Guadalupe (see Table 12). Current goals of the Forest Service is to improve habitat conditions to encourage increases in native fish populations.

Table 12. Fish presence in the Rio Guadalupe near Porter Landing in Reach 6 as determined by New Mexico Game and Fish survey 2003.

Fish Species	Native/Non-Native
Rio Grande chub	Native
Rio Grange sucker	Native
Longnose Dace	Native
German brown trout	Non-Native

Wildlife Species

Table 13. Threatened and sensitive wildlife species of the Guadalupe Watershed 2004.

Scientific Name	Common Name	Status
Haliaeetus leucocephalus	Bald Eagle	Threatened
Strix occidentalis lucida	Mexican spotted owl	Threatened
Coccygus americanus occidentalis	Western yellow-billed cuckoo	Candidate
Zapus hudsonicus luteus	New Mexican jumping mouse	Sensitive
Accipiter gentilis	Northern goshawk	Sensitive
Falco peregrinus anatum	Peregrine falcon	Sensitive
Rana pipiens	Northern leopard frog	Sensitive
Plethodon newmexicanus	Jemez Mountains salamander	Sensitive
Onchorhynchus clarki virginalis	Rio Grande cutthroat trout	Sensitive
Rumex orthoneurus	Chiricahua dock (plant species)	Sensitive

The Rio Guadalupe Watershed is home to a diverse array of wildlife including two threatened and seven sensitive species (see Table 13). The threatened species that is of most concern in the watershed is the Mexican spotted owl. Cool, steep canyons and mixed conifer forest typical to the Rio Guadalupe characterize Mexican spotted owl habitat. Mexican spotted owls have been observed in the recent owl surveys in the Guadalupe Watershed. Bald eagles, another threatened species in the watershed, are of lesser concern in watershed management because of their transient use of the area. Bald eagles do not over winter in the Rio Guadalupe and utilize the area occasionally for forage (USDA, 2004).

The sensitive species present in the Guadalupe Watershed are of concern in its management. Northern goshawks and peregrine falcons reside in ponderosa pine, mixed conifer, and spruce-fir forests. While northern goshawks nest and forage in these forests, peregrine falcons only forage. Northern goshawk is sensitive to habitat loss from logging, catastrophic wildfire and other disturbances especially during breeding season. Northern leopard frog habitat is present within riparian corridor. Northern leopard frog is typically associated with streams and rivers, although lakes, marshes and irrigation ditches are also occupied. In New Mexico, they occur at elevations of about 3,500 to 11,000'. Threats to local populations include alterations in wet areas, stocking of predatory fish; local extinctions as water dries up during years of low precipitation, and predation and competition by bullfrogs. The Jemez Mountain salamander (JMS) is found primarily in habitats between 7,200 and 9,600' in the Guadalupe Watershed in relatively high humidity microhabitats and soils that contain deep igneous, subsurface rock that is fractured to allow retreat underground to below the frost line. Much of the life cycle occurs underground with surface activity inside rotted coniferous logs or under rocks during a brief period of the summer when conditions are warm and wet. Habitat is typically Douglas-fir, blue spruce, Engelmann spruce, ponderosa pine, or white fir (personal communication with Jo Wargo, 2005). Rio Grande Cutthroat Trout can be found in the upper watershed, but in very low numbers. Rio Guadalupe is designated as proposed habitat for future reintroduction of Rio Grande cutthroat trout. Threats to populations include habitat loss, predation, competition, hybridization, and years of drought.

Non-listed wildlife can be used as indicators of habitat condition in the Guadalupe Watershed. Management Indicator Species present in the watershed include Rocky Mountain elk (*Cervis elaphus neisoni*), hairy woodpecker (*Picoides villosus)*, Merriam's turkey (*Meleagris gallopavo*), Piñon jay (*Gymnorhinus cyanocephalus)* and mourning dove (*Zenaia macroura*). The elk population in the Guadalupe Watershed is stable to increasing. Elk inhabit most of the area covered in the 2004 stream inventory. The hairy woodpecker population is ranked as abundant in the Forest. The woodpecker can be used as an indicator species for the presence of down logs averaging 17 inches diameter at breast height (DBH) and greater than 30 feet long, which are their foraging habitat. The turkey population in the Forest is ranked as common with 1,000 to 10,000 breading pairs. Ponderosa pine forests and surface water are requirements for turkey habitat common to the lower reaches of the survey. The Piñon jay nest mainly in piñon-juniper or pine woodlands, which occur in the lower Guadalupe Watershed. No Piñon jays have been observed in this area. The mourning dove population in the forest is ranked as common with between 1,000 to 10,000 breeding females. The dove habitat is abundant and occurs primarily in the lower elevations of the survey (USDA 2004 and Jo Wargo, personal communication, 2005).

Stream Improvements

Rio Guadalupe has received stream channel improvement structures in reach 6 as noted by the 2004 inventory. There is no record of these structures and further investigations are needed. Over the years Rio de las Vacas and Rio Cebolla have received numerous instream structures. Early stream improvements involved removing beaver dams and log structures and replacing them with trash collectors, which are made of steel posts with hog-wire. The purpose of the trash collectors was to imitate beaver dams and log structures. Other structures included large woody debris placement and V type log structures, mainly in the Rio Cebolla during the 1980's and early 1990's (FS Files). Most of these early structures have failed when stream channel was able to move around the structure and cause extensive erosion damage. These stream improvements used the best technology of the time. In 2004, using new ideas that work with natural stream dynamics, Rio de las Vacas received about 20 instream structures with rock and wood to create pool habitat and increase the large woody debris component to the system. Further monitoring will be done to determine the success of that project.

Another aspect of current stream improvement is to change the management that affects the stream banks and vegetation. This includes pulling back vehicles from the banks of the Rio Guadalupe and the Rio Cebolla. A Forest closure was enacted in 2004 on the Rio Guadalupe and 2005 on the Rio Cebolla that prohibits all vehicle use from the land between the Forest Road (FR) 376 and the two rivers. Miles of buck-n-pole fence construction, rock placements, and decommissioning user created roads are being used to block vehicles from sensitive riparian areas while still providing pullout areas and walk-in access. Results have already been seen with vegetation growth, healing stream banks, and a drastic reduction in trash.

LAND USE

Cultural Resources

Note: Many thanks to Chris Jenkins and Connie Constan, Jemez Ranger District archaeologists, for their historical interpretation of the Jemez area.

Archeologists have surveyed a portion of the watershed, but due to high frequency of site in the area there is a large percentage that has not been surveyed. Sites range from early Puebloan to the narrow gauge railroad that paralleled Rio Guadalupe in the 1920s.

The Jemez Springs area has long been noted for the presence of impressive late prehistoric ruins. These ruins are the remains of the large villages formerly occupied by the ancestors of the present-day Jemez people. Networks of hundreds of small one to four-room structures, known as field houses, surround the large villages. The term field house may be something of a misnomer, since many sites classified as such could have been used for a variety of functions, such as seasonal dwellings, hunting camps, and lookouts. Some field houses have been recorded with very large artifact scatters leading one to believe that they may have been occupied on a more permanent basis.

Scattered evidence suggests exploitation of the abundant obsidian resources of the mountains as early as Paleoindian times (ca. 10,000 BP). Archaic Period hunters and gatherers continued to exploit the obsidian sources, but also camped while foraging and hunting for food. Jemez Cave, near Jemez Springs and along the shores of the Jemez River, exhibits evidence of early horticulture in the form of corn remains dating to 800 BC (Ford 1975; Alexander and Reiter 1935).

Population remained low during the Developmental Period of the Upper Rio Grande Classification (ca. AD 600-1150). Population and site frequency increased dramatically during the Coalition Period (ca. AD 1150-1350). The majority of known prehistoric sites on the Jemez District date between 1350 and 1700 (Classic and Historic Periods). Field houses, rock art and artifact scatters are often found associated with large pueblo ruins.

The first contact during the historic period begins in 1598 when New Mexico became a Spanish colony and the Spanish priests began to build missions and convert the Indians to Catholicism. In 1680 during the Pueblo Revolt the Jemez helped to drive the Spaniards from New Mexico. Twelve years later De Vargas reconquered New Mexico. Discontent with Spanish rule, the Jemez revolted again in 1696 and retreated to large pueblo sites on the Mesa tops. Between 1696 and 1706 most of the Jemez people abandoned the Jemez Mountains and joined other pueblos. The modern day Jemez Pueblo was established in 1706 as the Jemez people returned to their native lands. As a result of European contact many of the Jemez peoples' lifeways were permanently changed. Some of these permanent changes are apparent in artifacts such as pottery and the introduction of Spanish metals.

The Hispanic presence in the area effectively dates from 1598 when don Juan de Oñate established the first permanent colony near San Juan Pueblo. The Canon de San Diego Land Grant was made in 1798, with major settlement near the confluence of the Jemez and Guadalupe Rivers. In 1821 Mexico gained independence from Spain and assumed control over New Mexico until the war of 1846 with the United States. After the treaty of Guadalupe Hidalgo in 1848, the United States assumed control over most of New Mexico, and the Anglo presence in the Jemez area became much greater.

Beginning in the 1800s, Hispanic and Anglo use of the Jemez Mountains focused on stock grazing, logging, mining, and hunting, as discussed in Baker and Winter (1981). The original Jemez Forest Reserve was created in 1905, while the Santa Fe National Forest was created in 1915 with the combination of the Jemez and Pecos Forest Reserves (Gillio 1980).

The Santa Fe Northwest Railway was built between 1922 and 1924 (Myrick 1990, Glover 1989). It was the logging railroad used by the White Pine Lumber Company running from Bernalillo to San Ysidro to Gilman and up canyon along the Rio Guadalupe to Porter. Side lines ran up various canyons beyond Porter. Decline in residential construction forced the White Pine Lumber Company into bankruptcy. From the bankruptcy formed the New Mexico Lumber and Timber Company, which then switched to trucks along the logging spurs. In 1937, the railroad was shortened to thirty-eight miles with a loading platform at Gilman. The Rio Guadalupe and Jemez River flooded in 1941 and washed out three miles of track and damaged several bridges. This ended the use of the railroad for logging in the Jemez Mountains.

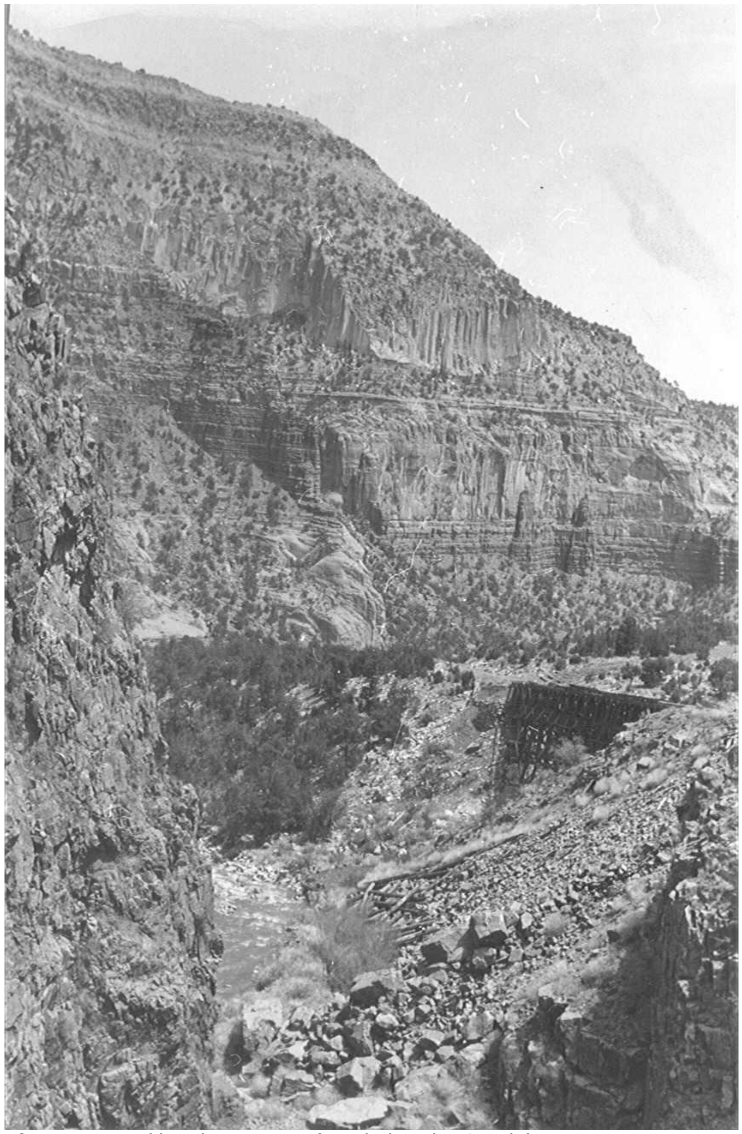


Photo 11. Looking downstream from below the Guadalupe Box.
A Railroad trestle can be seen in the foreground (4/1944).

Hispanic and Anglo use of the Jemez Mountains has focused on stock grazing, logging, mining, and hunting. The original Jemez Forest Reserve was created in 1905, while the Santa Fe National Forest was created in 1915 with the combination of the Jemez and Pecos Forest Reserves. Commercial logging of the area began in 1922 with formation of the White Pine Lumber Company and construction of a lumber mill and logging railroad from Bernalillo up the Jemez and Guadalupe Rivers (Glover 1989). Important railroad logging towns included Porter at the source of Rio Guadalupe and O'Neil Landing on the Rio de las Vacas. The railroad line was abandoned in 1941 following a damaging flood. Use of the sawmill at Gilman, however, continued into the 1970's.

During the 1930's President Franklin D. Roosevelt created the Civilian Conservation Corps to provide work for unemployed males during the Depression and to cope with national conservation needs. CCC personal involved in a variety of conservation activities on the forest, including building fences and cattle guards for grazing management, constructing dams and erosion control along streams and drainages, and constructing roads, trails, campgrounds, and picnic areas for recreation purposes.

Photo 12. Porter Landing around the 1920's.

Timber

Forests in Rio Guadalupe Watershed consist primarily of ponderosa pine. However, higher elevations produce Douglas-fir and a mix of spruce and fir. Timber harvesting has gone on for as long as people have inhabited the area. There is no record to show when the first timber harvest occurred in Rio Guadalupe.

In the 1920's and 30's, heavy timber harvesting was occurring in this watershed. Logging camps existed at Porter Landing and Dear Creek Landing. A railroad line was built in the 1920's to transport the timber from the logging camps to the sawmill, located just upstream of Virgin Canyon in the Rio Guadalupe Watershed at Gilman. This included the blasting of Gilman Tunnels in Rio Guadalupe Canyon to accommodate the train. The railroad line followed the Rio Guadalupe and split at Porter landing continuing up Rio de las Vacas and Rio Cebolla. During the 1940's the railroad trestles washed out during a flood, and were not rebuilt. Logs were then transported by truck, and the Gilman Tunnels were widened to accommodate the log trucks (Chris Jenkins, personal communication, 2002).

In the 1960's, there was a period of harvesting called "free thinning", in which all tree species other than ponderosa pine were removed. Thinning efforts continued through the 1970's until budget cuts terminated thinning crews.

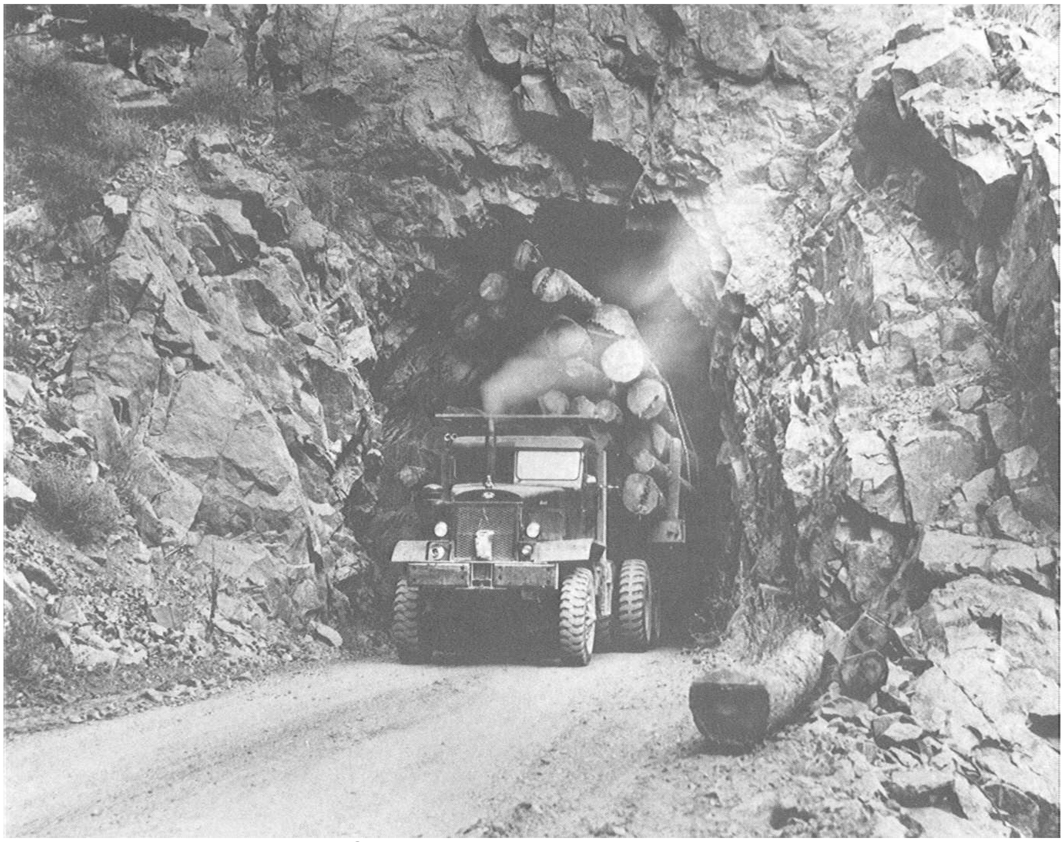


Photo 13. Logging truck exiting the Gilman Tunnels around the 1950's.

Presently, the upper parts of the watershed in Rio de las Vacas and Rio Cebolla are the focus of today's timber thinning activities. The purpose of these thinnings is fuels reduction. With the objective of reducing fuels these watersheds are also receiving prescribed burns to return the forest to healthy and diverse stands that are less crowded and more resistant to catastrophic fire.

In 1963, in reaction to an outbreak of spruce budworm, the Santa Fe National Forest sprayed the Jemez District with DDT. No detrimental effects were found in the study areas. The helicopters flew low in the areas of concern to avoid any drift of spray (FS Files).

Mining

Rio Guadalupe has had little effects from mining. There is one mine claim near the Rio Guadalupe at Dear Creek Landing but it is unknown what the commodity is. The Forest Service also operates a personal use gravel collection area for up the up FR 652.

Roads

Fish habitat degradation can result from poorly planned, designed, located, constructed, or maintained roads (Furniss et. al 1991). Even in good condition, roads introduce large quantities of sediment to streams (Grayson et al. 1993). The increased fine sediment concentrations that result from high road densities has been associated to decreased fry emergence, decreased juvenile densities, loss of winter carrying capacity, and increased predation of fishes. The introduction of fine sediment has also been related to the reproductive degradation in salmonids. Survival of incubating salmonids from embryos to emergent fry has been inversely related to the proportion of fine sediment in spawning gravels (USDA Forest Service 2000).

Table 14. The number of acres, road miles and road densities for the watershed as well as just the water draining into the Rio Guadalupe from the confluence with the Rio de las Vacas and the Rio Cebolla down to the mouth at the conflunce with the Jemez River.

Watershed	Acres	Road Miles	Road Density
Guadalupe Watershed	171,194	1165	4.4
Guadalupe Mouth to Headwaters	31,039	309	6.4

The Rio Guadalupe Watershed road system is connected by FR 376, which turns into Highway 485 at Gilman. FR 376 runs along the Rio Guadalupe and crosses the river at Porter Landing continuing upstream along the Rio Cebolla for about three miles. Once the road splits from the Cebolla it continues on for about 7 miles until it joins with Highway 126, which leads to La Cueva to the east and Cuba to the west. The 376 road corridor is the heaviest traveled level three road (graveled) on the Jemez Ranger District (Peterson, personal communication 2005) providing access to the Jemez Mountains for hunting, fishing, ATVs, camping, utilities, and cattle grazing. There is 4.4 miles of road per square mile in the entire watershed. This extensive road network has numerous stream crossings and contains an unknown amount of user created roads and off highway vehicle trails. The road density in the Rio Guadalupe Watershed is above the U.S. Fish and Wildlife Service and the Forest maximum recommended road density of 2.5 miles of road per square mile of watershed (see Table 14).

Specific problems related to the roads in the Rio Guadalupe Watershed were identified during the 2004 Stream Inventory. The Holiday Mesa Road fords Rio Guadalupe and is causing the stream channel to widen and shallow, causing thermal heating and evaporation as well as adding sediment to the creek (see Photo 14). The Holiday Mesa Road its self is in very poor condition and is supplying sediment into the creek. In the Guadalupe Box FR 376 encroaches on the left stream bank and is in places only a few feet from the water's edge. With the high amount of vehicle traffic and damage that was occurring along the Rio Guadalupe, a road to river vehicle closure was put in place in 2004 to help reduce the damage that was occurring along the banks. Analysis of specific road related issues is limited to the Rio Guadalupe and not the entire watershed.

Photo 14. Holiday Mesa FR 656 crossing during spring run-off (20-April- 2004).

Fires

Historically, fire has played an important role in the forests of northern New Mexico. The forests adapted to a natural fire regime, which played an important role in the ecology of these systems. The historic fire regime consisted of smaller, more frequent fires that burned at a lower temperature than the current catastrophic, large scale burns. Historic burns reduced the density of trees and shrubs, the amount of dead wood and kept forest fire fuels low. However, human intervention has dramatically altered the historic fire regime. Over a century of fire suppression has further reduced the fire regime frequency creating an abundance of fuel and increasing the potential for catastrophic fires similar to the 2000 Viveash Fire. Catastrophic fires create larger and hotter burns, dramatically altering the ecosystem.

Wildfire is the biggest potential impact to water quantity and quality. Recent wildfires including Dome, Cerro Grande and Viveash has given us experience in the magnitude of changes in peakflow, timing and sediment delivery to the stream systems. After the Dome Fire, monsoon floods increased peakflow 100 times baseflow during the first year (MacRury, 2003).

Table 15. Historic Fire Frequencies in the Southwestern US.

Forest Cover Type	Average Frequency/Interval
Pinyon-Juniper (PJ)	4-9 years on drier sites in PJ/oak 10-30 years on PJ or PJ/pine sites
Ponderosa Pine	5-15 years on average 16-51 years maximum range
Mixed Conifer, dry	4-12 years 18-32 years maximum for major fire
Mixed Conifer, wet	20-25+ years
Spruce-Fir/Aspen	Infrequent: 200-400 years

(From Swetmnam and Baisan 1995, Touchan and Swetnam 1995, Wright and Bailey 1982)

Two large fires over 1,000 acres have occurred in the Upper Guadalupe Watershed in recent history. The Porter Fire in 1977 burned 1,700 acres on Stable Mesa and the Lake Fire in 2002, which burned 3,900 acres near Fenton Lake and along FR 376 and Rio Cebolla. Turbidity in Rio Cebolla and Rio Guadalupe can still be observed after rain events from the Lake Fire. Other smaller fires such as the 2nd Porter Fire, School House Fire, and the Virgin Fire have occurred in the drainage (see Table 17, USDA, 2004).

Table 16. Documented recent Rio Guadalupe Watershed fire history. All fires are located within the watershed.

Year	Name	Acres	Square Miles
1977	Porter Fire	1,700	2.7
1993	2nd Porter Fire	380	0.6
1999	School House	NA	NA
2002	Lake Fire	3,900	6.1
2003	Virgin Fire	400	0.6

Stock Grazing

Ranching is a tradition and has been a way of life in Northern New Mexico since the Europeans arrival in the 1540's (USDA Forest Service 1996). Grazing on public lands has occurred for nearly a century.

The Rio Guadalupe flows through the San Diego Range Allotment. The grazing that occurs in the Guadalupe portion of the allotment consists of 77 adult cattle for a period of two weeks in the spring and in the fall. There is a coral near Dear Creek landing where the cattle are released and gathered in the spring and fall. This riparian pasture is a transition pasture to summer and winter pastures and rarely experiences full utilization. The rest of the grazing takes place higher in the uplands and does not affect the riparian conditions along Rio Guadalupe. Upstream there are numerous allotments in the Rio de las Vacas and the Rio Cebolla watersheds. A majority of the gazing in Rio de las Vacas and Rio Cebolla is to be in the uplands and have limited use in the riparian areas, but trespass cattle and over utilization can be seen especially along Rio Cebolla. More information pertaining to these allotments can be aquired in the Rio de las Vacas and Rio Cebolla Stream Inventory Reports.

Recreation

Each summer the Rio Guadalupe Watershed receives a considerable influx of people recreating along its streambanks. During the summer of 2003 a dispersed campsite inventory was taken along the Rio Guadalupe, Rio Cebolla and Rio de las Vacas as part of a program called Respect the Rio. This involves watershed restoration and education programs to promote and implement better user stewardship in the watershed. Overall there are 84 complexes and 329 individual dispersed campsites along the three rivers. The Rio Guadalupe alone has 22 complexes and 127 individual campsites (see Table 18). These campsites are characterized by large areas of brown out, which during rain events can lead to heavy sediment loading of the streams. There is approximately 123.4 acres of disturbed ground along Rio Guadalupe associated with dispersed camping (USDA 2003).

Table 17. Summary of Dispersed Campsite Inventory

Corridor	**# Complexes**	**# Individual Sites**	**# Fire Rings**	**Total Acres Disturbed**	**Acres/ Complex**	**Total Acres Exposed Soil (denuded of veg)**	**Trees Damaged**	**Unstable Banks (ft)**	**Toilet Proximity to Steam (ft)**
Rio Guadalupe	22	127	265	123.4	5.6	43	435	420	130
Rio Cebolla	29	130	226	131.9	4.5	45	710	822	9
Rio de las Vacas	33	72	113	39.0	1.2	11	324	1,269	21
Total	**84**	**329**	**604**	**294.3**	**-**	**99**	**1,469**	**2,511**	**-**

A Contact Ranger Program was implemented in 2003 and 2004. 2003 outlined the...

intensity of use, where visitors resided, changes they witnessed (for repeat visitors), and suggestions for improving the experience. In addition visitors were asked if they would pay a fee to visit the area to pay for the improvements. A highlight of the findings suggest different types of users in different corridors, a growth in visitors and sites, that most visitors resided in Albuquerque area, and a willingness to pay a minimal fee:

- Individuals contacted - 1,488;
- Visitors had been visiting area on average for the last 9 years;
- Mostly weekend visitors (Friday and Saturday night);
- 3:1 ratio of overnight campers to day users; most day use was along Rio Guadalupe;
- 83% of visitors were from Albuquerque area; 5% were from out-of-state;
- ATV use has grown over last ten years; while fishing and swimming remained the most popular recreation activities;
- More people and more trash were the most popular response for changes noticed;
- Trash bins and toilets were the most suggested improvements;
- Common concern regarded ATV use and that non-ATV users would like to see ATV users regulated or offered an alternative area;
- Overall, there was a willingness to pay a nightly fee of about $5 per night.

The dispersed campsite inventory can be used to monitor change. It is suggested that the rate of the inventory be done on a 10-year rotation. Meanwhile, the Contact Ranger Program should continue to be utilized annually to assist in assuring compliance with these changes through educational messages and keeping the public informed of change. It was clear that the public appreciated the Forest Service showing an interest in their opinions and generally making an appearance" (USDA 2003).

Photo 15. T. Anderson at a campsite in Reach 6 (22-July-2004).

Rio Guadalupe underwent some new changes in management during the summer of 2004 under the Respect the Rio program as a result of the campsite inventory. These changes include:

- Modifying dispersed campsites that encroach on the stream banks;
- FR 376 road to river closure for all vehicles;
- Converting Deer Creek Landing, a popular swimming hole, into a "Day Use Only" area;
- Replanting degraded riparian areas with native vegetation;
- Educational signing placed throughout the watershed to inform visitors on low impact camping, native ecosystems, and the ideas behind restoration.

After one season we are starting to see a large reduction in trash, vegetation is starting to re-establish, and best of all people our reading, understanding, and seeking out the Respect the Rio messages.

RECOMMENDATION SUMMARY

Education

Objective:
Educate forest users regarding the effects of their activities on the natural resources, inform them of ways to minimize impacts and promote better use of the resource. Educate public on current and future restoration projects in riparian areas and stream channels.

Concerns:
Public education is one of the most important changes that must be made for management to be successful. Without education degrading activities will continue along with the associated damage. Rehabilitation programs spend millions of dollars repairing damage, but if the public isn't properly informed about a project, the money will have been spent needlessly.

Implementation methods:
Continue the contact ranger program indefinitely. A team of educators will contact forest users during intensive use times (summer) in high use areas as well as developed campgrounds. Interpretive campfire programs and one on one contacts inform visitor of proper camping, fishing, and other recreational practices including "Leave No Trace" ethics. The team will also inform users of restoration and regulation changes occurring in the area.
Members of the public, including local and state decision makers, will be invited to join Forest fisheries staff in seminars focused on stream integrity, including snorkeling seminars. Special seminars will also be offered to teachers and university courses.
Development and implementation of K-12 classroom educational programs. Several schools are either currently or becoming interested in water quality and riparian monitoring on forest water bodies.
Continue development and updates to the Respect the Rio website (www.fs.fed.us/rtr) as a way to educate visitors on proper camping techniques, watershed health, and local restoration projects and improvements and the importance in the watershed.

Riparian

Objective:
Restore a natural riparian vegetation community, promoting watershed integrity and function.

Concerns:
Currently, the riparian vegetation is degraded in the Rio Guadalupe. Land use practices including, but not limited to, dispersed recreation and fire management are causing significant impacts on the riparian zone. Reduction of riparian zone species and decreased density are examples of the current degradation. The integrity of the riparian zone is crucial to stream function and coldwater fish habitat. The current riparian vegetation and management practices should be altered to simulate and promote a healthy vegetation community.

Implementation methods include:

- Augment current riparian area density by planting native species by historic dispersed recreation
- Reduce number and limit the use of dispersed trails and campsites within the riparian zone.
- Maintain vehicle closure and barriers.

Photo 16. Campers respecting road to river vehicle closure (17-July-2004).

Large Woody Debris

<u>Objective:</u>
Increase LWD densities to within natural range of variability, improving coldwater fisheries habitat and stream integrity.

<u>Concerns:</u>
Large woody debris (LWD) in the Rio Guadalupe is below the desirable densities in forested reaches.

<u>Implementation methods:</u>
Arrange LWD in the floodplain and stream in strategic locations, increasing habitat complexity and fish habitat. These projects would utilize the best available science for LWD implementation to avoid previous stream improvement mistakes.

Native fish populations

<u>Objective:</u>
Restore and protect populations of native Rio Grande cutthroat trout in their historic range.

<u>Concerns:</u>
RGCT have been extirpated from their historic range in the Rio Guadalupe. The population should be extended downstream from the Rio de las Vacas to occupy more of their historic range.

Implementation methods:
Work in partnership with NMGF and the communities to methodically expand the range of RGCT to downstream reaches and tying together with other streams such as the Rio de las Vacas and the Rio Cebolla
Utilize natural barriers (Reach 3 and 5) or areas of confinement, such as bedrock canyons in Reaches 3 and 5to minimize the construction of man-made barriers. The natural confinement and possible barriers in Reach 5 (see Photo 17) could be used as the first step of many in creating an expansive metapopulation.

Photo 17. NOS 204, F15. Natural barrier and confinement that would make a good site for man-made barrier (8-July-2004).

REACH SUMMARIES

Photo 18. Reach 5, NSO 197, P62. Bed-rock wall and a defined bankfull line (8-July-2004).

Reach 1: Confluence With Jemez River to Just Above Private

Reach 1 was not surveyed as it runs through private land. This reach begins at the confluence of the Rio Guadalupe and the Jemez River at (T17N R2E Sec. 29 elev. 5,700') and continues up to a dry arroyo above private property, just south of the abandoned Gilman sawmill site (T17N, R2E, Sec. 8, elev. 5,920'). The Rosgen channel type for this reach is C. It appears that this reach has been heavily utilized and is lacking LWD and shade cover.

Photo 19. Rio Guadalupe looking upstream from at the mouth (May 2004).

Reach 2: Just Above Private to USGS Station Below Guadalupe **Box**

The start of the survey begins at Reach 2 where a dry arroyo meets the stream on the right bank above private property, just south of the abandoned Gilman sawmill site (T17N, R2E, Sec. 8, elev. 5,920'). The arroyo's source is located between Mesa Garcia (elev. 6977') and a small nameless mesa (elev. 6,697'). Reach 2 ends at the USGS flow station located at the bottom of Guadalupe Box Canyon (T17N, R2E, Sec. 6, elev. 6,040'). FR 376 parallels the left bank but is often more than 300 feet from the stream. The base of the mesas to the east forms the right bank. The old Gilman sawmill site runs along a large portion of the left bank. This reach was surveyed from June 14th through June 15th, 2004. The measured length of Reach 2 is 1.0 miles. The average gradient is 2.3% with a mapped sinuosity of 1.02. The Rosgen channel type is B3 with a cobble dominated substrate.

Dense vegetation lies along the stream banks. Vegetation becomes fairly sparse farther away from the stream. Vegetation consisted mainly of willow, alder, Apache plume (*Fallugia paradoxa*), red-osier dogwood (*Cornus sericia*), Rocky Mountain Juniper and Piñon pine. Many of the piñon pines are dying due to a bark beetle infestation that is progressive due to a drought in the area. A few noxious salt-cedar (*Tamarix Pentandra*) and Russian olive (*Elaeagnus angustifolia)* plants were noted along the streambanks associated with the Gilman Sawmill site. Two ponderosa pines were noted. There is little to no chance for LWD recruitment from within the reach, due to the lack of large trees in the lower elevations. This vegetation does however protect most of the stream from sedimentation, but due to human trails and 4WD crossings some unstable bank was observed. There is no canopy shade cover; therefore the area is very sunny creating warmer water, which can hold less dissolved oxygen. The stream contained relatively clear water, with minimal aquatic vegetation. <There were some habitat areas: riffles with high amounts of algae> There was no large woody debris. A few pieces of wood were observed toward the top of the reach but were not large enough to count.

Varieties of fish were seen while surveying this reach. Downstream from two people fishing, a Rio Grande chub was found floating. Anglers had two adult rainbow trout on a stringer. At the end of the reach, five or more adult trout were observed in a pocket pool. Few juvenile and adult trout were found throughout the reach. Also, one Rio Grande sucker was observed.

Reach 2 contained two side channels. The first side channel was 89 feet long and relatively close to the same size as the main channel. The second side channel was located at the end of the reach and was 600 feet long with some amount of braiding and woody debris.

Photo 20. Reach 2, NSO 21, R17. Looking downstream at a typical riffle with Gilman Peak in the background (15-June-2004).

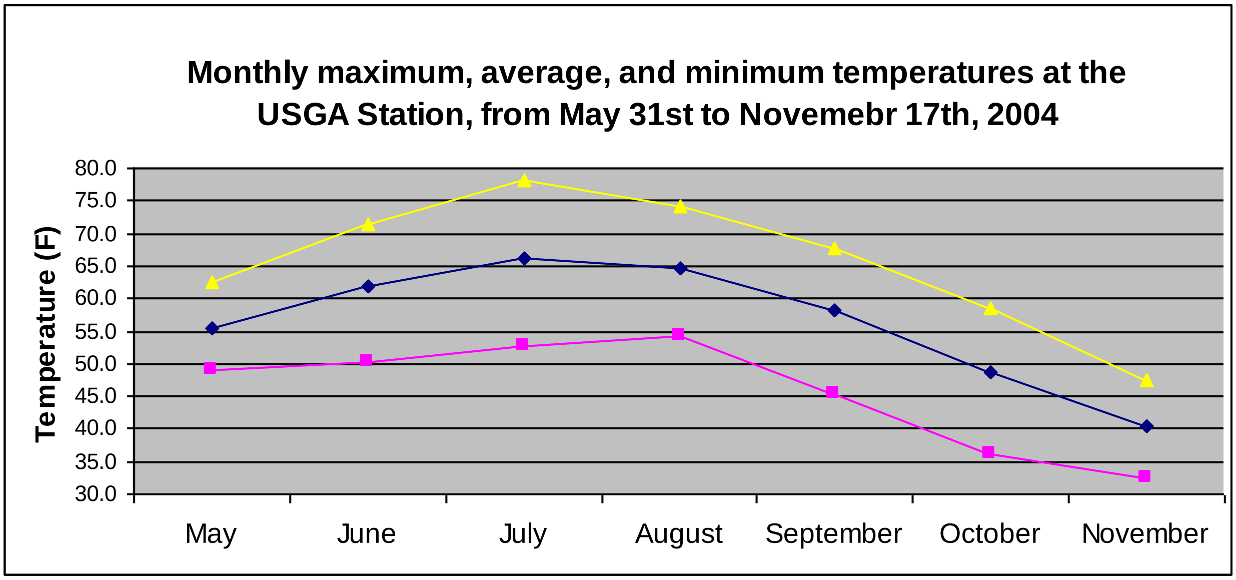
Human impacts along this reach were noted as user created roads, angler trails, and fords. Dispersed camping is prevalent along the left bank. These sites were inventoried in the summer of 2003. “Logging Camp” runs along the left bank from the beginning of Reach 2 and ends near NSO 18 (3737’ or 0.71 miles). The area related to Reach 2 on Forest Service land is designated Day Use Only. However, overnight camping is common practice in “Logging Camp”. This area is mainly used for fishing and swimming. There are angler trails that run along most of the left bank and parts of the right bank. Another dispersed site is found at the end of the reach, called “Gilman Peak,” which is commonly used by locals and recreationists as an illegal dumping site. There was a lot of trash found throughout the reach: fender from a car, cans and bottles, and clothing.


Photo 21. Reach 2, NSO 3, P1. Trail leading down to the water at "Logging Camp" (14-June-2004).

Water temperatures were measured at random intervals during the survey using a handheld thermometer. Main channel temperatures were taken in the water column. Four temperatures were taken during the survey of Reach 2. The highest temperature was 71°F (13:58) and the lowest 59°F (10:30), with the average being 64.3°F.

A water temperature station was established at the end of Reach 2 on May 31st and removed on November 11th, 2004. The highest temperatures were between June and August (see Figure 6). Rio Guadalupe is compared to Forest and NMED standards for classification as either properly functioning, not properly functioning or at risk (see Temperature section). Temperatures at the USGS temperature station are **not properly functioning** by Forest classification 47 of the 116 days between June 3rd and September 30th 2004. 12 of the 116 days were classified as **not properly functioning** under the NMED temperature standards. Only 10 days at the Forest standard 42 days by the state and days were classified as properly functioning.

Figure 4. Maximum, minimum and average temperatures for each month from the thermograph station at the end of Reach 2. Max and min are one-time temperatures and avg. is based on daily average.



Habitat Characteristics

Reach 2 is divided into 23 NSOs, measuring 1.0 miles or 5,457 feet. Five (3) NSOs are pool habitats, and comprised 2.0% of the stream habitat. 18 riffle habitats make up 81.8 % of the stream habitat in Reach 2 (see Table 19).

Table 18. Summary of Reach 2 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	3	128	2.4	2.0	>30%
Riffle	18	5229	97.6	81.8	-
Culvert	0	0	0	0	-
Tributary	0	0	0	0	-
Falls	0	0	0	0	-
Side Channel	2	1034	NA	16.2	-
Total	23	6,391	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 2 contains characteristics that are both not properly functioning and properly functioning. The parameters that are **not properly functioning** include pool development and LWD density. **Properly functioning** factors include bankfull width-to-depth ratio, bank stability, pool quality, and sediment content.

Table 19. Summary of habitat and substrate percentages for riffles in Reach 2.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
2	18	290.5	22.1	1.2	1.9	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
2	16.1	20.0	39.4	24.5	0.0	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

All factors related to riffle habitat are **properly functioning**.

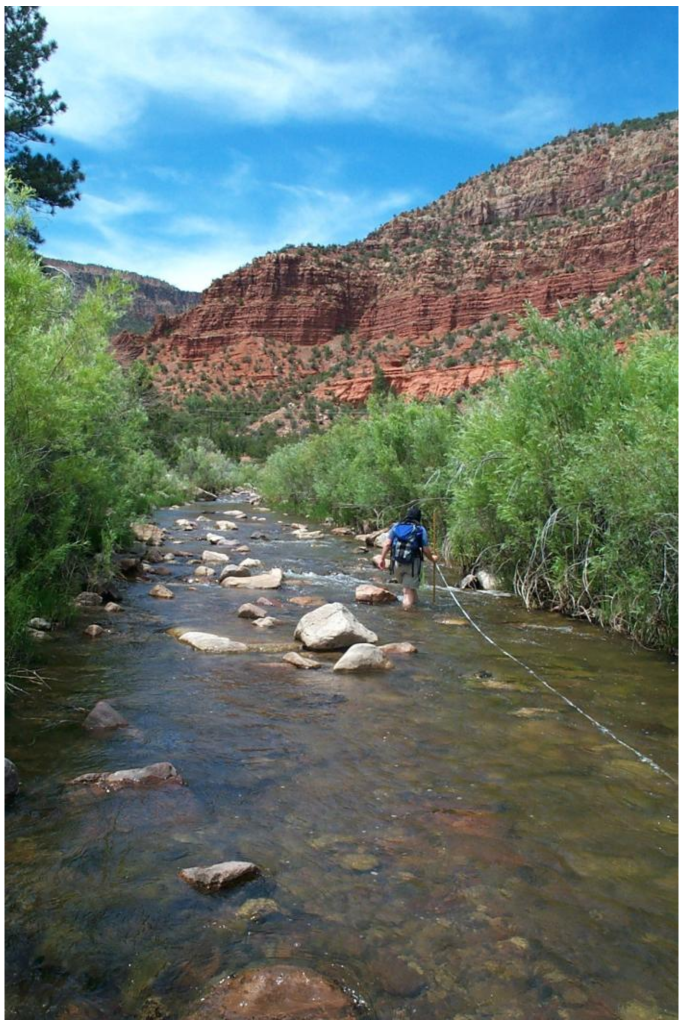


Photo 22. NSO 15, R13. Typical riffle looking upstream (14-June-2004).

Pool development in Reach 2 is **not properly functioning,** representing 2.0% of the stream length (see Table 18). The 2 of the 3 pools of Reach 2 were quality pools with maximum depths greater than 3 feet. Pool substrate is dominated by cobble substrate.

Table 20. Summary of Pool Habitat and Substrate Percentages in Reach 2.

Pool Habitat Summary											
Reach	# Of Pools	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools/Mile	# of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	# of Pools w/ Max. Depth >3'	# of Pools w/ Max. Depth >3'/Mile
2	3	42.7	15.2	2.7	1.3	1.4	3.0	2	2	2	2
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
2	16.7	26.7	40.0	13.3	3.3	100.0

Large woody debris density in Reach 2 is **not properly functioning**. No LWD was found in the reach (see Table 21). Large woody debris is a key factor in pool development and is related to the substandard pool development in the reach.

Table 21. Habitat Characteristics for Reach 2 of Rio Guadalupe.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
2	1:6	16:1	0.0	60	1.0
Properly Functioning Indicators	-	12-30	>30	-	<10

Recommendations

One suggested alteration, which could contribute greatly to a reduction in erosion problems, is a properly constructed trail along the river and decommissioning the ford across the river that accesses the power line corridor. With increasing visitation to the Jemez Mountains, a designated trail system may be necessary in order to limit resource damage. The majority of garbage seen in this reach was from the old mill site (i.e. clothing, car parts, beer cans/bottles, plastic cups). Any educational campaign, such as Respect the Rio, would benefit the area.

Other recommendations for Reach 2 focus on improving factors that are **not properly functioning**. Increasing LWD density of the reach along with pool development are two factors that are interrelated. Planting cottonwoods would provide over story shade cover and increase future LWD recruitment. With increased LWD density, habitat complexity will also improve including the formation of side channels.

Reach 3: USGS Station to Upper End of Guadalupe Box Canyon

Reach 3 begins at the USGS flow station at the bottom of lower Guadalupe Box canyon (T17N R2E Sec. 6, elev. 6,040'). The USGS station is on the right bank and is a green box on a metal pole (about 3 feet in diameter) with stairs leading up to it. Reach 3 ends 0.5 miles upstream above the box canyon (T17N, R2E, Sec. 6 Elev. 6,200'). The average gradient is 6.1% with a mapped sinuosity of 1.03. This reach was surveyed June 16th. The Rosgen channel type is an A2 with cobble being dominate in pools and boulders in riffles.

In Reach 3's beginning, the geomorphology is marked by a transition of an open valley into a box canyon. A steep canyon wall on the right bank and a steep talus slope on the left bank characterize this reach. The left bank is the route of the old railroad and is now FR 376 and the Gilman Tunnels. Throughout the reach, pools were fairly prevalent. A step pool complex with four pools characterizes the bottom of this reach. Four chutes with pools or high gradient riffles between each chute characterize the top. It is possible that some of these are barriers to upstream migration during times of low flow. There is a gradient of greater than 10% at this point. The reach ends when the valley floor opens up considerably. The left canyon wall breaks away and the right canyon wall is still fairly close to the river, but is noticeably more distant than downstream.

Upland vegetation was mainly found along the left bank within the talus. There were areas of deposition along the bedrock wall of the right bank that did support some vegetation. Vegetation consisted mainly of young willows, apache plume, non-native Virginia creeper, New Mexico locust (*Robinia neomexicana)*, and one narrow leaf cottonwood. There is no canopy cover for this stream, and little chance for local large woody debris recruitment. However one small piece was found in NSO 45/R28. The stream contained little aquatic vegetation, but there were areas where boulders were heavily covered with filamentous algae.

Six juvenile trout were seen in NSO 34/Pool 8. A slow moving backwater area contained many young-of-the-year, possibly trout. No side channels were found in this reach. However there were two areas that were braided, and were covered with young willow vegetation.

There was not any instability measured. Both banks were well armored with bedrock and boulders; therefore, no bank instability was observed.

Human impacts in this area are represented by in and around the water, graffiti on the rocks, jeep trails, and angler trails. Fishing line was found in the stream near the chutes at the top. Other trash included a large tractor tire wall in the stream. Gilman tunnels are a popular stopping point to forest visitors. One such reason for stopping is swimming. Pools located near the top of Reach 3 are used as swimming holes.

Water temperatures were measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings were taken in the water column. Two temperatures were taken in Reach 3 (58°F at 10:00 and 62°F at 12:15; both on June 16th, 2004).

Photo 23. NSO 27, R20. Looking upstream at talus slope. Notice the lack of overstory (16-June-2004).

Habitat Characteristics

The 0.5 miles (2,615 ft) of Reach 3 is divided into 28 NSOs. Almost half of the 12 NSOs were pool habitat, but only comprised of 18.7% of the stream habitat. 77.5 % of the stream habitat is riffle with the remaining 3.8% of the habitat consisting of falls (see Table 22). Because Reach 3 is less than the 0.5-mile minimum length requirement, ocular estimations are not statistically valid.

Photo 24. NOS 46, P13. D. Hoffman looking for max depth in a pool below a chute (16-June-2004).

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 3 contains characteristics that are both not properly functioning and properly functioning. The parameters that are **not properly functioning** include pool development, LWD density, and bankfull width-to-depth ratio. **Properly functioning** factors include bank stability, pool quality, and sediment content.

Table 22. Summary of Reach 3 stream habitat.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	12	489	18.7	18.7	>30%
Riffle	12	2026	77.5	77.5	-
Culvert	0	0	0	0	-
Tributary	0	0	0	0	-
Falls	4	100	3.8	3.8	-
Side Channel	0	0	0	0	-
Total	28	2,615	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.

Riffles, the dominant habitat type, are properly functioning for relative sediment content (see Table 23). Bankfull width-to-depth ratio is outside the expected range for an A2 stream. Reach 3 far exceeds this expected range (see Table 25), which is due to survey error.

Table 23. Summary of habitat and substrate percentages for riffles in Reach 3.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
3	12	168.8	15.1	1.4	2.7	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
3	9.2	17.5	28.3	30.8	14.2	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool development calculated by habitat length is **not properly functioning** in Reach 3 with only 18.7%, which is well below the matrix standard (see Table 22). While the percent of habitat is low, 75% had a max depth greater than 3 feet in depth (see Table 24).

Table 24. Summary of pool habitat and substrate percentages in Reach 3.

Pool Habitat Summary											
Reach	# Of Pools	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools/ Mile	# of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	# of Pools w/ Max. Depth >3'	# of Pools w/ Max. Depth >3'/Mile
3	12	40.8	18.5	4.2	1.2	3.0	24.0	11	22.0	8	16
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary								
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total	
	3	11.7	18.3	28.3	25.8	15.8	100.0	

LWD density in Reach 3 is **not properly functioning**. No LWD was found in this reach (see Table 25). LWD density is far below the greater than 30 pieces per mile matrix standard and could be attributed to historic use in the area. Recent studies have found that LWD is an essential part of pool formation and critical in providing complex fish habitat (Fausch and Northcote 1992).

Table 25. Habitat characteristics of Reach 3.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
3	1:1	25:1	0	0	0
Properly Functioning Indicators	-	<12	>30	-	<10

Streambank condition is **properly functioning** in Reach 3 with no unstable banks (see Table 25).

Photo 25. NOS 49, R29. Looking at a riffle downstream. Notice the gradient and valley confinement (16-June-2004).

Recommendations

Several measures could be taken to improve stream habitat in Reach 3, primarily related to impacts from the current historic high amounts of visitors. Some visitors “pack it in” but do not “pack it out”. This has led to large amounts of trash being pitched off the road and into the river below. The canyon walls oppsite the road are popular for beer bottle shattering. A large amount of graffiti also covers the rock faces on the walls surrounding the river deterring from it scenic beauty. Any educational campaign, such as Respect the Rio, would benefit the area.

While habitat parameters are below established standards, they are likely within the range of natural variability. LWD introduction could be warranted but should only be placed to enhance pools. The series of natural chutes and falls could be modified to permanently prevent upstream migration as part of a RGCT recovery effort.

Reach 4: Top of Guadalupe Box Canyon to the Bottom of the Upper Box Canyon

Reach 4 begins at the top of the lower Rio Guadalupe box canyon (T17N, R2E, Sec. 6, elev. 6200') and ends at the bottom of the upper box canyon (T18N, R2E, Sec. 24, elev. 6660'). Reach 4 at the lower end of the canyon wall opens up on the right bank, extending the valley floor to roughly 100 feet wide, yet is still confined by FR 376 on the left bank and the 200 ft high canyon wall on the right bank. Reach 4 is 3.7 miles long and has a gradient of 2.4%. The mapped sinuosity was 1.03 and the Rosgen stream type is a B3 with cobble being the dominant substrate.

The reach was survey from June 17th to June 29th, 2004. The vegetation consisted mainly of willow, apache plume, gambel oak, New Mexico locust, ponderosa pine, rocky mountain juniper, aspen *(Populus tremuloides*), alder, narrow leaf cottonwood, rose (*Roseacea spp.*), and sagebrush (*Artemisia* spp.). The noxious plant salt-cedar was observed on both banks in NSOs 56, 58, and 83. This vegetation doesn't provide a large canopy; however, some shade was provided.

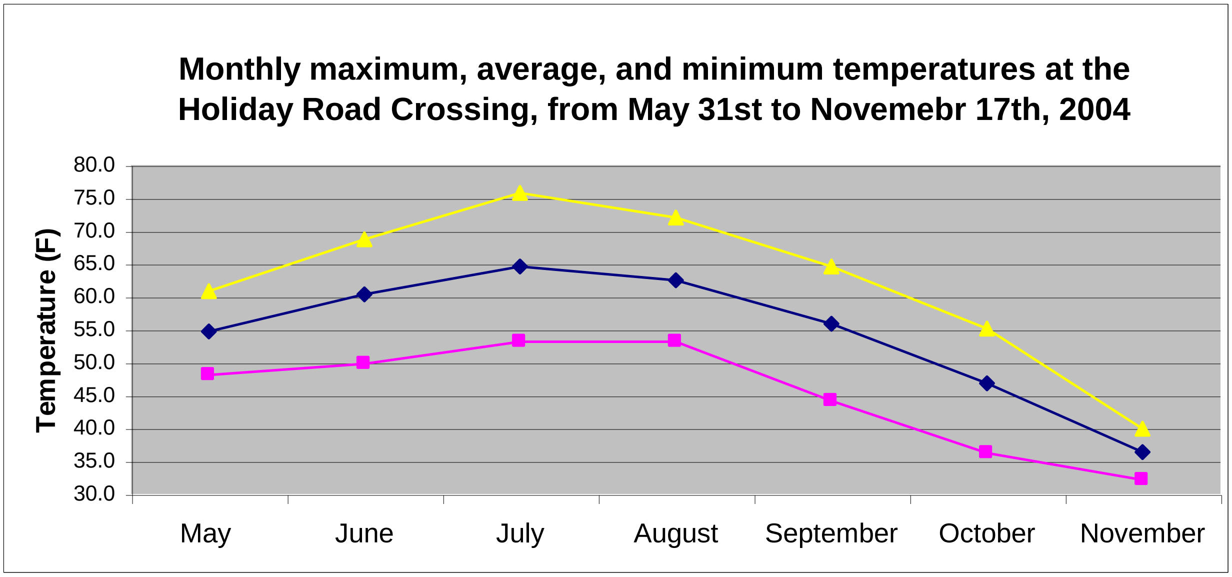
Four adult trout were seen (one dead). Juvenile trout and young-of-the-year were observed throughout the reach.

Photo 26. NSO 77, S4. Human Impacts on the Banks of the Guadalupe (22-June-2004).

Human impacts included user-created roads and trails. An old ford crossing causes 30 feet of unstable bank in NSO 70 at Deer Creek Landing. Dispersed camping has taken place along both banks of the stream, but mostly on the FR 376 side. Deer Creek Landing has a user-created pool that is heavily used for swimming. Trails on both sides of the stream as well as garbage and toilet paper were noted at Deer Creek Landing. Angler trails were observed throughout the reach.

Water temperatures were measured at random intervals during the survey using a handheld thermometer. Main channel temperatures were taken in the water column. 11 temperatures were taken during the survey of Reach 4. The highest temperature was 72°F (15:36) and the lowest 60°F (on four different times), with average being 63.1°F.

Figure 5. Maximum, minimum and average temperatures for each month from the thermograph station in Reach 4. Max and min are one-time temperatures and avg. is based on daily average.



A water temperature station was established near the end of Reach 4 at the Holiday Mesa Road crossing on May 31st and removed on November 11th, 2004. The highest temperatures were between June and August (see Figure 5). Rio Guadalupe is compared to Forest and NMED standards for classification as either properly functioning, not properly functioning or at risk (see Temperature section). Temperatures at the USGS temperature station are **not properly functioning** by Forest classification 47 of the 116 days between June 3rd and September 30th 2004. 12 of the 116 days were classified as not **properly functioning** under the NMED temperature standards. Only 10 days at the Forest standard and 42 days by the state and days were classified as properly functioning (see temperature section).

Photo 27. Reach 4, NSO 108, P31. Looking upstream at LWD at the top of a pool (28-June-2004).

Habitat Characteristics

The 3.7 miles (19,468 ft) of Reach 4 is divided into 65 NSOs. 17 of the NSOs are pool habitat and only comprised 5.0% of the stream habitat. The rest of the habitat is comprised of 90.2 % riffle habitat and 4.8% side channel habitat (see Table 26).

Table 26. Summary of Reach 4 stream habitat.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	17	1,013	5.2	5.0	>30%
Riffle	41	18,455	94.8	90.2	-
Culvert	0	0	0	0	-
Tributary	1	0	0	0	-
Falls	0	0	0	0	-
Side Channel	6	990	0	4.8	-
Total	65	20,458	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 4 contains characteristics that are both not properly functioning and properly functioning. The parameters that are **not properly functioning** include pool development and LWD density. **Properly functioning** factors include bank stability, pool quality, bankfull width-to-depth ratio, and sediment content.

Table 27. Summary of habitat and substrate percentages for riffles in Reach 4.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
4	41	450.1	115.9	1.1	2.2	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
4	19.3	23.7	30.2	23.4	3.4	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

All factors related to riffle habitat are **properly functioning**. However, fine sediment is nearing 20%. If fine sediment goes over 20% it will be not properly functioning. The evaluated parameters include bankfull width-to-depth ratio for related Rosgen stream classification and sediment content (see Table 27).

Pool development calculated by habitat length is **not properly functioning** in Reach 4. Pool habitat comprises a mere 5.0% of the stream habitat, which is well below the matrix standard (see Table 26). Meager pool development is part of the lack of stream habitat diversity throughout Reach 4. All the pools in Reach 4 are functioning properly for pool quality yet only 35% of them had a max depth greater than 3' (see Table 28).

Table 28. Summary of pool habitat and substrate percentages in Reach 4.

Pool Habitat Summary											
Reach	# Of Pools	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools/ Mile	# of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	# of Pools w/ Max. Depth >3'	# of Pools w/ Max. Depth >3'/Mile
4	17	59.6	19.0	3.0	0.9	2.1	4.6	17	4.6	6	1.6
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary								
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total	
	4	24.1	28.2	24.7	18.8	4.1	100.0	

LWD density in Reach 4 is **not properly functioning**. Four pieces of LWD are located in the reach, creating a density of 1.1 pieces per mile (see Table 29). LWD density is far below the greater than 30 pieces per mile matrix standard and could be attributed to historic use in the area (logging, dispersed recreation, and fuel wood removal). Recent studies have found that LWD is an essential part of pool formation and critical in providing complex fish habitat (Fausch and Northcote 1992).

Table 29. Habitat characteristics of Reach 4.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
4	1:2.4	14:1	1.1	125.0	0.6
Properly Functioning Indicators	-	12-30	>30	-	<10

Streambank condition is **properly functioning** in Reach 4 with 0.6% unstable (see Table 29).

Photo 28. NSO 91, P26. Unstable bank (23-June-2004).

Recommendations

Recommendations for Reach 4 focus on improving factors that are **not properly functioning**. Increasing LWD density of the reach along with pool development are two factors that are interrelated. With increased LWD density, habitat complexity will also improve including the formation of side channels.

Reach 5: The Bottom of the Upper Box Cayon to the Top of the Canyon

Reach 5 flows through the upper box canyon beginning at (T18N, R1E, Sec. 24, elev. 6,600') and ending just below the Llano Loco Spring (T18N, R1E, Sec. 13, elev. 6,960'). The measured length of Reach 5 is 2.2 miles long. FR 376 parallels the left bank but is often not visible and approximately ¼-mile away. Reach 5 flows through areas of a steeper valley floor, and occasionally high bedrock walls on both banks. Where bedrock walls were not present on both banks, the most common substrate counted was cobble. The reach was surveyed from 6-Jul-2004 through 21-July-2004. Reach 5 has a gradient of 2.6% and a mapped sinuosity of 1.1. The Rosgen stream type is an F3b.

Streambank vegetation was thick in sections where there was no bedrock. Some sections contained a lot of down dead wood. Vegetation along the banks consisted mainly of willow, red-osier dogwood, ponderosa pine, alder, oak, spruce, New Mexico locust, Douglas fir, Virginia creeper, juniper, poison ivy (*Toxicodendron rydbergii)*, and cottonwood. As the survey went through the reach more old growth ponderosa pines were observed. There was a total count of 25 pieces of LWD. This is a high number when compared the totals for the reaches surveyed below. Twelve (12) waterfalls were inventoried with two waterfalls that were large enough to be noted as barriers.

Much less human impact was noted in Reach 5. Trails and garbage were rarely observed and is most likely due to limited access. Forest Road 376 is typically a half mile from the stream.

Reach 5 contains five out of the seven tributaries that are found in this survey including Joaquin Canyon and Butterfly Springs. Butterfly Springs is a unique feature that forms a complex that feeds Rio Guadalupe with approximately 10% of its flow.

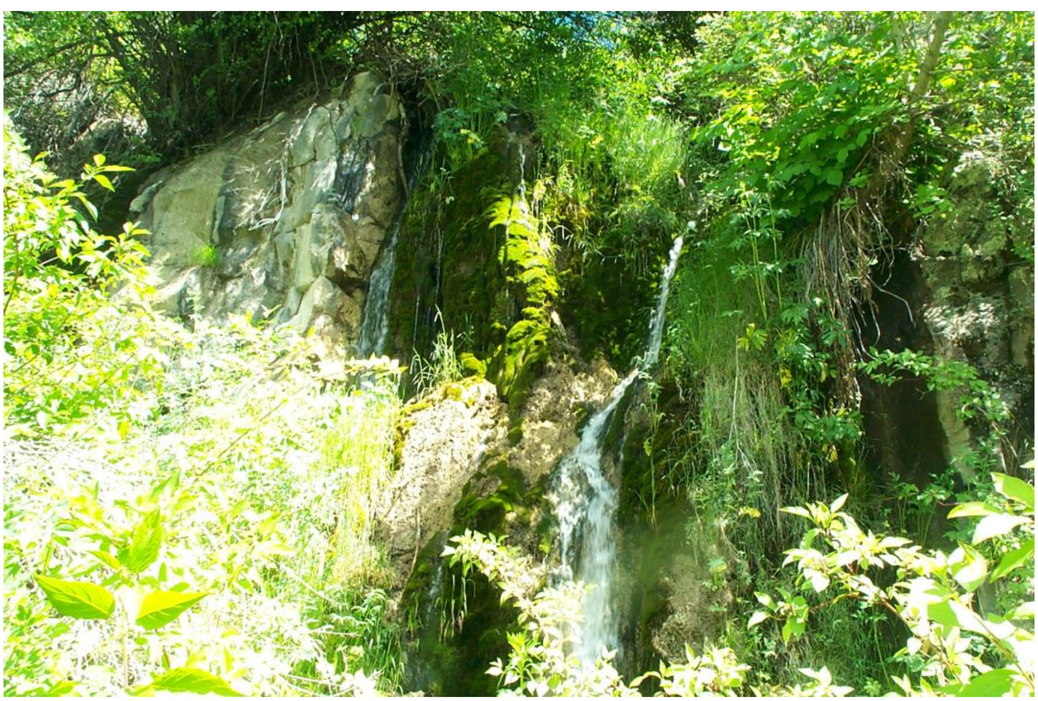


Photo 29. NSO 178, T4. Butterfly Springs contributing about 10% flow (6-July-2004).

A high number of trout were observed throughout the reach. Many pools and riffles throughout the canyon contained as many as 9 or 10 trout.

Water temperatures are measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings were taken in the water column. Eleven (11) temperatures were taken during the survey of Reach 5. The highest temperature was 70°F and the lowest 59°F with an average temperature of 63.5°F.

Photo30. Reach 5, NSO 136, R79. A typical riffle (1-July-2004).

Habitat Characteristics

The 2.2 stream miles (11,507 ft) of Reach 5 is divided into 94 NSOs. 33 NSOs are pool habitat comprising 16.2 % of the stream habitat. 40 of the NSOs are riffles that make up 79.0% of the stream habitat. Four side channels (1.8%) and 12 falls (3.0%) make up the remainder of the habitat (see Table 30).

Table 30. Summary of Reach 5 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	33	1,899	16.5	16.2	>30%
Riffle	40	9,251	80.4	79.0	-
Culvert	0	0	0	0	-
Tributary	5	408	NA	NA	-
Falls	12	357	3.1	3.0	-
Side Channel	4	211	NA	1.8	-
Total	94	11,718	100	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande Cutthroat trout streams, Reach 5 contains both not properly functioning and properly functioning characteristics. Parameters that are **not properly functioning** include the large woody debris density, pool development, and sediment content in riffles. **Properly functioning** characteristic includes pool quality, and bankfull width-to-depth.

Riffle habitat is **not properly functioning** for sediment content. Sediment content in riffles, 20.9%, is just above the standard (see Table 31). The bankfull width-to-depth ratio, 21:1, is **properly functioning** (see Table 33).

Table 31. Summary of habitat and substrate percentages for riffles in Reach 5.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
5	40	231.3	25.2	1.2	3.0	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
5	20.8	17.3	25.0	23.0	14.0	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Lack of pools within the Reach 5 creates **not properly functioning** characteristics for pool development. Pool quality is **properly functioning** with all of the pools having a residual depth greater than 1 foot. Increasing pool habitat should be a priority in the management of this reach (see

Table 30).

Photo 31. NSO 203, F15. T. Anderson and A. Kirkpatrick in front of falls with a ten foot drop (8-July-2004).

Table 32. Summary of pool habitat and substrate percentages in Reach 5.

Pool Habitat Summary											
Reach	# Of Pools	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools/ Mile	# of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	# of Pools w/ Max. Depth >3'	# of Pools w/ Max. Depth >3'/Mile
5	33	57.5	16.7	3.6	0.9	2.7	15.0	33	15.0	25	11.4
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
5	27.0	17	17.0	16.1	22.7	100.0

Large woody debris density is **not properly functioning** with 11.4 pieces per mile found in the reach (see Table 33). The desirable LWD density is greater than 30 pieces per mile. Large woody debris is a key factor in the development of pool habitat and could be related to the not properly functioning condition of pool development in the reach. LWD is an essential part of pool formation and critical in providing complex fish habitat (Fausch and Northcote 1992). Increasing the LWD density should be a focus in management of this reach. This would be done through recruitment from upstream reaches (mostly).

Table 33. Habitat characteristics of Reach 5.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
5	1:1.2	21:1	11.4	0	0
Properly Functioning Indicators	-	12-30	>30	-	<10

Streambank condition is **properly functioning** in Reach 5 with 0% unstable banks (see Table 33).

Photo 32. NSO121, P34. D. Hoffman surveying a pool with bedrock confinement, common throughout Reach 5 (1-July-2004).

Recommendations

Large woody debris has been shown to increase habitat complexity, which includes pool formation (Fausch and Northcote 1992). With strategic placement of LWD, pool formation and increased habitat complexity would occur. With the introduction of LWD, both parameters that are not properly functioning could be alleviated. This needs to be further analyzed to determine the best approach for creating LWD recruitment.

Reach 6: The Top of the Upper Box to Porter Landing

Reach 6 begins at the top of the upper box canyon, just below the Llano Loco Spring (T18N, R1E, Sec 13 elev. 6,960) and ends at the confluence with Rio Cebolla and the Rio de las Vacas at Porter landing (T18N, R1E, Sec. 1 elev. 7,200'). The measured length of Reach 6 is 2.0 miles. The canyon walls of the upper box flatten out during the length of Reach 6. FR 376 runs parallel to the left bank, but only visible in some sections and approximately 400 feet from the river. Reach 6 has a mapped sinuosity of 1.1 and a gradient of 1.5%. Reach 6 was surveyed from 21-July-2004 through 26-July-2004. Cobble is the dominate substrate and the Rosgen stream type is B3.

Vegetation mainly consisted of ponderosa pine, juniper, spruce, alder, red osier dogwood, willow, and oak. Vegetation provides shade in some areas. The stream contained little aquatic vegetation, but there were areas where boulders were covered with filamentous algae.

A few adult trout were observed along with fry. There had been heavy rains prior to the survey resulting in murky water. Five side channels were noted in this reach along with some braided sections.

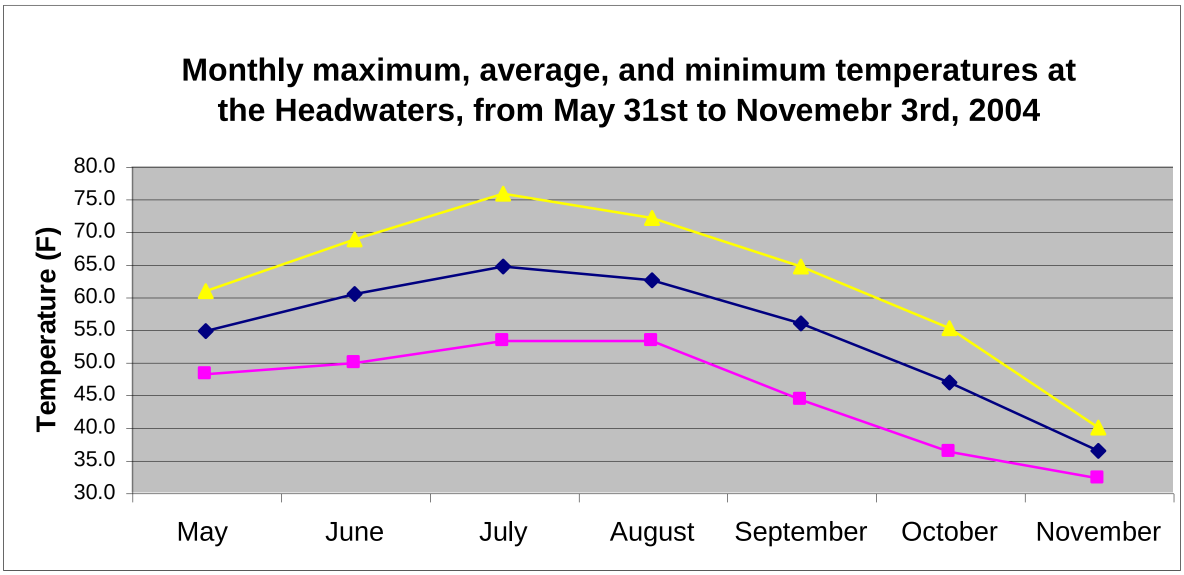
Human impact was noted in areas related to dispersed camping as indicated by trash, browned out areas, unstable banks, and a user created dam. There were trails located on both banks in some areas. Impacts become more prevalent at the top of the reach were easy access is available off FR 376 and the Butterfly Springs Road near Porter Landing.

Photo 3. Reach 6, NSO 255, R138. The Rio Cebolla (right) and the Rio de las Vacas (left) joining to form the Rio Guadalupe. The upper thermograph site was located here. Notice the turbidity coming from the Rio Cebolla from the 2002 Lake Fire (21-July-2004).

Water temperatures were measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings were taken in the water column. Nine (9) temperatures were taken during the survey of Reach 6. The highest temperature was 75°F and the lowest was 60°F. The average temperature was 69.4°F.

A water temperature station was established in Reach 6 on May 31st and removed on November 3rd, 2004. The highest temperatures were between June and August (see Figure 6). The Rio Guadalupe is compared to Forest and NMED standards for classification as either properly functioning, not properly functioning or at risk (see Temperature section). Temperatures at the Headwaters Station are **not properly functioning** by Forest classification 10 of the 116 days between June 25th and September 30th 2002. 44 of the days were classified as **at risk** by NMED temperature standards.

Figure 6. Maximum, minimum and average temperatures for each month from the thermograph station at the end of Reach 6. Max and min are one-time temperatures and avg. is based on daily average.



Habitat Characteristics

2.0 stream miles (10,738 feet) of Reach 6 are divided into 45 NSOs. Thirteen (13) NSOs are pool habitat, 6.8% of the stream habitat. 26 riffle habitats comprise 89.7% of the stream habitat and the remainder is made up of 5 side channels (3.5%) (see Table 34).

Photo 34. NSO 233, R126. Looking upstream at a typical riffle (21-July-2004).

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 6 contains both not properly functioning and properly functioning characteristics. The parameters that are **not properly functioning** include large woody debris, pool development, and bankfull width-to-depth ratio. The **properly functioning** characteristics include the length of unstable banks, pool quality, and riffle sediment content.

Table 34. Summary of Reach 6 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	13	759	7.1	6.8	>30%
Riffle	26	9979	92.9	89.7	-
Culvert	0	0	0	0	-
Tributary	1	NA	NA	NA	-
Falls	0	0	0	0	-
Side Channel	5	385	NA	3.5	-
Total	45	11,123	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.

Riffle habitat in Reach 6 is **properly functioning** for relative sediment content. The sediment content, 18.1%, is below the matrix standard (see Table 35), but approaching not properly functioning.

Table 35. Summary of habitat and substrate percentages for riffles in Reach 6.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
6	26	383.8	17.8	1.1	2.3	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
6	18.1	21.2	31.2	22.7	6.9	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool habitat is related to both **properly** and **not properly functioning** matrix parameters. Pool quality is properly functioning as determined by residual depth. Average residual depth is 2.8 feet, well above the 1 foot standard. Many of the deep pools of Reach 6 are formed by large bedrock features, creating pools greater than 5 feet in depth (see Photo 335). Several small pools were created by stream improvement structures spread throughout the reach. No information is available about these structures. Pool development is **not properly functioning**. Pool development by area of pool is determined by the length of pool habitat relative to the other habitat types (see Table 34).

Photo 35. NSO 214, P67. Tara in a typical pool (21-July-2004).

Table 36. Summary of pool habitat and substrate percentages in Reach 6.

Pool Habitat Summary

Reach	# Of Pools	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools /Mile	# of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	# of Pools w/ Max. Depth >3'	# of Pools w/ Max. Depth >3'/Mile
6	13	58.4	22.0	3.7	0.8	2.9	6.5	13	6.5	10	5
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary

Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
6	29.2	22.3	17.7	19.2	11.5	100.0

Large woody debris is an essential part of pool formation and critical in providing complex fish habitat (Fausch and Northcote 1992). Five pieces of LWD in Reach 6 create a density of 2.5 pieces per mile. The LWD is **not properly functioning.** The condition of this parameter could be related to other degraded parameters and especially pool formation (see Table 37).

Bank stability is **properly functioning** in Reach 6. Bank stability, 0.1%, is below the matrix standard (see Table 38). Bankfull width- to-depth ratio, 31:1, is not within the expected range for Rosgen stream classification, B3, and is therefore **not properly functioning** (see Table 37). It is likely within the range of natural variability.

Table 37. Habitat characteristics for Reach 6 of the Rio Guadalupe.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
6	1:2	31:1	2.5	20	0.1
Properly Functioning Indicators	-	12-30	>30	-	<10

Recommendations

Recommendations for management of Reach 6 include mitigation of the **not properly functioning** parameters: LWD density and pool development. Large woody debris has been shown to increase habitat complexity, which includes pool formation (Fausch and Northcote 1992). With strategic placement of LWD, pool formation and volume as well as increased habitat complexity would occur. Reach 6 is the best target for LWD placement or all the reaches in Rio Guadalupe.

APPENDIX A:
Supporting Information

Table 1. Summary of measurements and estimations used in the Region 3 Hankins/Reeves stream survey protocol (Stream Inventory Handbook April 2002).

Measurements	Estimations
Maximum depth of pools, riffles, and side channels	Average depth of riffles
Depth of pool tail crest	Substrate percentages in bankfull width
One bankfull width depth transect per reach	Average wetted width of riffles and pools*
Number of large woody debris within bankfull	Length of bank instability
Surveyor collected main channel and tributary water temperature and time	Total length, wetted width, and maximum depth of side channels
Thermograph collected water temperature (Recorded every four hours)	Length of first habitat unit of tributaries and percent stream flow contribution

*Width estimations were corrected by the comparison of a minimum of 10% measured habitats in each reach to the related estimates. This technique was used to produce correction factor for each reach, which was then applied to analysis of the widths of that reach and the entire stream analysis.

Table 2. Feature types collected by Trimble Geo Explorer 3 GPS units.

Reach Breaks	**Tributary Mouth**
Woody Debris Jams (of 3 or More Pieces)	Barriers to Fish Passage
Areas of Concern (Major Erosion, Road Crossings, Etc…)	Side Channels (only longer than 10 times the wetted width of the main channel)
Beaver Dams (If Active and over 1’ in Height)	Thermograph Stations
Snorkel Survey Transect Locations	Culverts
Flow Stations	Water Temperature Monitoring Stations

APPENDIX B:

Table 1. Historic fish stocking for the Rio Guadalupe obtained from a NMGF stocking report (FS Fisheries Files).

YEAR	TAXA NAME	NUMBER PLANTED	YEAR	TAXA NAME	NUMBER PLANTED	YEAR	TAXA NAME	NUMBER PLANTED
1929	Rainbow Trout	200,000	**1951**	Loch Leven Trout	150,000	**1973**	Rainbow Trout	33,750
1931	Loch Leven Trout (brown)	270,000		Rainbow Trout	317,750	**1975**	Rainbow Trout	40,000
	Rainbow Trout	120,000	**1952**	Rainbow Trout	198,720	**1976**	Rainbow Trout	63,750
	Rainbow Trout	350,000	**1958**	Rainbow Trout	15,500	**1977**	Rainbow Trout	70,000
1932	Rainbow Trout	150,000	**1959**	Rainbow Trout	4,800	**1978**	Rainbow Trout	55,030
1933	Rainbow Trout	170,000		Rainbow Trout	100,000	**1980**	Rainbow Trout	50,000
1934	Native Black Spotted Trout*	170,000	**1962**	Brown Trout	447,440	**1981**	Rainbow Trout	50,000
	Rainbow Trout	87,500	**1963**	Brown Trout	217,930	**1985**	Brown Trout	150,000
1935	Rainbow Trout	187,000		Rainbow Trout	16,200	**1986**	Brown Trout	243,090
1936	Rainbow Trout	283,750	**1964**	Brown Trout	399,560	**1987**	Brown Trout	200,000
1937	Rainbow Trout	139,500	**1965**	Brown Trout	488,500		Rainbow Trout	4,001
1938	Rainbow Trout	150,000	**1966**	Brown Trout	517,000	**1989**	Brown Trout	250,610
1939	Rainbow Trout	400,000	**1967**	Brown Trout	500,000	**1990**	Brown Trout	198,240
1941	Rainbow Trout	284,020		Rainbow Trout	72,150		Rainbow Trout	14,500
1942	Rainbow Trout	100,500	**1968**	Brown Trout	507,840	**1995***	Brown Trout	NA
1943	Rainbow Trout	7,000		Rainbow Trout	203,340	**1996***	Brown Trout	NA
1944	Rainbow Trout	380,600	**1969**	Brown Trout	602,250	**1997***	Brown Trout	NA
1945	Rainbow Trout	50,960		Rainbow Trout	100,800	**1998***	Brown Trout	NA
1946	Rainbow Trout	326,220	**1970**	Brown Trout	442,260	**2005-2006***	Brown Trout	up coming
1947	Rainbow Trout	98,400	**1971**	Brown Trout	341,630			
1949	Loch Leven Trout	505,920		Rainbow Trout	100,000			
1950	Rainbow Trout	294,500	**1972**	Brown Trout	497,200			

The data from these years was obtained through personal communications with members of the NMGF and a copy is attached to stocking records in FS Fisheries Files.

* Records are unclear as to what species this is.

GLOSSARY

Eutrophication: Having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces dissolved oxygen content and often causes the extinction of other organisms.

Gabion Structures: Wire boxes filled with cobble or larger sized substrate to create “walls” and used for bank stability. Much like riprap, these structures to have equally adverse affects as streams adjust to this hardening.

Hybridization: The result of a genetic cross between different species. In the fish populations of New Mexico, Rio Grande cutthroat trout when in contact with rainbow trout will cross breed to produce cut-bows. Hybridization destroys the genetic purity of Rio Grande cutthroat trout populations.

HUC Code: Hydrologic Unit Code used to identify watersheds.

Large Woody Debris (LWD): Wood that is within the bankfull channel for a habitat unit and is above the minimum size requirement. Woody debris is classified into categories with relation to length and diameter. The smallest wood classified in this survey must be greater than 6 inches in diameter at a length of 20 feet from the largest end. For analysis only wood with a diameter of greater than 12 inches at a length of 35 feet from the large end are used (designated as medium and large pieces).

Large Woody Debris Jams: A minimum of 3 pieces of LWD interacting within the bankfull channel.

Meadow Reach: Predominance of valley formation has meadow characteristics which includes lacking trees in the active floodplain. No LWD recruitment within the reach.

Natural Sequence Order (NSO): A division system used to classify stream habitats. Each habitat is assigned a unique NSO number in consecutive order from the mouth upstream.

Response Reach: Low-gradient and/or constricted reaches typically located downstream from high gradient transportation reaches. Response reaches are noted for their channel and habitat formation caused by upstream factors.

Riparian Vegetation: Streambank or streamside vegetation; influenced by wet conditions associated to a high water table or live water.

Riprap: A loose assemblage of broken stones erected in water or on soft ground as a foundation. Riprap is used to improve bank stability in streams, but has other and occasionally adverse effects.

Seep: A tributary with very slow flow, often associated with draining wet meadows

Spring: A flowing tributary with a source within 100 feet from the stream channel.

Stream: All tributaries that are not classified as a seep or spring. Usually streams are associated with a distinct drainage and have a more significant flow than the other tributary types.

Stream Habitat (%): A calculation of relative habitat types, which includes culverts, falls, pools, riffles and secondary channels. Tributary habitats are not included in the calculation.

Stream Length (%): A calculation of relative main channel habitat types which includes culverts, falls, pools, and riffles. Tributary and secondary channel habitats are not included in the calculation.

Transport Reach: High gradient and non-constricted reaches that act as a conveyor belt of source materials, such as large wood, substrate and fine materials.

LITERATURE CITED

Alexander, H.G. and P. Reiter. 1935. *Report on the Excavation of Jemez Cave, New Mexico*. A Monograph of the University of New Mexico and the School of American Research, Monograph Series 1:3.

Brodie, J. 1996. Bureau of Land Management. Environmental Education Homepage. www.blm.gov/education/riparian/define.html

deByle, N. V. 1985. Wildlife. In: DeByle, N. V. and R. P. Winokur, eds., Aspen: Ecology and Management In the Western United States. Rocky Mt. For. And Range Exp. Sta., USDA Forest Service, Ft. Collins, Colorado.

Dunham, J. 1999. Stream temperature criteria for Oregon's Lahontan cutthroat trout *Oncorhynchus clarki henshawi*. Department of Biology and Biological Resources Research Center University of Nevada.

Fausch, K. D., T. G. Northcote. 1992. Large woody debris and salmonid habitat in a small coastal British Columbia stream. Canadian Journal of Fisheries and Aquatic Sciences 49: 682-693.

Ford, R.I. 1975. Re-Excavation of Jemez Cave. *Awanyu* 3(3):13-27.

Furniss, M. J.; Foelofs, T. D.; Yee, C.S. 1991. Road construction and maintenance. In: Meehan W. R. (ed.). Influences of Forest and Rangeland Management on salmonid fishes and their habitats. Special Publication 19. Bethesda, MD: American Fisheries Society: 297-323.

Gard, R. 1961. Effects of beaver on trout in Sagenhen Creek, California. J. Wildl. Manage. 25:221.

Grayson, R.B., S.B. Haydon, M.D.A. Jayasuriya, and B.L. Finlayson. 1993**.** Water quality in mountain ash forests; separating the impacts of roads from those of logging operations. *Journal of Hydrology* 150: 459-480.

Hatch, M.D., J.E.Sublette, M. Sublette. The Fishes of New Mexico. 1990. University of New Mexico Press, Albuquerque.

Jenkins, P.C. 2002 Jemez Ranger District, Resource Area Archeologist. Personal Communication.

New Mexico Environmental Department, 1999. Total Maximum Daily Load for Turbidity and Stream Bottom Deposits for the Jemez River and Rio Guadalupe. Santa Fe, NM.

Olson, H. 1962. Rehabilitation of the Rio las Vacas, Cebolla, and Guadalupe Creeks. New Mexico Department of Game and Fish, New Mexico.

Olson, R. and Wayne, H. 1994. Beaver: Water resources and riparian habitat manager. University of Wyoming, Laramie, Wyoming

Parker, M., F. J. Wood, B. H. Smith, and R. G. Elder. 1985. Erosional down cutting in lower order riparian ecosystems: Have historical changes been caused by the removal of beaver? Pgs. 35-38, In:

Riparian Ecosystems and Their Management: Reconciling Conflicting uses. North American Riparian Conference, Gen. Tech. Rep., USDA Forest Service, April 16-18, University of Arizona, Tucson.

Petterson, J. 2005. Jemez Ranger District. District Ranger. Verbal Communication (2/2005).

Rosgen, D. and L Silvey. 1998. Field guide for stream classification. Wildland Hydrology. Pagosa Springs, CO.

Smith, C. E., W. P. Dwyer, and R. G. Piper. 1983. Effect of water temperature on egg quality of cutthroat trout. Progressive Fish Culturist 45:176-178.

Snotel Information. 2004
http://www.wcc.nrcs.usda.gov/cgibin/past_up2.pl?report=nm&year=2004&month=05&day=01

Snotel 2004b. Historical daily table.
http://www.wcc.nrcs.usda.gov/snotel/snotelday2.pl?site=744&station=06p10s&state=nm&report=precip_accum_hist

State of New Mexico Water Quality Control Commission. 2000. Water Quality and Water Pollution Control in New Mexico. Santa Fe, NM. 114 pp. plus appendices.

Sublette, J., M. Hatch, M. Sublette. 1990. The Fishes of New Mexico. The New Mexico Department of Game and Fish: 62-65, 68-70.

Touchan, R., Allen, C., Swetnam, T. 1996. Fire History and Climatic Patterns in Ponderosa Pine and Mixed-Conifer Forests of the Jemez Mountians, Northern New Mexico. In Fire Effects in Southwestern Forests, Proceedings of the Second La Mesa Fire Symposium, March 29-31, 1994, Los Alamos, NM. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station General Technical Report RM-GTR-286: 33-46.

USDA Forest Service Documents:

1996. A study of Pre-Colombian and historic uses of the Santa Fe National Forest: competition and alliance in the Northern Middle Rio Grande. Volume 1: the archaeological and historical cultural resources: 258.

2000. Forest roads: A synthesis of scientific information. Hermann Gucinski, et al. (Ed.): 33.

2002. Stream Inventory Handbook Level I and II. Region 3 Version 2.0.

Santa Fe National Forest Fisheries Files. Santa Fe National Forest. Jemez Springs, NM.

2003. Respect the Rio Annual Report. Santa Fe National Forest. Jemez Springs. NM

2004. Draft Environmental Impact Statement for the San Diego Range Allotment. Santa Fe National Forest, Santa Fe, NM

2004b. Hydrologic Condition Assessment. Santa Fe National Forest. Jemez Springs, NM.

Vieira, N., Clements, W. Ecological, Hydrological, and Geochemical Effects of Wildfire on Watersheds in Sante Fe National Forest and Bandelier National Monument, New Mexico. Department of Fishery and Wildlife Biology, Colorado State University, Denver.

Wargo, J. 2005. Jemez Ranger District. Recourse Area Wildlife Biologist. Verbal and email personal communication (2/2005).

Acknowledgements

The Santa Fe National Forest Fisheries Program would like to thank those who assisted in the production of this report. The Jemez Range District for all their support, helpful insight, and assistance. The New Mexico Environment Department, especially Gary Shiffmiller, for the supporting water quality and fish population information. New Mexico Game and Fish for their stocking and fish population history. Special thanks to Tara Anderson and Dylan Hoffman for their dedication and enthusiasm in the field.

Photo 36. The Crew (L to R): Tara Anderson (team leader) and Dylan Hoffman.