Table Of Contents

Section	Page Number
Map of the area	3
Introduction	5
Basin Summary	6
Executive Summary	7
Habitat Characteristics	9
Reach by Reach Comparison	14
Tributaries	15
Stream Flow	16
Water Quality	17
Riparian Vegetation	20
Beaver Activity	21
Fisheries	24
Amphibian and Reptile Species	29
Stream Improvements	29
Land Use	31
Roads	31
Timber Harvest	31
Fires	33
Grazing	33
Recreation	34
Recommendation Summary	36
Reach Summaries	39
Reach 1: Mouth to Downstream of McMillan Canyon	40
Reach 2: McMillan Canyon to O'Neil Landing	46
Reach 3: O'Neil Landing to School Section Canyon	51
Reach 4: School Section Canyon to Private Land Boundary	58
Reach 5: Private Land: Not Surveyed	64
Reach 6: Road Canyon to Rock Creek	65
Reach 7: Private Land: Not Surveyed	69
Reach 8: Private Land Boundary to Clear Creek	70
Reach 9: Clear Creek to Existing Barrier	74
Reach 10: Barrier to Rito de las Perchas	80
Reach 11: Rito de las Perchas to an Open Meadow	85
Reach 12: An Open Meadow to Rito Anastacio	91
Reach 13: Rito Anastacio to an Unnamed Tributary	96
Glossary	102
Appendix A	104
Appendix B	105
Appendix C	107
References	109
Acknowledgements	111

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 de las Vacas 2001 Stream Survey

The Santa Fe National Forest Fisheries Crew conducted a stream survey on Rio de las Vacas during the summers of 2001, 2002, and 2003. A total of 25.1 miles of stream were surveyed, from the mouth (T18N R1E S1 at 7190' elevation) to the headwaters located in San Pedro Parks Wilderness (T22N R1E Sec 22 at 10440' elevation) where the Rio de las Vacas starts at a spring source. Rio de las Vacas is a 5th order tributary to Rio Guadalupe. Rio de las Vacas and Rio Cebolla come together at Porter Landing to form Rio Guadalupe (see map on Page 1).

Photo 1. Reach 10. NSO 302, P99. Large boulders on the Vacas (9-Oct-02).

A modified Hankin/Reeves stream inventory methodology (Region 6) was adopted by Region 3 and was utilized for this survey. Stream habitats were broken up into riffles,

pools, side channels, dry channels, culverts, and falls and given a Natural Sequence Order number (NSO). In addition, tributaries, such as streams, seeps and springs, were inventoried and given an NSO. The NSO that calculated stream length were riffles, pools, culverts, and falls. The other NSO units were used to calculate available stream habitat, not stream length. This stream habitat survey specifically catalogues aquatic habitat. The Properly Functioning Condition survey conducted by the Santa Fe National Forest determines hydrologic function and condition. Even though these two surveys have similar categories of conditions, they determine different findings.

Geographical Positioning System (GPS) units are also utilized for survey data collect. Trimble Geo Explorer 3 units are used to identify special features throughout the survey (Appendix A). 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 main objectives of this survey were to: 1) collect historical information that outlines effects on stream and watershed condition; 2) collect baseline data to determine the quality of habitat and floodplain condition and sources of habitat loss in Rio de las Vacas; 3) identify areas for possible migration barrier construction; 4) identify restoration needs; and 5) determine fish species and distribution.

Basin Summary

Table 1. Stream Summary Table for Rio de las Vacas.

SURVEYORS:	Katrina Lund, Damon Goodman, Serina Adams, Chris Glenney, Sarah Eddy, Tara Anderson, and Bridget Borg
FIELD ASSISTANTS:	Veronica Trujillo, Duane Lefthand, Adrian Velosco, and Jenny Wenberg
SURVEY DISTANCE:	119,090 ft 22.6 miles
LOCATION:	
County:	Sandoval and Rio Arriba
Forest:	Santa Fe National Forest
District:	Jemez and Cuba Ranger Districts
Drainage:	Rio de las Vacas
Tributary to:	Rio Guadalupe
Mouth Location:	T18N R1E S1
WATERSHED:	
HUC Code:	130202020201
Watershed Area:	101,343 acres
Stream Order:	5
Stream Length:	25.1 miles
AQUATIC BIOTA:	
Fish Species:	rainbow trout, brown trout, cut-bow, Rio Grande chub, Rio Grande sucker, and Rio Grande cutthroat trout
Amphibian Species:	tiger salamander, western toad, leopard frog, and chorus frog

Overall, the gradient on Rio de las Vacas is extremely variable, ranging from less than 1% in Reach 4 to over 5% in Reach 9 downstream from San Pedro Parks Wilderness, averaging 2.1%.

Table 2. Description and Length of Stream Reaches on Rio de las Vacas.

Reach	River Miles	Landmark at Beginning and End	Land Owner
1	0-2.8	Mouth to just below mouth of McMillan Canyon	Santa Fe National Forest (SFNF)
2	2.8-3.9	Below mouth of McMillan Canyon to road crossing between O'Neil's landing and the Girl Scout Camp	SFNF
3	3.9-7.3	Road crossing between O'Neil's landing and the Girl Scout Camp to meadow between Trail Creek and School Section Canyon	SFNF, Girls Scouts of America
4	7.3-9.4	Below mouth of School Section Canyon to boundary of private land	SFNF
5	9.4-11.3	Private land boundary to fence-line at mouth of Road Canyon	Private Land (Not Surveyed)
6	11.3-12.3	Fence-line at mouth of Road Canyon to private land boundary upstream from Rock Creek	SFNF
7	12.3-12.9	Private land boundary upstream from Rock Creek to bridge at end of private property	Private Land (Not Surveyed)
8	12.9-13.3	Bridge at end of private property to mouth of Clear Creek	SFNF
9	13.3-16.2	Mouth of Clear Creek to migration barrier upstream of FS RD 70	SFNF
10	16.2-17.9	The migration barrier to Rito de las Perchas	SFNF, San Pedro Parks Wilderness
11	17.9-20.6	Rito de las Perchas to an unnamed tributary on the upstream left	SFNF, San Pedro Parks Wilderness
12	20.6-21.5	Unnamed tributary on the left to Rito Anastacio	SFNF, San Pedro Parks Wilderness
13	21.5-25.1	Rito Anastacio to an unnamed tributary on the upstream left.	SFNF, San Pedro Parks Wilderness

Rio de las Vacas begins in an open meadow high in San Pedro Parks (10,440 feet). The stream flows down a wide valley with forested patches dividing open meadows in Reaches 12 and 13. Canyon-type morphology begins in Reach 11 as the stream's gradient increases. Rio de las Vacas continues through a steep canyon to the mouth of Clear Creek at the beginning of Reach 9. From this point down, Rio de las Vacas flows through a mix of Forest Service and private land to its confluence with Rio Cebolla at Porter. At the confluence with Rio Cebolla, Rio de las Vacas becomes Rio Guadalupe as it flows south into the Jemez River. Survey access was denied to the private lands of Reaches 5 and 7. These areas were not surveyed and excluded from stream habitat analysis.

The stream is a flashy system. Several times during the summer of 2001 flows would increase dramatically after monsoon events typical to the Jemez Mountains. No irrigation withdrawals or active ditches were found during the survey, although there is a

point of diversion located in San Pedro Parks Wilderness. Geologically, Rio de las Vacas flows through areas associated with the Nacimiento Uplift. The rock in this area consists mainly of granitic rock formation. This non-porous bedrock material and the loss of wetland formation are what make the watershed so flashy. Excessive fine sediment loads and high turbidity are found in Rio de las Vacas, exacerbated by historic grazing practices, an extensive road system, past timber harvest, and dispersed recreation practices within the active floodplain.

Habitat Characteristics

Table 3. Overall Stream Survey Summary for Rio de las Vacas.

ENTIRE STREAM					
Stream Length Surveyed:		119,090 feet		22.6 miles	
Habitat Type	**Total Number**	**Total Feet of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	344	18,127.5	15.2	14.8	>30%
Riffle	361	100,957.5	84.8	82.7	-
Culvert	0	0	0	0	-
Tributary	52	-	-	-	-
Falls	3	6	0	0	-
Side Channel	76	12,324	NA	10.1	-
Total	835	131,414	100.0	100.0	-

During the habitat survey conducted on Rio de las Vacas, the river was divided into 835 total NSOs (Habitat Units), which measured a total of 119,090 feet. Of the NSOs, 344 were pools, 361 riffles, 52 tributaries, 3 falls and 76 side channels. There were no stream length measurements for tributaries, as they did not contribute to the habitat in the main stem of the river.

A matrix of factors and indicators was developed to tie to stream habitat information collected during this survey (See Table 4). The matrix originally was developed in Region 6 (Washington and Oregon), 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 RGCT. Rio de las Vacas is **not properly functioning** for all of the criteria in categories of habitat characteristics, and channel condition and dynamics, except pool quality and streambank condition.

Table 4. Matrix of Factors and Indicators of Stream Health Condition for Historic and Occupied Rio Grande Cutthroat Trout 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˚ (64ºF) < 21.1˚ (70ºF) (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		<30% pool habitat by area
	Pool Quality	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[3]	<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
[2] Pool Development numeric are applicable to 3rd order or larger streams
[3] Streambank Condition numeric are not applicable in reaches with > 4% gradient

Rio de las Vacas is primarily riffle habitat. Riffle habitat length comprises 76.8% of the total stream, and only 13.8% is pool habitat. The length of pool habitat is below the greater than or equal to 30% properly functioning indicator. In the San Pedro Parks Wilderness (Reaches 10-13) the amount of pool habitat drastically increases. In the front country (Reaches 1-9) only 3.7% of stream habitat is comprised of pools. In the wilderness 30.1% of the stream habitat is pools, which is considered properly functioning. Lack of pool habitat in the front country is attributed but not limited to stream widening, decrease in sinuosity, lack of large woody debris (LWD), and sediment input filling in pools. LWD is instrumental in the creation of pool habitat. Water running over LWD scours out deep pools in areas dominated by sand, gravel, or cobble substrates. LWD also helps dam up areas and create pools above the jam. Sediment input from bank instability and upland erosion occurring in the watershed has greatly diminished pool volume in the length of Rio de las Vacas outside of the wilderness. The amount of fine sediment input from erosion is a factor in limited pool habitat.

Table 5. Stream Conditions on the Rio de las Vacas

Factors	Indicators	Rio de las Vacas Conditions
Water Quality	Temperature 3 Day Average	**Below the Wilderness Boundary: Properly Functioning**
		Mouth: At Risk
		Above Porter Landing: Not Properly Functioning
		Below Private Land: Not Properly Functioning
	Temperature 7 Day Average	**Below the Wilderness Boundary: At Risk**
		Mouth: Not Properly Functioning
		Above Porter Landing: Not Properly Functioning
		Below Private Land: Not Properly Functioning
Habitat Characteristics	Sediment	**Not Properly Functioning**
	Large Woody Debris	**At Risk**
	Pool Development	**Not Properly Functioning**
	Pool Quality	**Properly Functioning**
Channel Condition and Dynamics	Width Depth Ratios By Channel Type	**Not Properly Functioning**
	Streambank Condition	**Properly Functioning**

Red= Not Properly Functioning
Yellow= At Risk

Over the entire channel length side channels constitute 9.4% of the available habitat. In the front country 10.4% of the available habitat were side channels. In the wilderness, 9.6% of stream habitats were side channel.

Photo 3. Reach 1, NSO 1, R1. Long Riffle in Reach 1.

The lower reaches have numerous long riffles, while the upper reaches have a smaller number of shorter riffles. There were several riffles in reaches 1 through 6 that were

critical habitat for rearing, foraging, overwintering, and resting. The lack of quality pools can be attributed to pools being filled in with fine substrates and limited LWD recruitment. The dominant substrate in pools throughout the entire stream was sand, which typically fills in pools in disturbed areas. Lack of deep pools equates to decreased thermal protection.

Rio de las Vacas had 6.7% unstable banks throughout the entire river. However, this measurement does not include Reaches 9 and 10 in the equation, as the average gradient of these reaches was greater than 4%. Streambank condition is not applicable to streams with a gradient greater than 4%. The streambank condition of Rio de las Vacas was **properly functioning**, as the percentage was below the indicator of <10%.

Table 8. Habitat Characteristics for Rio de las Vacas.

Reach	Pool:Riffle Ratio	Avg. Riffle Width:Avg. Riffle Depth	Pieces of LWD per Mile	Total Unstable Banks	Percentage of Unstable Banks
Entire River	1:1.1	16.5:1	21.0[1]	12,619 feet[2]	6.7
Properly Functioning Indicators	-	-	20 to 30 At Risk	-	<10

[1] This numeric does not take into account un-surveyed or meadow (2, 4, 8, 12 and 13) reaches.
[2] This numeric does not take into account Reach 9 as it had a gradient over 4%

The large woody debris density for the Rio de las Vacas was 21.0 pieces per mile. This number is biased by the amount of wood found in the wilderness reaches. On average in the wilderness there are 51.3 pieces of LWD per mile. In the front country (reaches 1-9) there is an average of 4.3 pieces of LWD per mile. Reaches 2, 4, 8, 12 and 13 were excluded from this analysis, as they were meadow reaches. The total average LWD per mile indicates that the river is **at risk** for LWD. A properly functioning stream must have >30 pieces of LWD per mile.

There are several factors involved in the low amount of LWD in the Rio de las Vacas. First, the geomorphology of Rio de las Vacas greatly affects the levels of LWD. In a typical stream, there are high gradient reaches in forested areas that add LWD to the stream. These reaches are called transport reaches. The wood falls into the stream, and because it has a high gradient, the wood is transported downstream. Once the gradient decreases, the wood begins to settle into the riparian area or gets caught in bedrock features. These areas are called response reaches. Rio de las Vacas has typical

are: Insect outbreaks, which have been reduced due to insecticide use; windstorms, which are not common in this region; and landslides, which have limited impact on this watershed due to its geology (Gregory *et al* 2003).

The third factor in low amounts of LWD is due to wood removal. During the 1920's, a railroad was constructed along the Rio de las Vacas. This railroad connected logging camps along Rio de las Vacas to the sawmill in Gilman. The railroad was active until the 1940's when several railroad trestles were washed out during a flood. During this time heavy amounts of logging were occurring in the Rio de las Vacas Watershed (Chris Jenkins, personal communication). A stream survey report written in 1972 recommended that logjams be removed from Rio de las Vacas, as they impeded fish movement and created "bad" fish habitat (FS Files). It is likely that much of the LWD found in the stream was removed during this time. In addition, LWD has been removed for fuelwood.

Reach by Reach Comparison

Rio de las Vacas was divided into 13 different reaches. Table 9 has summarized the habitat characteristics for each reach and the entire river.

Seven of the 11 surveyed reaches of the Rio de las Vacas are **properly functioning** for bank stability; Reaches 4, 8, 12, and 13 are **at risk**. Reaches 9 and 10 were excluded from analysis due to high gradient (>4%), which naturally induces higher bank erosion rates. Riparian areas in the lower three reaches are well developed and in some cases limit bank erosion.

Table 9. Reach by Reach Summary for Habitat Characteristics for the Rio de las Vacas.

Reach	Total Length (Miles)	% Gradient	Rosgen Channel Type	% Pool Habitat	% Riffle Habitat	% Side Channel Habitat	Dominant Substrate in Pools	Dominant Substrate in Riffles	LWD Per Mile	Bankfull W:D Ratio	% Unstable Banks
1	2.8	2.2	B3	2.0	85.5	12.5	Sand	Cobble	3.2	13:1	1.4
2	1.1	0.7	C3	0.4	87.4	12.2	Cobble	Cobble	4.5[1]	19:1	7.0
3	3.4	2.0	B3	2.9	91.4	5.7	Sand	Cobble	6.5	34:1	7.3
4	2.0	0.3	E3	1.4	95.9	2.6	Sand/Silt	Cobble	0[1]	34:1	15.6
5	1.9	0.3	**Private**	**Not**	**Surveyed**						
6	1.1	2.4	B3	2.4	86.9	10.7	Sand	Cobble	0	26:1	0.5
7	0.6	0.9	**Private**	**Not**	**Surveyed**						
8	0.4	1.0	E3	4.4	59.8	35.8	Sand	Cobble	7.5[1]	11:1	5.2
9	2.9	5.2	A2	7.5	84.7	7.8	Boulder	Boulder	16.8	19:1	20.7[2]
10	1.8	4.5	B2	6.1	90.0	12.6	Boulder	Boulder	57.2	17.1:1	0.7[2]
11	2.6	3.6	B2	17.8	64.0	18.3	Boulder	Boulder	45.3	16.9:1	2.0
12	1.0	2.8	E3	28.1[3]	62.6	9.2	Cobble	Cobble	0.0[1]	4.9:1	15.9
13	3.5	1.4	E5	56.0[3]	44.0	0.0	Sand/Silt	Sand/Silt	0.0[1]	1.EMC	/P <</MCID

The reach with the highest density of large woody debris (LWD) is Reach 10 with a density of 53.3 pieces per mile or 104 pieces of medium and large size classes. Reach 11 also has a high density of LWD with 57.2 pieces per mile. Both Reaches 10 and 11 are forested canyon reaches in San Pedro Parks. Reaches 2, 4, 8, 12, and 13 are meadow reaches with no local recruitment of LWD. Meadow reaches are excluded from LWD analysis and the lengths of these reaches are not included in the stream average. The lower reaches have low densities of LWD. One reason for the lack of LWD in Reaches 1-8 is due to past management practices. LWD was physically removed from the floodplain, as it was thought to create fish barriers. Another common practice is firewood removal. The wood in the floodplain is often the easiest wood to get. Many roads run along Rio de las Vacas, making access to the wood much easier. Reach 10 and 11 are not easily accessed and therefore it was likely that LWD was never removed from these reaches.

Photo 4. Reach 10, NSO 319, R154. Lots of downed LWD in stream.

Tributaries

According to USGS 1:24000 Quad Maps, there are 39 tributaries to Rio de las Vacas, of which only 9 are perennial, including major tributaries such as Rito Penas Negras, Rito de las Palomas, Rito de las Perchas, Rito Anastacio, and Clear Creek. 11 tributaries were identified during the 2001 survey, 28 tributaries were classified in 2002, and 13 additional tributaries were found in 2003, a total of 52 tributaries. Note that seeps and springs are classified as tributaries. The mouths of some main tributaries, such as

American Creek and Rito Penas Negras are located on private land, and not classified during the survey.

Table 10. Tributaries 5% or greater of the main channel flow in the Rio de las Vacas.

Reach	Habitat Number	Bank	Type	Name	Percent Flow	Time	Tributary Temp (F)	Stream Temp (F)	Comments
3	T6	Left	Stream	Trail Creek	10	1545	60	60	Unstable banks from dispersed campsite.
6	T10	Left	Stream	Rock Creek	5	1515	61	63	Unstable Banks, some revegetation. Fish?
8	T11	Left	Stream	Clear Creek	30	1530	60	60	Evidence of Beavers. Fish Present.
10	T14	Right	Stream	Rito de las Perchas	40-50	1111	50	49	5 to 10% gradient with evidence grazing utilization
12	T28	Left	Stream	-	5	1120	39	46	Spring feeds into stream
12	T31	Left	Stream	Rito Anastacio	40	1600	51	49	Ends Reach 12
13	T33	Right	Spring	-	5	1259	43	44	Low gradient with no significant drainage
13	T38	Right	Seep	-	5	1515	57	47	Many seeps converge to create this tributary
13	T42	Right	Stream	-	30	1800	57	60	
13	T48	-	Seep	-	50	-	-	52	
13	T51	Right	Stream	-	50	1502	64	50	Has cutthroats
13	T52	Right	Stream	-	100	1610	50	64	Lots of woody debris

Stream Flow

Peak flows in Rio de las Vacas are governed by snowmelt, typically spiking in the spring, usually late May to early June. The river is spring-fed at its headwaters. Low flow often persists from late summer until the snowmelt in the spring. However, Rio de las Vacas Watershed typically receives monsoon events in July through September. During monsoon events small spikes in stream flow are observed. A flow measurement was taken at the beginning of the survey on July 30, 2001, near the confluence with Rio Cebolla, measuring 2.5 CFS. A study conducted in 1999 determined that Rio de las Vacas had a similar flow of 2.65 CFS during measurements taken on June 28, 1999. (NMED 1999). Low stream flow measurements may be attributed to the 20-year drought conditions.

There are no lakes in the Rio de las Vacas Watershed. There is one reservoir, San Gregorio Reservoir, sourced by clear creek and located within the San Pedro Parks Wilderness. There may be a few scattered ponds, none of which are significant.

There are two irrigation ditches in the Rio de las Vacas Watershed, the Nacimiento Ditch, which diverts water from both the Rio de las Vacas, approximately 1 mile upstream of the wilderness boundary, and Clear Creek. At times, this ditch removes all the water from Clear Creek leaving a dry channel, and the ditch eventually enters Nacimiento Creek. There is a second, Leche Ditch, which removes water from the headwaters of Clear Creek above San Gregorio Reservoir. At the time of the survey, Nacimiento Ditch's diversion on the Rio de las Vacas was not in use due to ditch failure.

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).

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%.

Forest standards (noted as SFNF in Table 12) 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 three-day average 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 4).

Two thermograph tidbits were placed in Rio de las Vacas, from June 15th to October 24th, 2001, to collect stream temperature data. Records were taken at 4-hour intervals during this time period. The first thermograph was placed in Reach 1 near the confluence with Rio Cebolla. The second thermograph was placed in Reach 9 near the Las Vacas Campground to measure the temperatures coming out of San Pedro Parks Wilderness Area. Data collected by the thermographs was exported to Microsoft Excel 2000 for analysis and comparison to water quality standards.

In 2003, four thermograph tidbits were places in Rio de las Vacas, from June 12th to October 22nd. Records were taken at 4-hour intervals during this time period. The first thermograph was placed above the Rio las Vacas Campground in Reach 9. The second thermograph was placed downstream of private land in Reach 4. A third was placed a mile above Porter Landing in Reach 2 and the fourth was placed at Porter Landing at the mouth of the river (Reach 1). Of these four, only the thermographs placed below the private land and the one above Porter landing were recovered. The thermograph placed above the private land was found out of water. Looking at the temperature measurements, the approximate time it came out of the water was estimated.

Table 11. SFNF and NMED Water Quality Temperature Standards.

Water Temperature Standards	Properly Functioning	At Risk	Not Properly Functioning
SFNF 7-Day Average Max.	≤ 64°F	64 to 70°F	> 70°F
NMED 3-Day Average Max.	< 68°F	68 to < 73.4°F	≥ 73.4°F

Data collected from the four (4) thermograph stations is compared to Forest and New Mexico Environment Department (NMED) Water Quality Standards for temperature. Both standards classify water temperature as **properly functioning**, **at risk**, or **not properly functioning**, but with different requirements (see Table 11).

When Forest standards are applied, three out of the four stations were **not properly functioning**. The Wilderness Boundary was the only section functioning **at risk** (see Figure 1). The thermograph located below the private land in Reach 4 had the most not properly functioning days, indicating significant warming occurred above this site in the private land. Not properly functioning days then decreased by almost half by as the river passed through Forest land to the station a mile above Porter Landing. The mouth is located at Porter Landing. All of the stations with days exceeding the not properly functioning standard must be mitigated for survival of coldwater fish populations.

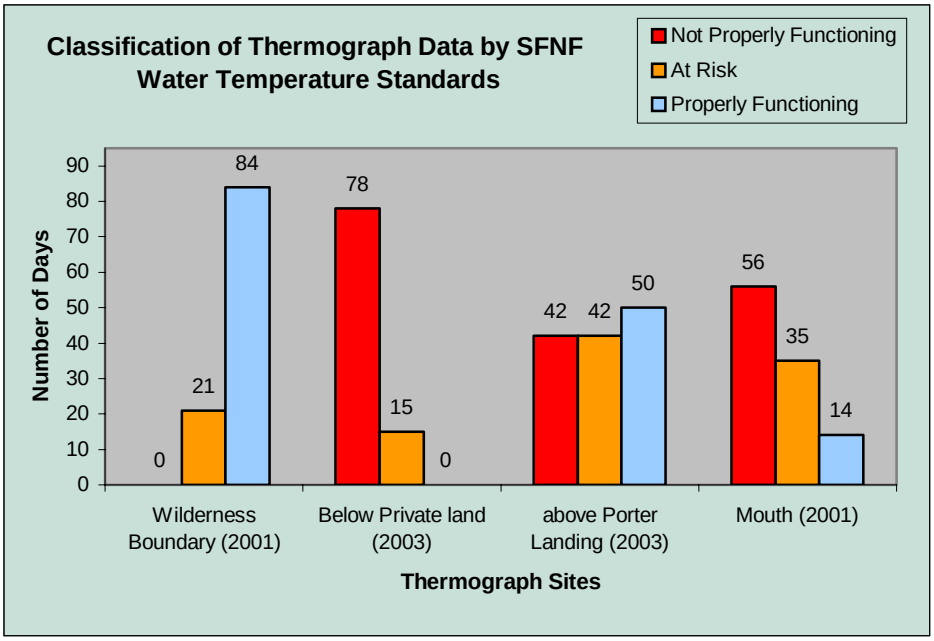
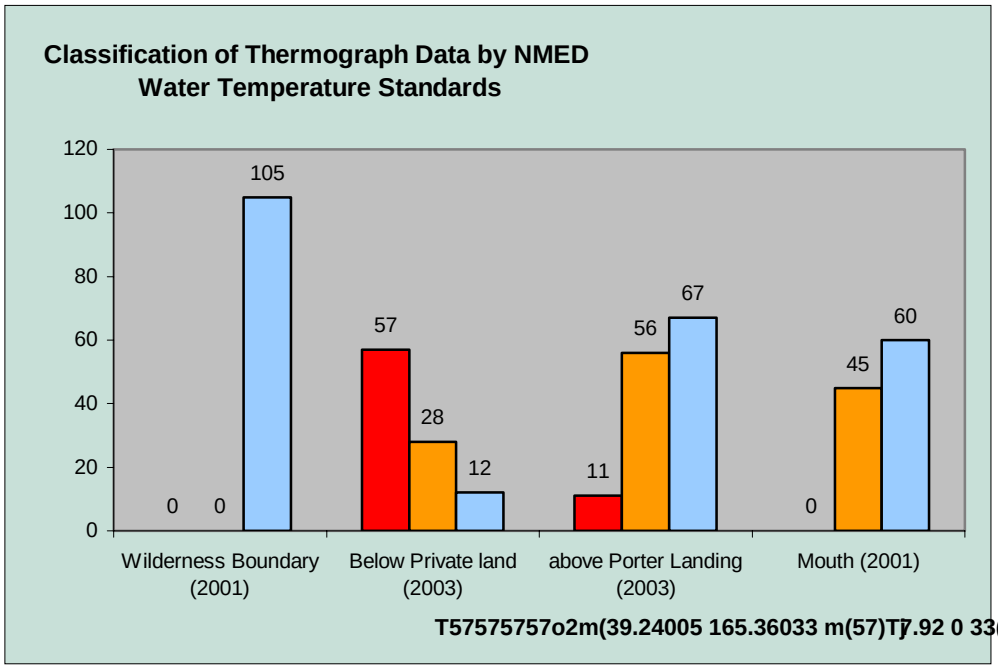


Figure 1. Classification of Thermograph Data by Santa Fe National Forest Temperature Standards.

Two stations recorded **not properly functioning** days when classified by NMED standards: Above Porter Landing and Below Private Land (see Figure 2). The Mouth is functioning **at risk**. The Wilderness station was the only place where temperatures were **properly functioning**. Under both Forest and NMED standards, the Below Private land station exceeded not properly functioning standards the most of the four stations. Factors creating the elevated temperatures at these stations must be mitigated to insure the viability of coldwater fish populations.



T57575757o2m(39.24005 165.36033 m(57)T7.92 0 33(r)T87.924005 165.360 Si3 m(5

Diurnal or daily high to low temperature fluctuations are analyzed from the thermograph stations. On June 23, 2003, a particularly warm day, diurnal fluctuations ranged from 31.2ºF below private land in Reach 4 to 21.7°F just above Porter Landing.

In 1999 New Mexico Environmental Department (NMED) conducted a TMDL Study on Rio Guadalupe and Rio de las Vacas (NMED 1999). NMED determined that the standards for Rio Guadalupe are:

1. In any single sample: conductivity shall not exceed 400 umhos, pH shall not be within the range of 6.6 to 8.8, temperature shall not exceed 20 C (68 F), and turbidity shall not exceed 25 NTU. These use-specific numeric standards set forth in Section 3101 are applicable to the designated uses listed above in Section 2106A.
2. The monthly geometric mean of fecal coliform bacteria shall not exceed 100/100 ml; no single sample shall exceed 200/100 ml (see Section 1103B).

In 1998, NMED found the average temperature for the middle Rio de las Vacas to be approximately 56.12°F (13°C). The temperatures were recorded on 6/28/1999 (NMED 1999).

Riparian Vegetation

Throughout Rio de las Vacas, alder and willow species dominate the riparian vegetation. Grasses are present throughout, which help stabilize stream banks. Conifers are present in the upper sections of Reach 3 and particularly Reach 9. Dogwood is present in canyon sections. The lower portion of Reach 1 had oak in

In Reach 4, cinquefoil was observed. Cinquefoil is a native species that is associated with dry sites. Finding cinquefoil in the riparian area is a red flag. The riparian area is being converted from a wet to a dry site, usually associated with major disturbances such as overgrazing and soil compaction. Thistle was also observed in Reach 4. Both plants are associated with disturbances. A large number of cattle were observed in this reach, which is a likely cause of disturbance. Reach 8 had cinquefoil in its meadows as well.

Reaches 1,2,3,6, and 8 had areas of large willows. The upper portion of Reach 4 had young willows. Reach 8 had a high number of dead willows due to past beaver activity, as well as old beaver chewings. Portions of the San Pedro Parks Wilderness are home to the regionally-sensitive Arizona willow (*Salix arizonica*), which can be found in sporadic locations along Rio de las Vacas (Atwood 1997, USDA Forest Service 2002).

Rio de las Vacas has a history of heavy cattle grazing, particularly in the floodplain (See Photo 2). In 1972, the Forest Service fisheries biologist noted that "Rio de las Vacas riparian vegetation is deteriorating, number of species is declining, existing trees are poor in vigor, browsing is heavy and appears to be the result of heavy cattle use. Formerly there were associations of narrow leaf cottonwood, willow, alders, and others." He continued to show that the decreased riparian vegetation had increased stream temperatures and the changing species composition had effects on wildlife (FS Files).

In 1983, the Forest Service fisheries biologist proposed a tree-planting project as high priority for Rio de las Vacas. He stated that two major problems with this stream were the lack of shade on the stream surface and the eroding banks (FS Files).

Beaver Activity

While the beaver's role in a watershed has been misunderstood by the public, land managers and biologists, studies over the last few decades conclude that beaver are a critical component to increasing stream integrity as well as biotic productivity within the stream and floodplain. Beaver dams were methodically removed from streams on public land only until recently (FS Files).

Beavers have many affects 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 waters 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 ninety percent in studied streams (Olson 1994). 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

In 1983, the Santa Fe National Forest fisheries biologist recommended stocking of rainbow trout. He states in a memo "rainbows are more easily caught by anglers than brown trout, but are not as easily caught as cutthroats." This same biologist said in 1984 that "maybe if the district (Cuba) was aware that angling is an important resource, they would be more willing to make an effort to increase it." This same person stated, "Trout production in (Rio de las Vacas) is low and does not provide a fishery. Trout numbers average 1 brown trout per 15 linear feet of stream and 1 rainbow trout per 80 linear feet of stream" (FS Files). The low density of fish is due to a multitude of factors mostly attributed to the predacious nature of German brown trout and poor habitat and water quality conditions.

In 1962, NMG&F released a statewide fisheries investigation that included Rio Puerco, Rio de las Vacas, Rito de las Palomas, Rio las Perchas, and Clear Creek. In this document they state "…Rio las Vacas and lower Clear Creek are the only streams capable of maintaining a fish population…*the upper Rio las Vacas (is) overpopulated with cutthroat trout.* Brown trout and rainbow trout are recommended for lower Clear Creek and lower Rio las Vacas. The catchable-size rainbow plantings should be minimized as much as possible and an effort be made to establish brown trout populations…It was also recommended that these streams be treated with rotenone to control development of the undesirable species" (FS Files).

Photo 8. Rio Grande sucker found in Rio de las Vacas in 2001.

The "undesirable" species are non-game fish, such as native Rio Grande sucker and chub. In 1959, a document reports, "The lower Vacas has a large population of suckers and minnows. These undesirable species constitute nearly 85% of the present population." (FS Files) Further studies by NMG&F in 1962 confirmed, "The predominant fish species in the lower Rio las Vacas are the mountain sucker (*Pantosteus plebeius*) (now known as Rio Grande sucker) and the Rio Grande chub (*Gila nigrescens*). Game fish present include the rainbow trout and the brown trout." (FS Files)

Table 12. Fish Distribution for Rio de las Vacas.

Fish Species	Native/Non-Native	Distribution	Reaches
Rio Grande Cutthroat	Native	Man-made barrier to headwaters; possibly from 8500' elevation to barrier; upper sections of tributaries*-Penas Negras, Rito Café, American, Palomas, Clear Creek (San Gregorio Reservoir to 10,000' elevation) possibly Rock Creek Mile 16.2-Headwaters	9-13
Brown Trout	Non-Native	Entire System, including above the barrier to Rito Anastacio. Mile 0- 16.2+	1-13
Rainbow Trout	Non-Native	Mouth to Man-Made Barrier; Clear Creek(mouth to 9580' elevation) Mile 0-16.2	1-9
Rio Grande Sucker	Native	Mouth to Clear Creek* Mile 0-13.3	1-8
Rio Grande Chub	Native	Lower Boundary of Girl Scout Camp to Clear Creek* Mile 3.9-13.3	3-8

* Denotes need for further study.

In the upper part of the watershed, surveys in 1959 showed that only RGCT were found in the upper section of Rio de las Vacas. In 1960 NMG&F treated 1.25 miles of upper Rio de las Vacas with rotenone and were surprised at how many big fish they caught. In 1962, another NMG&F document stated, "water temperatures and low volume indicate that brown trout would be the most desirable species for these streams." (FS Files) Thus, the waters were stocked with non-native fish species.

In 1982, the Santa Fe National Forest Supervisor approved the use of a piscicide on 9 miles of upper Rio de las Vacas, above a man-made barrier to remove non-native and hybrid species and to reintroduce a pure strain of RGCT. The barrier (see Photos 7 and 8 and 9 for comparison) was constructed in 1981 and is still in existence. The upstream portion was chemically treated to eradicate non-native fish species (i.e. brown trout) and was then stocked with native RGCT. Unfortunately, there has been a limited monitoring program related to this barrier. In June 2001, the Santa Fe NF fisheries crew conducted a snorkeling survey in this area of stream. Numerous RGCT were observed along with one brown trout above the barrier. Anglers reportedly caught two 8-inch brown trout at the confluence of Rito Anastacio and Rio de las Vacas during the summer of 2001 (Jim Eaton, personal communication). The presence of brown trout above the barrier is likely due to the development of a jump pool below the barrier and the loss of barrier height on the right bank. The pool has been carved out by high flows. The Santa Fe NF fisheries program is currently electrofishing these waters to eradicate brown trout and is recommending that the jump pool be filled in. In 2003, the pool was filled in (see Photo 9) and the barrier is scheduled to be repaired in 2004.

Photo 9. Adult RGCT from Rio de las Vacas (Above the barrier).

At least one natural barrier was once part of the Rio de las Vacas Watershed. In "An Analysis of Streams Containing Native RGCT in the Santa Fe National Forest" (1975), David Propst surveyed Clear Creek and states that "the natural barrier that previously prevented upstream migration of rainbows and browns that were stocked in San Gregorio Reservoir has been eliminated…the barrier was probably lost at this year's spring runoff…It is quite possible that Clear Creek no longer contains a pure strain of RGCT" (FS Files). It has been noted that there is a significant bedrock waterfall on Clear Creek below San Gregorio Reservoir.

1981

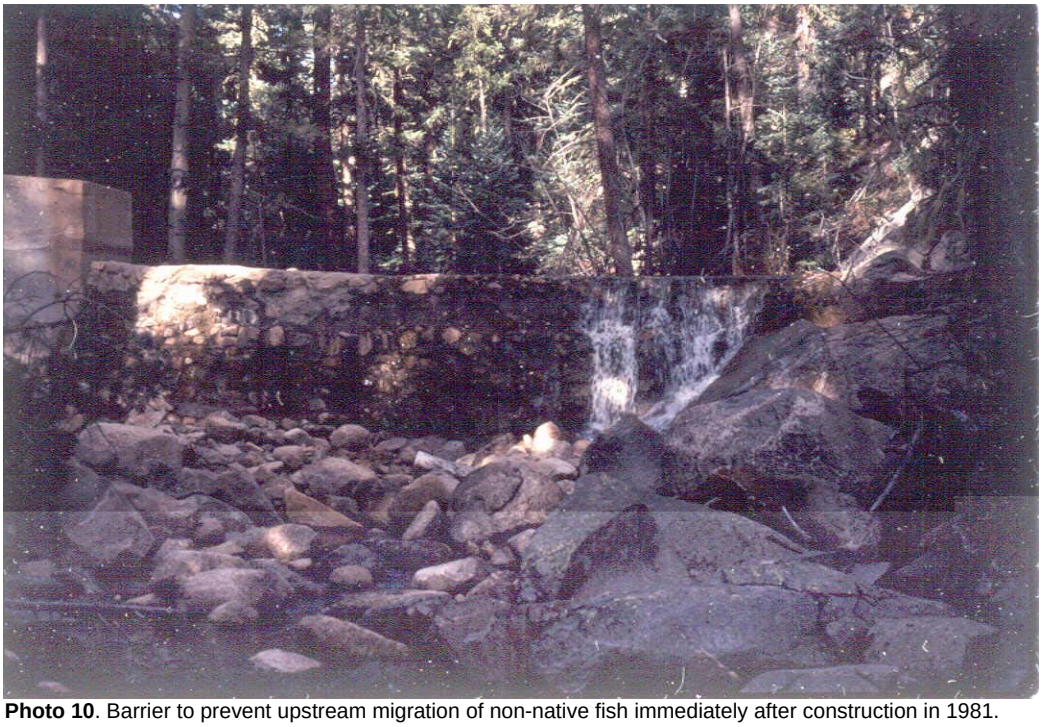


Photo 10. Barrier to prevent upstream migration of non-native fish immediately after construction in 1981.

2001

Photo 11. Reach 9, NSO 285 P89. Barrier in 2001. Note: Loss of height on RB and scour pool formation.

2003

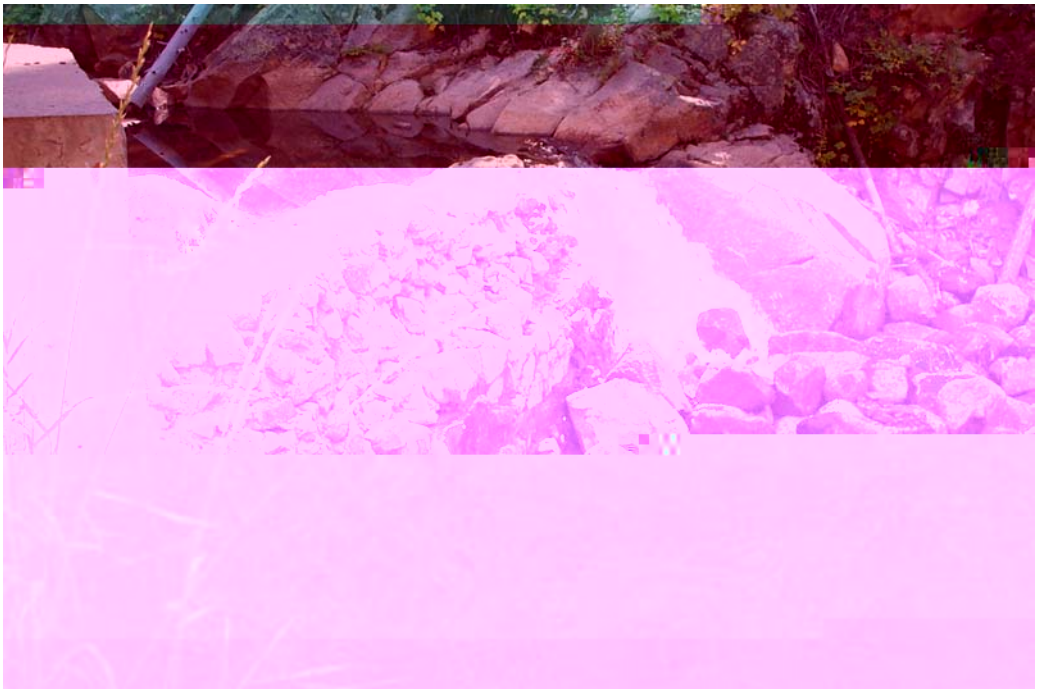


Photo 12. Reach 9, NSO 285 P89. Barrier in 2003 after lower pool was filled in.

Stocking

In 1987, NMG&F released 51,314 brown trout into Rio de las Vacas. Today, Rio de las Vacas is still stocked with 5,000 non-native rainbow trout annually. Surveys conducted

However, by 1972 the Forest Service released a "Las Vacas Stream Survey" report in which they state that the trash collectors helped improve the nearby riparian vegetation, but instead of creating pools, they were causing a series of interconnected sediment dams, leaving no clean gravels. Further studies showed that these structures did not improve water quality. However, portions of the stream did have lower water temperatures, most likely resulting from the increased water depth (FS Files).

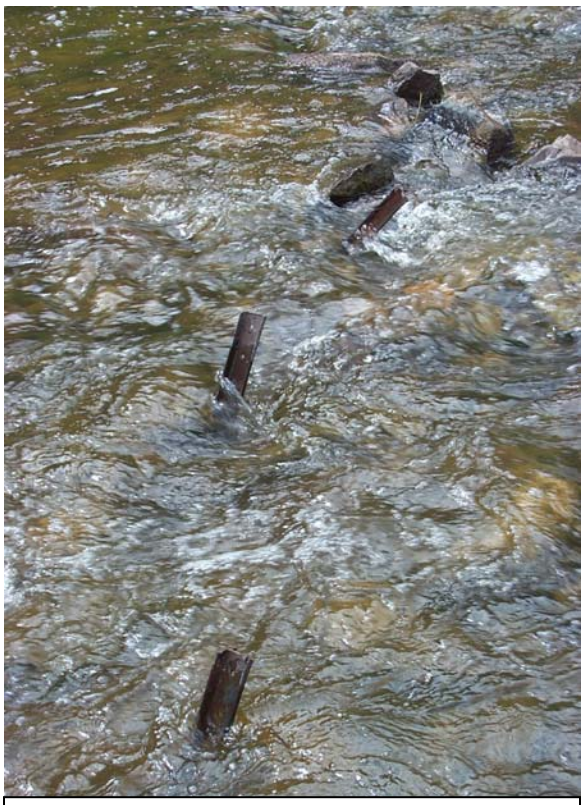


Photo 14. Reach 4, NSO 128, R68. Old metal stakes left from trash

The steel posts that were used to construct trash collectors can still be seen today (see Photo 11), and are liable to cause injury. They start appearing in Reach 3 in the middle of the Girl Scout Camp, and are present from Reach 4 to Reach 8. Removal of these structures is recommended.

Other stream improvements were encountered during the 2001 survey. During the 1960's and 70's, after discovering that trash collectors were not working, agencies moved to using log structures. "Single log, K-dams" were built in Rio de las Vacas in Reach 6. Bolted and cabled spanner logs were observed in Reaches 3 and 4.

In contrast, in 1972, as a part of a stream improvement project, the Forest Service recommended that logjams must be removed to "protect the stream from stream bank cutting so that the stream is not diverted from its normal channel and so it will not constitute a barrier" (FS Files).

In 1983, the Forest Service fisheries biologist proposed a boulder placement project to improve pool habitat. The biologist was hoping to get more rainbow trout in the stream (FS Files). There is no record that the boulder project occurred; nor did the 2001 survey observe obvious signs of this project.

It has been determined that Rio de las Vacas is devoid of wood in the stream and floodplain. LWD plays a critical role in providing fish habitat. LWD also provides food and habitat for aquatic invertebrates, an important prey base for fish. It is recommended that LWD be placed in the floodplain of Rio de las Vacas. A stream habitat improvement project began in summer of 2003 in Reach 1; however, Reaches 2-8 need LWD placements as well.

Land Use

A variety of land use practices occur in the Rio de las Vacas watershed.

Roads:

Rio de las Vacas has an extensive road system throughout the watershed. There are approximately 4.4 miles of road per square mile of watershed area. While there is no factors and indicators related to road density, U.S Fish and Wildlife Service and National Marine Fisheries Service jointly recommend less than 2.5 miles of road per square mile in watersheds occupied by salmonids (Matrix of Factors and Indicators for bull trout and steelhead). However, the roads assessment does not account for private, County, or State roads in the watershed. NM Highway 126 runs along the upper reaches of Rio de las Vacas. There are also large tracts of private land within the watershed that are riddled with road systems. Thus, the actual road density for Rio de las Vacas is higher than 4.4 miles per square mile. Many of the roads located in the watershed on Forest Service land are old roads that are not currently in use or maintained. The majority of the roads on private land are poorly maintained as well. These poorly maintained and unmaintained dirt roads are sources of extensive sediment delivery into the Rio de las Vacas Watershed. During rain events, roads gully or wash out, inputting sediment into the stream. Many of the current roads are poorly designed, as most roads are constructed below grade causing rain water to collect on the roads, increasing erosion. Many roads run parallel to Rio de las Vacas in the floodplain. These roads should be relocated, re-designed, or closed permanently to help restore natural floodplain function within the watershed.

Timber Harvest:

Forests in the Rio de las Vacas Watershed consist primarily of ponderosa pine (*Pinus ponderosa)*. However, higher elevations produce Douglas-fir (*Pseudotsuga menziesii*) 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 the Rio de las Vacas Watershed, but there is a noted history of private harvest on the 100,000 acre San Diego Land Grant that was turned over to the USDA Forest Service in 1965. As Scott Wilkinson, Santa Fe National Forest silviculturalist, stated, “Overall, [the Rio de las Vacas Watershed] has been pretty much picked over” (personal communication, 2001).

In the 1920’s and 30’s, heavy timber harvesting was occurring in this watershed. Logging camps existed at O’ Neil Landing (Reach 2), a spring in Bales Canyon (Reach 1), in Ojitos Canyon (Reach 3), as well as a few others scattered around the vicinity. 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. This included the blasting of Gilman Tunnels in the Rio Guadalupe Canyon to accommodate the train. The railroad line followed Rio de las Vacas and continued up Ojitos Canyon, which is now part of the Girl Scout Camp. 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.

In the late 1980's, harvesting increased and the upper part of the Rio de las Vacas Watershed was the hardest hit below the wilderness boundary. Most of the timber units were for thinning purposes; however, total overstory removal did occur.

Presently, the lower watershed is the focus of today's timber thinning activities. The O'Neil Unit (Reaches 1 and 2) is currently under way, with some units having already been harvested, some under contract, and the rest in the paperwork stage. The purpose of these thinnings is fuels reduction. Every tree that was not marked as a "leave" tree was removed, including one-foot tall trees. Anything that was 9"+ in diameter at breast height (DBH) was sold as saw timber. Smaller DBH trees will go as firewood.

The middle section of Rio de las Vacas Watershed experienced thinning projects as well. In 1992, the Trail Timber Units, located south of Trail Creek (Reach 3), were thinned. The Middle Fork Units, centered around Middle Fork Ojitos Canyon (Reach 3), experienced a pre-commercial thinning (>12"DBH) in 1995-96 before commercial harvest in 1999. The South Fork Units, only a few of which cross over into the Rio de las Vacas Watershed from the Rio Cebolla Watershed, were cut in 1999 (See File Map). The following table contains the most recent timber sales (all thinning projects) and how much was removed:

Table 13. Timber thinning projects in the Rio de las Vacas Watershed in the past 10 years.

Reach	Timber Sale	Timber Removed (MMBF)
1	Bales	1296
1	Beta	203
1	McMillan	989
1	Alpha	557
1	Charlie	250
1	Delta	1122
1&2	O' Neil	1487
3	Middle Fork	~3500
3	South Fork	4598
3	Abuelo	900
3	South Camp	1510
	Total	16,412

The Girl Scout Camp has been actively thinning their overly dense ponderosa pine forests. During the survey (August 6, 2001), there was noticeable evidence of thinning (i.e. stumps) and large slash piles throughout the camp.

For aquatic resource and floodplain protection, future recommendations for timber management in the Rio de las Vacas Watershed should be to manage riparian, floodplain and adjacent slopes as potential sources of LWD and to protect natural soil conditions. Harvesting of timber within 300' of live water should only occur to meet this objective. While this is a general statement, there are site specific opportunities to conduct riparian thinning inside this buffer.

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).

Fires:

In the 1950's a fire was reported in the O'Neil Landing area (Reach 2). However, no data was available regarding this fire. Recently the watershed sees about 10-15 small fires a year totaling about 25 acres. These small fires are generally caused by lightening strikes. The largest recent fire started on Thanksgiving Day in 1996. This fire, called the Stuffing fire started on the Rio de las Vacas and then moved into the Penas Negras drainage. It totaled about 1,000 acres (Montoya, personal communication, 2003).

Grazing:

Grazing has been a tradition in Northern New Mexico since the settlement of this area. Public land grazing has occurred for nearly a century. Prior to the establishment of the Santa Fe National Forest, the watershed had likely been grazed for 50-100 years.

In Rio de las Vacas Watershed, there are nine major grazing allotments: San Pedro, Senorito, Ojito Frio, South Ojitos, Vacas, San Miguel, Red Top, Palomas, and Penas Negras Allotments. These allotments are made up of different pastures, where the cattle are rotated from June 1 to October 31, with a total of 7,172 Animal Unit Months (AUM). The allotments are managed for cow calf pairs.

Table 14. Grazing Allotments in the Rio de las Vacas Watershed.

Allotment	Numbers of Cattle	AUM	Grazing Period	Reaches Affected
San Pedro	440 Pair	1063	6/16-10/15	10+
Senorito	402 Pair	1608	6/16-10/15	9
Ojito Frio	177 Pair	808	6/1-10/15	4-7
South Ojitos	76 Pair	76	-	3-4
Vacas	199 Pair	1099	6/1-10/31	4-9
San Miguel	78 Pair	390	6/1/10/31	1-3
Red Top	60 Pair	300	6/1-10/31	3-4
Palomas	109 Pair	545	6/1-10/31	10+
Penas Negras	263 Pair	1283	6/1-10-31	6+
Total	**1804 Pair**	**7172**		

The range staff of the Santa Fe National Forest has made several improvements to the Rio de las Vacas Watershed over the past 10 years. There has been approximately 17 miles of riparian area that has been fenced off to protect the streamside vegetation throughout the Rio de las Vacas Watershed. In some of the areas that are not fenced off, rotational grazing will be used, and grazing in the riparian areas will be limited to 5 days a year (Jim Eaton, personal communication).

Recreation:

Rio de las Vacas has 4 developed recreational sites within the watershed: Las Vacas Campground, Clear Creek Campground, Las Vacas Trailhead and Palomas Trailhead. There is one undeveloped trailhead as well (Penas Negras Trailhead). Along with these developed sites, there is the San Pedro Parks Wilderness Area. San Pedro Parks was congressionally designated in 1964 and is 41,132 acres in size. This area receives heavy recreational use from horseback riders, outfitter guides, as well as hikers and backpackers. The Continental Divide Trail runs through San Pedro Parks Wilderness.

In addition to these developed recreation sites there are many dispersed trails and campsites throughout the Rio de las Vacas Watershed. The Forest Recreation Staff has recognized the corridor as a high use dispersed recreation area and has taken measures to reduce the amount of dispersed recreation occurring in the area. The Santa Fe National Forest has constructed buck and pole fences to reduce areas where dispersed camping occurred next to streams. Dispersed roads have been closed to prevent further degradation to soils and vegetation. These recreational closures have affected over 3 miles of stream habitat.

The heavy use of these areas has degraded riparian areas, as well as the stream itself. The numerous dispersed trails and campsites, especially near the river, have created sediment inputs to the stream. The trails and campsites have also caused soil compaction as well as stream widening, which prevents riparian vegetation from re-establishing in these areas. Many of the dispersed campsites can be found in the floodplain, and have created similar problems to the riparian vegetation. These areas have been totally “browned out” (no vegetation in the campsites due to soil compaction).

These dispersed sites were inventoried in 2003 to determine condition and to assist in development of a management plan through a project called Respect the Rio. Surveyors found 33 complexes along Rio de las Vacas that contained a total of 72 individual campsites. Within these 72 campsites were 112 fire rings. Thirty-nine (39) acres were considered disturbed by recreational uses, including 11 acres of raw, exposed soil. Along the stream 1,269 feet of bank instability was directly related to human recreation (USFS 2003). An in depth look at recreational impacts on Rio de las Vacas can be found in the *Respect the Rio Annual Report 2003*.

Recreation should be managed to promote a healthy riparian and floodplain area. Possible practices to improve recreation management that have been identified through the Respect the Rio program include:

1. Moving and modifying dispersed campsites and trails along Rio de las Vacas so that vehicle camping is 100’ away from the stream banks;
2. Designating specific sections of stream as “Day Use Only” to protect natural and cultural resources;
3. Re-establishing riparian vegetation to restore natural functions to the riparian ecosystem;
4. Educating site users through signs placed at trailheads and modified campsites;
5. Inform the visiting public through a contact ranger program (started in 2003) about low-impact recreation and local regulations;
6. Designating a river access trail system in high use corridors.

Recommendation Summary

A restoration plan was developed in the summer of 2002, which incorporated numerous recommendations for improving riparian, in-stream and floodplain conditions (USDA Forest Service, 2002b) as related to findings from this survey.

In addition to the specific recommendations outlined in that restoration plan, the following are general recommendations based on findings related to the survey as well as forest-wide recommendations from the fisheries program.

Education

Objective: To educate forest visitors regarding effects of their activities on the natural resources, inform them of ways of minimizing impacts and promote better use of the resource.

Concerns: Public education is clearly the most effective tool to promote change that must be made for any of the other recommendation to be successful. Programs can spend millions of dollars repairing damage that was done in the past, but if the public isn't properly informed about what you are doing and why you are doing it, then the money will have been spent needlessly. Without education the same activities will occur, and the damage will continue.

Implementation methods:

1. Create a contact ranger program. A team of educators will contact forest users during intensive use times (summer), informing them of low-impact camping, fishing and other uses. The team will also be informing them of restoration and regulation changes occurring their dispersed campsites.
2. Members of the public as well as local and state decision makers will be invited to join Santa Fe National Forest fisheries staff in seminars focused on stream health, including snorkeling seminars. Special seminars will also be offered to teachers and college field courses.
3. Several K-12 schools are either currently or becoming interested in water quality and riparian monitoring on forest waterbodies. In-classroom riparian and stream health program and curriculum are being developed as well.

Riparian

Objective: To restore a natural riparian area with native vegetation and promote watershed health and function.

Concerns: A healthy riparian community in the Santa Fe National Forest is critical to help improve the water quality and function of all waterbodies.

Implementation Methods:

1. Augment current riparian areas by planting native species in the riparian areas. Willow, aspen and cottonwood plantings would be the dominant species selected.
2. Grazing practices should be managed to protect the riparian area. Possible practices include using a range rider, implementation or improvement of riparian exclosures, or rotational grazing that would not allow grazing until the dormant season or minimize grazing during the growing season.
3. Another step that could be taken to restore riparian areas is to limit the use. dispersed trails and campsites through relocation, designation and/or regulations.

Large Woody Debris

Objective: To increase the amount of LWD to natural levels and restore natural stream function.

Concerns: The amount of LWD present in Rio de las Vacas is well below natural levels in all front country forested reaches surveyed.

Implementation Methods:

1. Physically place LWD in the floodplain and stream enhancing the current fish habitat. The projects would utilize current research in LWD function and availability. The first phase of this work began in 2003 in Reach 1 and 2. The closure of a system road along Rio de las Vacas is associated with this project. The closure will prevent off road vehicles from crossing the stream, and prevent further erosion and sediment inputs to the lower Rio de las Vacas.

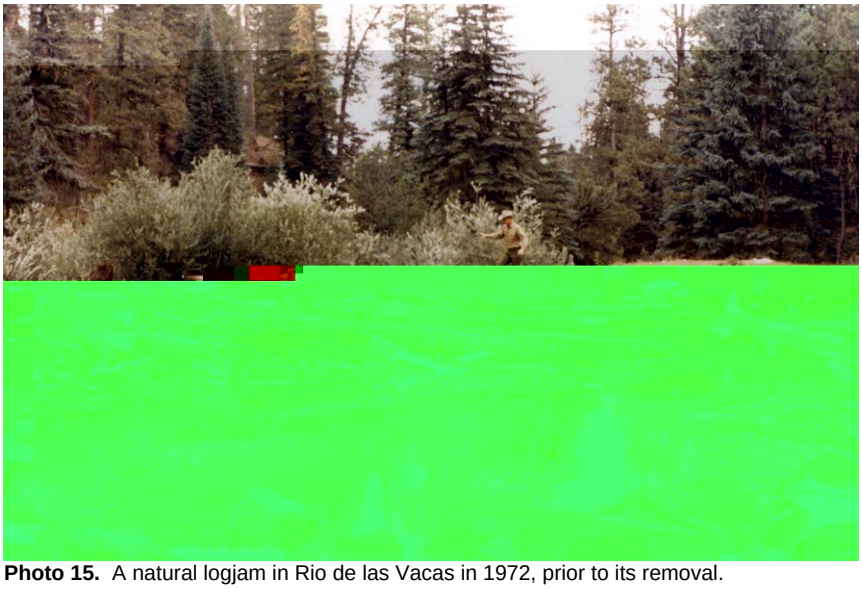


Photo 15. A natural logjam in Rio de las Vacas in 1972, prior to its removal.

Native Fish Populations

Objective: To restore and protect populations of native Rio Grande cutthroat trout, Rio Grande chub and Rio Grande sucker.

Concerns: The current population of RGCT must be protected; furthermore, the population should eventually be expanded to include all fish-bearing waters in the Rio de las Vacas Watershed in order to assure long-term survival of this native trout. The barrier at the end of Reach 9 needs to prevent non-native German brown trout from migrating upstream into native trout waters.

Implementation Methods:

1. The Santa Fe National Forest, NMED and NMGF have been manually removing German brown trout above the barrier since 2001. This technique should continue for several more years to determine if it is a viable way of eradicating non-natives from above the barrier. If it is found to be unsuccessful, the upper watershed will have to be chemically treated once again. In addition, the current barrier needs to be heightened.
2. In cooperation with partners, state and federal agencies, the native fish assemblage including RGCT could be expanded down to the Girl Scout Camp where a man-made barrier could be implemented. Further expansion could be explored from this point downstream to include Rio Cebolla, forming an extensive population into Rio Guadalupe down to Gilman Tunnels.
3. Beaver re-colonization should be promoted. Bringing beaver back to Rio de las Vacas would be a way of restoring habitat in a natural fashion that would benefit productivity of native fish species.

Reach Summaries

Photo 16. Reach 3, NSO 96, R52. Logjam on Rio de las Vacas.

Reach 1: Mouth to Downstream of McMillan Canyon

Reach 1 begins at the mouth, which is the confluence with Rio Cebolla, near Porter Landing (T18N, R1E, Sec 1). The survey of this reach started on July 4, and ended on July 22, 2001. The mouth is located at 7,190' above sea level and continues upstream for 2.8 miles just downstream from the confluence with McMillan Canyon at 7515' above sea level (T19N, R1E, Sec 26). This reach is moderately flat with an average gradient of 2.2%. The stream flows through a moderately confined valley with cobble-dominated substrate. Occasionally there are meadows, usually on one side of the stream or the other. The Rosgen channel type for this reach is B3.

Photo 17. Reach 1, NSO 10, R4. Typical riffle in Reach 1.

The riparian community consists mostly of woody species such as willow with some alder. Most of the ground was covered with grasses. This vegetation helped stabilize the banks. Majority of the overstory throughout this reach consisted of ponderosa pine, with some Douglas fir.

Brown trout were observed during the 2001 survey. Fingerlings were observed in the stream margins. During a fish survey in October, Rio Grande suckers were identified using electrofishing equipment. It is likely that the native fish assemblage is found in this reach, except for RGCT, along with non-native rainbow trout and cutbows.

Thermograph data collected in 2001 determined that the mouth of Rio de las Vacas was **not properly functioning**, exceeding the state standards 79 out of 127 days recorded. The site at the mouth exceeded the standards for salmonid development 50 out of 127 days recorded.

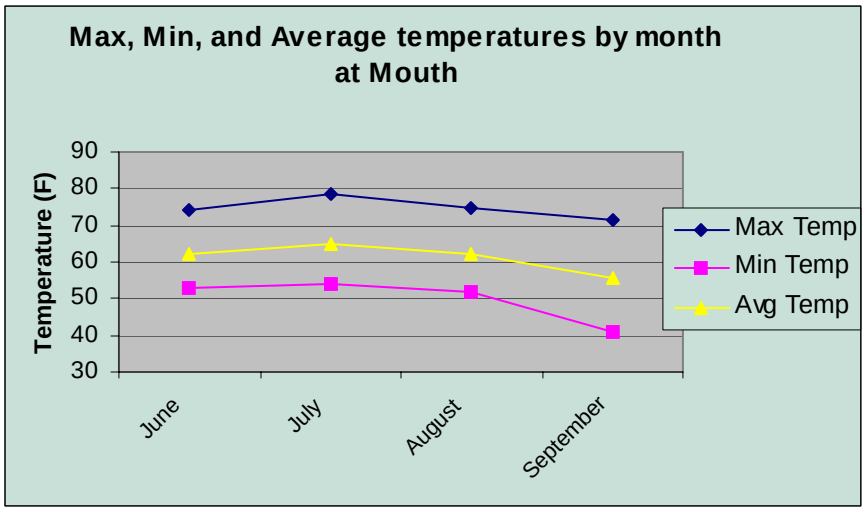


Figure 3. Maximum, minimum, and average temperatures for each month.

Water temperatures were measured at random intervals during the survey using an alcohol thermometer. Main channel temperature readings were taken in the water column in main channel habitats during the survey (grab samples). The 16 water temperature samples ranged between 58 and 77 F. Average grab sample temperature was 68.4 F.

Habitat Characteristics

During the habitat survey conducted on Reach 1, the river was broken up into a total of 63 NSOs, measuring 14,874 feet in length. Of the 63 NSOs, nearly 13% were pools. However, these 8 pools comprised only 2% of the stream habitat for Reach 1; 39 riffles accounted for 86% of the stream habitat. There is almost 43 times more riffle than pool habitat. The amount of side channel habitat is above average for the entire river. While pool volume is extremely low, there is opportunity to increase pool formation with the introduction of LWD. The amount of side channel habitat is due to the low gradient stream and the small logjams present in this reach.

Table 15. Overall Stream Summary for Reach 1.

Reach 1					
Stream Length Surveyed:		14,874		2.8 miles	
Gradient:	2.2		**Rosgen Channel Type:**	B3	
Habitat Type	**Total Number**	**Total Feet Of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	8	345	2.3	2.0	>30%
Riffle	39	14,529	97.7	85.5	-
Culvert	0	0	0	0	-
Tributary	4	-	-	-	-
Falls	0	0	0	0	-
Side Channel	12	2125	NA	12.5	-
Total	63	16,999	100.0	100.0	-

When compared to the matrix of factors and indicators of stream health condition for historic and occupied RGCT streams, Reach 1 is **not properly functioning** for all criteria in the category of habitat characteristics and channel condition, except pool quality and streambank condition.

Table 16. Summary of Habitat and Substrate Percentages for Riffles in Reach 1.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
1	39	372.5	18.8	0.7	1.7	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
1	21.3	24.4	36.9	15.9	1.5	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Riffles in Reach 1 are **not properly functioning** for average sediment amounts, with 21.3% sand, which exceeds the <20% criterion. Reach 1 is a low gradient reach, and because of this the velocity of stream flow through this reach is conducive for the settlement of fine substrates. Sand is typically collected in reaches with a gradient this low. The amount of sediment in this reach can be attributed to localized disturbances as well as unidentified upland disturbances.

Table 17. Summary of Pool Habitat and Substrate Percentages in Reach 1.

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
1	8	43.1	24.4	3.4	0.4	3.0	2.8	7	2.5	6	2.1
Properly Functioning Indicators	-	-	-	-	-	<1'	-	-	-	-	-
Substrate Summary											
		Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total			
		1	30.0	23.8	21.3	20.0	5.0	100.0			

Reach 1 was **properly functioning** for pool quality. The average residual pool depth was 3.0, exceeding the properly functioning indicator of 1' (See Table 16). Overall the average pool was of adequate quality, but the amount of pool habitat in Reach 1 was below acceptable levels. Reach 1 was **not properly functioning** for pool quantity, with the amount of pool habitat at 2.0%. The indicator for a properly functioning stream is ≥30% pool habitat. A stream with a "B" type channel should have more pools than is currently found in Reach 1. A typical B channel is a pool-riffle system, meaning that it has long riffles, with short pools in between. However, this reach is lacking in pool

formation. One reason for the lack of pool habitat in Reach 1 can be attributed to the lack of LWD throughout the reach. LWD aids in creating pool habitat through the natural scouring action of the stream flow. Pools are created around clusters of LWD.

Table 18. Habitat Characteristics for the Reach 1.

Reach	Pool:Riffle Ratio	Bankfull Width: Depth	Pieces of LWD per Mile	Total Unstable Banks	Percentage of Unstable Banks
1	1:4.9	13:1	3.2	425	1.4
Properly Functioning Indicators	-	12-30:1	>30	-	<10

Reach 1 was **not properly functioning** with 3.2 pieces of LWD per mile. LWD aids in creating pool habitat through the natural scouring action of the stream flow. The lack of LWD in the reach can be attributed to removal of LWD from fish bearing streams. It was a common practice, several decades ago, to remove LWD from streams. Logjams were seen as barriers to fish passage. A report made by the Santa Fe National Forest Fisheries Biologist recommends removing logjams, as they created a barrier to fish movement (FS Files). However, LWD does not hinder fish movements. In fact LWD is an essential part of pool formation, and is critical in providing fish habitat. The accessibility of this reach may be one reason why the amount of LWD is so low, allowing for firewood collection in the stream and floodplain. Historic fire suppression practices may be another reason for the lack of LWD in this reach. Fire ecology is an important part of the landscape in New Mexico. Large fires would remove the under story, and open up the canopy for ponderosa pine, the dominant species in this reach. Fires assist in natural LWD recruitment for streams in this region. The dying trees would eventually fall into the stream channel. The stream would then move the LWD during floods, settling in stream margins or in the channel, creating pool and side channel habitat. The lack of major fires over the last century has greatly diminished the amount of LWD in New Mexico streams.

Reach 1 would be considered a response reach in terms of LWD recruitment. A response reach recruits LWD from an upstream source, called a transport reach. Response reaches utilize LWD from transport reaches to create fish habitat. LWD will typically settle out in the floodplain, and with channel forming events, will be placed in areas of the stream where it will be most efficiently used by the stream.

Rio de las Vacas was **properly functioning** for stream bank condition with 1.4% unstable banks throughout the entire reach. A properly functioning reach must have <10% unstable banks.

The bankfull width-to-depth ratio for Reach 1 being 13:1, which is within 12-30:1, is considered **properly functioning** for a “B” Channel. However, this should be studied further, since stream fords were noted as causing extensive stream widening.

FS Road 539 is adjacent to Rio de las Vacas throughout this entire reach and has caused extensive stream widening at crossings (see Photo 14). There is a newly constructed road that bypasses the old FR 539. Although this makes easy access to the stream, the negative impacts from this road cannot be overstated. There are places where the road is 10-50' away from the stream. This road is not maintained and was designated for closure following completion of the Bales Canyon Timber Sale. However, despite a gate, this road is still in existence and people use it. Road cuts are causing severe unstable banks and the sediment inputs from this road are evident. The road fords the stream 2 times with an addition crossing created by a spur road. These crossings increase the wetted width of Rio de las Vacas up to 3 times its average width-to-depth ratio of 13:1. This, undoubtedly, contributes a significant amount of sediment directly into the stream. Numerous large puddles exist on this road, and some dump immediately into the stream. People, not wanting to drive through these puddles, have driven around them repeatedly causing sections of the road to widen.

Dispersed recreation, such as ORV use and dispersed camping sites, is likely the main causes of the bank instability in this reach, further causing stream widening. With some rehabilitation, such as planting willows and other native grasses and decommissioning the old FS Road 539, the sedimentation from the stream crossings could be reduced dramatically. LWD and pool development were other criteria that were not properly functioning. Both have relatively easy forms of rehabilitation. Adding LWD to Reach 1 would benefit the stream, by increasing stream health, and would also benefit the recreational anglers by creating better fish habitat. LWD placement would also aid in creating more pool habitat for Reach 1.

Photo 18. Reach 1, NSO 8, R3. First stream crossing of old FS Road 539.

In addition, the forested area is old enough to provide supplemental natural recruitment of LWD in the future, maintaining LWD numbers after project implementation. This would return the stream channel to its natural functioning condition, dramatically decreasing the bankfull width-to-depth ratio to natural levels.

Many dispersed camping sites are adjacent to the stream. Some of the recreators have created temporary pools at these campsites, by damming up the stream with rocks. These pools may help create pools temporarily, but they are washed out when any high flows occur, causing further stream widening and channel scouring.

If this reach were to be rehabilitated, then educational signs would be necessary in this area to ensure that the restoration would be truly effective. This area receives heavy recreational use from early spring to late fall. People need to understand the value of the riparian areas that they are unknowingly destroying.

Currently there is a project designed to help rectify these concerns. Respect the Rio began in the summer of 2003. Respect the Rio is designed to inform the public of their actions on the stream that they love recreating on. A Forest Service employee would educate the public on a one-to-one basis, providing visitors with the necessary information they need.

Currently there is a timber thinning project occurring in Reach 1 and continues through Reach 2. This is the O'Neil Fuels Reduction Project, consisting of 7 units, of which 3 are located directly next to the stream (see map on file). Trees were cut in fall 2001 and will continue through fall 2002. Log decks were observed approximately 50' upslope from the stream in the furthest downstream unit. Scott Wilkinson, Santa Fe National Forest silviculturalist, stated that there was no particular buffer distance, but stated that the timber sale had no influence on the stream (personal communication, 2001).

Reach 2: Downstream of McMillan Canyon to Road Crossing at O'Neil Landing and the Girl Scout Camp

Reach 2 begins downstream of McMillan Canyon and ends at the road crossing at O'Neil Landing and the Girl Scout Camp. The survey of this reach started on July 22 and continued through July 24, 2001. This reach begins at 7,515' above sea level (T19N, R1E, Sec 26) and continues up into the Jemez Mountains for 1.1 miles where it stops at the road crossing between O'Neil Landing and the Girl Scout Camp boundary at 7,555' elevation (T19N, R1E, Sec 14). This reach is nearly flat, with an average gradient of 0.7%, dominated by a cobble substrate. The Rosgen channel type for this reach is C3.

Photo 19. Reach 2. NSO 75, R38. Typical riffle habitat for this reach. (0078)

The riparian community consists mostly of woody species such as willow with some large alder. Most of the ground was covered with grasses. This vegetation helped stabilize the banks. The majority of the over-story throughout this reach consisted of ponderosa pine with some Douglas fir.

Brown trout were observed during the survey. During a fish survey conducted within the reach in October 2001, Rio Grande suckers were identified using electrofishing. It is likely that the native fish assemblage is found in this reach, except for RGCT, as well as non-native rainbow trout and cut-bows.

Water temperatures were measured at random intervals during the survey using an alcohol thermometer. Main channel temperature readings were taken in the water column in main channel habitats during the survey (grab samples). The 4 water temperature samples ranged between 63 and 68 F. Average grab sample temperature was 66.7 F.

A water temperature station was located 1.0 miles upstream from the confluence with Rio Cebolla and recorded temperatures between June 6th and October 22nd, 2003. The highest temperatures were in July and August (see Figure 4). This station was compared to Santa Fe National Forest Standards (SFNF) and New Mexico Environmental Department (NMED) standards for classification as either properly functioning, at risk, or not properly functioning. Temperatures above Porter Landing were **not properly functioning** by SFNF classification 42 of the 134 days and were **at risk** an additional 42 days. Temperatures were not properly functioning by NMED standards 11 days and were at risk 56 days out of 134 days.

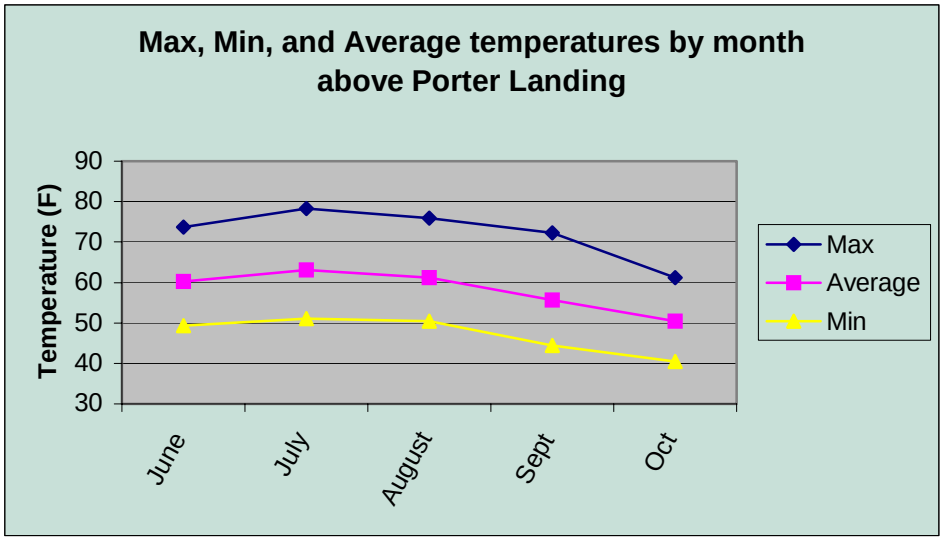


Figure 4. Maximum, minimum, and average temperatures for each month.

Habitat Characteristics

During the habitat survey conducted on Reach 2, the river was broken up into a total of 15 NSOs, measuring 5,755 feet in length. Of the 15 NSOs, approximately 7% were pools. However, this one (1) pool comprised only 0.4% of the stream habitat for the entire reach; 7 riffles accounted for 87.4% of the stream habitat. There is almost 218 times as much riffle habitat in this reach as there is pool habitat. Side channels make up 12.2% of the stream habitat.

When compared to the matrix of factors and indicators of stream health condition for historic and occupied RGCT streams, Reach 2, is **not properly functioning** for all criteria in the category of habitat characteristics and channel condition, except pool quality and bankfull width-to-depth ratio. The amount of LWD was omitted from analysis, as it was a meadow reach.

Table 19. Overall Stream Summary for Reach 2.

Reach 2					
Stream Length Surveyed:		5755 feet		1.1 miles	
Gradient:	0.7%		**Rosgen Channel Type:**		C3
Habitat Type	**Total Number**	**Total Feet Of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	1	26	0.5	0.4	>30%
Riffle	7	5729	99.5	87.4	-
Culvert	0	0	0	0	-
Tributary	0	-	-	-	-
Falls	0	0	0	0	-
Side Channel	7	800	-	12.2	-
Total	15	6555	100.0	100.0	-

Riffles in Reach 2 are **not properly functioning** for average sediment amounts, with 25.7% fines (sand, silt, and clay,), which exceeds the <20% criteria. Reach 2 is a low gradient reach, and because of the velocity of the stream flow, this reach is conducive for the settlement of fine substrates. Sand is typically collected in reaches with low gradients such as Reach 2. However, there are unnatural sources of sediment input into the stream. These sources of sediment are localized areas along the floodplain and unidentified upland sources.

Photo 20. Reach 2, NSO 68, R35. Typical glide found in Reach 2.

Table 20. 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	7	818.4	23.0	0.7	2.1	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
2	25.7	27.1	34.4	11.4	1.4	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Reach 2 was **properly functioning** for pool quality, with an average residual pool depth of 3.1', which exceeds the minimum of >1'. Overall the average pool was of adequate quality, but this is misleading since there was only one pool identified in this reach.

Table 21. 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	1	26	20	3.5	0.4	3.1	0.9	1	0.9	1	0.9
Properly Functioning Indicators	-	-	-	-	-	>1'		-	-	-	-

Substrate Summary							
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
	2	30.0	20.0	40.0	10.0	0.0	100.0

Reach 2 was **not properly functioning** for pool formation, with the amount of pool habitat of 0.4%, which is well below the necessary level of ≥30% pool habitat for a properly functioning stream. A typical "C" type channel should have more pools than Reach 2 has. Typical "C" channel types are a riffle-pool system, meaning that it has long riffles with short pools in between. However, this reach is lacking in pool formation.

Table 22. Habitat Characteristics for the Reach 2.

Reach	Pool:Riffle Ratio	Bankfull Width: Depth	Pieces of LWD per Mile	Total Unstable Banks	Percentage of Unstable Banks
2	1:7	19:1	4.5[1]	805	7.0
Properly Functioning Indicators	-	12-30:1	>30	-	<10

[1] LWD was removed from analysis as Reach 2 was a meadow reach.

LWD was excluded from analysis in this reach since it was a meadow reach.

Rio de las Vacas was **properly functioning** for stream bank condition with 1.4% unstable banks throughout the entire reach. A properly functioning reach must have <10% unstable banks.

The bankfull width-to-depth ratio for Reach 2 being 19:1, which is within 12-30:1, is considered **properly functioning** for a "C" Channel. However, this should be studied further, since stream fords were noted as causing extensive stream widening.

There are some concerns for Reach 2. First, FS Road 539 parallels the stream through the entire reach. There are sections of the stream bank that are unstable due to the road cuts. There are two road crossings through the stream as well. These crossings are increasing the wetted width of the stream tremendously. In one instance, the stream width is nearly doubled (20' to 38' at the crossing; see Photo 18).

FS Road 539 is inputting sediment into the stream. This is exacerbated by the two stream crossings. The historical logging practices in this area may have contributed to the fine sediment levels found in this reach.

Photo 21. Stream crossing located in Rio de las Vacas. Notice stream widening at crossing and raw exposed banks where erosion can occur.

It is recommended that old FS Road 539 be decommissioned. The closing of this road would prevent vehicle traffic and reduce the amount of sediment input into the stream. In 2004, LWD will be placed in the floodplain and stream to help return natural function to Rio de las Vacas.

Reach 3: O'Neil's Landing to School Section Canyon

Reach 3 begins at the road crossing between O'Neil Landing and the Girl Scout Camp. The survey of this reach started on July 24 and continued through August 7, 2001. This reach begins at 7,555' above sea level (T19N R1E Sec14) and continues upstream for 3.4 miles where it stops just below School Section Canyon, where the stream enters a meadow system at 7,920' elevation (T19N R1E Sec 35). Reach 3 is a confined valley stretch with low sinuosity. Reach 3 flows through the Girl Scout Camp. The average gradient for Reach 3 is 2.0%. The Rosgen channel type for this reach is a B3 type channel. The stream substrate is dominated by cobble.

The riparian area is much denser than Reaches 1 and 2 and consists of mostly alders with some willow. Conifers and dogwoods also appear at the upper end of the reach. There are lots of young willows at the upper end of Reach 3.

Reach 3 had two active beaver dams present in the stream (see Photo 19). There was evidence of past dams in this area as well. These dams were creating side channel and pool habitat.

Photo 22. Reach 3, NSO 117, R61. Active beaver dam in Rio de las Vacas.

A snorkel survey was conducted in Reach 3 on July 26, 2001. The snorkel survey began at the start of Reach 3 (NSO 79 R41), and continued upstream for 1 kilometer (3,281'). Fish species observed were Rio Grande suckers, Rio Grande chub, rainbow trout, and brown trout (see Table 23).

Table 23. Fish species and size class observed during snorkel survey on July98 0 0 7..2479.98 117.41994 6926,cies and size

there is a small 3' cascade section where there are many channels cut into the bedrock for the water to flow down. This is not a barrier.

Photo 23. Reach 3, NSO 83, R44. Bedrock cascade found in the lower Girl Scout Camp property, potential location for a man-made barrier.

There were two tributaries in Reach 3. One was a small spring (NSO 100, T5) on the left bank that was 27°F colder than the main channel (47°F versus 74°F). Fry were observed in this spring; species unknown. The other tributary was Trail Creek (NSO 114, T6), which enters from the left bank. It contributed approximately 10% of the flow to Rio de las Vacas and was the same temperature as the main channel. There was a dispersed campsite at the confluence that is creating a high composition of unstable banks, loss of vegetation, and soil compaction (NSO113, R59). Ojitos Canyon was completely dry; with no noticeable streambed.

When compared to the matrix of factors and indicators of stream health condition for historic and occupied RGCT streams, Reach 3 is **not properly functioning** for all criteria of habitat characteristics and channel condition except pool quality and streambank condition.

Table 25. 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	21	835.9	22.0	0.8	1.9	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
3	25.2	22.4	34.8	11.4	6.2	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Riffles in Reach 3 are **not properly functioning** for average sediment amounts, with 25.2% fines (sand, silt, and clay,), which exceeds the <20% criteria. Riffles are dominated by cobble. A large percent of the riffles in Reach 3 are long, deep, slow moving riffles, called glides. Reach 3 is a lower gradient reach, and because of the velocity of the stream flow, this reach is conducive for the settlement of fine substrates. Sand is typically collected in reaches with a gradient as low as the gradient found in Reach 3. That said, some of the fine sediment in Reach 3 could be attributed to unnatural sources within the reach (see Photo 21). These sources are localized disturbances along the stream channel and unidentified upland sources.

Table 26. Summary of Pool Habitat and Substrate Percentages in Reach 3.

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	9	62.0	17.4	2.6	0.8						

in the floodplain, and with channel forming events, will be placed in areas of the stream where it will be most efficiently used by the stream.

The lack of LWD in this reach can be attributed to at least two factors. First, fire suppression practices have reduced the amount of LWD recruited into the stream channel. Fire ecology is an important part of the landscape in New Mexico. Large fires would remove the understory, and open up the canopy for ponderosa pine, the dominant species in this reach. Fires assist in LWD recruitment for stream in this region. The dying trees would eventually fall into the stream channel. The stream would then move the LWD during floods to places where the wood could create habitat. The lack of major fires over the last century has greatly diminished the amount of LWD in New Mexico streams. Second is the accessibility of the stream to a road. LWD is typically removed for firewood, as it is an easy source of cured wood. LWD was also removed historically (as noted in a 1972 FS document) as it was thought to be a barrier to fish migration.

The road is adjacent to the stream throughout the reach, except for a short length where the road is diverted away (at the upper end of the Girl Scout Camp). In the Girl Scout Camp, there were areas where the road was very close to the stream, so much so that water and sediment could be splashed in from the road. Also in the camp, there were a few road crossings with signs that said "Horse and burro X-ing". These did not significantly alter the stream or the wetted width. However, upstream of the Girl Scout Camp is a place where the road is contributing an excessive amount of sediment to the stream (see Photo 22).

Photo 24. Reach 3, NSO 104, R56. Runoff from puddle in FS RD 539 in Rio de las Vacas. Note this is on a sunny day.

There is a bridge just downstream of Trail Creek where FS Road 531 and FS Road 539 intersect. This used to be a culvert (see Photos 23-35). In 1972, during a stream survey conducted by the US Forest Service, the culvert was determined to be a fish barrier. It was later replaced. The date of replacement is unknown.

Comparison study of FS Road 539 crossing at intersection with FS Road 431

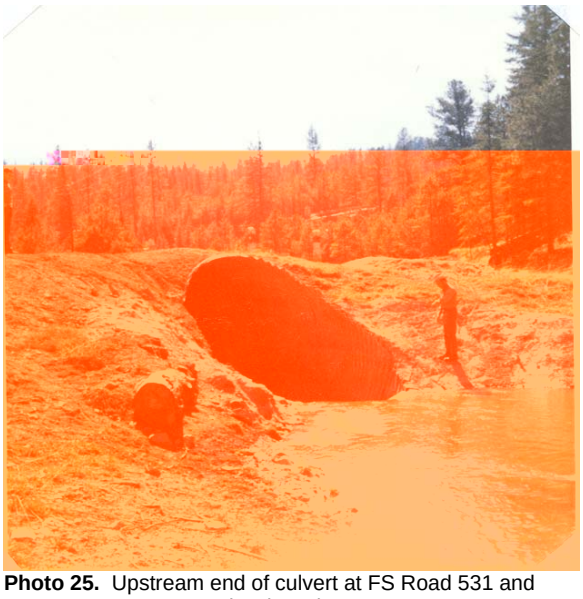


Photo 25. Upstream end of culvert at FS Road 531 and 539 Intersection (1972).

Photo 26. Downstream end of culvert showing bank erosion (1972).

Photo 27. Bridge over Rio de las Vacas that replaced the culvert shown above (2001).

The amount of unstable banks in Reach 3 was 7.3%; therefore, Reach 3 is **properly functioning** for streambank condition.

The bankfull width-to-depth ratio for Reach 3 being 34:1, which is not within 12-30:1, is considered **not properly functioning** for a "B" Channel. This should be studied further to determine fully the causes of stream widening.

The major factor leading towards habitat degradation in Reach 3 is the road. The close proximity of the road allows for the removal of LWD as well as allowing a vector for sediment input and providing dispersed recreation activities. This road should be redesigned; by moving the road away from the floodplain, eliminating any unnecessary roads, and rehabilitating any section of road that cannot be relocated or removed. Another rehabilitation measure for this section of stream is the addition of LWD to the floodplain and the stream. LWD would help create more pool habitat in this reach, which would help raise the productivity of this reach as well. The dispersed recreation sites should be modified to limit the impact on the stream and floodplain. The bedrock shelf in the Girl Scout Camp offers the potential for barrier implementation related to Rio Grande cutthroat trout re-introduction.

Photo 28. Reach 3, NSO 113, R59. Dispersed campsite at confluence of Trail Creek and Rio de las Vacas. Notice destruction of trees, riparian vegetation.

Water temperatures were measured at random intervals during the survey using an alcohol thermometer. Main channel temperature readings were taken in the water column in main channel habitats during the survey (grab samples). The 6 water temperature samples ranged between 59 and 71 F. Average grab sample temperature was 65.7 F.

A water temperature station was located just below the private land at the end of this reach and recorded temperatures between June 12th and September 18th. The highest temperatures were in July and August (see Figure 5). This station was compared to Santa Fe National Forest Standards (SFNF) and New Mexico Environmental Department (NMED) standards for classification as either properly functioning, at risk, or not properly functioning. Temperatures above Porter Landing were **not properly functioning** by SFNF classification 78 of the 93 days and were **at risk** an additional 15 days. Temperatures were not properly functioning by NMED standards 57 days and were at risk 28 days.

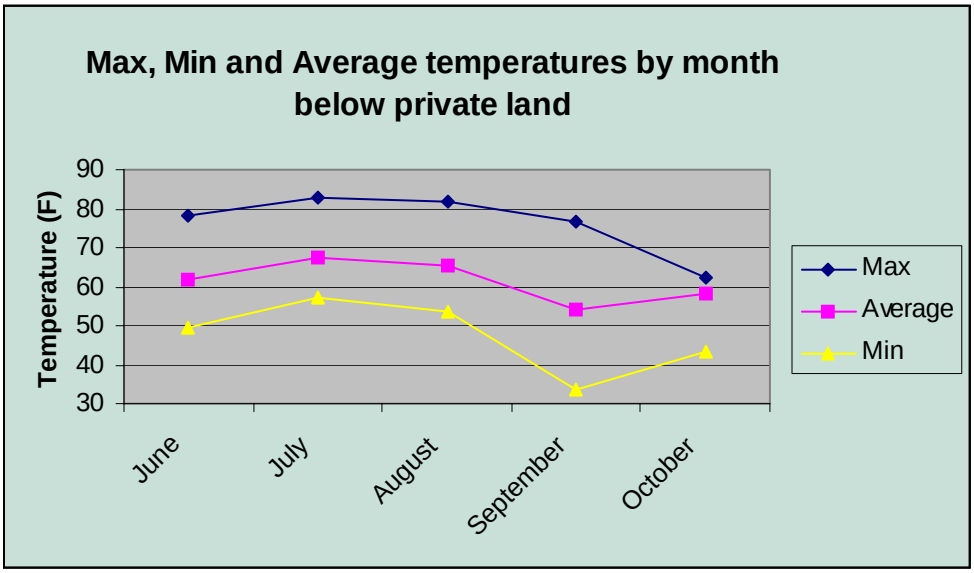


Figure 5. Maximum, minimum and average temperatures for each month.

Habitat Characteristics

During the habitat survey conducted on Reach 4, the river was broken up into a total of 18 NSOs, measuring 10,733 feet in length. Of the 18 NSOs, approximately 17% were pools. However, these 3 pools comprised only 1.4% of the stream habitat for the entire reach, 10 riffles accounted for 95.9% of the stream habitat. There is over 68 times as much riffle habitat in this reach as there is pool habitat. Side channels make up a very small part, 2.6%, of the stream habitat. The lack of pool and side channel habitat can be attributed to the high amount of sand (33% fines in riffle habitat) throughout the reach, high bank instability, stream widening, and lack of woody debris.

Table 28. Overall Stream Summary for Reach 4.

Reach 4					
Stream Length Surveyed:			10733 feet		2.0 miles
Gradient:	0.3%		**Rosgen Channel Type:**		E3
Habitat Type	**Total Number**	**Total Feet Of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	3	1			

within this reach have begun to fill in with fines. These fines are being transported from an upstream source and localized areas within Reach 4 (see Photo 28).

Photo 31. Reach 4, NSO 128, R68. Typical bank erosion observed in Reach 4. Localized sources of sediment in Rio de las Vacas.

Reach 4 was **not properly functioning** for pool formation, with the amount of pool habitat of 1.4%, which is well below the necessary level of ≥30% pool habitat for a properly functioning stream. A typical "E" type channel should have more pools than Reach 4 has.

Table 31. Habitat Characteristics for the Reach 4.

Reach	Pool:Riffle Ratio	Bankfull Width: Depth	Pieces of LWD per Mile	Total Unstable Banks	Percentage of Unstable Banks
4	1:3.3	34:1	0.0[1]	3355	15.6
Properly Functioning Indicators	-	<12:1	>30	-	<10

[1] LWD was removed from analysis, as Reach 4 was a meadow reach.

The amount of LWD was removed from analysis, as Reach 4 was a meadow reach. Meadow reaches do not recruit LWD from the local floodplain; therefore typically have little LWD. A meadow reach will have LWD that has been recruited into the system from transport reaches further upstream.

The amount of unstable banks in Reach 4 was 15.6%; therefore, Reach 4 is **not properly functioning** for streambank condition.

The bankfull width-to-depth ratio for Reach 4 being 34:1, which is not within <12:1, is considered **not properly functioning** for an "E" Channel.

Reach 4 is a candidate for restoration. The heavy recreational use and grazing pressure in the floodplain has degraded the riparian areas, as well as the stream itself. The cattle trampling has caused soil compaction, which prevents riparian vegetation from re-establishing in these areas as well as stream widening. The riparian pastures along this section of Rio de las Vacas should be rested to allow riparian species to revegetate the raw exposed banks, and stabilize the streambank.

Reach 5: Private Land, Not Surveyed

Reach 5 was not surveyed as it runs through a section of private land. This reach begins at 7,955' above sea level (T20N R1E Sec 24) and continues up into the Jemez Mountains for 1.9 miles where it stops at the private land boundary line at 7,990' above sea level (T20N R1E Sec 12 & 13 boundary). The average gradient for this reach is 0.3%. The Rosgen channel type for this reach is E. It appears as if this reach has been heavily grazed with many unstable cut banks visible.

Photo 32. Reach 5**.** The downstream end of private land not surveyed

Reach 6: Road Canyon to Rock Creek

Reach 6 begins at a fence line at the mouth of Road Canyon. The survey of this reach started on August 15th and concluded on the same date. This reach begins at 7,990' above sea level (T20N R1E Sec 12 & 13 boundary) and continues upstream for 1.1 miles. Reach 6 ends at the private land boundary just upstream of Rock Creek at 8,125' elevation (T20N R1E Sec 1 & 12 boundary). The average gradient for this reach is 2.4%. The Rosgen channel type for this reach is B3. The stream substrate is dominated by cobble substrate.

NM Highway 126 is located in this reach, though the road is not located within the floodplain. Highway 126 is slated to be paved with drainage improveme

Habitat Characteristics

During the habitat survey conducted on Reach 6, the river was broken up into a total of 18 NSOs, measuring 5,680 feet in length. Of the 18 NSOs, approximately 17% were pools. However, these 3 pools comprised only 2.4% of the stream habitat for the entire reach, 8 riffles accounted for 86.9% of the stream habitat. There is over 29 times as much riffle habitat in this reach as there is pool habitat. The lack of pool habitat can be attributed to the lack of LWD and the high amount of sand throughout the reach. Side channels make up a large part, 10.7%, of the stream habitat.

Table 32. Overall Stream Summary for Reach 6.

Reach 6					
Stream Length Surveyed:		5680 feet		1.1 miles	
Gradient:	2.4%		**Rosgen Channel Type:**	B3	
Habitat Type	**Total Number**	**Total Feet Of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	3	153	2.7	2.4	>30%
Riffle	8	5527	97.3	86.9	-
Culvert	0	0	0	0	-
Tributary	2	-	-	-	-
Falls	0	0	0	0	-
Side Channel	5	680	-	10.7	-
Total	18	6360	100.0	100.0	-

When compared to the matrix of factors and indicators of stream health condition for historic and occupied RGCT streams, Reach 6 is **not properly functioning** for all criteria in the category of habitat characteristics and channel condition, except pool quality, streambank condition, and width-to-depth ratio.

Table 33. 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	8	690.9	23.1	0.8	1.8	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
6	32.5	21.3	34.9	10.0	1.3	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Riffles in Reach 6 are **not properly functioning** for average sediment amounts, with 32.5% fines (sand, silt, and clay), which exceeds the <20% criteria. The riffles are dominated by cobbles. A large percent of the riffles in Reach 6 are long, deep, slow moving riffles, called glides. These glides were pools at one time, but due to the high amount of fines in the system, the pools have filled in to form glides. It is thought that a

large portion of the pool habitat was lost in this reach due to siltation. The high amount of fine sediments found in this reach is being carried downriver from upland disturbances and upstream conditions on private land. Reach 6 is a moderate gradient reach, and because of the velocity of the stream flow, this reach is conducive for the settlement of some fine substrates.

Table 34. 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	3	51.0	23.8	3.0	0.7	2.3	2.8	3	2.8	1	0.9
Properly Functioning Indicators	-	-	-	-	-	>1'		-	-	-	-

Substrate Summary							
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
6	50.0	20.0	20.0	10.0	0.0	100.0

Reach 6 was **properly functioning** for pool quality, with an average residual pool depth of 2.3', which exceeds the minimum of >1' for a properly functioning stream. Although, this is a significant decrease when compared to downstream reaches, indicating that pools are filling in. Overall the average pool was of adequate quality, but the amount of pool habitat in Reach 6 was below acceptable levels. Reach 6 was **not properly functioning** for pool formation, with the amount of pool habitat of 2.4%, which is well below the necessary level of ≥30% pool habitat for a properly functioning stream. A typical "B" type channel should have more pools than Reach 6 has.

Table 35. Habitat Characteristics for the Reach 6.

Reach	Pool:Riffle Ratio	Bankfull Width: Depth	Pieces of LWD per Mile	Total Unstable Banks	Percentage of Unstable Banks
6	1:2.7	26:1	0.0	60	0.5
Properly Functioning Indicators	-	12-30:1	>30	-	<10

An additional reason for the lack of pool habitat in Reach 6 is due to the lack of LWD. Reach 6 is **not properly functioning** for LWD, with 0.0 pieces per mile, which is well below the necessary >30 pieces per mile. Reach 6 would be considered a response reach in terms of LWD recruitment. A response reach recruits LWD from an upstream source, called a transport reach. Response reaches use the LWD from transport reaches to create fish habitat. LWD will typically settle out in the floodplain, and with channel forming events, will be placed in areas of the stream where it will be most efficiently used by the stream.

The lack of LWD in this reach can be attributed to two primary factors. First, due to the accessibility of the reach, LWD was likely removed for fuelwood or to 'improve fish passage.' Second, the private land management above this reach has all but eliminated a source of large wood.

The amount of unstable banks in Reach 6 was 0.5%; therefore, Reach 6 is **properly functioning** for streambank condition.

The bankfull width-to-depth ratio for Reach 6 being 26:1, which is within 12-30:1, is considered **properly functioning** for a "B" Channel.

It is recommended that LWD be added to Reach 6. The access for this reach is adequate enough that LWD placements would be feasible. The addition of LWD would help to increase pool quantities and depth throughout the reach. There are areas where the river flows through a forested riparian area, so LWD recruitment would have been possible in this reach. Another recommendation is to plant willows and alders along the stream banks throughout the reach. The addition of riparian vegetation would increase stream shading, decrease water temperatures, stabilize banks throughout, and allow the stream to function naturally. Stabilizing the banks would aid in reducing the sediment input to the stream, reducing the amount of fine sediments present in riffles.

Photo 34. Reach 6, NSO 151, R79. Typical riffle in Reach 6. Notice lack of riparian vegetation. Private land and Reach 7 begins at fenceline.

Another recommendation is the exclusion or limitation of cattle within the active floodplain. Livestock have removed much of the riparian vegetation from the streambank by browsing, as well as trampling and compacting the soil along the streambanks. The limitation of cattle access would allow the vegetation to grow and the streambanks to stabilize.

Reach 7: Private Land, Not Surveyed

Reach 7 was not surveyed as it runs through a section of private land. This reach begins at 8,125' above sea level (T20N R1E Sec 1 & 12 Boundary) and continues in an open meadow system for 0.6 miles where it stops at the private land boundary line at 8,155' above sea level (T20N R1E Sec 1 & 2 Boundary). The average gradient for this reach is 0.9%. The Rosgen channel type for this reach is E. It appears as if this reach has been heavily grazed with many unstable cutbanks visible.

Whirling disease testing was conducted in this reach in 2001. Results were negative for the presence of whirling disease. Fish observed during that sampling included native Rio Grande sucker and Rio Grande chub as well as non-native German brown trout and rainbow trout.

Reach 8: Private Land Boundary to Confluence with Clear Creek

Reach 8 begins at a bridge, which marks the end of the private land boundary (T20N R1E Sec1 & 2 Boundary). The survey of this reach started on September 4th and finished on this same date. This reach begins at 8155' above sea level and continues upstream for 0.4 miles to the confluence with Clear Creek at 8175' elevation (T20N R1E Sec 2). The average gradient for Reach 8 is 1.0%. The Rosgen channel type for this reach is an E3 channel. The stream substrate is dominated by cobble substrate.

Reach 8 had five (5) old beaver dams in the stream channel. The habitat in this reach had the highest amount of side channel habitat due to beaver dams and active wet meadows.

Photo 35. NSO 162, P32. Old beaver dam site forming a plunge pool

Alder and willow heavily shaded some of the side channel habitat, which created quality fish habitat.

There was one tributary found in this reach, Clear Creek (T11, NSO 169). Clear Creek was estimated to contribute 30% of the flow to Rio de las Vacas; however, this was hard to determine. An old beaver dam exists at the mouth of Clear Creek and holds back and spreads out the flow. Unidentified fish were observed in Clear Creek. The riparian area consisted primarily of alder, with some willow and grasses. Cinquefoil was observed in the surrounding meadow. Finding cinquefoil in the riparian area is an indication of an area being converted from a wet to a dry site, usually associated with major disturbances such as overgrazing and soil compaction. The upper portion of the reach was an old timber-landing site.

Water temperatures were measured at random intervals during the survey using an alcohol thermometer. Main channel temperature readings were taken in the water column in main channel habitats during the survey (grab samples). The 3 water temperature samples ranged between 63 and 74 F. Average grab sample temperature was 65.8 F.

Habitat Characteristics

Table 36. Overall Stream Summary for Reach 8.

Reach 8					
Stream Length Surveyed:		1905 feet		0.4 miles	
Gradient:	1.0		**Rosgen Channel Type:**		E3
Habitat Type	**Total Number**	**Total Feet Of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	5	130	6.8	4.4	>30%
Riffle	5	1775	93.2	59.8	-
Culvert	0	0	0	0	-
Tributary	1	-	-	-	-
Falls	0	0	0	0	-
Side Channel	5	1063	-	35.8	-
Total	16	2968	100.0	100.0	-

During the habitat survey conducted on Reach 8, the river was broken up into a total of 16 NSOs, measuring 1,905 feet in length. Of the 16 NSOs, approximately 33% were pools. However, these 5 pools comprised only 4.4% of the stream habitat for the entire reach, 5 riffles accounted for 59.8% of the stream habitat. There is over 15 times as much riffle habitat in this reach as there is pool habitat. Side channels make up a very large part, 35.8% of the stream habitat. The large amount of side channel habitat is attributed to the five old beaver dams found in this reach. The beaver dams created all side channel habitat in this reach. The lack of pool habitat can be primarily attributed to deposition of fines.

When compared to the matrix of factors and indicators of stream health condition for historic and occupied RGCT streams, Reach 8, is **not properly functioning** for all criteria in the category of habitat characteristics and channel condition, except pool quality, streambank condition, and width-to-depth ratio.

Table 37. Summary of Habitat and Substrate Percentages for Riffles in Reach 8.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
8	5	355	13.3	0.6	1.3	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
8	24.0	22.0	36.0	18.0	0	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Riffles in Reach 8 are **not properly functioning** for average sediment amounts, with 24.0% fines (sand, silt, and clay,), which exceeds the <20% criteria. A large percent of

the riffles in Reach 8 are long, deep, slow moving riffles, called glides. These glides were likely pools that have filled in due to siltation behind the beaver dams.

Reach 8 was **properly functioning** for pool quality, with an average residual pool depth of 1.3', which exceeds the minimum of >1' for a properly functioning stream. Overall the average pool was of adequate quality, but the amount of pool habitat in Reach 8 was below acceptable levels, this is a significant decrease when compared to downstream reaches such as Reach 4, indicating that pools are filling in, due to sediment collection in the beaver meadows.

Reach 8 was **not properly functioning** for pool formation, with the amount of pool habitat of 4.4%, which is well below the necessary level of ≥30% pool habitat for a properly functioning stream. A typical "E" type channel should have more pools than Reach 8 has.

Table 38. Summary of Pool Habitat and Substrate Percentages in Reach 8.

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
8	5	26.0	15.1	1.7	0.4	1.3	13.9	3	8.3	0	0
Properly Functioning Indicators	-	-	-	-	-	>1'		-	-	-	-

Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
8	52.0	20.0	18.0	10.0	0.0	100.0

The amount of LWD does not apply to Reach 8, as it is a meadow system. Local LWD recruitment would not occur in this reach, as there is no wood to fall into the channel. However, historically there may have been willows growing along the banks of the river. These willows would have provided some source of woody debris to the stream (although not countable). The location of Reach 8 would have made it a response reach. Response reaches collect LWD after it has moved through a transport reach, such as Reach 9. The location of Reach 8 would allow LWD to collect in this reach, including beaver activity that would pull trees off the slopes.

Table 39. Habitat Characteristics for the Reach 8.

Reach	Pool:Riffle Ratio	Bankfull Width: Depth	Pieces of LWD per Mile	Total Unstable Banks	Percentage of Unstable Banks
8	1:1	11:1	7.5[1]	198	5.2
Properly Functioning Indicators	-	<12:1	>30	-	<10

[1] LWD was left out of analysis, as Reach 8 is a meadow reach.

The amount of unstable banks in Reach 8 was 5.2%; therefore, Reach 8 is **properly functioning** for streambank condition.

The bankfull width-to-depth ratio for Reach 8 being 11:1, which is within <12:1, is considered **properly functioning** for an "E" Channel.

Photo 36. Reach 8, NSO 164, S38. Side channel formation from beaver activity. Note: Wet site indicator species throughout floodplain.

It is recommended for Reach 8 that the beaver meadow be carefully monitored. Beaver meadows create quality fish habitat, and are extremely productive areas. If beaver should not move into this area after a few short years, they should be reintroduced to this area. However, beavers should only be reintroduced if there is an adequate food supply there to support a healthy beaver population. Willow planting could be implemented to increase beaver activity.

Reach 9: Confluence of Clear Creek to Barrier

Reach 9 begins at the confluence with Clear Creek. The survey of this reach began on September 4, 2001 and continued through October 3, 2001. This reach begins at 8175' above sea level (T20N R1E Sec 2) and continues upstream for 2.9 miles to the man-made migration barrier upstream of the FS Road 70 crossing (T21N R1E Sec 27) at 8980' above sea level. The average gradient for Reach 9 is 5.2%. The Rosgen channel type for this reach is an A2 channel. The stream substrate is dominated by boulder substrate.

Reach 9 ended at the migration barrier, as it was an easily recognizable landmark. The survey continued in 2002 from this point. Please note that observers were changed during the survey, as the original observer had to leave for the rest of the season.

Reach 9 flows through a tight, steep canyon. Valley slopes were up to 40%. Due to the nature of this terrain, Reach 9 had limited human use. However, the places where humans were concentrated had a noticeable impact on the stream. There are many campsites centered on NM Highway 126, FS Road 70 and the Las Vacas Campground. Bank instability increases around these dispersed and developed camping areas (see Photo 34). Any LWD in the stream in these areas have likely been cut for firewood. Around the campground and dispersed sites, there is a significant amount of trash thrown into the stream. Fish habitat was poor next to these areas and improved upstream of the campground.

Photo 37. Reach 9, NSO 180, P39. Man-made pool by visitors to Las Vacas Campground. Note: Raw, eroding bank and bathroom in background.

Cattle were concentrated in these areas, particularly around FS Road 70. Cow fecal material was observed in the stream.

The riparian area in Reach 9 consisted of alder, willow, and dogwood. Conifers become more prevalent upstream and greatly influence the amount of LWD found in the stream. Much of the wood in the stream did not meet the necessary size specifications for the stream survey protocol. However, this small wood was still having a positive influence on fish habitat. Old beaver chewings on willow trees were present in Reach 9. The amount of young alders increased upstream. There were a few areas that had undercut banks up to 2.5 feet. These were mostly found under conifer rootwads along the bank.

Numerous fish were observed throughout the reach. Brown trout were the primary fish observed, but some RGCT were observed above the Las Vacas Campground beginning in NSO 257, R126.

On June 22, 2001 a snorkel survey was conducted in Reach 9. A total of 300 meters (948 feet) were snorkeled below the man-made barrier at the end of the reach (see Table 40).

Table 40. Fish identified during snorkel survey in Reach 9 on June 22, 2001

Species	Juvenile (<3")	Sub-Adult (3-6")	Adult (6-9")	Large Adult (9-12")	Big Fatty (>12")	Total
Unknown Trout	0	3	3	0	0	6
Brown Trout	3	13	9	2	0	27
Rainbow Trout	0	2	1	0	0	3
Rio Grande Cutthroat	1	2	1	0	0	4

A water temperature station was located just above the Rio de las Vacas campground below the Wilderness boundary and recorded temperatures between June 15th to October 5th, 2001. The highest temperatures were between June and August (see Figure 6). This station was compared to Santa Fe National Forest Standards (SFNF) and New Mexico Environmental Department (NMED) standards for classification as either properly functioning, at risk, or not properly functioning. Temperatures above the campground were **at risk** by SFNF classification 51 days of the 113 measured. Temperatures were **properly functioning** by NMED standards for all 113 days.

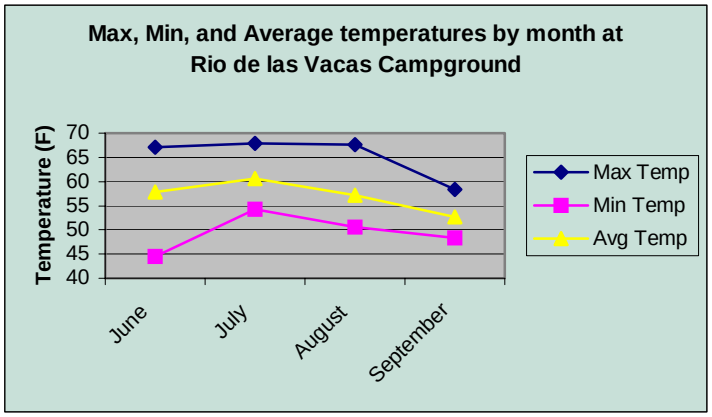


Figure 6. Maximum, minimum, and average temperatures for each month.

Table 42. Summary of Habitat and Substrate Percentages for Riffles in Reach 9.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
9	50	283.3	11.3	0.7	1.6	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
9	15.4	16.6	30.0	37.0	1.0	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Riffles in Reach 9 are **properly functioning** for average sediment amounts, with 15.4% fines (sand, silt, and clay,), which does not exceed the <20% criteria. A large percent of the riffles in Reach 9 are short, high gradient riffles and cascades, which is typical for an "A" channel, as they tend to be step pool systems.

Table 43. Summary of Pool Habitat and Substrate Percentages in Reach 9.

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
9	52	24.0	11.1	2.2	0.5	1.7	17.8	44	15.1	5	1.7
Properly Functioning Indicators	-	-	-	-	-	>1'		-	-	-	-
Substrate Summary											
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total				
	9	27.1	15.6	20.4	35.6	1.3	100.0				

Reach 9 was **properly functioning** for pool quality, with an average residual pool depth of 1.7', which exceeds the minimum of >1' for a properly functioning stream. Overall the average pool was of adequate quality, but the amount of pool habitat in Reach 9 was below acceptable levels.

Reach 9 was **not properly functioning** for pool formation, with the amount of pool habitat of 7.5%, which is well below the necessary level of ≥30% pool habitat for a properly functioning stream. A typical "A" type channel should have more pools than Reach 9 has. Part of the reduced amount of pools may be due to observer error. Large cascades may have been lumped together. A typical cascade is made up of a high gradient riffle with pocket pools sporadically throughout the cascade. Some pools may not have been identified as a pool for this reason.

Table 44. Habitat Characteristics for the Reach 9.

Reach	Pool:Riffle Ratio	Bankfull Width: Depth	Pieces of LWD per Mile	Total Unstable Banks	Percentage of Unstable Banks
9	1:1	19:1	16.8	1149	3.7[1]
Properly Functioning Indicators	-	<12:1	>30	-	<10

[1] Unstable banks are removed from the analysis for Reach 9 due to the high gradient

Reach 9 was **not properly functioning** for LWD, with 16.8 pieces per mile. This is below the >30 pieces per mile criterion for a properly functioning stream. Reach 9 would be considered a transport reach in terms of LWD recruitment. A transport reach acts as a source of LWD for response reaches, but also will have "nick points" which collect large wood in these typically high gradient reaches.

During the survey, it was observed that the majority of the LWD in the stream was quite old. There was very little new LWD recruitment occurring. One reason for the lack of LWD is likely due to past management practices. Historic fire suppression practices as well as past timber harvest in this part of the watershed may be another reason for the lack of LWD in Reach 9. Fire ecology is an important part of the landscape in New Mexico. Large fires would remove the understory, and open up the canopy for ponderosa pine, and Douglas fir, the dominant species in this reach. Fire assists in LWD recruitment for streams in this region. The dying trees would eventually fall into the stream channel, creating pool and side channel habitat. The lack of major fires over the last century has greatly diminished the amount of LWD in New Mexico streams.

Photo 38. Reach 9, NSO 176, R88. Large log jam in Rio de las Vacas.

Reach 9 was not analyzed for stream bank condition, as the overall gradient was greater than 4%. In reaches with a gradient greater than 4%, bank instability is quite normal, due to natural stream function. Again, there are concerns in human concentrated areas.

The bankfull width-to-depth ratio for Reach 9 being 19:1, which is not within <12:1, is considered **not properly functioning** for an "A" Channel. This needs to be studied further to determine if it was site specific or survey error.

It is recommended for Reach 9 that the dispersed campsites be closed and rehabilitated. Use of these sites has compacted the soil, and removed all vegetation from these areas. Another alternative is to educate visitors on what the destruction of the riparian area does to the stream that they come to enjoy. Another recommendation is to exclude or limit cattle in riparian areas. The cattle are destroying necessary riparian vegetation and causing further bank instability.

Reach 10: Constructed Barrier to Rito de las Perchas

Reach 10 begins at the human-made rock and cement barrier, just up stream from the Forest Service Road 70 crossing (T21N, R1E, Sec. 27, elev. 9,020'), and ends at the confluence with the Rito de las Perchas (T21N, R1E, Sec. 22, elev. 9,480'). The measured length of this reach is 1.8 miles. The channel is confined (100-200 feet high canyon walls) and the valley is very narrow throughout this reach. These geomorphologic characteristics produce a high gradient (4.5%). Classified as a Rosgen B2 reach, dominant habitat features include plunge pools and boulder braiding. The reach was broken due to a change in flow regime – Rito de las Perchas contributes between 40 and 50 percent of the stream flow.

The upland vegetation lies close to the stream, within 15 to 30 feet, and is comprised of white fir, ponderosa pine, Douglas-fir, and aspen. The streamside woody vegetation is willow and alder. Riparian vegetation is primarily willow, alder, moss, lichen, grass, ferns, thimbleberry, and other herbaceous plants (see Photo 36). The creek is clear and contains minimal aquatic vegetation.

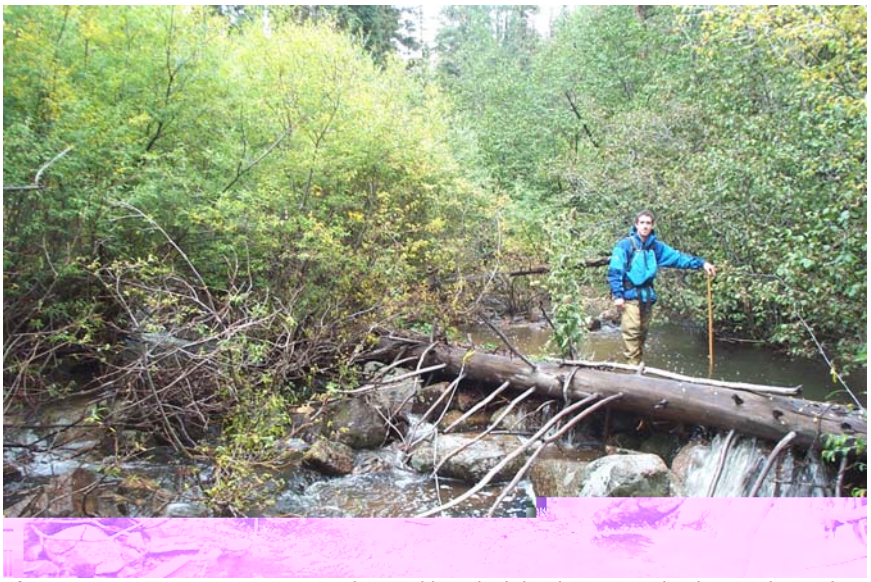


Photo 39. NSO 328, P101. D. Goodman with typical riparian vegetation in Reach 10 of the Rio de las Vacas (11-Sep-2002).

No fish were observed. However, a non-native species removal electric shock treatment of this stream, in August 2002, revealed that this section of the creek is inhabited by both Rio Grande Cutthroat trout and German brown trout.

This reach contains seven side channels, all of which are deep enough to provide fish rearing and refuge habitat. The majority of these side channels (six) are near the end of the reach. In addition, six dry, possible high flow, side channels are located throughout this reach. The survey was performed after and during a high precipitation event, so a long period of heavy rains would be needed to create flow in these dry side channels.

There are three tributaries near the end of the reach. Two of these are small springs, the first of which is deep enough to provide possible fish habitat (NSO 324, T13). The last tributary is the Rito de las Perchas (NSO 329, T14), where the reach ends. This stream provides good fish habitat.

A high density of large woody debris in Reach 10 also contributed greatly to fish habitat. There are more than 200 pieces of large woody debris, numerous debris jams, and 14 logjams (see Photo 37). The wood in the stream is a combination of newly fallen trees and old downed trees. Some of the older wood and logjams has created pools, forcing the channel to flow under them and scour out the bottom of a pool. However, most of the newly fallen wood has not yet influenced the stream in such a manner. A large amount of large woody debris was also observed above bankfull (only trees below bankfull are counted in this protocol). Wood and log jams were not concentrated in one section, but distributed throughout the reach. Most of the large woody debris appears to have been downed by wind and natural erosion along the steep banks.

Photo 40. NSO 313, R157. Damon Goodman with one of many logjams in Reach 10 (11-Sep-2002).

Almost no instability was observed along this reach, natural or human derived. Though the stream is highly confined by the steep canyon it runs through, the canyon is not steep enough to create a great deal of instability. The canyon, however, is too steep and too densely forested to warrant grazing and there is no streamside path to permit human access with ease. Due to all of these factors, the banks within this reach are almost entirely stable.

Though human impacts along this reach are minimal, they do exist. At the very beginning of this reach there is a dispersed campsite on the left bank, by the human-made barrier. This sight has gabions, which retain the bank. Due to its proximity to Forest Service Road 70, recreational impacts may continue to develop and expand. Near the very end of this reach is a human created side channel (NSO 325 S53) on the right bank (Nacimiento ditch). This side channel has a diversion ditch, which runs off to the left and

is currently dry (see Naciemento USGS quadrangle). Naciemento ditch is currently not in use from the section between Rio de las Vacas and Clear Creek. In fact, the ditch has blown out several hundred feet from the point of diversion (S. Ferrell, personal communication, 2003).

To maintain fish habitat, this reach must be carefully managed. Development at the beginning of this reach could increase instability in this section and have negative, sediment loading consequences. However, the human-made fish barrier could also be enhanced. It has deteriorated since its construction in 1981, and could be enhanced to ensure that downstream exotic fish (German brown trout) are unable to breach the barrier.

Water temperatures were measured at random intervals during the survey using an alcohol thermometer. Main channel temperature readings were taken in the water column in main channel habitats during the survey (grab samples). The 14 water temperature samples ranged between 50 and 58 F. Average grab sample temperature was 54.1 F.

Habitat Characteristics

Table 45. Overall Stream Summary for Reach 10.

Reach 10					
Stream Length Surveyed: 9,364 feet				1.8 miles	
Gradient: 4.5			**Rosgen Channel Type:**		**B2**
Habitat Type	**Total Number**	**Total Feet Of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	19	657	7.0	6.1	>30%
Riffle	22	8,702	93.0	81.2	-
Culvert	0	0	0	0	-
Tributary	3	-	-	-	-
Falls	1	5	0.0	0.0	-
Side Channel	8	1353	-	12.7	-
Total	53	10,717	100.0	100.0	-

During the habitat survey conducted on Reach 10, the river was broken up into a total of 43 NSOs, measuring 10,717 feet in length. Of the 53 NSOs, approximately 35.8% were pools. However, these 19 pools comprised only 6.1% of the stream habitat for the entire reach, 22 riffles accounted for 81.2% of the stream habitat. Riffle habitat is over 13 times longer than pool habitat in Reach 10. Side channels make up an additional 12.7% of the stream habitat. The amount of side channel habitat is attributed to the high gradient of Reach 10, complemented by LWD. Typically in steep reaches of mountain streams, wherever LWD collects, it forces the stream to split forming side channels. This side channel habitat provides refuge areas for small fish during high flows, as the flows in the side channels tend to be much less than the main channel.

When compared to the matrix of factors and indicators of stream health condition for historic and occupied RGCT streams, Reach 10, is **properly functioning** for all matrix indicators except pool development. Large woody debris density, pool quality, and riffle

sediment content are all within appropriate ranges. Bank stability is not evaluated in this reach due to high gradient.

Table 46. Summary of Habitat and Substrate Percentages for Riffles in Reach 10.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
10	22	438.3	14.4	0.9	1.9	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
10	10.0	20.5	30.0	39.5	0.0	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Riffles in Reach 10 are **properly functioning** for average sediment amounts, with 10.0% fines (sand, silt, and clay), which does not exceed the <20% criteria.

Table 47. Summary of Pool Habitat and Substrate Percentages in Reach 10.

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
10	19	34.6	15.2	2.3	0.5	1.8	10.6	19	10.6	4	2.2
Properly Functioning Indicators	-	-	-	-	-	>1'		-	-	-	-
Substrate Summary											
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total				
	10	17.4	28.4	23.7	25.8	4.7	100.0				

Reach 10 was **properly functioning** for pool quality, with an average residual pool depth of 1.8', which exceeds the minimum of >1' for a properly functioning stream. Overall the average pool was of adequate quality, but the amount of pool habitat in Reach 10 was below acceptable levels.

Reach 10 was **not properly functioning** for pool formation, with a length of pool habitat of 6.1%, well below the necessary level of ≥30% pool habitat for a properly functioning stream.

Table 48. Habitat Characteristics for the Reach 10.

Reach	Pool:Riffle Ratio	Bankfull Width: Depth	Pieces of LWD per Mile	Total Unstable Banks	Percentage of Unstable Banks
10	1:1.2	17.1:1	57.2	150	0.7[1]
Properly Functioning Indicators	-	12-30	>30	-	<10

[1] Unstable banks are removed from the analysis for Reach 10 because of high gradient

Reach 10 was **properly functioning** for LWD density with 57.2 pieces per mile. This reach had the highest density of woody debris on Rio de las Vacas and a total of 104 pieces (M and L only) over the 1.8 miles.

Reach 10 was not analyzed for stream bank condition, as the overall gradient was greater than 4%. In reaches with a gradient greater than 4%, bank instability is natural (see Photo 38).

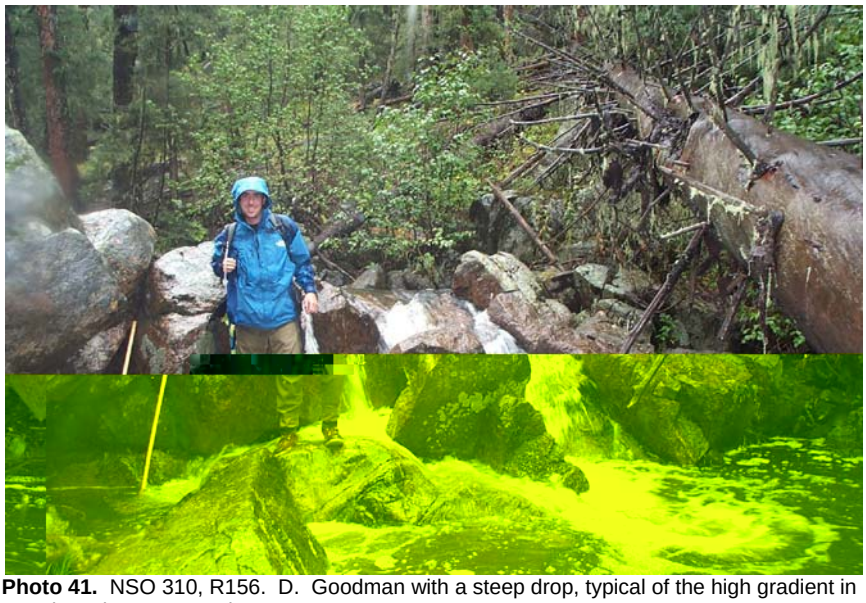


Photo 41. NSO 310, R156. D. Goodman with a steep drop, typical of the high gradient in Reach 10 (11-Sep-2002).

Bankfull width-to-depth ratio for Reach 10 is 17.1:1, which is within 12 to 30:1, and is therefore **properly functioning** for a "B" Channel.

To maintain fish habitat, this reach must be carefully managed. Development at the beginning of this reach could increase stability in this section and thus decrease sediment loading. The human-made fish barrier has deteriorated since its construction in 1981. This has allowed German brown trout to move upstream. Work was completed in 2003 to fill in the pool below the barrier. The barrier itself is scheduled for renovation in 2004.

Reach 11: Rito de las Perchas to an Open Valley System

Reach 11 begins at the creek's confluence with Rito de las Perchas, and ends 2.64 miles upstream at an unnamed tributary on the left bank (T21N R1E S1, elevation 9,980'). Classified as a Rosgen B2 reach, dominant habitat features include plunge pools and boulder braiding. Steep banks confine the channel and the valley is very narrow throughout this reach. In the middle of the reach the channel becomes less confined and gradient decreases for a short section. Overall, these geomorphologic characteristics produce a moderately-high gradient (3.6%). Gravel, cobble, and boulders characterize the substrate of this reach. The reach was broken due to a decrease in gradient and widening of the valley floor.

This reach contains 16 side channels, 13 of which are deep enough to provide possible fish habitat. The side channels are well distributed throughout the reach. There are seventeen dry side channels or sections of old main channel located throughout this reach. These dry side channels may be active after heavy precipitation events and demonstrate the dynamic capabilities if this river. There are eleven tributaries in this reach, most of which lie near the end. Two of these are small streams, which have enough depth and flow to provide possible fish habitat (NSO 432 T21 and NSO 456 T26).

Photo 42. NSO 410, R197. S. Adams and D. Goodman in a typical forested riffle of Reach 11 (11-Oct-03).

Over 45.3 pieces of large woody debris per mile are dispersed throughout this reach. More than 200 pieces of large woody debris total comprise numerous debris jams and 13 logjams. The wood in the stream is a combination of newly fallen trees and old downed trees. Some of the older wood and logjams have created pools, forcing the channel to flow under them and scour out the bottom of a pool. A large amount of large woody debris was also observed above bankfull (only trees below bankfull are counted in this protocol). Large woody debris and logjams were recorded throughout the reach, though they were most heavily concentrated in the first half of the reach. Most of the large

woody debris appears to have been downed by wind and natural erosion along the steep banks.

Short lengths of natural instability are dispersed through this reach. The lack of human caused instability is related to access issues. The canyon is steep, densely forested, and had no trail access. Most of the instability that was observed was due to natural processes, inherent to high gradient canyons with steep banks, and some cattle utilization. In the lower gradient sections of this reach there are small, open grassy areas – most of which have been impacted by cattle grazing. Some of these sections have slumped and impacted banks, with little vegetation growing on them (see Photo 40). Upland marshy areas and seeps also revealed cattle usage (muddy areas with cow excrement).

Photo 43. NSO 355, R174. Cattle caused bank instability in one of the open meadow sections of Reach 11 (11-Oct-03).

Human-caused impact, other than cattle grazing, is slight on this reach. Near the end of the reach are two rock dams, which successfully create a large pool (NSO 431 P144). This pool has a 2.6-foot maximum depth, 13 foot width, and 367 foot length. This pool is near an open grassy section and is perhaps an old watering hole for cattle and horses.

There are two beaver dams (see Photo 41) near the end of the reach, which create a double pool (NSO 447 P148). This well established pool has a 3.3 foot maximum depth, 21 foot length, and 205 foot length. The dams were built with small alder and willow. Both this pool and the human created pools provide quality fish habitat.

Photo 44. NSO 431, P139. S. Adams with a beaver dam complex in Reach 11 (11-Oct-02).

Upland vegetation lies close to the stream (within 15 to 30 feet) and is comprised of subalpine fir, Douglas fir, Englemann spruce, and aspen. Streamside woody vegetation is willow and alder, which overhang the stream in many locations, providing shade and provide thermal protection of the stream environment. Riparian vegetation is primarily willow, alder, moss, lichen, grass, ferns, thimbleberry, and other herbaceous plants. The creek is clear and contains minimal aquatic vegetation.

Rio Grande Cutthroat trout were observed once during the survey of this reach in a riffle. One unidentified trout was observed.

Water temperatures were measured at random intervals during the survey using an alcohol thermometer. Main channel temperature readings were taken in the water column in main channel habitats during the survey (grab samples). The 17 water temperature samples ranged between 36 and 54 F. Average grab sample temperature was 43.5 F.

Habitat Characteristics

During the habitat survey conducted on Reach 11, the river was broken up into a total of 125 NSOs, measuring 16,974 feet in length. Of the 125 NSOs, 36% were pools. However, these 45 pools comprised 17.8% of the stream habitat for the entire reach, 51 riffles accounted for 64% of the stream habitat. There is almost 3.6 times as much riffle habitat in this reach as there is pool habitat. Side channels make up an additional 18.2% of the stream habitat. The amount of side channel habitat is partially attributed to the high gradient of Reach 10, complemented by a high density of LWD. Typically in steep reaches of mountain streams, wherever LWD collects, it forces the stream to split forming side channels. This side channel habitat provides refuge areas for small fish during high flows, as the flows in the side channels tend to be much less than the main channel. The combination of pool and side channel habitat (36%) creates a diverse and dynamic assortment of habitat conductive to a healthy fish population.

Table 49. Overall Stream Summary for Reach 11.

Reach 11					
Stream Length Surveyed:		13,875 feet		2.6 miles	
Gradient:	**3.6%**		**Rosgen Channel Type:**		**B2**
Habitat Type	**Total Number**	**Total Feet Of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	45	3,020	21.8	17.8	>30%
Riffle	52	10,855	78.2	64.0	-
Culvert	0	0	0	0	-
Tributary	12	-	-	-	-
Falls	0	0	0	0	-
Side Channel	17	3098	-	18.2	-
Total	126	16,973	100.0	100.0	-

When compared to the matrix of factors and indicators of stream health condition for historic and occupied RGCT streams, Reach 11, is **properly functioning** for all criteria in the category of habitat characteristics and channel condition, except pool development.

Table 50. Summary of Habitat and Substrate Percentages for Riffles in Reach 11.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
11	52	212.5	9.3	0.6	1.1	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
11	10.8	18.1	35.0	35.8	0.3	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Riffles in Reach 11 are **properly functioning** for average sediment amounts, with 10.8% fines (sand, silt, and clay), which does not exceed the <20% criteria. The dominant riffle substrate is boulder with a slightly lesser amount of cobble.

Table 51. Summary of Pool Habitat and Substrate Percentages in Reach 11.

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
11	45	67.1	12.9	1.7	0.4	1.3	13.3	29	11.0	2	0.8
Properly Functioning Indicators	-	-	-	-	-	>1'		-	-	-	-

Substrate Summary							
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total	
11	26.1	18.7	21.6	32.0	1.6	100.0	

Reach 11 was **properly functioning** for pool quality, with an average residual pool depth of 1.3', which exceeds the minimum of >1' for a properly functioning stream. Overall the average pool was of adequate quality, but the amount of pool habitat in Reach 11 was below acceptable levels.

The pool habitat in Reach 11 was **not properly functioning** for pool development. Pool habitat made up only 17.8% of the stream habitat, below the greater than or equal to 30% properly functioning indicator. Although Reach 11 is **not properly functioning** for pool development, it has the highest relative quantity of pool habitat of the analyzed reaches (Reaches 12 and 13 excluded due to stream order) and is complimented by equal side channel habitat.

Table 52. Habitat Characteristics for the Reach 11.

Reach	Pool:Riffle Ratio	Bankfull Width: Depth	Pieces of LWD per Mile	Total Unstable Banks	Percentage of Unstable Banks
11	1:1.3	16.9:1	45.3	555	2.0
Properly Functioning Indicators	-	12-30:1	>30	-	<10

Reach 11 was **properly functioning** for LWD, with 45.3 pieces per mile. There were 118 total pieces of LWD. Reach 11 would be considered a transport reach in terms of LWD recruitment. A transport reach acts as a source of LWD for response reaches, but also will have "nick points" which collect large wood in these typically high gradient reaches.

Bank stability was less than the <10% properly functioning indicator. The length of unstable banks was only 2.0% or 555 feet of the 2.6 miles surveyed. The length of

instability was naturally caused in the highly dynamic canyon sections. In addition, Grazing impacts were observed in the open and accessible valley sections.

The bankfull width-to-depth ratio for Reach 11 being 16.9:1 is within 12-30:1 and **properly functioning** for a “B” Channel.

Reach 12: The Beginning of an Open Valley to Rito Anastacio

Reach 12 begins at an unnamed left bank tributary (NSO 457, T26), and ends 0.96 miles upstream at the river's confluence with the Rito Anastacio (T21N R1E S3, elevation 10,120 feet). Overall, these geomorphologic characteristics produce a moderately low gradient of 2.8 percent. This reach was considered a Rosgen E3 reach. Sand, gravel, and cobble characterize the substrate of this reach. The reach was broken due to a decrease in gradient, widening of the valley floor, and a change in flow regime – Rito Anastacio contributes approximately 40% to stream flow.

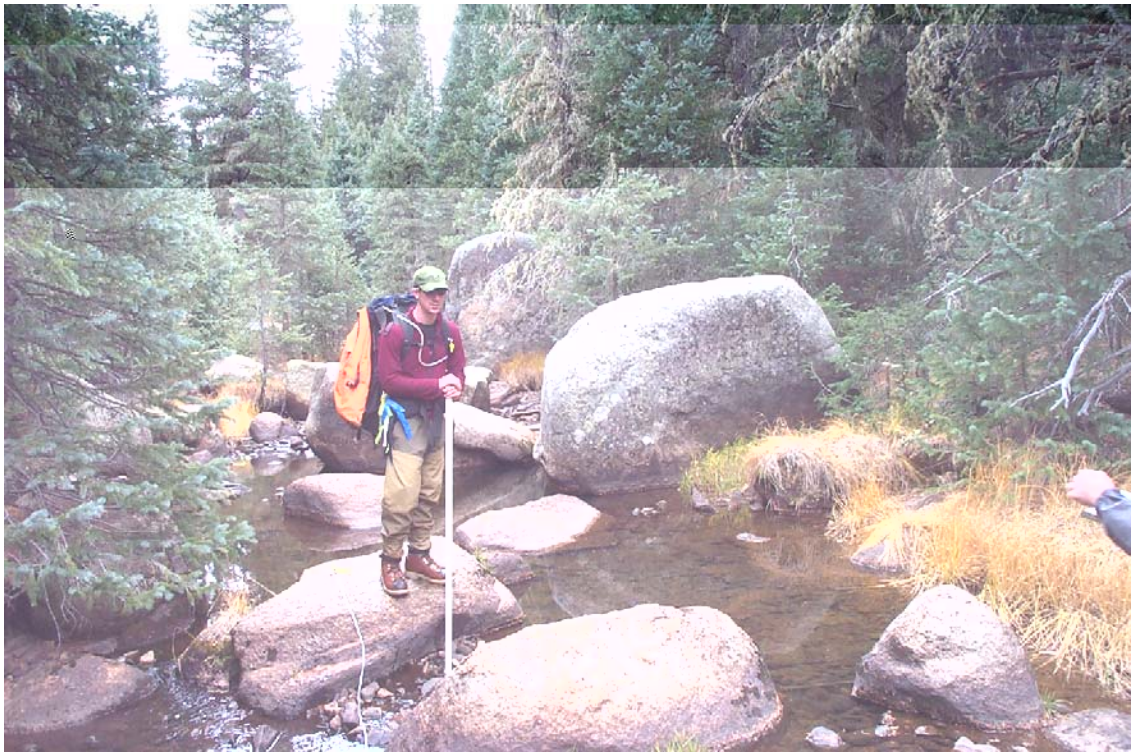


Photo 45. NSO 472, R221. D. Goodman with a pool filled with boulders, dominant substrate of pools in Reach 12 (12-Oct-02).

A combination of low gradient, open meadows and mildly confined forested areas describe this reach. Five distinct meadow and four forested sections comprise this reach – producing a stair step type of effect. The reach begins in a small open grassy meadow with low gradient. Though primarily covered with grass and other herbaceous vegetation, these areas do support a small amount of willow, some of which have been protected by cattle exlosures near the end of the reach. Overall, these sections provide the stream with little shade. Approximately one-eighth of a mile upstream from the beginning of the reach, the channel becomes mildly confined and has an increased gradient. The vegetation in these areas is primarily spruce, white fir, and aspen. These large trees grow close to the stream, replacing the streamside alder and willow that were present in previous reaches. These sections are heavily shaded, providing thermal protection of the stream environment. There are only three dry side channels or old main channels – as this reach does not have highly dynamic capabilities.

Side channels and tributaries provide fish habitat throughout this reach. This reach contains six side channels, five of which are deep enough to provide possible fish habitat. Side channels are concentrated near the beginning of the reach. There are four tributaries in this reach. Two of these are small streams, which have enough depth and flow (5% and 40% consecutively) to provide possible fish habitat (NSO 476 T28 and NSO 521 T31 – Rito Anastacio). Rito Anastacio has been surveyed and is occupied by Rio Grande cutthroat trout (San Perdo Parks Wilderness Monitoring Report, 2002).

There are only 6 pieces of large woody debris throughout this reach, which creates a small amount of fish habitat fish habitat.

This low gradient, open meadow system allows for increased accessibility for cattle and humans. Increased utilization of the stream and riparian habitat leads to increased stream impacts (instability is dramatically increased from the previous reach). Bank instability, compaction of banks and upland grasslands, browsed grass stubble, and slumping undercuts in the open meadow section are all signs of cattle impact. This section is within the San Pedro cattle allotment.

Forest Service Trail 51 runs along the last two-thirds of this reach, providing human access to the stream. The trail is up off the stream, minimizing bank instability, but two stream crossings do impact the stream. Two large dispersed campsites are located on either side of the bank, near the middle of the reach (NSO 475 R216). During the survey, the campsite on the right bank was in very poor condition. The occupants had attempted to bury all of their trash, including five large Coleman fuel bottles, all of which had been unearthed by curious animals (see Photo 43).

Photo 46. Stream side trash from improper waste disposal at a campsite along Reach 12 (12-OctOct-02).

Rio Grande cutthroat trout of varying size classes were observed in one pool during this reach.

Water temperatures were measured at random intervals during the survey using an alcohol thermometer. Main channel temperature readings were taken in the water column in main channel habitats during the survey (grab samples). The 6water temperature samples ranged between 38 and 49 F. Average grab sample temperature was 44.8 F.

Habitat Characteristics

Table 53. Overall Stream Summary for Reach 12.

Reach 12					
Stream Length Surveyed:		5075 feet		1.0 miles	
Gradient:	2.8		**Rosgen Channel Type:**		E3
Habitat Type	**Total Number**	**Total Feet Of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	27	1,573	31.0	28.1[1]	-
Riffle	27	3,502	69.0	62.6	-
Culvert	0	0	0	0	-
Tributary	5	-	-	-	-
Falls	0	0	0	0	-
Side Channel	6	515	-	9.2	-
Total	65	5,590	100.0	100.0	-

1 Pool development is excluded from analysis in Reaches 12 and 13 because the stream is less than 3rd order.

During the habitat survey conducted on Reach 12, the river was broken up into a total of 65 NSOs, measuring 5,590 feet in length. Of the 65 NSOs, 50% were pools. However, these 27 pools comprised 28.1% of the stream habitat for the entire reach, 27 riffles accounted for 62.6% of the stream habitat. There is over 2.2 times as much riffle habitat in this reach as there is pool habitat. Side channels make up an additional 9.2% of the stream habitat. This side channel habitat provides refuge areas for small fish during high flows, as the flows in the side channels tend to be much less than the main channel. The combination of pool and side channel habitat creates a diverse and dynamic assortment of habitat conductive to a healthy fish population.

When compared to the matrix of factors and indicators of stream health condition for historic and occupied RGCT streams, Reach 12, is **properly functioning** for all criteria in the category of habitat characteristics and channel condition, except bank stability, which is **at risk**. Large woody debris and pool development are exempt from matrix analysis in Reach 12.

Table 54. Summary of Habitat and Substrate Percentages for Riffles in Reach 121.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
12	27	129.7	5.1	0.5	1.1	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
12	18.1	27.8	40.0	13.7	0.4	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Riffles in Reach 12 are **properly functioning** for average sediment amounts, with 18.1% fines (sand, silt, and clay), which does not exceed the <20% criteria.

Table 55. Summary of Pool Habitat and Substrate Percentages in Reach 12.

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
12	27	58.3	8.3	1.8	0.2	1.6	28.1	26	27.1	0	0
Properly Functioning Indicators	-	-	-	-	-	>1'		-	-	-	-

Substrate Summary							
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
	12	26.7	27.0	34.8	11.1	0.4	100.0

Reach 12 was **properly functioning** for pool quality, with an average residual pool depth of 1.6', which exceeds the minimum of >1' for a properly functioning stream. The pool development in Reach 12 is exempt from analysis, although volume is nearly adequate for this size of stream. The reach is less than a 3rd order stream and not analyzed for pool development.

Table 56. Habitat Characteristics for the Reach 12.

Reach	Pool:Riffle Ratio	Bankfull Width: Depth	Pieces of LWD per Mile	Total Unstable Banks	Percentage of Unstable Banks
12	1:1	4.2:1	0.0[1]	1,613	15.9
Properly Functioning Indicators	-	<12:1	-	-	10-20 At Risk

[1] Reach 12 is a meadow reach and LWD analysis is exempt.

Reach 12 is a meadow reach with no large woody debris recruitment. Meadow reaches are exempt from large woody debris matrix analysis.

Length of stream bank stability in Reach 12 is between 10 and 20% unstable and within the **at risk** classification. Bank stability appears to be related to grazing.

Bankfull width-to-depth ratio for Reach 12 is 4.2:1, and within the <12:1 properly functioning indicator for an "E" channel.

Possible stream improvements include building bridges over two stream crossings on Forest Service Trail 51. Bridges should be built in a way to permit uninhibited flow during flood events. Areas that have been impacted by past grazing should be rested through the range rider program. At this point, the garbage-strewn campsite must be cleaned up by Forest Service employees. However, wilderness camping and use education is an important management step that will help encourage low impact camping techniques thereby improving the quality of Wilderness areas.

Reach 13: Rito Anastacio to Headwater Source

Photo 47. NSO 680, P262. Typical strectch in the upper half of Reach 13.

Reach 13 begins at the river's confluence with Rito Anastacio, and ends 2.0 miles upstream at the headwaters (T22N, R1E, S27, elevation 10,440 feet). Just before the headwaters the stream goes dry and a tributary was observed contributing 100% of flow in the July 2003 (though in October 2002 it was dry). The survey concluded 123 feet upstream of this tributary (a dry defined channel) at a marshy meadow with pockets of water, but no obvious flow.

Reach 13 is Rosgen stream type E5, running through an open meadow with a low gradient (1.42%) and high sinuosity (1.32). Top of the reach runs through a short steep wooded canyon to an open meadow that is the headwaters for Rio de las Vacas. Long narrow pool habitats distinguish this reach. In addition for the last 1.14 miles a thin layer of soil and grasses covers the stream leading to subterranean flow for short stretches. Sand, gravel, and cobble characterize the substrate of this reach.

Photo 48. NSO 522, P174. D. Goodman and S. Adams with a long (72') and narrow pool (7'), typical in Reach 13 (13-Oct-2002).

Overall, the valley floor is wide (1/8th mile) with spruce and white fir growing at the valley edges. Though primarily covered with grass, sedges (in wet areas) and other herbaceous vegetation, the valley does support a small amount of Bebb's willow and cinquefoil. Although there is little woody vegetation, thermal protection is provided by a thick mesh of tall grasses, deep undercut banks, and subterranean flows. Along the stream, some of the margins were marshy. There were also four small marsh areas (no larger than 40 feet by 50 feet) and deep stagnant water holes (perhaps cattle collapsed pockets) that did not appear to be directly connected to the stream. Another unique feature along this reach were short sections where the stream flow was actually subterranean (see Photo 45).

The lower half of the reach seems stable, with only two dry side channels. As you approach the headwaters, though there are multiple dry channels, showing a more active channel. In addition there many short riffles that are still thickly vegetated with grasses, showing they are either recent additions to the stream channel or that there is infrequent flow through them. Multiple ox bow pools (some dry and some still holding water) show that the stream has naturally changed its course several times.

Photo 49. NSO 622, P220. S. Adams with a slot pool and subterranean channel of Reach 13 (13-Oct-02)

Twenty-one tributaries enter this reach. Of these one spring is deep enough and provides sufficient flow (5%) to provide possible fish habitat (NSO 285 T33). Another tributary, a stream closer to the headwaters (T51) was noted to have Rio Grande cutthroat in it. The majority of the other tributaries within this reach are seeps that do not provide fish habitat.

The reach is in an open valley and highly accessible. It has experienced a large amount of cattle and human use. Increased usage of the stream and riparian habitat has led to increased stream impacts. Bank instability, compaction of banks and upland grasslands, browsed grass stubble, and slumping undercuts are all signs of cattle impact (see Photo

46). This section is within the San Pedro cattle allotment. In October 2002 seven cows were observed within this reach. Thirty-five cattle were observed near the stream on July 16, 2003.

Photo 50. NSO 551, R256. Grazing impacts cause bank instability (12-Oct-02).

Forest Service Trail# 51 runs along the entire length of this reach, providing easy human access to the stream. For the most part, the trail lies off of the stream, but in a few places where the trail comes close to the stream small slumping does occur. Near the beginning of the reach there is one human placed "stream improvement" – a log and rebar structure intended to create a pool (NSO 533 R241). However, the structure is not properly functioning, as water flows around it, widening, rather than deepening the channel.

Rio Grande cutthroat trout of varying size classes were observed in many pools throughout this reach.

Water temperatures were measured at random intervals during the 2002 survey using a handheld thermometer. Main channel temperature readings were taken in the water column in main channel habitats during the survey (grab samples). The 11 water temperature samples ranged between 34 and 53 F in 2002. Average grab sample temperature was 45.2 F.

Habitat Characteristics

Table 57. Overall Stream Summary for Reach 13.

Reach 13					
Stream Length Surveyed:		18,308 feet		3.47 miles	
Gradient:	1.4		**Rosgen Channel Type:**	E5	
Habitat Type	**Total Number**	**Total Feet Of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	171	10,260.5	56.0	56.0[1]	-
Riffle	120	8,046.5	44.0	44.0	-
Culvert	0	0	0	0	-
Tributary	8	-	-	-	-
Falls	0	0	0	0	-
Side Channel	0	0	-	0	-
Total	314	18,308	100.0	100.0	-

[1]Pool development is exempt and not analyzed in Reach 13 due to stream order (<3rd).

During the habitat survey conducted on Reach 13, the river was broken up into a total of 171 NSOs, measuring 18,308 feet in length. Of the 314 NSOs, approximately 54.5% were pools. These 171 pools comprised 56.0% of the stream habitat for the entire reach, 120 riffles accounted for the other 44% of the stream habitat. No flowing side channels were found in Reach 13.

When compared to the matrix of factors and indicators of stream health condition for historic and occupied RGCT streams, Reach 13 is **properly functioning** for all criteria in the category of habitat characteristics and channel condition, except sediment content. Sediment content was **not properly functioning**. Large woody debris and pool development analysis is exempt from matrix analysis.

Table 58. Summary of Habitat and Substrate Percentages for Riffles in Reach 13.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
13	120	67.1	2.7	.6	1.0	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
13	48.1	36.9	14.2	.8	0.0	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Riffles in Reach 13 are **not properly functioning** for average sediment amounts, with 48.1% fines (sand, silt, and clay), which exceeds the <20% criteria. The riffle substrate was dominated by sand. The high fine content, while partly attributable to the small flow regime, appears to be escalated by the amount of unnaturally unstable banks.

Table 59. Summary of Pool Habitat and Substrate Percentages in Reach 13.

Pool Habitat Summary

Reach	# Of Pools

A few improvements could be made to this reach. The sections of Forest Service Trail #51 that lie close to the stream, causing bank instability, could be rerouted away from the stream. The log and rebar structure, near the beginning of this reach could be removed to improve stream flow. Areas that have been impacted by past grazing practices should be rested through the range rider program. This action would also allow the banks to stabilize and encourage the growth of riparian vegetation, specifically willow.

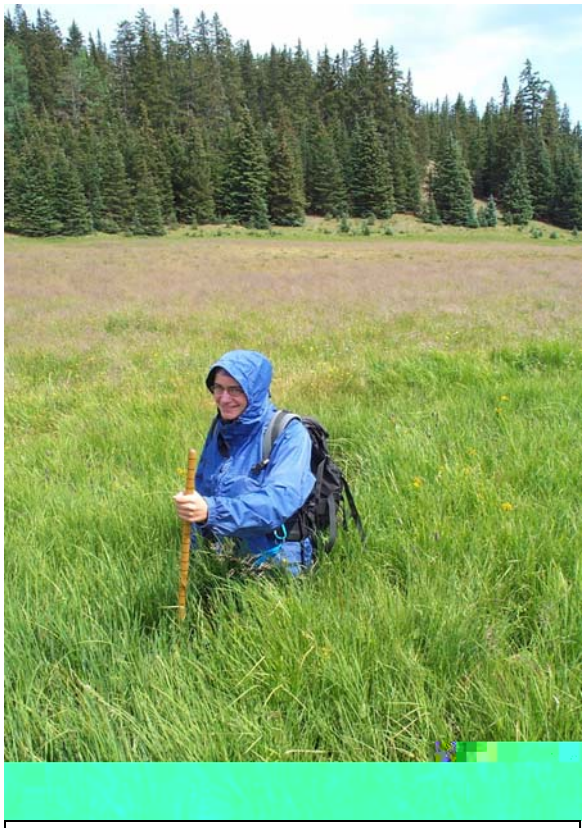


Photo 51. NSO 729. P 292. S. Eddy in a narrow pool near top of Reach 13.

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.

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

*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:
Pool Volume Proof

$$f(x,y) := \left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2$$

Area of an Ellipe

$$\int_{-a}^{a}\int_{-b\cdot\frac{\left(a^2-x^2\right)^{.5}}{a}}^{b\cdot\frac{\left(a^2-x^2\right)^{.5}}{a}} 1\,dy\,dx \rightarrow$$

3.14159265358979323 85

or π*b*a

Volume of a parabolic ellipsoid with h=height a=from ctr to b is from center to edge 1

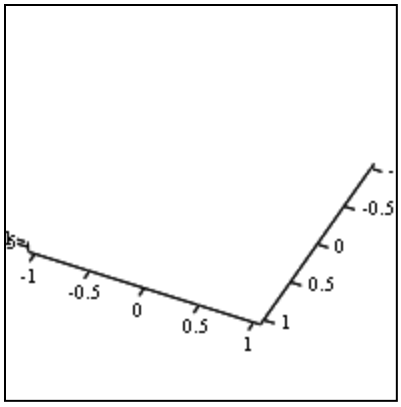
$$\int_{-a}^{a}\int_{-b\cdot\frac{\left(a^2-x^2\right)^{.5}}{a}}^{b\cdot\frac{\left(a^2-x^2\right)^{.5}}{a}}\int_{0}^{h\cdot\left(\frac{x^2}{a^2}+\frac{y^2}{b^2}\right)} 1\,dz\,dy\,dx \rightarrow$$

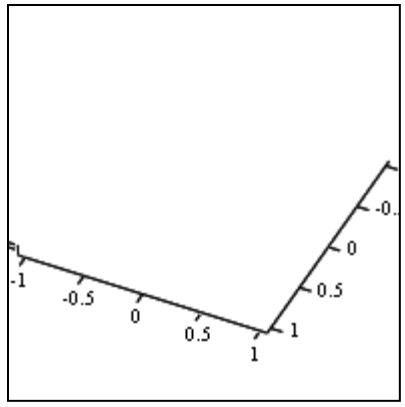
$\frac{\pi}{2}\cdot h\cdot b\cdot a$ I believe this is your volume

$a := 4 \qquad b := 5$

$$f(x,y) := \left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2$$

Surface Plot **Contour Plot**



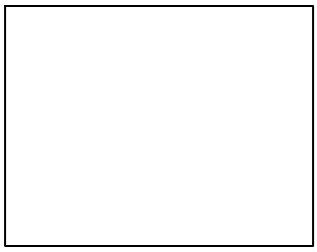


x = 0 y = 0

f f

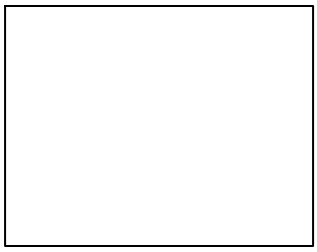
Cross Sections (2-D)

$f(0,y)$



y

$f(x,0)$



x

For pool volume calculations the corrected average width, average max depth and average length is applied to the formula and multiplied by the number of habitats. Pool volume proof was derived and submitted by Matthew Goodman.

Riffle volume is estimated by the volume of a prism. Measurements used are average length (L), corrected average width (W) and average depth (D) multiplied by the number of riffle habitats (N).

$L_{ave}*w_{ave}*d_{ave}*N$= Riffle Volume

Appendix C:
Tributaries

Table 1. Information summary of tributaries to Rio de las Vacas.

Reach Number	NSO Number	Habitat Number	Bank	Type	Name	% Flow	Date	Time	Trib Temp (F)	Stream Temp (F)	Comments
1	2	T001	left	stream		5	4-Jul-01	10:45	60	62	comes from a subterrain channel
1	3	T002	left	spring		<5	4-Jul-01	11:00	55	62	heavily shaded
1	4	T003	right	seep		<5	4-Jul-01	11:20	58	62	heavily shaded
1	5	T004	right	spring		<5	4-Jul-01	11:34	50	62	heavily shaded
3	100	T005	left	spring		n/a	6-Aug-01	15:15	47	70	Fry in spring
3	114	T006	left	stream	Trail Creek	10	7-Aug-01	15:45	60	65	unstable banks caused by dispersed camping
4	119	T007	left	spring		<5	7-Aug-01	12:05	61	66	large wet meadow
4	135	T008	n/a	stream	Telephone Creek	n/a	7-Aug-01	12:50	62	64	turns into a wet meadow
6	143	T009	left			<5	7-Aug-01	15:45	59	63	
6	153	T010	right	stream	Rock Creek	5	15-Aug-01	15:15	61	63	unstable banks
8	169	T011	left	stream	Clear Creek	30	4-Sep-01	15:30	60	60	old beaver dam on creek; fish present
10	324	T012	right	spring		<5	11-Sep-02	16:30	52	52	low but steady flow
10	325	T013	right	spring		<5	11-Sep-02	16:41	52	52	originates in dry sidechannel
10	330	T014	right	stream	Las Perchas	45	11-Sep-02	1111	50	49	viable fish habitat; significant grazing impacts
11	354	T015	right	seep		<5	10-Oct-02	1445	53	37	enters side channel; marshy; cattle impacts visible
11	364	T016	left	seep		<5	10-Oct-02	1050	37	37	marsh
11	365	T017	left	stream		<5	10-Oct-02	1125	41	37	lots of wood
11	388	T018	right	stream		n/a	11-Oct-02	15:05	39	40	large channel with boulders
11	389	T019	right	seep		n/a	11-Oct-02	15:10	45	40	low flow
11	423	T020	right	seep		<5	12-Oct-02	1245	47	44	heavily grazed
11	432	T021	left	spring		<5	12-Oct-02	1405	45	43	
11	434	T022	left	spring		n/a	12-Oct-02	n/a	n/a	43	comes from two sources; one is the same as T021
11	440	T023	left	stream		<5	12-Oct-02	n/a	n/a	43	
11	454	T024	left	seep		<5	12-Oct-02	1710	36	43	enters main channel at two locations
11	455	T025	right	seep		<5	12-Oct-02	1713	47	43	low gradient
11	456	T026	left	stream		n/a	12-Oct-02	1707	40	43	many boulders, channel does not consistantly contain water
12	463	T027	left	spring		<5	13-Oct-02	1015	42	38	
12	476	T028	left	stream		<5	13-Oct-02	1120	39	39	ends at a pool
12	503	T029	left	seep		<5	13-Oct-02	1424	44	44	drains wet meadow; enters stream in 3 locations with lowest the most significant
12	506	T030	right	seep		<5	13-Oct-02	1430	57	44	stagnant pool above mouth
12	521	T031	left	stream	Anastacio	40	13-Oct-02	1600	51	44	
13	554	T032	right	seep		<5	14-Oct-02	1106	42	37	low gradient

13	785	T048	n/a	seep		10	17-Jul-03	n/a	n/a	52	
13	805	T									

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