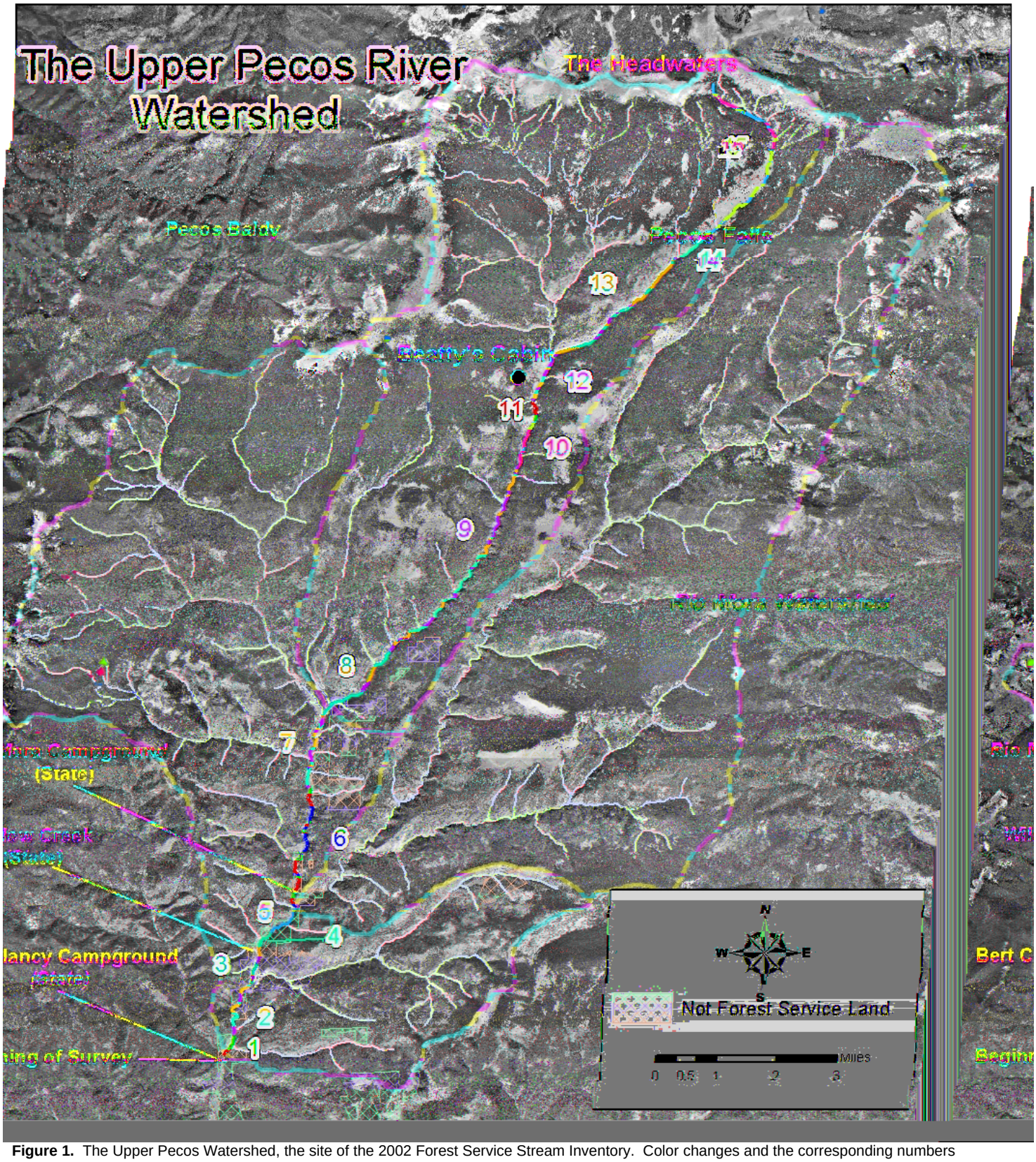

Figure 1. The Upper Pecos Watershed, the site of the 2002 Forest Service Stream Inventory. Color changes and the corresponding numbers represent the reach divisions of the stream survey.

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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

Pecos River 2002 Stream Survey

The Pecos River is the last south-flowing river system in the Rocky Mountain Range. The Pecos originates as a series of springs draining off the south slope of the Santa Barbara Divide in the Pecos Wilderness (Township 20 North, Range 13 East, Section 10 at 11,700 feet). The river flows through a series of reservoirs and dams over 926 miles before becoming part of the Rio Grande in Texas. The Santa Fe National Forest Fisheries Program conducted a stream survey on the upper headwaters section of the Pecos River during the summer of 2002. A total of 22.4 miles of stream was surveyed, from the confluence with Holy Ghost Creek (T18N, R12E, Sec. 33, 7760') up to the headwaters.

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

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

Snorkel surveys are another aspect of the stream inventory incorporated for understanding fish populations. Snorkel surveys evaluate fish species presence/absence, distribution within the system, relative composition, and size class analysis in selected areas of the stream. Snorkel protocol involves surveying upstream in one hundred meter transects and classifying fish that pass

downstream. Fish species are identified, placed into size categories and counted by the surveyor. Ideally, a snorkel survey includes 10-100 meter transects (totaling 1 kilometer), but are occasionally composed of less (USFS 2002).

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

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

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

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

The primary objectives of the Region 3 Hankins/Reeves survey include the compilation of historical information and in-stream habitat data to assist in proper management decisions of the surveyed stream and its watershed. The historical information provides a background of land use and management techniques collected from the Forest Service and a variety of other sources. Previous

land use and management practices reflect on the current condition of environmental systems. Historical information helps explain the current condition of the river and is incorporated into the survey. Understanding events that formed the habitat condition enhances decision-maker options. In-stream survey data is collected to provide an overview of the current condition of a stream. Survey data produces a "snapshot" in time of the stream's habitat condition and the factors affecting it. Survey information can be used to identify both degraded sections as well as ideal areas to be used as a reference or model for other similar sections of stream. By combining the historical and current information pertaining to a stream, management options can be more clearly identified, which is the goal of this document.

Photo 1. Snorkeler in a pool in Reach 6 during the 2002 Pecos Stream Inventory**.**

BASIN SUMMARY

Table 2. Stream Summary Table for the Pecos River.

LOCATION:	
County:	San Miguel and Mora County
Forest:	Santa Fe National Forest
District:	Pecos
Drainage:	Pecos River
Tributary to:	Rio Grande
Survey Began at:	T18N, R12E, S33 at 7,760 feet
WATERSHED:	
HUC Code[1]:	1302020202
Watershed Area:	95,673 acres 150 square miles
Stream Order:	5
Stream Length:	118,024 feet[2] 22.4 miles[2]
AQUATIC BIOTA:	
Fish Species:	Rio Grande cutthroat trout[3] *(Oncorhynchus clarki virginalis)*, rainbow trout (*Oncorhynchus mykiss)*, brown trout (*Salmo trutta)*

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

EXECUTIVE SUMMARY

Pecos River is a 5th order stream originating from springs draining the south side of the Santa Barbara Divide (T20N, R13E, Sec. 10, 11,700'), on the Pecos Ranger District of the Santa Fe National Forest (Forest). The stream survey covered a 22-mile stretch, from the confluence with the Holy Ghost Creek (T18N, R12E, Sec. 33, 7760') up to the source. This whole section is designated as a Wild and Scenic River. Fisheries populations are present from the beginning of the survey to a falls habitat at survey mile 21. The Pecos Headwaters drains a rugged area of the Pecos Wilderness with tributaries originating from mountains well over 12,000 feet such as the Truchas Peaks, Pecos and East Pecos Baldy, and Chimayosos Peak. The watershed encompasses 95,673 acres (150 square miles), owned by the Forest, New Mexico Department of Game and Fish (NMGF), and private landowners.

Pecos River is divided into 15 reaches, each containing relatively homogeneous habitat characteristics. Reach divisions are based on stream and valley morphology, dramatic changes in stream flow, impoundments, or land ownership boundaries. Reaches are numbered sequentially as the survey progresses upstream (see Table 3).

The average gradient of the Pecos River is 3.4% or 180.3 feet per mile. When evaluated by reach divisions, the gradient ranges from 0.01% in Reach 3 to 7.5% in Reach 14 (see Table 9).

Photo 2. The Pecos River Valley with the Truchas Mountains and Chimayosos Peak (right) in the background. Photo taken from Hamilton Mesa. All four peaks are over 12,000 feet (19 Aug 2002).

The Pecos River originates in the Pecos Wilderness of the Sangre de Cristo Mountains, the southern most section of the Rocky Mountains. The Rocky Mountains were formed approximately 70 million years ago during the Mesozoic Era. Their formation occurred during the *Cordillerian Orogeny* when the continental crust was folded and uplifted throughout the Americas from Alaska to the southern tip of South America. The Upper Pecos River flows through broad valleys and deep bedrock canyons. Rock formations in the watershed include red shale, sandstone, limestone, granite, amphibolite, quartzite and schist. The rock formations originated between 3000 + million years ago (Precambrian

Era) and 50 million years ago (Tertiary Period). The mountains surrounding the Upper Pecos River, including the Truchas Mountains, Pecos, East Pecos Baldy, and Chimayosos, were shaped by glaciers that covered most of North America (see Photo 2). The glaciers receded approximately 12,000 years ago, leaving behind the landscape seen today in the watershed (Sutherland & Montgomery 1975).

Stream flow in the Pecos River fluctuates between the high flow events in the spring and lesser events in the late summer to low flow in the mid summer. Spring high flow events originate from snow runoff and vary with the previous winter's snow pack. The snow pack of 2002 was unusually low and related to drought conditions that reduced the intensity of the spring runoff. The late summer high flow events are related to monsoon weather patterns, which typically develop in July and August. The flow related to monsoon events is not as severe as the spring runoff. Low flow in the Pecos River usually occurs in June, fall and winter seasons, when flow is dependent on spring sources.

Table 3. Description and length of reaches on the Pecos River.

Reach	River Miles	Landmark at Beginning and End	Land Owner
1	0.0 to 0.3	Holy Ghost Creek to beginning of canyon system near Terrero Store	Forest and NMGF
2	0.3 to 1.5	V-Shaped canyon type system to change in valley morphology below Willow Creek	Forest and NMGF
3	1.5 to 1.9	Broad canyon to a bridge marking the beginning of private land above Willow Creek Recreation Area.	Forest and NMGF
4	1.9 to 2.6	Private land marked by a bridge and fencing. **Not Surveyed.**	Private Land
5	2.6 to 3.2	End of private land to confluence with Rio Mora.	Forest and NMGF
6	3.2 to 5.5	Rio Mora to widening of valley below Cowles	Forest and NMGF
7	5.5 to 6.9	A wide valley system to confluence with Panchuela Creek	Forest
8	6.9 to 8.9	Just above Panchuela Creek to beginning of bedrock canyon.	Forest
9	8.9 to 13.1	Beginning to end of bedrock canyon system.	Forest (Wilderness)
10	13.1 to 14.0	End of bedrock canyon system to next bedrock canyon system.	Forest (Wilderness)
11	14.0 to 14.4	Second bedrock canyon system to confluence of Beatty's Creek	Forest (Wilderness)
12	14.4 to 15.2	Beatty's Creek to the confluence with Rito del Padre.	Forest (Wilderness)
13	15.2 to 18.1	Rito del Padre to the confluence with Jarosa Creek	Forest (Wilderness)
14	18.1 to 18.7	Jarosa Creek to the top of Pecos Falls	Forest (Wilderness)
15	18.7 to 23.3	Pecos Falls to source below Santa Barbara Divide.	Forest (Wilderness)

One water diversion is in the surveyed portion of the Pecos River: An irrigation ditch located near the Mora Campground in Reach 5. The ditch diverts water from a significant side channel on the

west bank of the river. The diversion consists of a natural side channel, which has been modified with a gabion dam to divert the water into a ditch (see Photo 3). The ditch diverts an estimated 20 to 30% of the total flow of the Pecos River. Stream alteration is evident at the entrance and within the side channel. Stream alterations related to the diversion include wood clearing in the secondary channel and a cobble structure at the top of the side channel that extends into the Pecos River. It is apparent that this is to increase flow into the side channel.

Water quality in the Upper Pecos River has received special attention because of the Terrero Mine Mill Site, located near the confluence with Willow Creek in Reach 3. The current Superfund Terrero Mine Cleanup has been justified through a variety of environmental assessments and water quality studies. The motivation for the clean up effort originated from a series of large-scale fish kills (approximately 90,000 fish in one event) occurring down stream of the old mine site subsequent to surface runoff events (Robinson 1995). Elements of specific concern from the mine site and its associated waste materials include copper, zinc, lead and selenium (Sinclair 1990).

Photo 3. Reach 5, NSO 32, S4. The only flow diversion on the surveyed length of the Pecos River. The gabion structure modified an existing side channel into a diversion that takes approximately 20 to 30% of the main channel flow (4 July 2002)

The 2002 survey was accompanied by temperature analysis at 4 thermograph or temperature recording sites. The thermograph sites were distributed from the beginning of the survey, just above the confluence of Holy Ghost Creek, up to Beatty's Cabin in Reach 12. The stream temperatures were analyzed and classified by both Forest and New Mexico Environment Department (NMED) Standards. The Forest and NMED temperature standards classify coldwater fisheries habitat as properly functioning, at risk, or not properly functioning. Water temperatures at the temperature stations are classified as **at risk** at 3 of the 4 sites by Forest standards and 2 of the sites by NMED standards.

Habitat Characteristics

The 22.4 surveyed miles (118,024 feet) of the Pecos River is divided into 598 Natural Sequence Order Habitat Units (NSOs). The 182 pool habitats comprise 5.8% of the stream habitat length. There are 281 NSOs that are riffle habitat, which comprises the majority of habitat in the Pecos River (see Table 4). Other habitat types in the Pecos River are tributaries, falls, and side channels. Tributaries to the Pecos River are not considered stream habitat and are excluded from length and habitat analyses.

Table 4. Stream summary information for the Pecos River Survey 2002.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	182	7,345	6.3	5.8	>30%
Riffle	281	110,392	93.5	86.9	-
Culvert	0	-	-	-	-
Tributary	84	-	-	-	-
Falls	6	287	0.2	0.2	-
Side Channel	45	8,980	-	7.1	-
Total	598	127,004	100.0	100.0	-

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

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, the Pecos River contains not properly functioning, at risk and properly functioning characteristics (see Table 5). The parameters that are **not properly functioning** include the density of large woody debris (LWD), and pool development. Temperature is **at risk** at two of the four stations by NMED standards and 3 stations by Forest standards. **Properly functioning** characteristics include riffle sediment content, pool quality and stream bank condition.

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

Factors	Indicators	Pecos River Conditions
Water Quality	Temperature 3-Day Average	**Site 1) Just above Holy Ghost**
		Site 2) Just above Rio Mora
		Site 3) Below Jacks Creek
		Site 4) Near Beatty's Cabin
Salmonid Development	Temperature 7-Day Average	**Sites 1-3) At Risk**
Habitat Characteristics	Riffle Sediment	**Properly Functioning**
	Large Woody Debris	**Not Properly Functioning**
	Pool Development	**Not Properly Functioning**
	Pool Quality	**Properly Functioning**
Channel Condition and Dynamics	Stream Bank Condition	**Properly Functioning**
	Width-to-Depth Ratio	**Not Properly Functioning**

Red= Not Properly Functioning Yellow = At Risk

The riffle habitat in the Pecos River is the dominant habitat, comprising 86.9% of all stream habitat types. The high relative quantity of riffle habitat reflects the lack of pool habitat. Sediment content

in riffle habitat (14.2%) was determined to be **properly functioning** (see Table 6). The dominant substrate type is cobble followed by boulder.

Table 6. Summary of habitat and substrate composition in the Upper Pecos River

Habitat Summary					
	# of Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth
Entire River	281	392	17.1	1.0	1.9

Substrate Summary						
	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Total (%)
Entire River	14.2	21.9	33.1	26.7	4.2	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool habitat is important over wintering, resting, and feeding habitat for fish. Pool habitat is evaluated by both quality or residual depth and area of pool habitat (by length). Pool quality is **properly functioning** in the Pecos River with 99% of the pool habitats with at least 1-foot residual depth. Residual depth is calculated by subtracting the maximum depth from the pool tail crest depth to determine the depth of water that would remain in the habitat if flow ceased. The average residual pool depth is over twice the properly functioning indicator (see Table 4). The relative quantity of pool habitat (5.8%) is **not properly functioning** (see Table 7). Increasing pool habitat in the Pecos River should be a priority in the river's management.

Table 7. Summary of pool habitat and relative substrate in the Upper Pecos River.

Pool Habitat Summary											
Area	Number of Pool Habitats	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools per Mile	Number of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	Number of Pools w/ Max. Depth >3'	Number of Pools w/ Max. Depth >3'/Mile
Entire River	182	40.0	15.7	2.8	0.8	2.0	8.1	180	8.1	62	2.8
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary						
Area	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	% Total
Entire River	27.3	17.0	22.0	18.9	14.8	100.0

Large woody debris (LWD) is related to habitat complexity and the health of fish populations in stream habitats (Fausch and Northcote 1992). LWD density is **not properly functioning** in the Pecos River. The LWD density is 18.5 piece per mile, far below the standard (see Table 8). The Pecos River had 414 pieces of wood classified as medium and large sizes. Wood classified as medium LWD must be greater than 12 inches in diameter at a length of 35 feet from the large end. Large pieces of LWD have a diameter of greater than 20 inches at a length of 35 feet from the large end. Increasing the LWD density should be a focus in the management of the Pecos River. Increasing LWD may also improve other degraded factors in the stream habitat including pool development.

Bank stability (4.4%) is **properly functioning** when analyzed by the length of the entire surveyed section of stream. When the length of the river is divided into reaches and then analyzed, Reach 5 is the only reach that is **not properly functioning** for bank stability. Although the length of bank instability is **properly functioning**, several areas could use mitigation. Areas of instability in need of management are primarily near the state campgrounds as well as several sections in Reach 15.

Table 8. Selected habitat charicterisics in the Pecos River.

Area

Reach by Reach Comparison

The 15 reaches of the Pecos River contain different combinations of properly functioning, at risk, and not properly functioning characteristics. Pool habitat, LWD density, bankfull width:depth ratio and unstable banks are parameters that are outside of properly functioning classification in at least one reach. None of the surveyed reaches are properly functioning in all categories (see Table 9).

Table 9. Reach characteristic summaries for the Pecos River 2002.

Reach	Total Length (mi)	Gradient (%)	Rosgen Channel Type	Pool Habitat (%)	Riffle Habitat (%)	Side Channel Habitat (%)	Dominant Substrate in Pools	Dominant Substrate in Riffles	LWD Per Mile	Bankfull Width to Depth	Unstable Banks (%)
1	0.3	1.7	B3c	0.0	100.0	0.0	-	Cobble	0.0	29:1	0
2	1.2	1.4	B3c	5.1	90.3	4.6	Gravel/ Cobble	Cobble	13.7	26:1	7.7
3	0.4	1.0	B3c	2.3	97.7	0.0	Cobble	Cobble	5.3	43:1	6.5
4	1.2	1.1	Private Land Not Surveyed								
5	0.6	1.7	B3	0.0	76.8	23.2	-	Cobble	0.0	31:1	31.4
6											

Red= Not Properly Functioning Yellow = At Risk

Photo 4. Reach 14, NSO 481, R238. Typical log jam; one of two reaches in the Pecos River with a properly functioning LWD density (28 Aug 2002).

Bankfull width-to-depth ratio is **not properly functioning** in 5 of the 15 reaches. Bankfull width-to-depth ratio in each reach is compared to the expected range for its related Rosgen stream type. Reaches 3 and 5 exceed the expected range while 10, 11 and 12 are below (see Table 9).

Photo 5. Reach 5, NSO 35, R25. Damon Goodman with bank instability and trampled riparian vegetation NMGF's Rio Mora Campground (4 July 2002) Note: The area was closed to public due to extreme fire danger.

Fourteen (14) of the fifteen reaches have **properly functioning** bank condition. Reach 5 is **not properly functioning** with 31.4% of the banks showing signs of current erosion. This high amount of bank instability is related to the reach's proximity to the degraded state managed Mora Campground (see Photo 5). The **properly functioning** reaches range from no bank instab Tc 0 Tw 12 0 02 40 3

Tributaries

Eighty-four (84) tributaries in the form of seep, spring, and stream habitats contributed surface flow to the Pecos River during the survey. Of the 84 tributary habitats, 12 are consideredsignificant, contributing 10% or more to the main channel flow (see Table 10). The flow contribution can be deceptive because of its relative and not discrete measurement. A majority of tributaries is found in the upper reaches.

Photo 6. Panchuela Creek, a significant tributary, marks the end of Reach 7 (25 July 2002).

Several significant tributaries altered the habitat enough to create a reach break. Tributaries that contributed to reach breaks are Rio Mora (at the top of Reach 5), Panchuela Creek (7), Beatty's Creek (11), Rito del Padre (12), and Jarosa Creek (14). Beatty's Creek is the only tributary that is at the end of a reach that did not contribute 10% or more to the main channel flow. The Beatty's Creek reach break at the end of Reach 11 was due to a change in valley morphology, which was marked by the entrance of the tributary.

The most significant tributary on the Pecos River is the Rito del Padre contributing over half of the main channel flow. Rito del Padre begins on the southeast slope of Chimayosos Peak and is soon joined by Rito Maestas and then Rito de los Chimayosos and finally Rito Sebadillos before it enters the Pecos. This complex drainage originates in some of the tallest mountains in the Pecos Wilderness including the three Truchas Peaks, the tallest of which is over 13,000 feet.

The Rio Mora did not contribute the greatest flow relative to the main channel, but it did contribute the most flow of any tributary. The Rio Mora has a large watershed that encompasses several tributaries including Valdez Creek and 34,530 acres. During the survey the Rio Mora was contributing ash to the Pecos River from the 2002 Trampas Fire. The Trampas Fire covered 4,751 acres located entirely within the Mora Watershed (See Fire Section). At the confluence of the Pecos and the Rio Mora, heavy recreational impacts are evident from the state-owned Mora Campground. This campground receives intensive use in the summer months and is leading to significant habitat degradation of both the Mora and Pecos Rivers.

Table 10. Summary of tributaries contributing more than 10% of the main flow of the Pecos River during the 2002 Stream Inventory.

Location		Bank	Habitat Type	Name	Percent Flow*	Time	Tributary Temp (°F)	Stream Temp (°F)	Comments
Reach	Tributary Number								
6	1	Right	Stream	Rio Mora	40	15:50	60	59	Heavy recreational impacts from state owned campground
7	7	Left	Stream	Winsor Creek	10	13:30	57	59	V-type stream improvements in tributary. Diversion from creek feeds Cowles fishing ponds.
7	9	Left	Stream	Panchuela Creek	40	13:35	60	59	Drains south slope of Pecos Baldy and the east slope of Redondo Peak
12	30	Left	Stream	Rio Padre	60	17:30	56	56	Drainage includes the Truchas and Chimayosos Peaks
13	53	Left	Stream	Jarosa Creek	25	11:30	49	49	Marks the end of Reach 13
15	70	Right	Stream	NA	20	11:10	48	48	
15	77	Left	Stream	NA	10	14:30	55	56	
15	80	Right	Stream	NA	40	15:30	48	NA	
15	81	Right	Spring	NA	>40	1540	47	NA	Tributary has five sources. Enters the Pecos 20 feet above T80
15	82	Right	Stream	NA	>40	NA	NA	NA	
15	83	Right	Stream	NA	20	1720	49	40	
15	84	Right	Spring	NA	40	1740	49	40	

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

Stream Flow

The Pecos River begins as a cluster of 5 springs on the southeast slope of the Santa Barbara Divide. From the headwaters to Holy Ghost Creek, the Pecos River is joined by several considerable watersheds including the Padre, Panchuela, Winsor and the Mora. All of the smaller watersheds that comprise the Upper Pecos River originate in the Sangre de Cristo Mountains. The snow pack of the

mountain basins governs the flow of the Pecos and its tributaries. Peak stream flow of the Pecos River occurs between late May and early June. Smaller high flow events take place after late summer monsoon events. Stream flow during the 2002 Forest Service Stream Inventory was lower than typical years due to drought conditions in Northern New Mexico.

Flow was measured utilizing Swoffer brand flow meter on July 15th 2002 in Reach 1, River Mile 0. The flow measurement location is at the beginning of the survey just above Holy Ghost Creek. The flow measurement location was in a straight section of riffle with as few flow restricting obstacles (boulders, logs, etc.) as possible. A transect was created and divided into 26 equally spaced sections. At each section, flow was taken at 60% of the depth in twenty-second intervals. The average flow is recorded from each section and related to area to calculate the stream flow. The Pecos River flow on July 15th was 26.9 cubic feet per second (cfs).

Water diversions in the surveyed length of the Pecos River include one irrigation ditch located in Reach 5 near the Mora Campground. The irrigation ditch diverts water from a significant side channel on the west bank of the river. The diversion consists of a natural side channel, which has been modified with a gabion dam to divert the water into a ditch. The ditch diverts an estimated 20 to 30% of the total flow of the Pecos River. Stream alteration is evident at the entrance and within the side channel. Stream alterations related to the diversion include wood clearing in the secondary channel and a cobble structure at the top of the side channel that extends into the Pecos River. It is apparent that this is to increase flow into the side channel.

The Cowles Fishing Ponds are human constructed ponds located near the confluence of Winsor Creek and the Pecos River in Reach 7. The two ponds are stocked by NMGF and provide fishing opportunities for children. These ponds receive heavy recreational use during the summer months. A culvert connects the ponds with the Pecos River. In several other areas the water seeps through the constructed barrier between the Pecos River and the ponds. The ponds are fed by a diverson in Winsor Creek. The water in Winsor Creek is significantly increased in the ponds. During the survey water temperatures increased from 57°F in Winsor Creek to 68°F prior to entering the Pecos River.

Water Temperature

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).

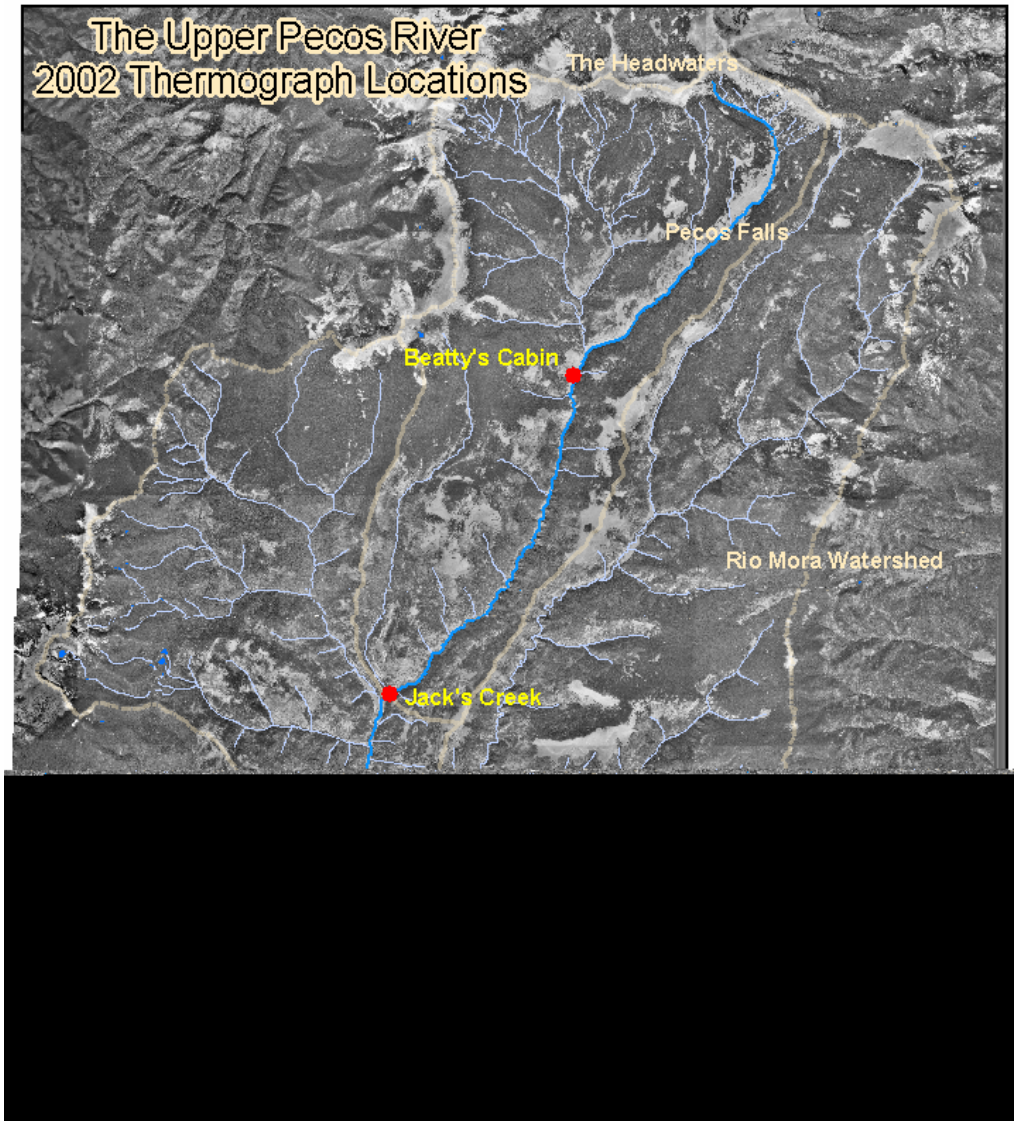


Figure 2. Map of the thermograph locations in the 2002 Upper Pecos Stream Inventory. Temperatures were taken at these sites every 15 minutes between June 25th and October 28th.

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 11) are based on seven-day average maximum temperatures and are stricter than the NMED standards. While it is stricter, the Forest standard is

more in line with approaches taken by U.S. Fish and Wildlife Service and NOAA Fisheries across the western United States. It also allows the SFNF to be more pro-active in improving watershed conditions for native fish as well as ameliorating impairments to water quality before a stream is listed as impaired on the 303(d) list.

NMED standards are based on 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 Appendix A, Figure 1).

Water temperature in the Upper Pecos River was monitored between June 25th and October 28th, 2002. Tidbit thermographs, small temperature recording devices, were strategically placed at 4 locations in the Pecos River. Thermographs recorded temperatures at 15-minute intervals for the duration of their time in the river, providing over 12,100 temperatures for each site. Data collected by thermographs was exported to Microsoft Excel 2000 for analysis and comparison to water quality standards.

Four temperature monitoring stations were established on the Pecos River. The stations were not moved for the duration of the monitoring period. The first station was placed at the beginning of the stream inventory, just above Holy Ghost Creek (Reach 1, River Mile 0.0). The next station was located immediately upstream from the confluence with Rio Mora (6, RM 2.75). The third station, was located immediately below Jacks Creek (8, RM 5.75). The uppermost temperature station was placed near Beatty's Cabin, just above Trail # 260 bridge (12, RM 15.0).

Table 11. Santa Fe National Forest and New Mexico Environment Department Water Quality Temperature Standards 2002.

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 (PF)**, **at risk**, or **not properly functioning (NPF),** but with different requirements (see Table 11).

When Forest standards are applied to the thermograph data, three out of the four stations are **at risk**. The upper most station, near Beatty's Cabin, is the only site that is not **at risk** for high temperatures. Thermograph sites above Holy Ghost and below Jacks Creek had the highest number of days **at risk**. None of the sites were classified as not properly functioning and all of the sites had more **properly functioning** days than days **at risk** (see Figure 3).

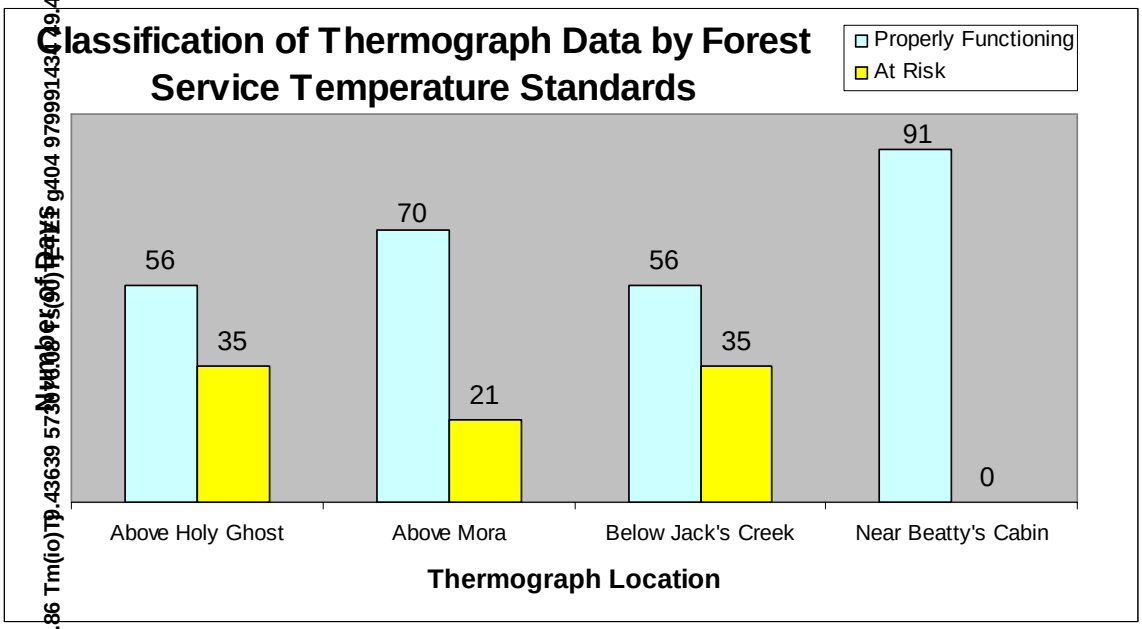
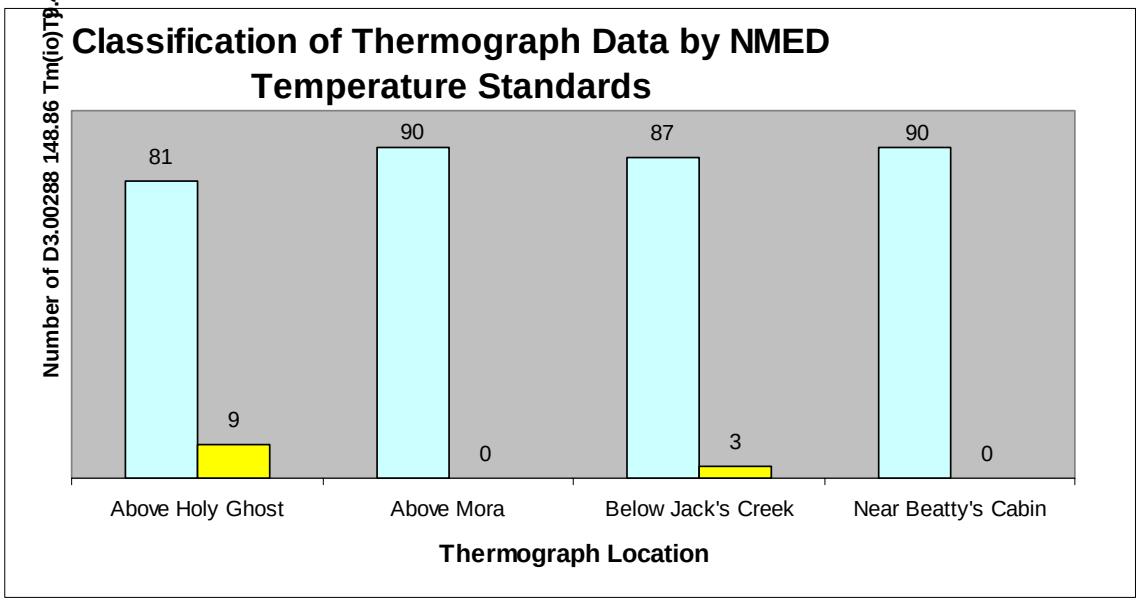


Figure 3. A comparison of at risk and properly functioning days at the thermograph sites on the Upper Pecos River between June 25th and September 30th, 2002. Classification based on SFNF Water Quality Standards of 7-day average max temperatures.

Two stations recorded **at risk** days when classified by NMED standards: Holy Ghost and Jack's Creek. The number of days that the two stations were at risk is much lower than when classified by Forest standards. Holy Ghost site had the highest number of days **at risk**, which was only 10% of the total number of days evaluated. The Jack's Creek Site was **at risk** only 3.3% of the time evaluated. No days were classified as not properly functioning during the 2002 survey**.**



The **at risk** classification of multiple sites by both the Forest and NMED water quality standards implies that water temperature should be a management consideration for the Upper Pecos River. Temperature mitigating strategies should be applied to protect the integrity of the coldwater fishery. Increasing native riparian vegetation and protecting bank stability in high use areas are two means of decreasing water temperatures on the Pecos River.

Utilizing the rate at which water temperatures increase, areas can be identified that are in the most need of temperature mitigation. The most rapid temperature increase is between the Mora River (River Mile 2.75) and Holy Ghost (RM 0). This area receives high recreational use from campers and anglers at NMGF recreation areas. Three recreation areas are located in this area: Bert Clancy Campground, Rio Mora Campground, and Willow Creek Day Use Area. These recreational areas receive very high visitation during summer months and are not managed or maintained. The river is degraded near the recreational areas in a variety of ways that affect stream temperatures. Observed stream degradation include trampled riparian vegetation, wood removed for campfires which are placed as close as 10 feet from the river, decreased bank stability, and other effects of an unmanaged recreation area. Another factor that could be influencing stream temperature between Mora confluence and Holy Ghost Creek is the stretch of private land and on-going Terrero Mine clean up efforts. The Superfund cleanup site leaves a large area of exposed fill material on a steep slope next to the Pecos River and Willow Creek (a tributary to the Pecos). During rain events the exposed soil runs around plastic barriers and into the Pecos River. The increased sediment load could be contributing to a temperature increase by causing stream shallowing.

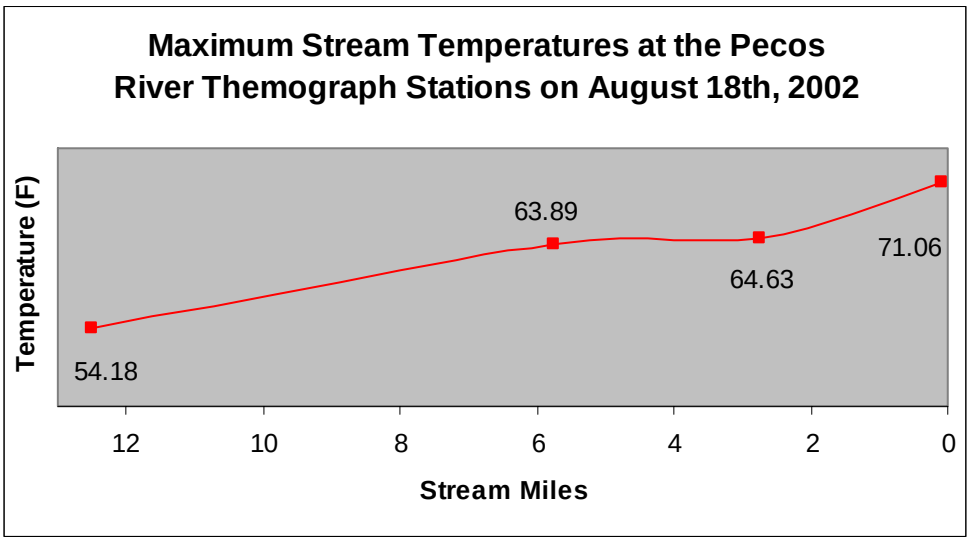


Figure 5. Maximum temperatures at the four thermograph sites on the Pecos River on a particularly warm day. The sites are listed from the highest (Beatty's Cabin) to the lowest (Holy Ghost) and demonstrate the change of temperature with distance.

Diurnal or daily high to low temperature fluctuations are analyzed from the thermograph stations. On August 18th, 2002, a particularly warm day, diurnal fluctuations ranged from 3.6 at the Beatty's Creek Site to 17.5°F at Holy Ghost.

Photo 7. The riparian vegetation of Reach 13 in the Pecos River (10,000 ft). In some areas of the upper reaches, riparian vegetation covers the stream completely (28 Aug 2002).

Riparian and Upland Vegetation

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

Pecos River riparian vegetation includes a variety of native and nonnative species. Native riparian vegetation includes alder, willow and cottonwood species (see Photo 7). Non-native or introduced riparian vegetation species include tamarisk and Russian olive. In some upper riparian stretches a variety of disturbances, including grazing pressures and an altered fire regime, have allowed an increase in coniferous species in what were historically riparian woodland sites (Sarabia 2002).

The upland vegetation species can be divided into three vegetation types: mixed conifer, ponderosa pine and spruce-fir. The mixed conifer zone ranges from approximately 8,000 to 9,500 feet and primarily contains white fir, Douglas-fir, corkbark fir, limber pine, scattered ponderosa pine and patches of aspen. Ponderosa pine forests range from the beginning of the survey (7,500 ft) to 8,000 feet. The spruce-fir forests range from 8,000 to 12,000 feet and consist of Engelmann spruce, subalpine fir or corkbark fir with patches of aspen or blue spruce (Sarabia 2002).

Several plant species in the Pecos River Watershed are listed on either the federal Threatened or Endangered Species List or the Regional Sensitive Species List. The only endangered plant species

Beaver Activity

Beaver activity in the Pecos River is located in Reaches 3, 6 and 10. A survey conducted in 1963 by NMGF observed signs of beaver activity in Reach 15; although were not observed in the 2002 survey. Beaver activity in Reach 3 is limited to downed trees and lacks any sign of habitation (i.e. a dam). The dam in Reach 6 is near the bottom of a side channel and only partially spans the Pecos River. Maximum depth is increased near the Reach 6 dam. Reach 10 has wide valley morphology and is located between bedrock canyon reaches. The beaver dam spans the entire channel of the Pecos River and the modification is astonishing. One distinct alteration is the river's increased wetted width. One beaver dam complex widens the river from 9 feet in the previous riffle to an estimated 55 feet (see Photo 8). Other disturbances on the stream system include riparian vegetation alteration (see Photo 9) and increased habitat complexity caused by the formation of new side channels. The side channels, which flow around the dam complexes, have created a wet meadow system with grasses approximately 5 feet tall, not found anywhere else near the river.

Photo 8. Reach 10, NSO 308, P93. Murray Boatright with a beaver dam (16 Aug 2002).

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 until recently (FS Files).

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

Beaver activity and its associated ponds have many affects on stream water quality, most of which are considered beneficial to trout habitat. The decreased stream velocity that occurs in pool habitat, such as beaver dams, decreases the water's ability to carry sediment suspended in the water column. Suspended sediment tends to settle into a pond's substrate, creating a sink for stream sediment and

reducing turbidity. Sediment transport has been reduced by as much as 90% in studied streams (Olson 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 streams, the nutrient storage in pond sediment creates a time-release system increasing productivity. After the beaver leaves an area and the pond drains, the nutrient rich soil is utilized by riparian vegetation to produce dense riparian areas.

Photo 9. Reach 10, NSO 315, S26. Beavers' influence on riparian vegetation (16 Aug 2002).

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

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

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

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

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

Fisheries

As with most of the rivers in New Mexico, extensive stocking practices with non-native trout species has led to a drastic change in species assemblages. Historically Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) was the only trout species found in the Pecos Watershed. Currently, a small population of Rio Grande cutthroat trout (RGCT) exists in Reach 15. It is likely that an occasional RGCT is found below Pecos Falls. From Pecos Falls to Holy Ghost non-native German brown trout *(Salmo trutta)* and rainbow trout (*Oncorhynchus mykiss)* occupy the river (see Table 12). Native white suckers (*Catostomus commersoni)* were found during the survey from Holy Ghost upstream to below Cowles.

Table 12. Fish distribution determined by USFS snorkel surveys (2002) in Reaches 2 and 6 and NMGF surveys 1997.

Fish Species	Native/Non-Native	Distribution by Reach
Rio Grande cutthroat trout	Native	15
German brown trout	Non-Native	1 through 14
Rainbow trout	Non-Native	1 through 14
White sucker	Native	1 through 6*

*Estimated distribution.

RGCT have been eliminated from the Pecos River by exotic trout. Exotic trout species have been stocked in the watershed since as early as 1896, with Forest Service records dating back to 1959. Between 1959 and 1964 the Mora and Pecos Rivers were stocked with rainbow and brown trout (FS Fisheries Files; see Table 13).

Table 13. Historic fish stocking rates for the Pecos and Mora Rivers (FS Fisheries Files).

Fiscal Year July 1-June 30	Brown Fry	Rainbow Less than 6"	Rainbow Greater than 6"
1959-60	19,925	21,200	4,356
1960-61	7,087	20,000	4,361
1961-62	8,448	20,000	5,344
1962-63	8,640	20,000	3,796
1963-64	8,505	50,000	4,924

The last time NMGF stocked brown trout in the Pecos River was 1980. Approximately 510,000 brown trout were stocked and about 50% of them were placed in the surveyed section of the Pecos. Rainbow trout are currently stocked in the Upper Pecos River. In 2001, 26,881 fish between 8 and 10 inches were placed in the Pecos River with approximately 50% of them above Holy Ghost. In 2002 the number of Rainbow trout decreased to 22,643 fish between 8 and 10 inches (Fry 2003).

The large number of exotic trout stocked in the Pecos River placed pressure on native trout that led to their extirpation. The exotic trout displaced the native population through competition for resources, hybridization and predation. Brown trout is a piscivore, consuming fish like RGCT. Brown trout also compete with native fish for food and living space in the river. A characteristic such as higher temperature tolerance (80.6°F) (Sublette et al. 1990) increases the brown trout's success over native trout in water where temperature is an issue. Rainbow trout freely hybridize with RGCT and threaten genetic purity of native populations (Sublette et al. 1990). Conflicts with exotic trout species are one factor that has defined the RGCT as a sensitive species for the Forest Service.

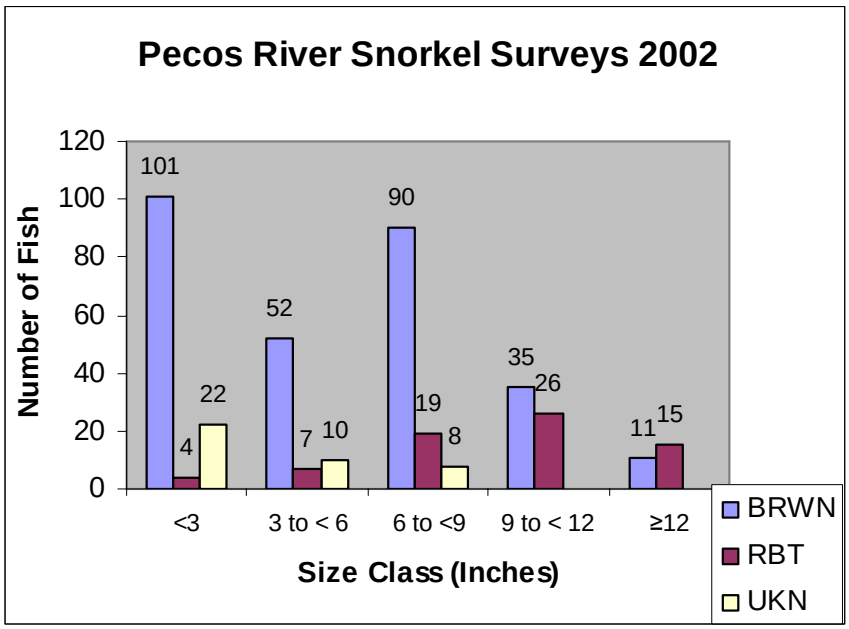


Figure 6. The number of fish by species and size class for the two snorkel surveys conducted during the summer of 2002 on the Pecos River.

Two USFS snorkel surveys were conducted during the summer of 2002 to investigate the fish population in the Pecos River (see Photo 10). 401 fish were observed in the 1300 meters of stream that was snorkeled in Reaches 2 and 6. Although brown trout are not currently stocked in the Pecos River, their population is dominant (289 fish). 71 rainbow trout were observed and 40 fish were unidentified. The "juvenile" size class is prevalent in all trout species of the Pecos River. One white sucker was observed in the Reach 6 snorkel survey.

A previous fish survey conducted in the summer of 1963 by NMGF covered an area between Beatty's Cabin (just above the confluence with Rito del Pa RGCT, erman brown, and rainbow trout were the only fish species reported. It is possible that trout were the

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of Pecos Falls to the Rio del Padre and yielded 143 trout. Samples just below the falls were primarily cutthroat trout rther downstream, the sample sites dem ing rainbow and brown trout and decreasing cutthroat populations. The lowest sample contained no cutthroat trout. A stocking rate of 10,000 er yea ended (H

In August 1988 NMGF surveyed the fish population above Pecos Falls. By this time, the RGCT population wa ated leavi only cut-bows. This electroshock sampling was one step toward the decision to renovate the fish population above Pecos Falls. In 1992 NMGF removed the fish population in

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Wildlife Species

The Pecos River Watershed is home to a diverse array of wildlife including two threatened and five sensitive species (see Table 14). The threatened species that is of most concern in the watershed is the Mexican spotted owl. Mexican spotted owl habitat is characterized by cool, steep canyons and mixed conifer forest typical to the Upper Pecos River. No Mexican spotted owls have been observed in the recent owl surveys of the Upper Pecos Watershed, but habitat makes their presence possible. Bald eagles, another threatened species in the watershed, are of lesser concern in watershed management because of their transient use of the area. Bald eagles do not over winter in the Upper Pecos River and utilize the area occasionally for forage (Sarabia 2002).

The sensitive species present in the Upper Pecos Watershed are of concern in its management. Boreal owls inhabit older spruce and fir forests above 8,000 feet. Potential threats to the owl include removal of tree snags and reduction of prey habitat. Northern goshawks and peregrine falcons reside in ponderosa pine, mixed conifer, and spruce-fir forests. While northern goshawks nest and forage in these forests, the peregrine falcons only forage. The northern goshawk is sensitive to habitat loss from logging, catastrophic wildfire and other disturbances especially during breeding season. White-tailed ptarmigan's habitat is above 10,000 feet and is sensitive to human presence and grazing practices. It is not known if the blue-black butterfly is present around the Upper Pecos River. The butterfly was not observed during recent surveys, although the necessary wet meadow habitat does exist. The butterfly's lifecycle is linked to the *Viola nephrophylla*, which grows in wet meadows and near seeps (Sarabia 2002).

Table 14. Threatened and sensitive wildlife species of the Upper Pecos Watershed 2002.

Species Type	Common Name	Scientific Name	Status
Birds	Bald eagle	*Haliaeetus leucocephalus*	Threatened
	Mexican spotted owl	*Strix occidentalis lucida*	Threatened
	Boreal owl	*Aegolius funereus*	Sensitive
	Northern goshawk	*Accipter gentiles*	Sensitive
	Peregrine falcon	*Falco peregrinus anatum*	Sensitive
	White-tailed ptarmigan	*Lagopus leucurus*	Sensitive
Insects	Blue-black silverspot butterfly	*Speyeria nokomis nokomis*	Sensitive

Non-listed wildlife can be used as indicators of habitat condition in the Upper Pecos Watershed. Management Indicator Species present in the watershed include Rocky Mountain elk (*Cervis elaphus neisoni*), Rock Mountain bighorn sheep (*Ovis canadensis Canadensis*), hairy woodpecker (*Picoides villosus),* Merriam's turkey (*Meleagris gallopavo*) and mourning dove (*Zenaia macroura*). The elk population in the Upper Pecos Drainage is stable to increasing and is ranked as common with 100 to 10,000 pairs. Elk inhabit most of the area covered in the 2002 stream inventory. The bighorn sheep population is considered to be at capacity for the available habitat. The sheep habitat is in steep and rocky areas common in the tundra and alpine areas near the headwaters of the Pecos River. The hairy woodpecker population is ranked as abundant in the Forest and breading pairs range from 10,000 to 100,000. The woodpecker can be used as an indicator species for the presence

of down logs averaging 17 inches diameter at breast height (DBH) and greater than 30 feet long, which are their foraging habitat. The turkey population in the Forest is ranked as common with 1,000 to 10,000 breading pairs. Ponderosa pine forests and surface water are requirements for turkey habitat common to the lower reaches of the survey. Wild turkeys were observed during the 2002 Stream Inventory near Beatty's Cabin (9,700 ft). The mourning dove population in the forest is ranked as common with between 1,000 to 10,000 breeding females. The dove habitat is abundant and occurs primarily in the lower elevations of the survey (Sarabia 2002).

Stream Improvements

Stream improvement structures have been installed in the Pecos and other rivers around New Mexico since the 1930's. Most of the structures were installed by the Forest Service, NMGF or as a cooperative effort between the two agencies. Historic stream restoration efforts were focused on improving fishing habitat and not stream habitat (Tatschl 1981). Tatschl's statement emphasizes the entertainment focus that historically dominated fisheries biology and management. Three basic types of stream improvement structures exist in the surveyed section of the Pecos River: trash catchers, log structures used to increase pool habitat, and bank stabilization structures.

In the 1950's Huey and Wolfrum (Huey 1956) evaluated trout utilization of beaver ponds. Noticing the increased numbers of trout in the ponds, beavers were utilized in trout management. Trapping and transplanting beaver populations was used as a stream improvement for several years. The high cost and limited beaver habitat severely limited it as a stream improvement option.

Using ideas created from the beaver dam habitat, a less expensive leaky dam improvement was designed. These structures were composed of I-beam stakes and hog-wire. Experimentation with these structures began on the Mora-Pecos River in 1958. From these experiments a low cost alternative was developed which is now known as a trash catcher. Between 1960 and 1967, approximately 2,500 trash catchers were installed in New Mexico by NMGF. The goal of the structures was to increase pool habitat to 50% of the stream habitat. Trash catchers were seen as ideal habitat improvements because of their low cost ($22.00 per structure), low upkeep (approximately 5% per year) and aesthetic appeal (Jester and McKirdy).

In the 2002 survey, remnant trash catcher structures were scattered from the survey's onset up to the beginning of the canyon section of Reach 9. The condition of the structures is poor and nothing more than bent fence posts in the substrate. None of the structures create pool habitat and actually create human hazards.

Log structures were also utilized to increase pool habitat in the rivers around New Mexico. In the early 1950's the structures were only used in wilderness areas where material transport was an issue. In wilderness situations stream improvements were built from native materials, with specific emphasis on aesthetic considerations. These structures were much more expensive to construct, averaging $100 per structure (Jester and McKirdy).

Photo 11. A visual comparison of one of the few successful structures (left, Reach 6, NSO 92, P26; 22 July 2002) and the more common unsuccessful (right; Reach 8, NSO 170, P53; 30 July 2002) log-type stream improvements.

The log-type structures are the most common stream improvements in the Pecos River. In lieu of the 1950's protocol of only installing these structures in wilderness areas, distribution begins with the survey up to the end of Reach 9. The log structure distribution approximately coincides with road access. It is rumored that a stream improvement project was conducted in the late 1980's, although no record exists of this activity. The fixed log structures were anchored in place, either straight across or in a "V" shape spanning the river channel. The logs created a drop in the channel and eventually a scour pool. While initially quality habitat was formed, most of the structures are not successful in creating long-term pool habitat. Nearly all of the anchored log structures caused the stream's width to increase or forced the stream to move around the structure. Due to the anchored and unbending nature of the modifications, many ended up breaking due to the flow's extreme force, leaving only evidence and scraps of their existence.

Photo 12. A gabion structure stabilizing the right bank of Reach 1. Highway 63 is 10 feet from the Pecos River in some areas of this reach (2 July 2002).

Bank stabilization projects include the installation of gabion/riprap and log structures. Gabion structures are comprised of broken rock anchored by fencing (similar to chicken wire) in areas where erosion is a concern. Riprap is piled and placed boulders, most often angular, to stabilize exposed banks often around road crossings or places of road encroachment. On the Pecos River, bank stabilization projects are common when roads approach the river. The gabion/riprap bank stabilization structures were used to maintain road integrity. In at least one instance, logs were cabled to the stream banks to increase bank stability. This structure was located above the Holy Ghost Bridge on the right bank in Reach 1. During the 2002 survey most of these structures were still intact. Unfortunately, by unnaturally hardening stream banks, water is forced to destabilize other areas downstream or upstream from this point in order to find equilibrium.

LAND USE

This historic description is taken from portions of the Brazel Prescribed Burn report by Jeremy R. Kulisheck, and written by Brent Able and William Barfuss (2003) from the Santa Fe National Forest Heritage Program.

Paleo-Indian use of the upper Pecos Valley appears to have been minimal. Nordby (1981) suggests that this may be due to the absence of game species, such as bison, in the area prehistorically, but current research indicates that few contemporary hunting and gathering camps actually focus on the hunting of large game (Cordell 1979; Tainter and Gillio 1980). The base of a Paleo-Indian point has been located in the high country of the Pecos Wilderness area during recent surveys conducted by the Forest (Abel 1989a). This artifact was found on a Late Archaic/Basketmaker site and may be a curate item.

A few Archaic Period (5000 B.C. - A.D. 1) lithic sites have been recorded in the area. These sites are frequently found on high benches above major watercourses (McGrary 1983). The warmer and drier climate of this period is thought by some to have contributed to the extinction of larger game animals, while artifact assemblages reflect the hunting of smaller species.

The first known sedentary community in the upper Pecos Valley, near the present Pecos Pueblo, was occupied ca. A.D. 800. Excavated pithouses have yielded evidence for the use of maize, wild plants, mule deer and antelope (Nordby 1981). Agricultural fields were typically situated on the lower terraces above Glorieta Creek. Despite evidence for sedentary and semi-sedentary occupation between A.D. 800 and 900, no increase in valley population seems to have occurred until approximately A.D. 1200-1300.

About A.D. 1200 population size increased, resulting in establishment of larger communities, such as Forked Lightning Ruin, Dick's Ruin, Hobson-Dressler Ruin, and Black-on-White House, over which the pueblo of Pecos was later built. Farming, hunting and gatherin

ecos Pueblo,

s

ggests that raiding Plains Indians

Europeans first visited Pecos Pueblo during Coronado's exploration of the upper Rio Grande valley in 1540 (Jenkins and Schroeder 1974). The Pueblo was next visited by the Rodriquez-Chamuscado expedition in 1581 and the Espejo- Beltran expedition in 1582. Castano de Sosa captured the pueblo in 1590 and the defeated inhabitants fled (Kidder 1962). Castana de Sosa soon left and Europeans did not visit the pueblo until Onate's colonization of New Mexico in 1598. Sometime between 1598 and 1620, a mission was built and used until the Pueblo Rebellion in 1680 (Kidder 1962), when the Spanish evacuated the territory (see Photo 13).

Photo 13. The Mission at the Pecos Pueblo as it looks today.

During the Spanish absence, conflict between the Pecos inhabitants, the Tanos to the west and the Tewas to the north may have led to the abandonment of several Tano towns (Kidder 1962). When De Vargas reoccupied New Mexico in 1692, the Pecos inhabitants fled once again, but they soon returned and another mission was built at the pueblo. In 1750 a war party seeking Comanches may have been ambushed, resulting in the death of most of the adult male population of Pecos (Kidder 1962). A smallpox epidemic struck in 1788 leaving only 180 survivors. Other diseases spread through the community until, in 1838, the remaining 17 occupants moved to Jemez Pueblo (Kidder 1962).

In the 1790's Spanish settlers began to use the area, and by the early 1800's there were several hundred families in a dozen tiny placitas within the river valley (Meining 1971). Trade between the United States and Mexico was established by 1822, and the Santa Fe Trail passed through the Pecos area and Glorieta Pass.

New Mexico became a United States territory in 1846. Since that time the area has been exploited by both Anglo and Hispanic populations for the available timber, mineral and grazing resources.

Between March 26-28, 1862 the key battle of the Civil War in the western U.S. territories took place near the present town of Glorieta. The final battle took place in a series of skirmishes on March 28, 1862 in and around Glorieta Pass near Pigeon's Ranch located along present day Highway 50. Confederate troops were attempting to pass through the area to attack the Union’s stronghold at Fort Union, located about 30 miles north of the town of Las Vegas along the Santa Fe Trail, but they

Roads

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

Table 15. The number of acres, road miles and road densities for the three HUC 6 watersheds as well as combined for the entire surveyed area. Watershed differentiations are shown in yellow on the Upper Pecos Watershed Map (Figure 1).

Watershed	Acres	Road Miles	Road Density
Headwaters	29,108.1	7.32	0.17
Holy Ghost to Panchuela Creek	32,034.2	77.74	1.55
Rio Mora	34,530.3	4.33	0.08
Combined Watersheds	95,672.6	89.39	0.60*

*Calculated value proportional to each watershed's size.

The Pecos River Watershed road system is connected by Highway 63. The highway is the backbone of the road system which gives access to businesses, homes, wilderness access points and other recreational uses of the Pecos River Watershed. Road analysis can be separated into 3 sub-watersheds within the survey area: Headwaters, Holy Ghost to Panchuela, and Rio Mora. Each watershed has different road densities. The highest density of roads occurs between Holy Ghost and Panchuela Creek while the lowest density is in the Rio Mora (see Table 15). Analyzed separately or combined the road density in the Upper Pecos River Watershed is below the U.S. Fish and Wildlife Service maximum recommended road density of 2.5 miles of road per square mile of watershed.

Several specific problems related to the roads in the Upper Pecos Watershed were identified during the 2002 Stream Inventory. In several areas roads cause the degradation of stream habitat on the Pecos River. Concerns are primarily related to the proximity of roads to the river as well as improper bridge construction. Analysis of specific road related issues is limited to the Pecos River and not the entire watershed.

Highway 63 parallels the Pecos River from the beginning of the survey to Reach 8. In several places the highway approaches within 10 feet of the river. In some areas the stream bank has been reinforced with gabion structures to stop the river from eroding away the road (see Photo 12). This stabilization causes other areas of instability downstream of the structures. Other areas where Highway 63 approaches the Pecos River no stabilization structures exist. Large areas of bank instability are occurring from the proximity of the road to the river (see Photo 14).

Photo 14. Murray Boatright near bank instability in Reach 6 caused by the proximity of Highway 63 to the Pecos River (4 July 2002).

Several bridges cross the surveyed section of the Pecos River. A few bridges were not properly constructed and cause flow alterations and bank destabilization. One bridge in Reach 7 is eroding into the river (see Photo 15). Large slabs of cement are flaking into the river on the left side of the bridge and erosion is occurring on both banks increasing the river's sediment load. The wetted width of the river has increased significantly on the downstream side of the bridge. The wide and shallow habitat created below the bridge increases stream temperatures. At the time of the survey this bridge did not appear to be in use. If unneeded, the bridge in Reach 7 should be considered for removal. The other bridges crossing the Pecos River should be evaluated for impacts to stream habitat.

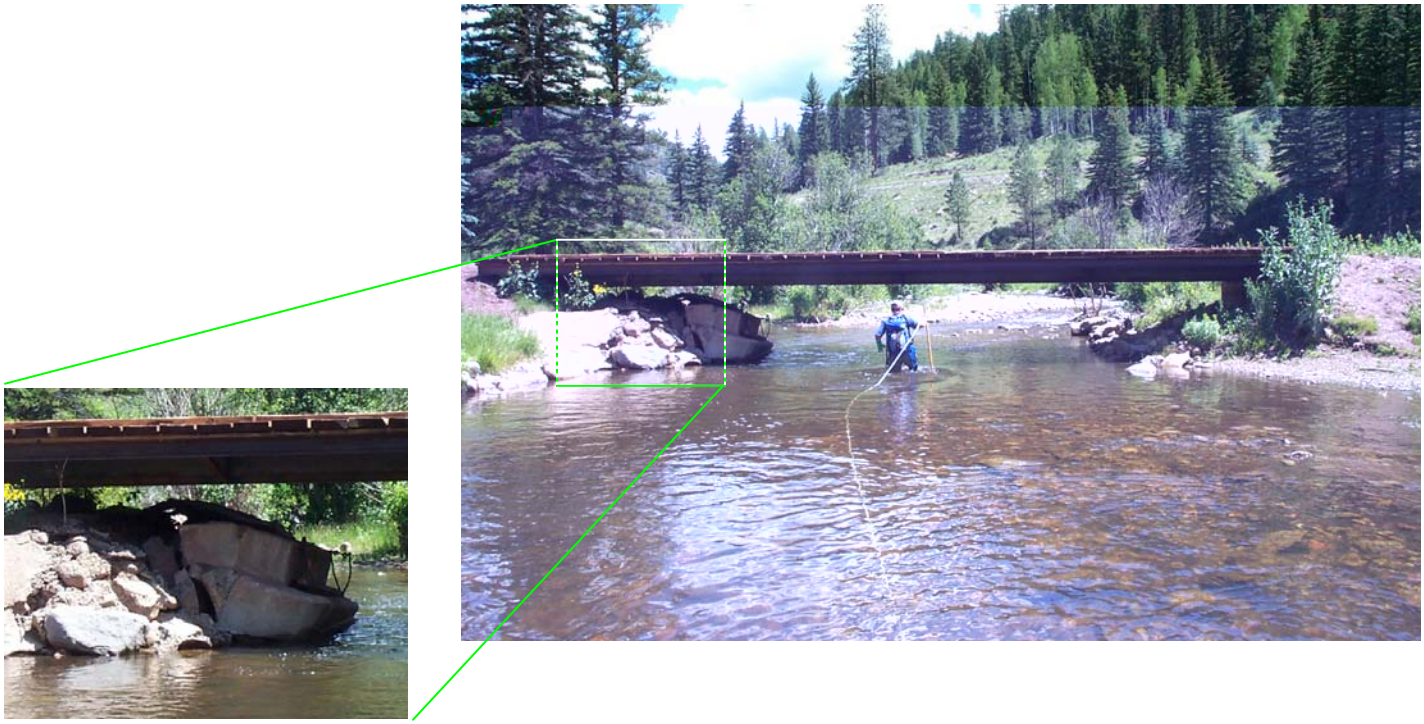


Photo 15. Reach 7, NSO 133, P39. Murray Boatright with a poorly constructed bridge. Inset: Cement support eroding into the Pecos River (25 July 2002).

Mines

The Terrero Mine is located at the confluence of Willow Creek and the Pecos River (Reach 3). Between 1927 and 1939 the mine harvested over two million tons of primarily lead and zinc, but also copper, silver and gold ore (Robinson 1990). Once abandoned, the mine waste was left in large piles on site (see Photo 16). The mine waste caused serious water quality problems in the Pecos River, which is used for domestic water supply, fish culture, irrigation, and recreation. The serious nature of the mine's impact on water quality eventually led to a Superfund cleanup.

Photo 16.

removed, treated with lime and capped under roadways to prevent leeching (Science Applications International Corporation 1996).

In 1990 a more in-depth analysis of the Terrero Mine site identified Comprehensive Environmental Response, Compensation, and Liability Act regulated conditions that warranted a Superfund cleanup. High concentrations of zinc and lead were discovered, as well as elevated concentrations of zinc, lead, copper, and selenium (Sinclair 1990).

The general cleanup plan is a capping effort to stabilize the mine tailings in place. The cap is designed to prevent introduction of mine materials in to the air, ground or surface water. The cleanup effort also included a replacement of a wetlands complex. The wetlands located just below the Terrero Mine site, has been subject to contaminated runoff for years. Deposition of contaminants has likely caused a high concentration of toxins in the pool-like wetlands complex. As part of the cleanup, the sediment in the wetlands was removed and replaced. Sections of Willow Creek were also dredged and modified for quality fish habitat.

Photo 17. The Terrero Mine cleanup effort near Willow Creek at the time of the survey. No vegetation was planted on the capping material during the 2002 survey.

During the 2002 stream survey, the Terrero Mine Cleanup was underway. Capping materials were spread across the site over the summer. A lack of stabilization of the cap during wind and rain events allowed exposed sediment to blow and runoff the site. During rain events the cap covered Highway 63 as it made its way off site into the constructed wetlands. Soil runoff brings up questions about the cleanup's impacts on stream habitat. It is likely that the constructed wetlands complex is being filled in by cap material.

Fires

Historically, fire has played an important role in the forests of northern New Mexico. The forests adapted to a natural fire regime, which played an important role in the ecology of these systems. The historic fire regime consisted of smaller, more frequent fires that burned at a lower temperature than the current catastrophic, large scale burns. Historic burns reduced the density of trees and

shrubs, the amount of dead wood and kept forest fire fuels low. However, human intervention has dramatically altered the historic fire regime. Fire frequency in the Sangre de Cristo Mountains has declined since the 1750's, possibly due to intensive grazing and shrub removal (Touchan et al. 1994). Over a century of fire suppression further reduced the fire regime frequency creating an abundance of fuel and increasing the potential for catastrophic fires similar to the 2000 Viveash Fire. Catastrophic fires create larger and hotter burns, dramatically altering the ecosystem.

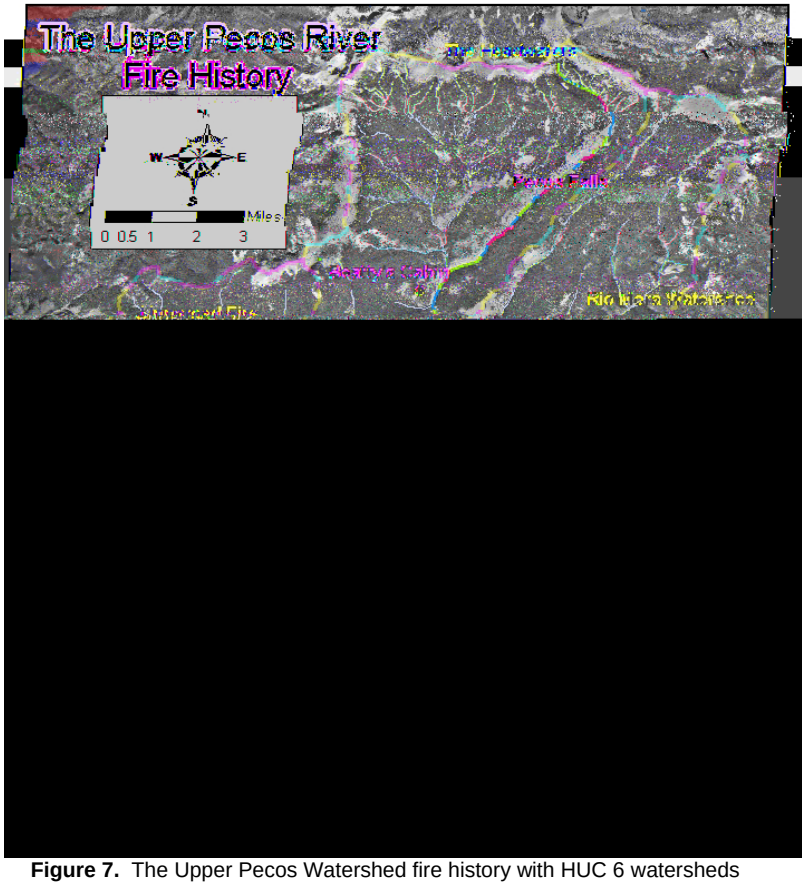


Figure 7. The Upper Pecos Watershed fire history with HUC 6 watersheds (yellow). All fires were within the Upper Pecos Watershed except the Viveash Fire, which bordered the Mora Watershed.

Two large fires have occurred in the Upper Pecos Watershed in recent history. The Trampas Fire of 2002 in the Rio Mora Watershed and an unnamed fire in the Panchuela Creek Watershed (see Figure 7). Trampas Fire, which burnt in the summer of 2002, covered 7.4 square miles in the Pecos Wilderness. Smoke from this fire was visible at the beginning of the 2002 Stream Inventory. The unnamed fire of 1989 was a relatively minor fire, burning 0.1 square miles in the Pecos Wilderness (see Table 16) . The Viveash Fire of 2000 was located in an adjacent watershed reaching the border of the Mora Watershed. This catastrophic fire covered 45.6 square miles, demonstrating the extreme fire potential in the area.

Table 16. Documented recent Upper Pecos River Watershed fire history. All fires are located within the watershed.

Year	Name	Acres	Square Miles
1989	89l172062438 (Fire ID Number)	39.7	0.1
2002	Trampas Fire	4750.5	7.4

Stock Grazing

Ranching is a tradition and has been a way of life in Northern New Mexico since the Europeans arrival in the 1540's (USDA Forest Service 1996). Grazing on public lands has occurred for nearly a century. Four grazing allotments are within the Upper Pecos River Watershed: Bear Lake, Grass Mountain, Rosilla, and Valle del Medio.

Photo 18. Reach 15, NSO 537, R258. Murray Boatright with bank instability in the headwaters of the Pecos River. Notice the cattle in the background, one possible cause of the instability (29 Aug 2002).

Bear Lake Allotment is located in the Pecos Wilderness. Cattle are grazed on this allotment between July 1st and September 30th each year. The allotment boundaries and size have varied over the years, making historical cattle use numbers incomparable. During the grazing season of 2002, 280 head of cattle were grazed on the allotment. The number of cattle grazed in 2002 is far below the 563 head maximum limit for the allotment.

Grass Mountain Allotment is located in the Panchuela Creek Watershed area. The allotment is limited to a maximum grazing pressure of 18 horses between June 1st and October 15th (137 days). For example, in the 2002 season only 9 horses grazed on the allotment; the other 9 horses grazed on the Rosilla Allotment.

The Valle del Medio Allotment is located in the Rio Mora Watershed. The heaviest use in this allotment occurs in Valle Largo off Trail #240 and adjacent to the Trampas Canyon (location of Trampas Fire). Valle del Medio is allotted a maximum of 80 head of cow/calves, which graze from June 16th through October 15th.

Cattle access to the Pecos River is limited by areas of steep canyons and exclosure fencing. The area with the most cattle related impacts is in Reach 15 between Pecos Falls and the upper cattle exclosure, which is part of the Bear Lakes Allotment (see Photo 18). Habitat degradation that may be related to the cattle's presence includes increased bank instability, leading to increased fines and

reduced riparian vegetation, which then leads to increased stream temperatures. Other stock related
trail leading up the Pecos River from Beatty's Cabin. Evidently this
in lieu of the official trail to push cattle up to the headwaters area. Other areas that

Pecos River is utilized for a variety of recreational activities. Fishing, hiking, hunting,

ecreational areas are managed either by the Forest or NMGF.

d by

ed in the lower reaches.
Five of the recreation areas are managed by the Forest:
Iron Gate, Jacks Creek, Panchuela Creek, Cowles, and
Winsor Creek. Three separate recreational areas managed
Creek
receive
extremely heavy recreational use, especially during

on tributaries and not directly on the Pecos River. The
Forest Service camping areas were not evaluated for
n
s

ponds with the Pecos River, create significant bank instability and erosion (see Photo 19). The erosion is a source of sediment to the river. The pond's outflow increases the Pecos River's stream temperature. W

Photo 20. Reach 5, NSO 35, R25. A common sight at NMGF recreation areas. This site is part of Mora Campground (4 July 2002). Note: The area was closed to public due to extreme fire danger.

During the survey, NMGF managed recreation areas were observed to have heavy recreational use and severe habitat degradation associated with these activities (see Photos 20 and 21). No sign of active management was noted at these sites. Vegetation, both riparian and upland, was reduced from trampling, user created roads or use of wood for campfires. Bank stability was decreased from a high density of dispersed trails accessing the river. Decreased bank stability increases sediment load to the Pecos. NMGF recreation areas are the primary source of habitat degradation of the surveyed section of the Pecos River. For example, Reach 5, which is mostly NMGF-managed Rio Mora Campground, has an alarming lack of pool habitat and large woody debris and over 31% unstable banks, giving it the worst rating of all reaches surveyed.

Photo 21. Reach 5, NSO 39, R29. Dispersed camping area part of NMGF's Mora Campground. Notice the complete lack of ground cover (4 July 2002). Note: The area was closed to public due to extreme fire danger.

A combined effort between NMGF and FS to mitigate negative impacts of recreation on the Pecos River would benefit stream habitat. Camping should only be permitted at designated and regulated sites. Sites that will be open to camping should be improved with an emphasis on protecting stream habitat. Campsite improvements should be augmented and supported by an educational approach. Education should focus on proper camping techniques as well as stewardship of the environment. Recreation should be managed to increase riparian zone vegetation and stream integrity.

A watershed restoration and education program, entitled Respect the Rio, has been established on the Jemez Ranger District. This program can be used to promote and implement better user stewardship in the watershed.

Suggested practices to improve management through the Respect the Rio program include:

1) Dispersed campsites and trails along the Pecos River could be modified, rehabilitated and regulated by moving vehicle camping at least 100' away from the stream.
2) Some sections of stream could be designated "Day Use Only" to protect natural and cultural resources. Closed campsites would allow degraded riparian vegetation to reestablish.
3) Riparian vegetation could be replanted and reestablished to restore riparian ecosystem function.
4) An educational sign about low impact camping could be placed at campsites. Education campfire programs could be offered in designated areas to further inform the public.
5) A person, known as a contact ranger, could patrol these areas informing the public about benefits and proper practices necessary for low-impact recreation.
6) Establish a designated trail system in high use corridors and obliterate multiple trails.

RECOMM

Education

Objective:
Educate forest users regarding the effects
ways to minimize impacts and promote b

Concerns:
Public education is one of the most impor
successful. Without education degrading
Rehabilitation programs spend millions o
informed about a project, the money will

Implementation methods:

1) Create a contact ranger program.
   intensive use times (summer), info
   recreational practices including “L
   restoration and regulation changes
2) Members of the public, including
   Forest fisheries staff in seminars f
   Special seminars will also be offe
3) Development and implementation
   are either currently or becoming interested in water quality and riparian monitoring on forest
   water

iparian

Objective:
cc .

ver. Land use practices including, but
ot limited to, dispersed recreation and grazing are causing significant impacts on the riparian zone.
nd decreased density are examples of the current degradation.
T f t one e c t
current riparian vegetation and ma rac

Large Woody Debris

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

Concerns:
Large woody debris (LWD) in the Pecos River is below the desirable densities in forested reaches.

Implementation methods:

1) Arrange LWD in the floodplain and stream in strategic locations, increasing habitat complexity and fish habitat. These projects would utilize the best available science for LWD implementation to avoid previous stream improvement mistakes.

Native fish populations

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

Concerns:
Except for the reintroduced population of Reach 15, RGCT have been extirpated from their historic range in the Pecos River. The population should be extended downstream from Reach 15 to occupy more of their historic range.

Implementation methods:

1. Work in partnership with NMGF and the communities to methodically expand the range of RGCT to downstream reaches and tying together with other streams such as Jarosa Creek, Rito del Padre, Jack's Creek, Panchuela Creek and Winsor Creek.
2. Utilize natural barriers (Reach 13) or areas of confinement, such as bedrock canyons in Reaches 6, 9 and 11 to minimize the construction of man-made barriers. The natural barrier in Reach 13 (see Photo 56) is below Jarosa Creek and could be used as the first step of many in creating an expansive metapopulation.

REACH SUMMARIES

Photo 22. Reach 12. Upper Pecos Headwaters near Beatty's Cabin with Rito del Padre entering on the left.

Reach 1: Holy Ghost Creek to the beginning of a canyon system

Reach 1 begins at the confluence with Holy Ghost Creek (T18N, R12E, Sec. 33) and ends above Bert Clancy State Campground at the beginning of a canyon system (T18N, R12E, Sec. 33). This reach was surveyed on July 2nd, 2002. Beginning at an elevation of 7,650 ft, Reach 1 ends 0.33 miles upstream, 7680 ft. The average gradient is 1.7% with a mapped sinuosity of 1.07. The Rosgen channel type is B3c for with a cobble-dominated substrate.

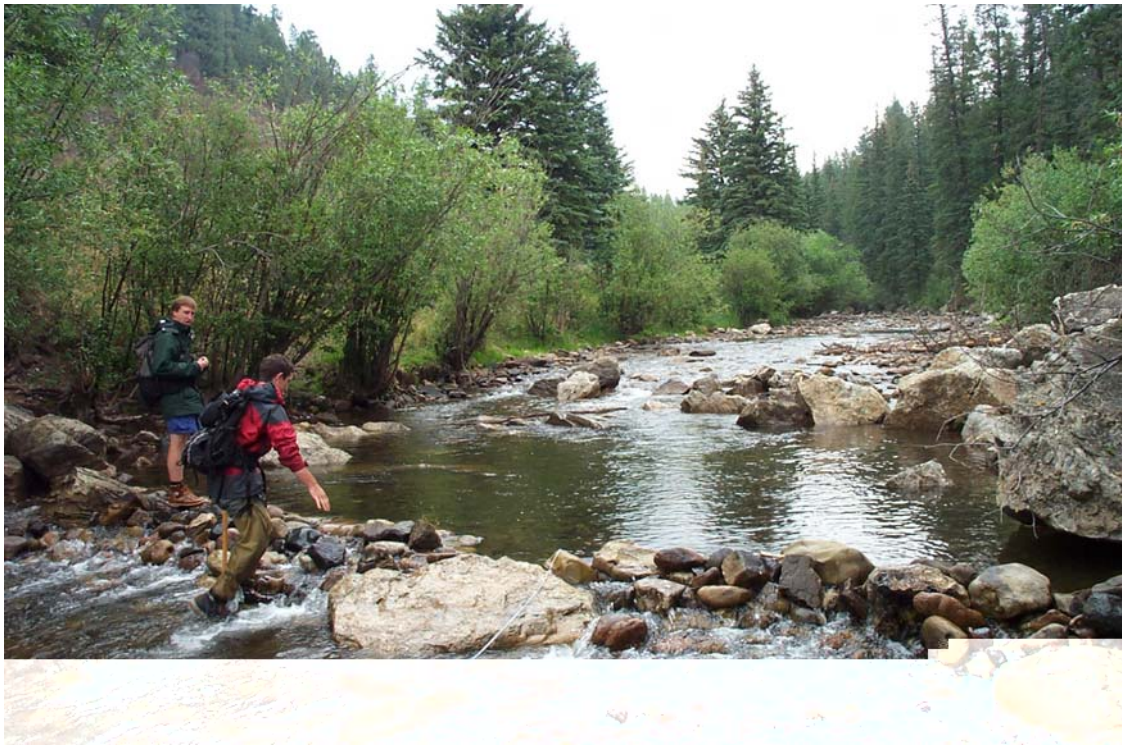
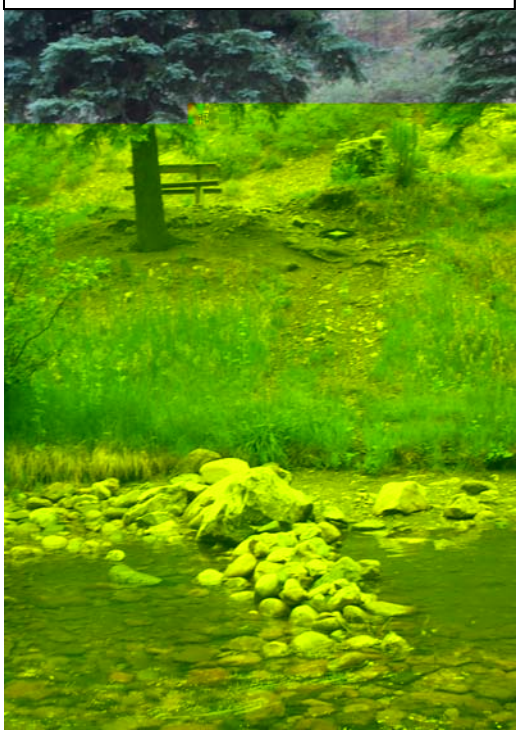


Photo 23. Reach 1, NSO 4, R4. Typical riffle with a man made cobble dam (L to R: Sean Ferrell and Damon Goodman; 2 July 2002).

The valley is predominately an open meadow with camping areas, roads, houses and the Terrero Store. Upstream from the highway and store, riparian vegetation appears on the right bank including willow and alder. Cottonwood trees are dispersed throughout the reach. Upland vegetation remains largely unaffected by recreational activities occurring in the river valley and consists of ponderosa pine mixed with lesser quantities of spruce and fir. Signs of heavy recreational use including camping, fishing, swimming, and driving are apparent on both sides of the river. Effects of unregulated recreational use of the reach include decreased bank stability and riparian vegetation, and alteration of stream habitat by cobble dam building (see Photo 23). State Highway 63 approaches the Pecos River halfway through the reach and runs within 15 feet of the river. Road fill is supported by gabion structures.

Two major factors that influence Reach 1 are Bert Clancy State Campground and Highway 63. The campground, which is located on the left bank, runs the greater portion of the reach. This campground appears not to be maintained and has dispersed and developed campsites spread throughout, many of which border the river. Some fire pits are within 15 feet of the left bank, with signs of ash leeching into the river. In areas where access trails connect the campground to the

Photo 24. Reach 1, NSO 4, R4. Dispersed trail accessing a man-made cobble dam (2 July 2002).



Pecos the riverbank is destabilized (see Photo 24). Problems arising from extensive bank erosion are compounded by removal of riparian vegetation by campers, distinguishable from beaver activity by clean cuts or ax marks. There is also a dispersed camping area at the beginning of the reach along the right bank. Along the entire right bank, multiple access trails connect the highway to the river further destabilizing the bank.

A water temperature station was located at the beginning of the survey and recorded temperatures every 15 minutes between June 25th and October 29th, 2002. The highest temperatures were in August (see Figure 8). Pecos River was compared to Forest and NMED standards for classification as either properly functioning, at risk or not properly functioning (see Temperature section).

Temperatures at the Holy Ghost Temperature Station were analyzed during the 90 days between June 25th and September 30th, 2002. Temperatures exceeded the **at risk** classification for both standards. The site exceeded Forest standards 35 days and 9 days under NMED classification.

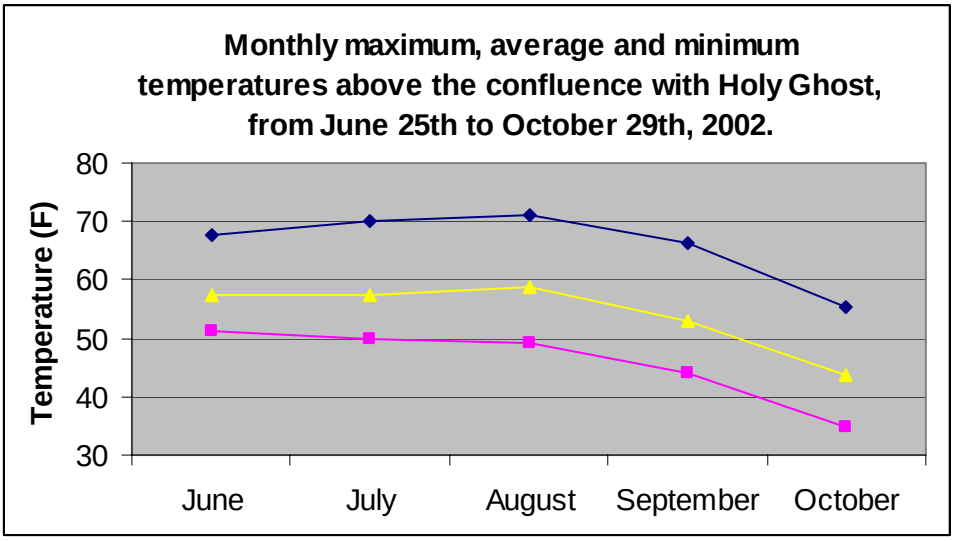


Figure 8. Monthly temperature analysis of temperature station located at the beginning of the 2002 Stream Inventory of the Pecos River. Max and min are one-time temperatures and avg. is based on daily average.

Habitat Characteristics

Reach 1 is divided into 5 NSOs, measuring 0.3 miles or 1,721 feet. This reach is under the recommended 0.5 mile minimum for a reach; therefore, ocular estimates are not statistically valid. Although several attempts were made by recreationists to create pool habitat with cobble dams (see Photo 23), all five NSOs are riffle habitat (see Table 17).

Table 17. Summary of Reach 1 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	0	0	0	0	>30%
Riffle	5	1,721	100	100	-
Culvert	0	0	0	0	-
Tributary	0	0	0	0	-
Falls	0	0	0	0	-
Side Channel	0	0	0	0	-
Total	5	1,721	100.0	100.0	-

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

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 1 includes not properly functioning and properly functioning characteristics. The parameters that are **not properly functioning** include length of pool habitat, quality of pool habitat and large woody debris densithy. **Properly functioning** characteristics include the relative sediment content in riffle habitat, bankfull width-to-depth ratio and bank stability.

Table 18. Summary of habitat and substrate composition in riffle habitat of Reach 1

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
1	5	344.2	35.0	1.2	2.1	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
1	14.0	30.0	40.0	16.0	0.0	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Riffle habitat, the only habitat type in Reach 1, is **properly functioning** for average relative sediment content (see Table 18). Lack of pool habitat creates two not properly functioning characteristics. Both pool development and average residual pool depth are **not properly functioning** in Reach 1. Bank stability is **properly functioning**. Bankfull width-to-depth ratio is **properly functioning** for a Rosgen B3c stream.

No large woody debris (LWD) is in the reach and is **not properly functioning** for the number of pieces per mile. The accessibility of this reach may be the primary reason for the lack of LWD. Campers and other recreational users may have physically removed LWD for use in campfires. In addition, the stream may have been cleared out periodically to protect investments such as the highway and the bridge located downstream. The gabion structure on the right bank prevents LWD deposition, forcing wood to transport downstream. LWD is an essential part of pool formation and critical in providing complex fish habitat (Fausch and Northcote 1992).

Table 19. Habitat characteristics of reach 1.

Area	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
Reach 1	1:0	29.3:1	0	0	0
Properly Functioning Indicators	-	12<30	>30	-	<10

Recommendations

Recommendations to improve Reach 1 include the regulation of Bert Clancy State Campground and other dispersed camping along the river. The state campground could be greatly improved with designated raised and somewhat confined campsites moved further back from the riverbank. Permanent fire rings and regulation along with improved sites would deter people from constructing fire rings so close to the river (see Photo 25), lessening the impact to the riverbank. An educational approach such as Respect the Rio, directed towards people camping in the area, about the impacts humans can inflict on a river system would probably benefit this reach. Commercially available firewood could take some stress off the riparian vegetation, which is currently used by campers to supply campfires. Designated and maintained river access trails with the closure of other dispersed trails would improve bank stability in this high use area.

Photo 25. Reach 1, NSO 4, R4. Fire ring and trash at Bert Clancy Campground, just above Pecos River (2 July 2002).

Reach 2: First canyon to Open Valley below Willow Creek

Reach 2 begins with a change in geography from an open valley system to an enclosed canyon. This reach was surveyed from July 2nd through July 3rd, 2002. Beginning at an elevation of 7680 ft (T18N, R12E, Sec. 33), the reach ends 1.2 miles upstream at the beginning of an open valley system (T18N, R12E, Sec. 33), 7765 ft. The average gradient is 1.4% with a mapped sinuosity of 1.1. The Rosgen channel type is B3c with a cobble-dominated substrate.

Photo 26. Reach 2, NSO 15, P4. Murray Boatright with a 7 foot deep pool. Notice the large bedrock feature on the left bank (3 July 2002).

Reach 2 starts at the beginning of the first canyon system encountered, approximately 0.2 miles upstream of Bert Clancy State Campground. Some major features of this reach are its steep canyon walls, deep pools, and log jams. Generally the canyon is confined, interspersed with a few short meadow areas. However, it is not too steep as to prevent such activities as road construction, which occurred on the right bank quite some time ago and is present for most of the reach. The road has been out of vehicle use for some time (approximated 20 plus years) and currently supports a well-established foot trail. Reach 2 has relatively little human impact due to the lack of road access. Vegetation consists of nice sections of thick riparian alder, willow and cottonwood, with some ponderosa pines, spruces, oaks, and a few Douglas-firs and true firs.

Factors influencing stream habitat are primarily centered on recreation. This includes heavily used fishing trails, trampled riparian vegetation, and large pieces of scrap metal and other garbage washed down from camping areas and a historic dump located in Reach 3. Recreational use and the associated impacts are focused around pool areas. Additionally, the old road, which most likely was utilized for logging purposes, continues to cause erosion problems due to its proximity to the right bank. Midway through the reach, there are primitive campsites along a high-flow island on the right bank and many small trees (~5-6’’ diameter) in the area have been cut down for firewood. This high-flow island is where the only historic side channel exists. Reach 2 is in close proximity to the Terrero Mine cleanup site, which contributes large amounts of sediment to the system downstream, especially during heavy rains. During this time the river is observed to have a very deep, brick red

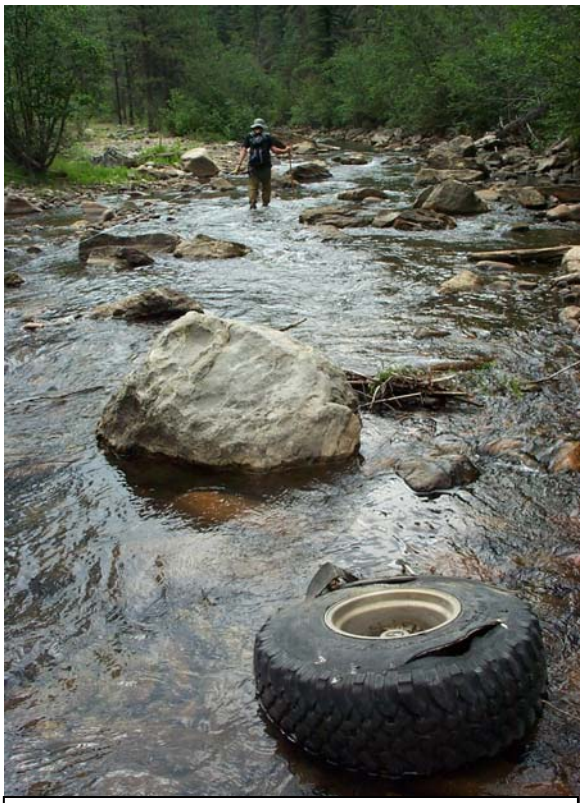


Photo 27. Reach 2, NSO 22, R16. The large quantities of trash in Reach 2 come from both upstream camping areas and a historic dump in Reach 3 (3 July 2002).

color. Unlike the previous reach, Reach 2 contains many pools and possibly accumulates some of the contaminated runoff from the Superfund mine cleanup operation in Reach 3.

A snorkel survey was conducted in Reach 2 during the 2002 Stream Inventory. Four surveyors covered 5-100 meter snorkel transects on July 6th, 2002. 213 fish were counted in the survey. 135 fish were brown trout ranging from less than 3 to over 12 inches in total length. The brown trout population is dominated by juvenile (< 3") and sub-adult (6<9") size classes. 48 rainbow trout had a dominant size class of large adult (9<12"; see Figure 9). 30 fish were unidentified.

Water temperatures were measured at random intervals during the survey using a handheld thermometer. Main channel temperatures were taken in the water column. Four temperatures were taken during the survey of Reach 2. The highest temperature was 60°F (16:25) and the lowest 55°F (09:13).

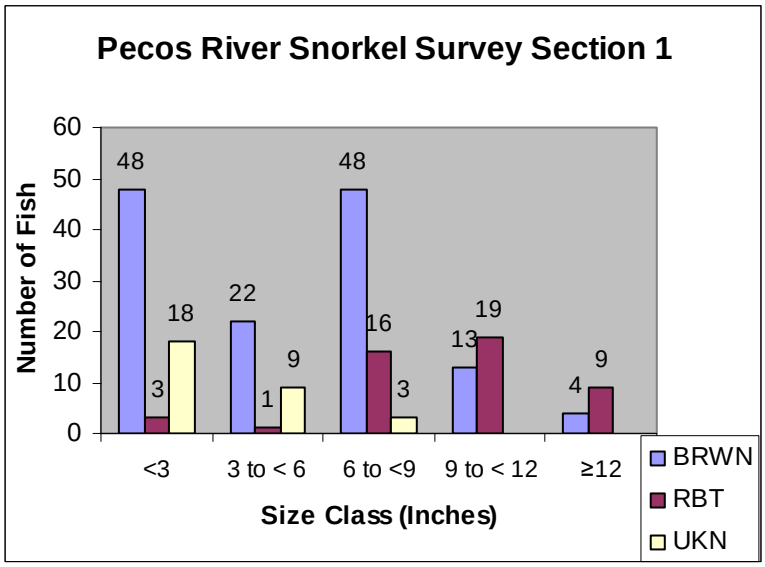


Figure 9. The first of two snorkel surveys conducted during the 2002 Stream Inventory.

Habitat Characteristics

Reach 2 is divided into 20 NSOs, measuring 1.2 miles or 6,150 feet. Five (5) NSOs are pool habitats, and comprised 5.3% of the stream habitat. 13 riffle habitats make up 94.7 % of the stream habitat in Reach 2 (see Table 20).

Table 20. Summary of Reach 2 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	5	328	5.3	5.1	>30%
Riffle	13	447.8	94.7	90.3	-
Culvert	0	0	0	0	-
Tributary	0	0	0	0	-
Falls	0	0	0	0	-
Side Channel	2	299	NA	4.6	-
Total	12	2,502	100.0	100.0	-

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

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

Table 21. 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	13	447.8	17.6	1.3	2.4	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
2	13.1	26.9	36.1	20.8	3.1	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

All factors related to riffle habitat are **properly functioning**. The evaluated parameters include bankfull width-to-depth ratio for related Rosgen stream classification and sediment content (see Table 21).

Pool development in Reach 2 is **not properly functioning,** representing just over 5% of the stream length (see Table 20). The five pools of Reach 2 were all quality pools with maximum depths up to 7 feet. Although pool substrate is dominated by cobble/gravel substrate, the most significant pools were all related to large bedrock features (see Photo 26).

Table 22. Summary of Pool Habitat and Substrate Percentages in Reach 2.

Pool Habitat Summary									
Reach	# Of s	Avg. Leng th	Avg. idth	Avg. Max De	h	s/Mile	# of Pools w Res Dep	Pools w/ Residual Depth	# of Pools ax. pth 3

Reach 3: Open valley near Willow Creek and the Terrero Mine

Reach 3 begins with a change in geography from an enclosed canyon to a wider valley. This reach was surveyed on July 3rd, 2002. Beginning at an elevation of 7765 ft (T18N, R12E, Sec. 33), Reach 3 ends 0.4 miles upstream at private land, 7785 ft (T18N, R12E, Sec. 27). The average gradient is 1.0% with a mapped sinuosity of 1.0. The Rosgen channel type is B3c with a cobble-dominated substrate.

The valley morphology of Reach 3 contains a broad grassy canyon floor with moderately steep, forested canyon sides. The broad and flat canyon floor is characteristic of a meandering and sinuous river channel with many secondary channels and pool habitats, very different from what is presently there. The current habitat configuration is possibly due to historic land use of the area.

Historic anthropogenic impacts on Reach 3 are primarily related to the historic Terrero Mine and its housing as well as state managed Willow Creek Recreation Area. The Pecos River has been forced to the left side of the valley floor, likely due to historic land use. The Terrero Mine removed 2.2 million tons of ore between 1926 and 1939 (Robinson 1995). The minerals extracted from the ore included zinc, lead, copper, silver and gold. The mine was located near the confluence of Willow Creek and the Pecos River and the ore was processed 16 miles downstream at a mill on Alamitos Canyon (outside of the survey area). Housing, a trash dump (see Photo 29), and other developments related to the mine were located on the canyon floor in Reach 3.

Photo 29. Reach 3, NSO 26, R19. The historic dump from the Terrero Mine. The trash from this dump is eroding into the Pecos River and is spread through the downstream reaches (3 July 2002).

Housing was removed subsequent to the mine closure 1939 (Sinclair 1990), but its effects still remain. The housing is a possible explanation for the currently poor condition of the stream habitat. Although the housing was removed, the dump still remains, forming the right streambank in several

sections. Fluvial processes are currently eroding the "dump banks," introducing the contents to the river (see Photo 29). Dump materials, including scrap metal, were found in the river downstream in Reaches 2 and 3. Historic land use is the likely explanation for the current poor habitat characteristics of this reach.

The Terrero Mine's affects on the water quality of the Pecos River are also a concern. The minerals extracted from the mine have potential to create serious water quality problems. March 1991 is a perfect example of the water quality issues related to the mine waste. Overland flow caused by snowmelt introduced mine waste to the Pecos River and killed an estimated 90,000 fish (Robinson 1995). The serious nature of the waste problem spurred a cleanup and capping effort that was in progress during the survey.

Aside from the capping effort, a wetlands filtration system was constructed to act as a buffer between the mine waste and the river. At the time of the survey the hazardous materials were already capped in place but a lack of stabilization of the materials allowed the cap to blow away and wash down from the site. Sediment was observed coming off of the cleanup site, bypassing the sediment retention barriers, and filling in the wetlands system (see Photo 30). Some of the cap materials could also be reaching the Pecos River, where seeps were observed coming from constructed wetlands that were bright red and black, possible signs of contamination and at the very least causing increased turbidity.

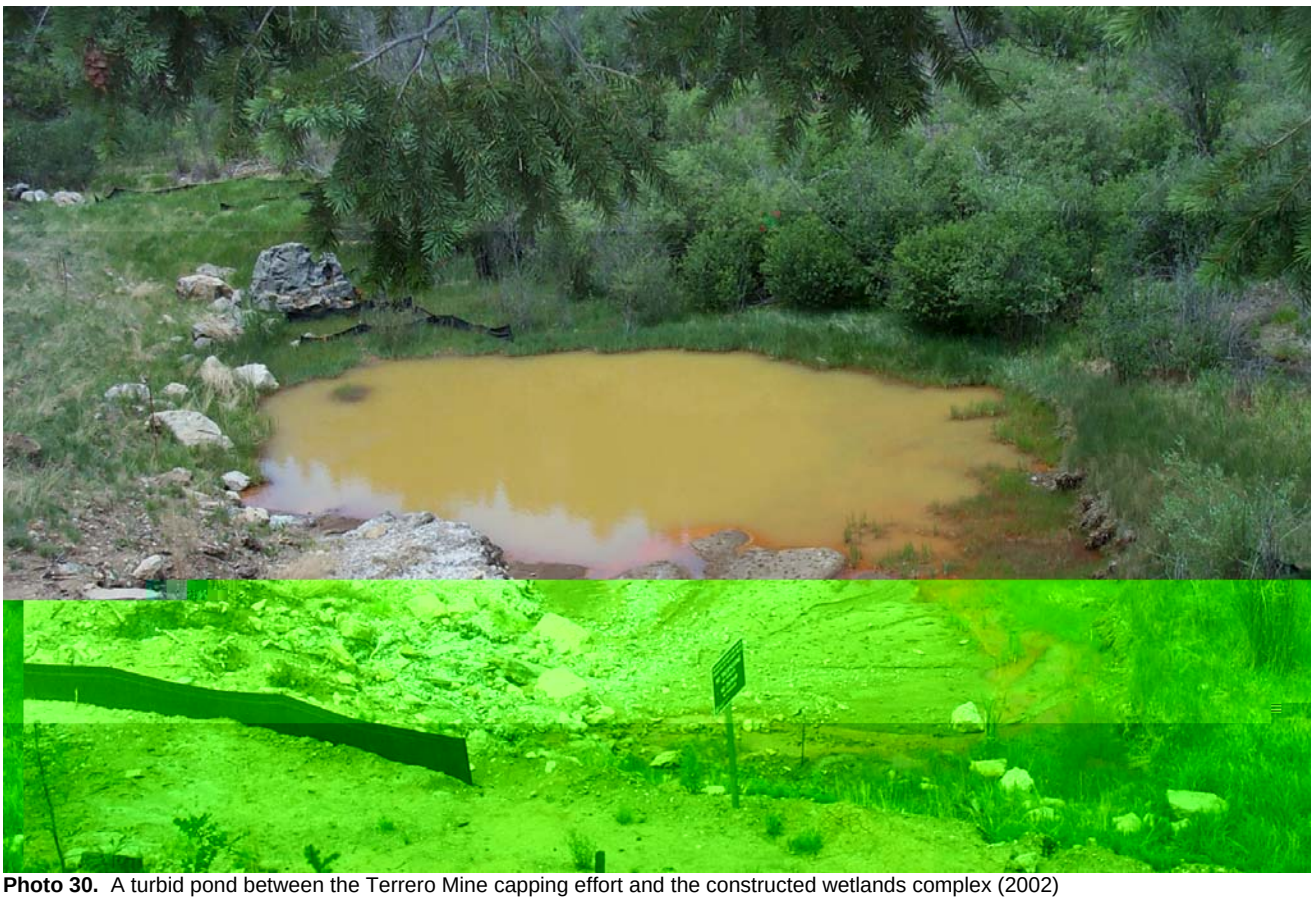


Photo 30. A turbid pond between the Terrero Mine capping effort and the constructed wetlands complex (2002)

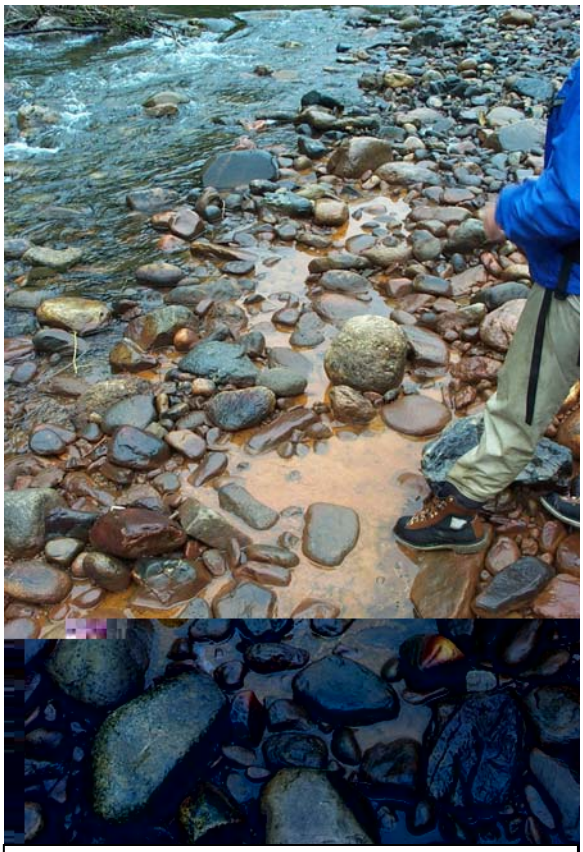


Photo 31. Reach 3, NSO 26, R19. Willow Creek draining constructed wetlands complex (3 July 2002).

A designated state recreation area near the top of the reach, Willow Creek Recreation Site, is on the right bank. At the time of the survey the recreation site was the storage facility for the materials used in the Terrero Mine cleanup and was closed to public access. The storage currently has approximately 30-foot tall piles of capping material, which could be a source of sediment to the Pecos River during overland flow events. Adjacent to Willow Creek Recreation Site is evidence of a developed campground that is now unused and overgrown with vegetation.

Willow Creek is the only tributary in Reach 3 and it comes in on the right bank. Willow Creek habitat restoration was also part of the Terrero Mine cleanup and involves significant modification. The velocity of Willow Creek slows significantly as it travels through the constructed wetlands complex, before finally reaching the Pecos River. With reduced velocity or energy, sediment and heavy metals settle into the wetlands sediment. Once contaminants are in the wetland sediment, the contaminants are absorbed and stabilized by vegetation. Where Willow Creek enters the Pecos River, unusual red and black colors tints the water and stains the rocks. The odd colorations bring up the possibility that contaminants are making it though the wetlands filtration system and reaching the Pecos River. Even if toxic materials are not making it though the wetlands filtration system, the tributary is still a source of dissolved solids, sediment and turbidity to the Pecos.

Riparian vegetation in Reach 3 includes coniferous trees, willows and alders on the left bank. Right bank riparian vegetation is lacking coniferous trees, but includes cottonwood. Cottonwood trees were also downed in the river with evidence of beaver activity. Riparian vegetation is sparse through much of the reach, providing little shade for the river and possibly allowing stream temperature increase.

Stream habitat in Reach 3 shows a distinct decrease in diversity. Stream characteristics changed, at least partially due to the shift in valley morphology, from a tight canyon in Reach 2 to a broad canyon floor. Although the change in valley morphology can explain some of the change in stream habitat, lack of habitat diversity is not an expected characteristic of an open floodplain system. Long cobble dominated riffles made up most of Reach 3, with a lack of secondary channels and only one pool. The lack of habitat diversity is likely explained by historic land use. If the river was allowed to meander naturally to occupy the entire floodplain, habitat diversity could increase.

Water temperatures were measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings were taken in the water column. Two temperatures were taken in Reach 3 (59°F at 15:04 and 58°F at 15:47; both on July 3rd, 2002).

Habitat Characteristics

The 0.4 miles (2,001 ft) of Reach 3 is divided into 3 NSOs. One (1) NSO is pool habitat and comprised 2.3% of the stream habitat. The other 97.7 % of the stream habitat is riffle (see Table 24). Because Reach 3 is less than the 0.5-mile minimum length requirement, ocular estimations are not statistically valid.

Table 24. Summary of Reach 3 stream habitat.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	1	46	2.3	2.3	>30%
Riffle	2	1,955	97.7	97.7	-
Culvert	0	0	0	0	-
Tributary	0	0	0	0	-
Falls	0	0	0	0	-
Side Channel	0	0	0	0	-
Total	3	2,001	100.0	100.0	-

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

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

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	2	977.5	35.9	1.3	2.35	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
3	15.0	20.0	45.0	20.0	0.0	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Riffles, the dominant habitat type, are properly functioning for relative sediment content (see Table 26). The bankfull width-to-depth ratio is **not properly functioning** when related to the Rosgen stream classification for Reach 3. The expected range for a B3c stream is between 12 and 30. Reach 3 far exceeds this expected range (see Table 27).

Pool development calculated by habitat length is **not properly functioning** in Reach 3. The single pool comprises a mere 2.3% of the stream habitat, which is well below the matrix standard (see Table 24). Meager pool development is part of the lack of stream habitat diversity throughout Reach 3. The pool is defined as a quality pool with a maximum depth over 3 feet (see Table 26).

Table 26. Summary of pool habitat and substrate percentages in Reach 3.

Pool Habitat Summary											
Reach	# Of Pools	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools/Mile	# of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	# of Pools w/ Max. Depth >3'	# of Pools w/ Max. Depth >3'/Mile
3	1	46	22.0	3.1	1.1	2.0	2.6	1	2.6	1	2.6
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary								
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total	
	3	10	20	30	20	20	100.0	

LWD density in Reach 3 is **not properly functioning**. Two pieces of LWD are located in the reach, creating a density of 5.3 pieces per mile (see Table 27). LWD density is far below the greater than 30 pieces per mile matrix standard and could be attributed to historic use in the area. Recent studies have found that LWD is an essential part of pool formation and critical in providing complex fish habitat (Fausch and Northcote 1992).

Table 27. Habitat characteristics of Reach 3.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
4	1:2	43:1	5.3	260	6.5
Properly Functioning Indicators	-	12-30	>30	-	<10

Streambank condition is **properly functioning** in Reach 3 with 6.5% unstable (see Table 27). One section of the instability is allowing the historic Terrero dump to erode into the river. The dump is a source of trash and scrap metal to the Pecos River (see Photo 29).

Recommendations

Several measures could be taken to improve stream habitat in Reach 3, primarily related to impacts from the historic Terrero Mine. One of the greatest needs is to plant vegetation over the Terrero Mine Cap. With stabilization provided by vegetation, the sediment and possible contaminant input to the Pecos River would decrease. Water quality testing needs to be done to investigate chemical composition of water coming from Willow Creek and the wetlands complex.

Other improvements related to the Terrero Mine include a cleanup of the dump materials that are eroding into the Pecos River and wetlands. This cleanup should extend to remove scrap metals that have already washed into the river.

Other recommendations for Reach 3 focus on improving factors that are **not properly functioning**. Increasing LWD density of the reach along with pool development are two factors that are interrelated. With increased LWD density, habitat complexity will also improve including the formation of side channels. The bankfull width:depth ratio would also be improved.

Reach 4: Private Land Above Willow Creek Recreation Area

Reach 4 is contained entirely within privately owned property and is approximately 1.2 miles long. Gradient is 1.1 % beginning at an elevation of 7790 feet (T18N, R12E, Sec. 27) and ending at 7830 feet (T18N, R12E, Sec. 22). The Forest was denied access to survey through this particular reach, hence its designation as its own reach. Reach Four begins in the same valley and river type as Reach 3, but soon appears to enter a more canyon-like system. Viewed from the road it is easy to see the human-made dams composed of large cobble, boulders, and woody debris put in place by the landowner to enhance the local fishery. At the upper end of the reach, there is a large pile of limbed logs (approximately 30' in length) apparently waiting to be placed in the river. Several houses and other structures border the river and are well within its floodplain. Due to its canyon-like features, the middle portion of the reach is unobservable from the road.

Photo 32. Murray Boatright at the upstream end of Reach 4 (4 July 2002).

Reach 5: The end of private land to Rio Mora

Reach 5 begins at the end of the private property of Reach 4. This reach was surveyed on July 4th, 2002. Beginning at an elevation of 7,830 ft (T18, R12E, Sec. 22), Reach 5 ends 0.6 miles upstream at the confluence with Rio Mora, 7,880 ft (T18, R12E, Sec. 22) due to a dramatic decrease in flow. The average gradient is 1.7% with a mapped sinuosity of 1.0. The Rosgen channel type is B3 with a cobble-dominated substrate.

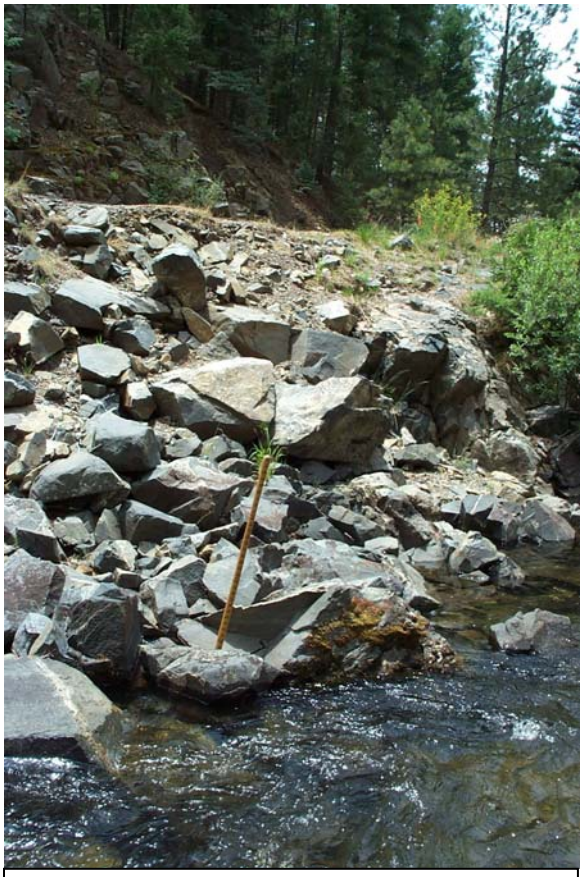


Photo 33. Reach 5, NSO 33, R23. Highway edge approaches within 15' of the river bank (4 July 2002).

Reach 5 begins at the end of private property of Reach 4. Following the short canyon of Reach 4, the valley opens slightly at the beginning of Reach 5. Valley walls still have a steep gradient, but the river itself has a wider floodplain. In some areas, it appears the river is being constrained by the existence and maintenance of Highway 63 on the right bank (see Photo 33). In this reach, the Pecos and surrounding area are heavily used and exhibit many signs of anthropogenic degradation. While disturbance on state land stems from the visiting public, there is also some disturbance from irrigation projects as well. The irrigation project, utilizes a side channel along the left side of the river. Gabion structures have been placed where the side channel naturally enters back into the Pecos, causing water to be diverted into the irrigation headgate (see Photo 34). When surveyed, the irrigation gate was partially open, allowing approximately 40% of the side channel's flow and 20% of the main channel's flow to pass into the ditch. Upland vegetation in this reach is dominated by ponderosa pine with some Douglas-fir and true fir. The riparian vegetation consists of cottonwood trees, alders, and willows. Reach 5 has a general decrease in riparian density when compared to previous reaches.

The disturbance from recreation in this area is extensive, resulting from overuse of Mora State Campground along the right bank. Bank instability is severe and shows no sign of improvement as much of the riparian vegetation has been removed and very little woody debris exists along the bank, especially on the right. Camping in the area and the associated fire pits are common along the right bank and trucks and campers are driven and parked wherever possible. In addition to the terrestrial disturbance, numerous human-made cobble dams exist throughout the reach.

Water temperatures are measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings were taken in the water column. Three (3) temperatures were taken during the survey of Reach 5. The highest temperature was 63°F at 14:30 and the lowest 55°F at 10:50 on July 4th, 2002.

Photo 34. Reach 5, NSO 32, S4. A gabion structure modifies flow from a side channel into a diversion ditch (4 July 2002).

Habitat Characteristics

The 0.6 stream miles (2,991 ft) of Reach 5 is divided into 11 NSOs. Nine (9) NSOs are riffle habitat comprising 100 % of the stream length. Two side channels make up 23.2 % of the habitat length. No pool habitat is within this reach.

Table 28. Summary of Reach 5 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	0	0	0	0	>30%
Riffle	9	2991	100	76.8	-
Culvert	0	0	0	0	-
Tributary	0	0	0	0	-
Falls	0	0	0	0	-
Side Channel	2	902	NA	23.2	-
Total	11	3,893	100.0	100.0	-

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

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

Riffle habitat is **properly functioning** for sediment content. Sediment content in riffles, 15.6%, is below the standard (see Table 29). The bankfull width-to-depth ratio, 31:1, is outside the expected range of the related B3c Rosgen stream type and is therefore **not properly functioning** (see Table 30).

Table 29. Summary of habitat and substrate percentages for riffles in Reach 5.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
5	9	332.3	29.9	1.3	2.1	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
5	15.6	27.8	42.2	14.4	0.0	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Lack of pools within the Reach 5 creates two **not properly functioning** characteristics: pool development and quality. Increasing pool habitat should be a priority in the management of this reach (see Table 28).

Large woody debris density is **not properly functioning** with no pieces found in the reach (see Table 30). The desirable LWD density is greater than 30 pieces per mile. Large woody debris is a key factor in the development of pool habitat and could be related to the not properly functioning condition of pool development in the reach. LWD is an essential part of pool formation and critical in providing complex fish habitat (Fausch and Northcote 1992). The accessibility of this reach may the reason for low LWD density. Campers and other recreational users may have physically removed LWD for use in campfires. Increasing the LWD density should be a focus in management of this reach.

Table 30. Habitat characteristics of Reach 5.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
5	N/A	31:1	0.0	1,879	31.4
Properly Functioning Indicators	-	12-30	>30	-	<10

Streambank condition is **not properly functioning** in Reach 5, far exceeding the matrix standard. To this date, this reach has the highest bank instability measured on the Santa Fe National Forest. Much of the bank instability of the reach is related to unregulated use of Rio Mora Campground.

Recommendations

NMGF's Rio Mora Campground is directly related to stream habitat degradation in Reach 5. Mora River receives high visitation through summer months with no active management. The Forest has no management capabilities because it is state owned land, but management recommendations are offered. Pecos River habitat would be improved if all dispersed camping were closed. Rio Mora Campground should be improved and managed to protect the surrounding environment. All improvements should be augmented and supported by strict enforcement, as well as education. As

with the other reaches, the Respect the Rio Campaign would benefit this area. Once degradation caused from use of Rio Mora Campground is stopped, then stream habitat conditions can be improved. **Not properly functioning** parameters should be mitigated including bank stability, LWD density and pool development.

Photo 35. Reach 5, NSO 33, R23. The proximity of Highway 63, compounded with access trails, are sources of bank instability (4 July 2002).

Streambank stability should improve with increased management of Mora Campground. The high use the area receives creates many dispersed trails that access the stream. Access trails cause bank instability and is a source of sediment to the Pecos River. Proximity of Highway 63 is also a cause of bank instability. In many areas where Highway 63 approaches the river, dispersed access trails compound the bank instability (see Photo 35). Bank instability could be mitigated with construction of designated trails and planting native vegetation.

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

Reach 6: Rio Mora Confluence to the end of a canyon below Cowles

Reach 6 begins at the confluence with Rio Mora and ends where the valley widens below Cowles. This reach was surveyed from July 4th to the 23rd, 2002. Beginning at an elevation of 7,880 ft (T18N, R12E, Sec. 22), Reach 6 ends 2.3 miles upstream at a change in valley morphology, 8120 ft (T18N, R12E, Sec. 10). The average gradient is 2.0% with a mapped sinuosity of 1.2. The Rosgen channel type is B3 with a cobble-dominated substrate.

The beginning of the reach has a moderately entrenched channel and flows through a floodplain bordered on both sides by steep valley walls. The reach enters a steep-walled canyon approximately one-quarter mile upstream. As with Reach 5, Mora State Campground borders the right bank and there is heavy recreational use of the Pecos and surrounding area. Recreational use lessens up canyon with increasing difficulty of access. Towards the end of the reach, recreational use increases as roadside access again becomes available. Heavy bank use associated to the Mora Campground has impacted riparian vegetation, which is sparse in places. Several solid patches of dense riparian vegetation still exist, particularly along the left bank.

Photo 36. Reach 6, NSO 85, R52. Damon Goodman with a logjam and bedrock walls in the canyon section (22 July 2002).

The lower section of the reach is subjected to the greatest amount of anthropogenic use and related degradation. Similar to Reach 5, bank instability is severe and will most likely continue to worsen as unmanaged recreation in the immediate area continues, camping areas remain unregulated, and no attempts are made at mitigation. Much of the riparian vegetation has been removed and very little woody debris exists along the bank (especially on the right bank). Fire pits are common along the right bank and trucks and campers are driven and parked wherever possible. In addition to the terrestrial disturbance, numerous human-made cobble dams exist throughout the reach. Within the canyon, the Pecos becomes less disturbed as the difficulty of access increases (see Photo 36). Pools are abundant (see Photo 37), riparian vegetation is vigorous, and banks are stable. Garbage decreases greatly in the canyon stretch. Although out of sight, several bank-side crashed and abandoned cars are reminders that Highway 63 still parallels the river from a few hundred feet above (see Photo 39). Angler trails existing in the canyon are not overused and are not causing any significant erosion.

Photo 37. Reach 6, NSO 89, P25. A significant pool enclosed by bedrock walls. Depth stick is 5 feet tall (22 July 2002).

A snorkel survey of the fish population in Reach 6 was conducted on August 1st, 2002. Eleven (11) snorkelers covered 8-100 meter transects. 188 fish were observed. The majority (154) of fish in Reach 6 are brown trout with a juvenile (< 3") dominated population. Rainbow trout are also in the reach with a large adult dominated population (>9"). The species of the other eleven fish were unknown except for one white sucker.

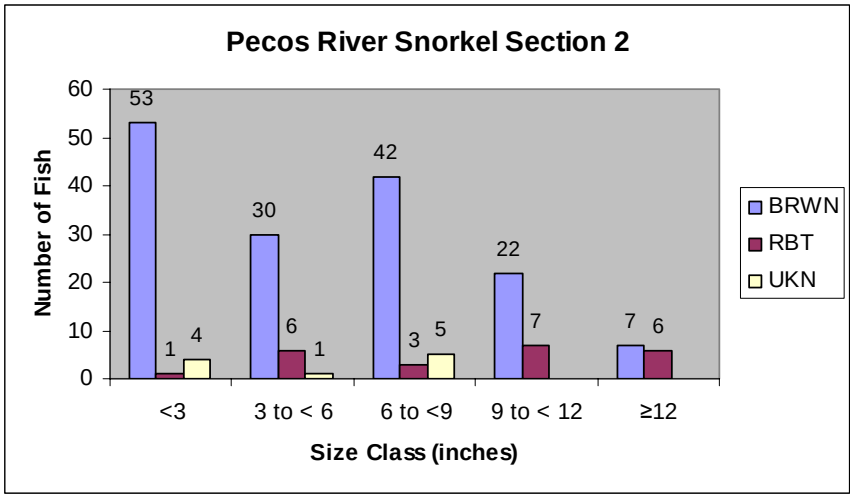
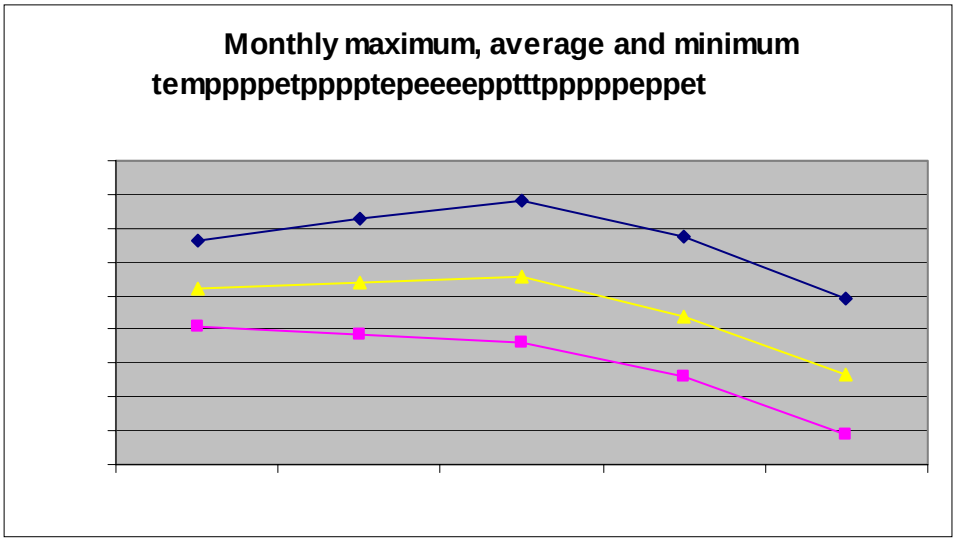


Figure 10. Brown, rainbow and unidentified fish observed in a snorkel survey of Reach 6.

Water temperatures were measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings were taken in the water column. Seventeen (17) temperatures were taken during the survey of Reach 6. The highest temperature was 60°F and the lowest was 55°F.

A water temperature station was established in Reach 4 on June 25th and removed on October 29th, 2002. The highest temperatures were between June and August (see Figure 11). The Pecos River is

compared to Forest and NMED standards for classification as either properly functioning, not properly functioning or at risk (see Temperature section). Temperatures at the Mora Campground temperature station are **at risk** by Forest classification 21 of the 90 days between June 25th and September 30th 2002. All of the days were classified as **properly functioning** under the NMED temperature standards. No days were classified as not properly functioning under either standard.



Riffle habitat in Reach 6 is **properly functioning** for relative sediment content. The sediment content, 13.9%, is below the matrix standard (see Table 32).

Table 32. 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	33	309.5	24.0	1.3	2.2	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
6	13.9	21.8	32.4	26.4	5.5	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool habitat is related to both properly and not properly functioning matrix parameters. Pool quality is **properly functioning** as determined by residual depth. Average residual depth is 2.8 feet, well beyond the preferred 1 foot. Many of the deep pools of Reach 6 are formed by large bedrock features, creating pools greater than 5 feet in depth (see Photo 37). Several smaller pools were created by one of the many stream improvement structures spread through the reach. Pool development is **not properly functioning**. Pool development by area of pool is determined by the length of pool habitat relative to the other habitat types. Reach 6 has less than half of the properly functioning indicator standard for pool development (see Table 33).

Table 33. 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	26	75.9	24.4	4.0	1.2	2.8	11.3	26	11.3	22	9.5
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary							
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
	6	26.1	13.1	18.9	17.7	24.2	100.0

Large woody debris is an essential part of pool formation and critical in providing complex fish habitat (Fausch and Northcote 1992). 31 pieces of LWD in Reach 6 create a density of 13.4 pieces per mile. The LWD density is less than half of the properly functioning indicator (see Table 34). The **not properly functioning** condition of this parameter could be related to other degraded parameters and especially pool formation.

Bank stability and bankfull width-to-depth ratio are **properly functioning** in Reach 6. Bank stability, 8%, is below the matrix standard (see Table 34). Majority of bank instability is at the beginning and end of the reach where recreational access is easier. Another major cause of bank

instability is the proximity of Highway 63 to the river. In one spot the road is less than 10 feet from the water's edge (see Photo 38). At this site the asphalt is eroding into the river and mitigation measures are needed to protect the integrity of the road as well as stream habitat. Bankfull width-to-depth ratio, 16:1, is within the expected range for Rosgen stream classification, B3c, and is therefore properly functioning (see Table 34).

Table 34. Habitat characteristics for Reach 6 of the Pecos River.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
6	1:1.3	16:1	13.4	1,955	8.0
Properly Functioning Indicators	-	12-30	>30	-	<10

Recommendations

Recommendations for management of Reach 6 include mitigation of the **not properly functioning** parameters: LWD density and pool development. Management of the reach can be divided into areas that are easily accessible by Highway 63 and the canyon section. Areas that have roadside accessibility should receive the highest priority in the reach's management. The canyon section is not in as dire need for management, but could still use attention.

Photo 38. Reach 6, NSO 48, R34. Highway 63 forms the right bank of the Pecos River in several areas of Reach 6. The depth stick is 5 feet long, providing a reference for the proximity of the road to the river's edge (4 July 2002).

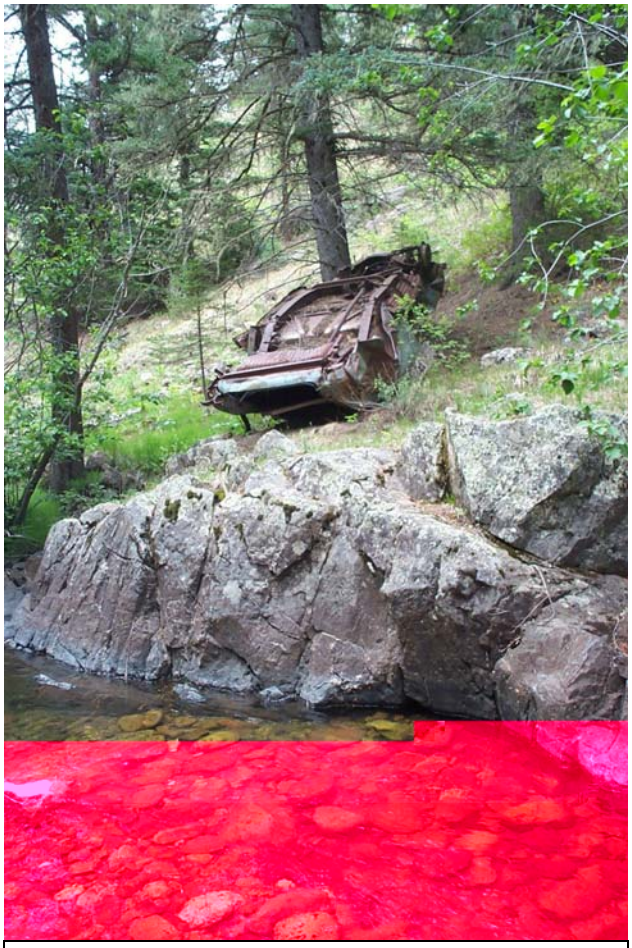


Photo 39. Reach 6, NSO 77, R48. One of two bank-side wrecked cars that tumbled down from Highway 63 (7 July 2002).

The easily accessible sections are riddled with bank instability and other degradations related to heavy recreational use. An educational campaign, like Respect the Rio, would benefit this reach. Similar to Reach 5, the education should be augmented with planting native riparian vegetation and designating river access points. Increasing LWD density would also improve habitat complexity and pool development. The proximity of Highway 63 also creates several bank stability problems. The areas were Highway 63 is eroding into the Pecos River (see Photo 38) should be stabilized with vegetation or large woody debris at the toe of the slope.

The canyon stretch where the access difficulty increases is in less need of attention. The only management recommendation for this area is the removal of the two bank-side wrecked cars. These cars tumbled down from Highway 63 from several hundred feet above. Although these cars are not creating stream habitat degradation, they do impact the river's aesthetic value.

Reach 7: The valley below Cowles up to Panchuela Creek

Reach 7 begins with a change in valley morphology from the canyon type system in Reach 6 to an open meadow system. This reach was surveyed from July 23rd through July 25th, 2002. Beginning at an elevation of 8,120 ft (T18N, R12E, Sec. 10), Reach 7 ends 1.5 miles upstream at a significant tributary, Panchuela Creek, 8,220 ft (T19N, R12E, Sec. 34). The average gradient is 1.4% with a mapped sinuosity of 1.1. The Rosgen channel type is B3c with a cobble and bedrock dominated substrate.

In Reach 7's beginning, the geomorphology is marked by a transition of a canyon (Reach 6) into a widened open valley. Through most of the reach, the Pecos River runs along the left side of the valley. Generally, the left side of the valley is forested while the right is open and grassy.

Riparian vegetation of Reach 7 consists of a mix of riparian and upland vegetation. The riparian vegetation alternates between grasses in the open meadows to patches of willow and alder. The riparian vegetation in the vicinity of several homes contained species that were not seen in any other site of the Pecos River Stream Inventory and are possibly introduced ornamental or other exotic species. Upland vegetation consisted of coniferous species.

Photo 40. Reach 7, NSO 113, R68. A bank stability project (left), protecting a bank-side house just below Cowles Ponds and unstable bank just downstream on the opposite bank (right) (24 July 2002).

Several human caused impacts affects the stream habitat in Reach 7 including "stream improvement" structures, as well as houses, bridges, and fishing ponds. One major influence is the "stream improvement" structures scattered throughout the reach. These structures consist of two or more logs secured into a section of the stream by rebar and other logs. These structures were apparently designed to create pool-type habitat by forcing stream flow to plunge over logs, creating a scour. Many examples exist of both successful and unsuccessful attempts of bank stabilization and pool creating structures (see Photo 40). The pool creating structures in both successful and unsuccessful "stream improvement" attempts increase wetted width and decrease stream depth.

Another human influence on stream habitat is home sites along both banks of the river. These houses have multiple access trails to the river causing bank instability. Presence of houses on the river also alters the riparian vegetation in several ways. In some cases riparian vegetation is reduced near homes and in other areas the species composition is changed (possibly exotics). Two single lane car bridges accessing homes create another impact on stream habitat. The bridges, which are not properly designed to handle a high flow event, are constricting the stream and have caused bank instability on both the upstream and downstream banks (see Photo 41).

Cowles Ponds have been constructed on the left bank of the Pecos to provide fishing opportunities. The ponds are fed by Winsor Creek and creating large, shallow ponds separated from the Pecos River by less that 20 feet in some places. The shallow design of the ponds combined with the lack of riparian vegetation creates warm water temperature in the ponds (69°F at 12:30, July 24th). Through one designated culvert and several seeps where water has breeched the constructed dam, water from the pond is introduced to the Pecos River and likely is impacting stream temperatures. Several of the seeps coming from the ponds contain a red colored tint that stains the substrate in the area, a possible sign of heavy metals in the dam fill. Multiple trails lead from the fishing ponds down to the Pecos River causing erosion and bank instability.

Photo 41. Reach 7, NSO 111, R66. Bank stability related to and directly below a bridge. It is possible that the bridge was not constructed to properly handle high flow events of the Pecos River (23 July 2002).

Six (6) tributaries and no secondary channels are within Reach 7. The most significant tributaries are Winsor and Panchuela Creeks. Winsor Creek contributes an estimated 10% of the main channel flow after it feeds Cowles Fishing Ponds. Several stream improvements are in Winsor Creek. Panchuela Creek contributes an estimated 40% of the main channel flow and marks the end of Reach 7. Some of the tributaries include the seeps breaching Cowles Pond.

Water temperatures are measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings are taken in the water column. Eleven (11) main channel temperatures were taken during the survey of Reach 7 (July 23rd through the 29th 2002). The highest temperature was 62°F and the lowest, 57°F.

Photo 42. Reach 7, NSO 115, T5. A tributary seeping through the constructed dam of Cowles Ponds. The substrate and water of this tributary are bright red, a sign of heavy metal content (possibly iron) that may be related to the dam fill material (24 July 2002).

Habitat Characteristics

The 1.5 stream miles (7,921 ft) is divided into 32 NSOs. Seven NSOs are pool habitat, 5.1% of the reach's stream habitat. Eighteen NSOs are riffles comprising 94.9 % of the stream habitat (see Table 35). The remaining 7 NSOs are tributary habitats.

Table 35. Summary of Reach 7 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	7	402	5.1	5.1	>30%
Riffle	18	7,519	94.9	94.9	-
Culvert	0	0	0	0	-
Tributary	7	NA	NA	NA	-
Falls	0	0	0	0	-
Side Channel	0	0	NA	0	-
Total	32	7,921	100.0	100.0	-

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

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 7 contains both not properly functioning and properly functioning characteristics. Parameters that are **not properly functioning** include large woody debris density, and pool development. **Properly functioning** characteristics include bankfull width-to-depth ratio, streambank condition, pool quality and riffle sediment content.

Riffle habitat in Reach 7 is **properly functioning** for relative sediment content. Relative fine sediment or sand content of the riffles in the reach are 6.6% below the properly functioning indicator of less than 20%. Riffle substrate is dominated by cobble (see Table 36).

Table 36. Summary of riffle habitat and substrate in Reach 7.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
7	18	417.7	31.7	1.5	2.6	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
7	14.4	21.1	37.7	23.2	3.5	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

The pool quality in Reach 7 is **properly functioning,** with an average residual pool depth of 2.3 feet. (see Table 37). Although pool quality is properly functioning, pool development is not. The pool development or t **ly functioning**.

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Table 38. Habitat characteristics of Reach 7.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
7	1:2.6	17:1	10.7	803	5.1
Properly Functioning Indicators	-	12-30	NA	-	<10

Recommendations

Photo 43. Reach 7, NSO 107, R64. User-created cobble dams are common in the lower reaches of Pecos River, altering stream habitat (23 July 2002)

Beyond increasing LWD density and pool development, several steps could be taken to mitigate human caused impacts of Reach 7. Suggested management of the reach includes the removal or modification of the failed stream improvement structures, increased riparian vegetation and chemical and thermal analysis of the tributaries from fishing ponds. Some failed "stream improvements" should be removed entirely (especially the exposed rebar). This would reduce the risk of public injury as well as increase the aesthetics of the river. The successful "stream improvements" should be monitored and removed or modified upon failure. The Forest should work with Leasees to make certain they are compliant with Special Use Permits and not causing unnecessary impacts to the stream.

Many informal or user created stream improvements are in Reach 7 (see Photo 44). Most of the structures are simply cobble dams, common to the lower reaches of the Pecos. In one instance, logs and debris have been placed in the river to create a dam-like feature that raises the river by 3.5 feet. The dam should be evaluated and removed if degrading fish habitat. High density of cobble dams spread through this reach and the rest of the lower reaches of the Pecos also need attention. These dams have several negative impacts on stream habitat and are never successful in creating long-term pool habitat; rather they typically will cause stream widening and bank instability. The Respect the Rio program should be implemented to combat this issue and improve stream habitat conditions.

Increased native riparian vegetation, especially along the areas near the homes, would help decrease water temperatures. The single lane car bridges that access some of the houses should be improved to properly pass annual high flow events. Riparian vegetation should also be planted near the bridges to reduce erosion. While Cowles Ponds were tested for heavy metals in 1993 with no significant contribution, the tributaries from Cowles Ponds should be re-tested for heavy metals or other contaminants that might be leaching into the river and determine if it is creating a significant impact on the fisheries populations. A temperature analysis should be conducted to determine the impact that the ponds are having on the water temperature of the Pecos River. If the ponds are significantly affecting the water temperature of the Pecos, then steps should be taken to mitigate the temperature increase. The multiple trails near the fishing pond should be marked closed. Designated trails should be constructed that lead down to the river.

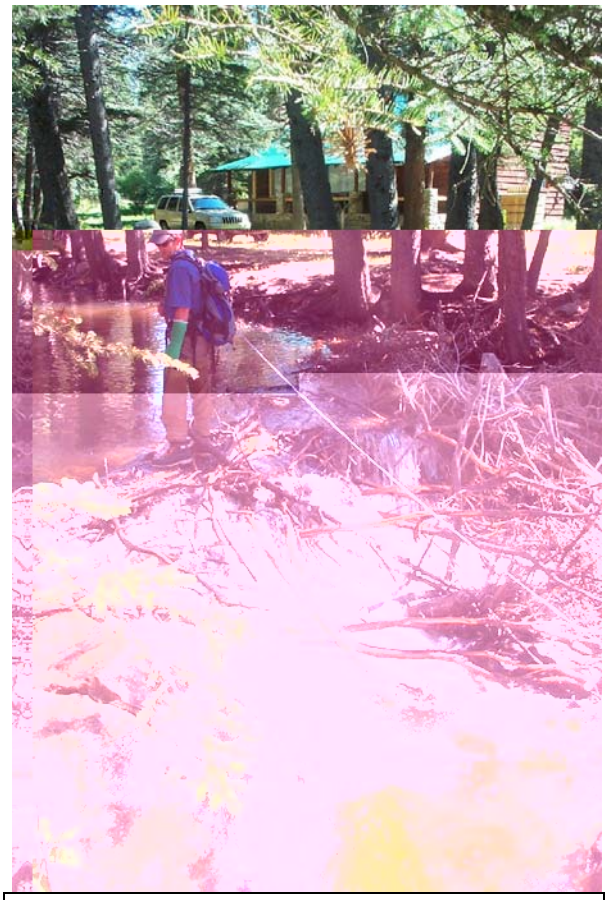

Photo 44. Reach 7, NSO 128 P38. Human-made dam structure alters stream habitat and bank integrity (25 July 2002).

Photo 45. Reach 7, NSO 122, R71. Murray Boatright with bank instability caused by a dispersed access trail near the beginning (24 July 2002).

Reach 8: Panchuela Creek to the beginning of a bedrock canyon

Reach 8 begins with approximately a 30% reduction in flow upstream from Panchuela Creek, beginning in a valley similar to Reach 7. This reach was surveyed from July 29th through July 31st, 2002. Beginning at an elevation of 8,220 ft (T19N, R12E, Sec. 34), Reach 8 ends 2.0 miles upstream at the beginning of a bedrock canyon, 8,440 ft (T19N, R12E, Sec. 26). The average gradient is 2.1 % with a mapped sinuosity of 1.1. The Rosgen channel type is B3 with a cobble-dominated substrate.

The valley morphology in the beginning of Reach 8 is a broad canyon. Upstream of the roadside access, the canyon begins to tighten. As the valley floor becomes smaller the morphology alternates between a grassy floor and several short areas of bedrock canyon.

State Highway 63 parallels the right bank of the Pecos River in the beginning of the reach but soon crosses the river and heads up towards Jacks Creek. A small dirt road continues to parallel the Pecos, providing access to summer homes for approximately 0.25 miles. At the end of the road, Trail # 397 begins which has several branches to dispersed fishing trails. Evidence of heavy recreational use throughout the reach is exemplified by trail access on riverbanks, multiple manmade structures (both active and failed) and dispersed campsites.

Riparian vegetation consists primarily of alder with some willow and conifers. Upland vegetation is primarily coniferous with some grassy areas. In several areas, especially around pools and man-made structures, riparian vegetation has been trampled and removed in some areas due to recreational use.

Photo 46. Reach 8, NSO 147, R84. The final house of Reach 8 before the bedrock canyon. Notice the cement foundation becomes the left bank of the Pecos River; also note cobble dams (29 July 2002).

The reach contains a high density of manmade structures that influence stream habitat. Homes, bridges, cobble dams, artificial log-type plunge pools, and dispersed trails are examples of manmade

structures and impacts that have altered the stream's habitat. Summer lease homes are located on both sides of the river for approximately the first mile of the reach, ending with the dirt road. Several impacts are created by riverside homes including bank erosion, increased trash and other impacts caused by heavy human use of the stream. In one case, a cement wall extends into bankfull, forming the stream bank (see Photo 46). Two car bridges and two walking bridges cross the Pecos River in Reach 8. Several bridges were not designed properly to deal with high flow events causing erosion, altering stream velocity and widening the river. Effects of the improperly designed bridges can be seen both above and below with increased wetted width and bank erosion. Another human alteration, cobble dams (built in several places along the reach), creates negative impacts on the fish habitat, including stream widening and increasing water temperature. Artificial log dams with "wing walls" were spread throughout the reach. Some of the features had failed due to high flow events or improper placement (see Photo 47), but many of the structures were still active, creating plunge pools beneath the dams.

Photo 47. Reach 8, NSO 170, P53. Failed stream improvement (30 July 2002).

Upstream of the road access, Trail #249 becomes the primary access to the river along the left bank. Dispersed trails branch off of the main trail, providing direct access to the riverbanks throughout the rest of the reach. The dispersed trails increase erosion in the canyon and around the stream. Many of the dispersed trails lead to successful manmade plunge pools that are scattered through the reach. Impacts from popular recreation spots include increased erosion, collapsed undercut banks and decreased riparian vegetation. In at least one area, riparian vegetation was cut down, probably to provide fuel for nearby fire-rings. Trail #249 crosses the river 1/3 of a mile below the end of the reach and heads up to Iron Gate. For the remainder of the reach, a dispersed trail follows the river on the left bank providing access to the river.

Four (4) tributaries enter the Pecos River in Reach 8. The most significant of the tributaries, Jacks Creek, enters from the left and contributed approximately 30% of the flow to the Pecos River. The other three tributaries contributed 1 to 3% of the flow. The tributary temperatures ranged from 56° (seep) to 60°F (Jacks Creek).

Water temperatures are measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings are taken in the water column. Ten (10) temperatures were taken during the survey of Reach 8. The highest temperature was 62°F at 15:20 and the lowest, 51°F at 9:50.

A water temperature station was established in Reach 8 below Jacks Creek on July 2nd and removed on October 29th, 2002. The highest temperatures were between July and August (see Figure 12). The Pecos River temperatures are compared to Forest and NMED standards for classification as either properly functioning, at risk or not properly functioning (see Temperature section). Temperatures at the Jacks Creek temperature station had 0 days of not properly functioning condition under either standard. Thirty-five days are **at risk** by Forest standards and 3 days by NMED of the 91 days between July 2nd and September 30th 2002.

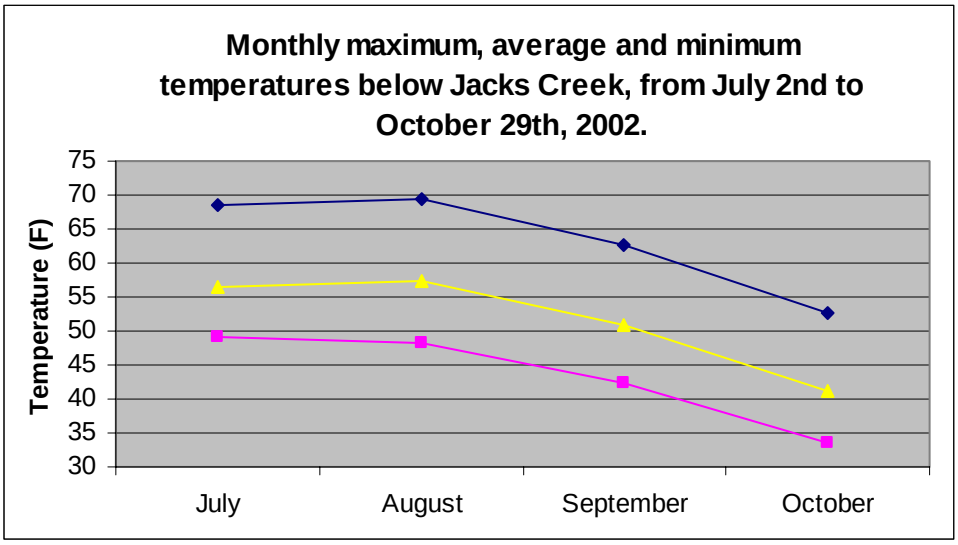

Figure 12. Maximum, minimum and average temperatures by month from thermograph station in Reach 8. Max and min are one-time temperatures and avg. is based on daily average.

Habitat Characteristics

1.8 stream miles (9,652 ft) of Reach 8 are divided into 59 NSOs. Twenty-two (22) NSOs are pool habitat and comprise 7.8% of the stream habitat. 30 riffle habitats consist of 82.9% of the stream habitat (see Table 39).

Table 39. Summary of Reach 8 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	22	790	8.2	7.6	>30%
Riffle	30	7,392	86.9	82.9	-
Culvert	0	0	0	0	-
Tributary	3	NA	NA	NA	-
Falls	0	0	0	0	-
Side Channel	4	470	NA	4.6	-
Total	59	10,122	100.0	100.0	-

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

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 8 contains not properly functioning, at risk and properly functioning characteristics. The only parameter that is **not properly functioning** is pool development. Large woody debris content is **at risk.** The **properly functioning** characteristics are bank stability, pool quality, riffle sediment content and the bankfull width-to-depth ratio.

The riffle habitat in Reach 8 is **properly functioning** for relative sediment content with only 12.7% fines (see Table 40).

Table 40. Summary of riffle habitat characteristics including substrate composition in Reach 8.

Riffle Habitat Summary						
Reach	Number of Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
8	30	279.3	20.7	1.2	1.9	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
8	12.7	19.3	35.3	28.3	4.3	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool development is the only **not properly functioning** parameter in the reach. The desirable pool content is greater than or equal to 30% of the stream habitat length. Reach 8 contains 7.6% pool habitat and is far below the matrix standard. Pool quality, measured by residual depth, is **properly functioning** (see Table 39).

Table 41. Summary of pool habitat characteristics including substrate composition of 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	22	35.9	18.4	3.2	1.0	2.2	12	22	12	11	6.0
Properly Functioning Indicators	-	-	-	-	-	≥1 ft	-	-	-	-	-

Substrate Summary							
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
	8	14.8	17.6	23.3	27.6	16.7	100.0

Large woody debris density in Reach 8 is **at risk** when compared to the properly functioning indicator. 38 pieces of wood in the reach creates a density of 20.8 pieces per mile (see Table 42). The "**at risk"** classification is between 20 and 30 pieces per mile. The desirable density is greater than 30 pieces per mile.

The bankfull width-to-depth ratio is within the expected range for the related Rosgen stream classification and is therefore **properly functioning** (see Table 42).

Table 42. Habitat characteristics for Reach 8 of the Pecos River.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
8	1:1.4	14.1:1	20.8	420	2.2
Properly Functioning Indicators	-	12-30:1	>30	-	<10

Bank stability is **properly functioning** for length of unstable banks. The length of unstable bank is a mere 2.2% of the stream length.

Recommendations

Recommendations for this reach include a more detailed look at some of the manmade structures that are altering stream habitat, as well as attention to the **not properly functioning** parameters. Bridges (see Photo 48), homes, and stream improvement structures should all be given a more comprehensive survey to determine their effects on the stream habitat and modified accordingly. The many cobble dams spread thoughout the reach should be addressed. The Forest should work with Leasees to make certain they are compliant with Special Use Permits and not causing unnecessary impacts to the stream. An educational campaign like Respect the Rio could be used to educate the public about the negative impacts of cobble dams. Secondarily the dispersed trails that are increasing erosion to the stream should be closed and soil stabilization should be implemented. **Not properly functioning** pool development and **at risk** large woody debris density should also be mitigated.

Photo 48. Reach 8, NSO 135, R80. A Highway 63 bridge that was not properly constructed to handle high flow events (left) and the downstream effects (right) (29 July 2002).

Reach 9: The bedrock canyon system

Reach 9 begins with a change in geomorphology from an open valley to a tight bedrock canyon. This reach was surveyed from August 2nd through August 15th, 2002. Beginning at an elevation of 8,440 ft (T19N, R12E, Sec. 26), Reach 9 ends 4.2 miles upstream at the beginning of another open valley, 9,150 ft (T19N, R13E, Sec. 7). The average gradient is 3.2% with a mapped sinuosity of 1.1. The Rosgen channel type is B2 with a boulder-dominated substrate.

Tight bedrock canyon walls interspersed with short areas of small meadows distinguish Reach 9. The canyon walls enclose the river, occasionally becoming the riverbanks (see Photo 50). Through fluvial action, the canyon walls become a source of stream substrate. Steep canyon walls provide ample shading to the river as do small areas of riparian vegetation. Alder with some coniferous trees dominate the riparian vegetat12 514.38962 s

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stock access to this reach due to the difficulty of

The bedrock canyon influences stream substrate composition. Fluvial actions of the stream cause the bedrock canyon walls to erode, depositing jagged substrate into the stream. Much of the substrate in this reach is very unstable and not embedded; creating the possibility that below the initial stream substrate is a layer of bedrock. Erosion of bedrock walls combined with loose substrate creates a potential source of substrate to transport to downstream habitats.

Riparian vegetation is limited by the space available between the water's edge and canyon walls. Vegetation growth is further limited by low light availability due to the shading provided by the canyon height and aspect. Aside from limiting factors present in Reach 9, riparian vegetation is vigorous. Alder dominated riparian vegetation is present through most of the reach, with some trees growing over the main channel. Other vegetation

on steps in the canyon walls and up steep grades where soil is present (see Photo 50). Ferns were observed in highly shaded areas of the canyon. The riparian vegetation in Reach 9 was dense and healthy, likely due to limited stock and human use.

Access to the Pecos River through Reach 9 is limited by the steep gradient canyon geomorphology. The closest access is provided by trails # 25 and 249, which are located 800 to 1,000 feet higher and up to one mile from the river. In steep gullies located between sheer cliff walls, several animal (possibly elk) trails lead down to the river, but did not appear to be major access routes. A few campsites were observed in the canyon floor, but did not appear to be used recently. Overall impact of human and wildlife use in the canyon and on the river itself was minimal, leaving it in a near pristine condition.

Reach 9 contains nine (9) tributaries all contributing very little flow to the main channel.

Photo 51. Reach 9, NSO 251, S20. A logjam within a side channel complex (5 August 2002).

Reach 9 contains nine (9) side channels with an average length of 248 feet, comprising over 9% of the habitat. One unusual side channel complex, located in an area where the canyon floor widened, contained approximately 50 braids and side channels interwoven through a forested plane. Multiple pools, logjams, and undercut banks greater than 5 feet deep were observed in the habitat. Several small woody debris jams suggests that this was the site of a historic beaver dam, although it was not present at the time of the survey. The side channel complex had multiple connections to the main channel. A high concentration of fish was present in the side channel complex (see Photo 51).

Water temperatures are measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings are taken in the water column. Nineteen (19) temperatures were taken during the survey of Reach 9. The highest temperature was 64°F at 15:09 and the lowest, 54°F at 10:50.

Habitat Characteristics

The 4.2 stream miles (22,268 ft) of Reach 9 are divided into 101 NSOs. Thirty-one (31) NSOs are pool habitat and comprise 5.2% of the stream habitat. 56 riffle habitats consist of 85.7% of the stream habitat (see Table 43).

Table 43. Summary of Reach 9 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	31	1,264	5.7	5.2	>30%
Riffle	56	21,004	85.7	94.3	-
Culvert	0	0	0	0	-
Tributary	9	NA	NA	NA	-
Falls	0	0	0	0	-
Side Channel	9	2,236	NA	9.1	-
Total	101	24,504	100.0	100.0	-

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

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 9 contains both not properly functioning, and properly functioning characteristics. The parameters that are **not properly functioning** include pool development and large woody debris content. The **properly functioning** characteristics are bank stability, pool quality, riffle sediment content and bankfull width-to-depth ratio.

Table 44. Summary of riffle habitat characteristics including substrate composition in Reach 9.

Riffle Habitat Summary						
Reach	Number of Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
9	56	375.1	17.8	1.1	2.2	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
9	10.6	18.8	32.9	34.8	2.9	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

The riffle habitat in Reach 9 is **properly functioning** for relative sediment content with 10.6% (see Table 44).

Pool development is **not properly functioning** with only 5.2% pool habitat volume. The desirable pool content is greater than or equal to 30% of the stream habitat length (see Table 43). Pool quality, measured by residual depth, is **properly functioning** (see Table 45).

Table 45. Summary of pool habitat characteristics including substrate composition of 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	31	40.8	15.8	2.8	1.0	1.8	7.4	29	6.9	7	1.7
Properly Functioning Indicators	-	-	-	-	-	≥1 ft	-	-	-	-	-

Substrate Summary								
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total	
	9	27.4	14.2	19				

Reach 10: An open valley between bedrock canyons

Reach 10 begins with a change in valley morphology from a tight bedrock canyon into a wider and more open valley. This reach was surveyed on August 16th and 17th, 2002. Beginning at an elevation of 9150 ft (T19N, R13E, Sec. 7), Reach 10 ends 0.84 miles upstream at the beginning of another bedrock canyon, 9240 ft (T19N, R13E, Sec. 7). The average gradient is 2.6% with a mapped sinuosity of 1.2. The Rosgen channel type is C3b with a cobble-dominated substrate.

Reach 10 has a significant change in valley morphology from the previous reach. The canyon opened up to a much wider valley floor. Although the steep canyon is similar to the previous reach, the canyon sides are spaced much father apart. Valley widening changed many of the stream characteristics of the Pecos River. Major changes in the stream characteristics include increased sinuosity, shift in dominant substrate, riparian vegetation, and flora composition.

The anthropogenic impacts of Reach 10 are minimal. Several signs of human presence are evident including footprints, dispersed pieces of trash, and one campsite. The observed changes on stream habitat from human use were insignificant. The campsite, designated by a fire ring, demonstrated no frequent or recent use. Difficulty of access limits human use. Closest access is provided by Trails #25 and 249, which are located 800 to 1,000 feet above the river and as far as one mile away. Between the two trails and the river are steep slopes with some areas of canyon walls and chimneys. Several animal trails weave their way down to the river, but these trails showed no signs of human use. Limited Access prevents livestock use.

Riparian vegetation composition was a mix of willow, alder and grass species. Mixed grasses dominated the upland vegetation. In some areas, specifically the wet meadows, grasses grew densely and as tall as 5 feet high.

Photo 52. Reach 10, NSO 315, S26. Damon Goodman with the dynamic effects of a beaver dam on the stream and riparian habitat (16 Aug 2002).

Very dynamic habitat characteristics were found through Reach 10, primarily due to beaver activity and the wide valley. The beavers' influences on stream characteristics are significant, creating multiple dams, pools, side channels and other habitat complexities (see Photo 52). Three (3) beaver complexes were observed: two in the main channel and one in a side channel. The first of the beaver dam complexes was composed of one large dam that increased the wetted width of the Pecos River from an average of 16 feet to an estimated 55 feet. The maximum depth of this active beaver dam was 3.3 feet and had an estimated 80% sand substrate. Many willows and alders were found submerged, but still alive in the pool, a sign of a recent increase in the size of the beaver pond. The dam was built out of willow and alders. Two small pieces of large woody debris were found in the pool. This dam also created several side channels including one complex that merged 948 feet downstream from the dam (see Photo 53). The side channel complex formed a wet meadow off of the right bank of the river, altering riparian vegetation. In another beaver dam complex found in a side channel off the left bank, water temperature was 74°F at 16:45, nine degrees warmer than the main channel temperature at 15:30. The increased water temperature was probably due to the increased wetted width and slower velocity of the water in the dams. Many large adult brown trout **(***Salmo trutta*) were observed in pools and several were found dead. The cause of death is unknown.

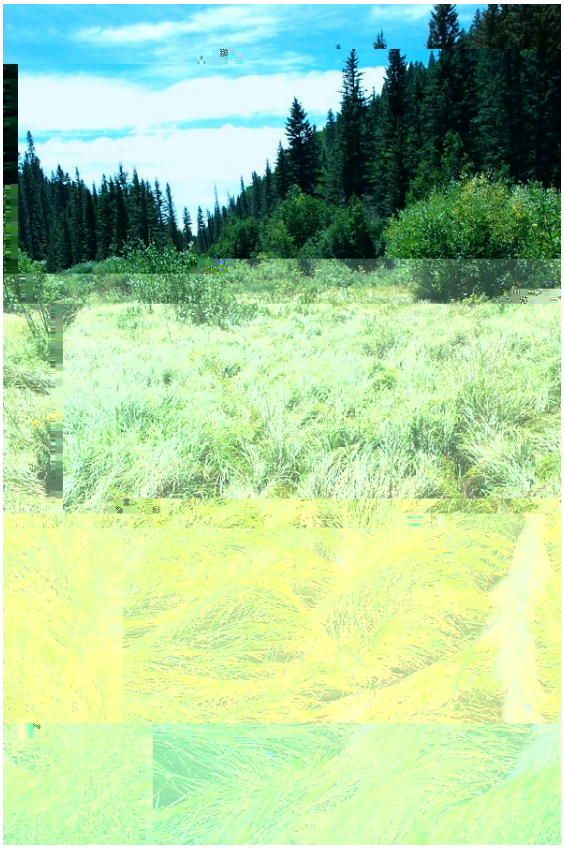

Photo 53. Reach 10, NSO 302, S22. A beaver dam created side channel that is almost 950 feet long that feeds a wet meadow system (16 Aug 2002).

Six (6) side channels, mostly related to beaver activity, are in Reach 10. The side channels would pour around the sides of the beaver dams with one extending as far as 948 feet. This specific side channel created a wet meadow system and the water temperature was 56°F at 13:00, nine degrees cooler than the main channel temperature at 15:30. Many of the side channel complexes contained several braids that connected to the main channel. Side channel complexes are just one example of the increased dynamics of the stream habitat due to beaver activity.

Water temperatures are measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings are taken in the water column. Four (4) temperatures were taken during the survey of Reach 10. The highest temperature was 65°F at 15:30 and the lowest, 48°F at 9:45. The temperature in a side channel with a beaver dam was 74°F at 16:45.

Habitat Characteristics

0.8 stream miles (4,430 ft) of Reach 10 are divided into 24 NSOs. Seven (7) NSOs are pool habitat and comprised 6.1% stream habitat. 11 riffle habitats consisted of 63.1% stream habitat. 6 side channels consist of 30.8% or 1,970 feet of the reach's stream habitat (see Table 47).

Table 47. Summary of Reach 10 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	7	393	8.9	6.1	>30%
Riffle	11	4,037	91.1	63.1	-
Culvert	0	0	0	0	-
Tributary	0	NA	NA	NA	-
Falls	0	0	0	0	-
Side Channel	6	1,970	NA	30.8	-
Total	24	6,400	100.0	100.0	-

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

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 10 contains not properly functioning, at risk and properly functioning characteristics. The parameters that are **not properly functioning** include pool development and bankfull width:depth ratio. Large woody debris content is **at risk. Properly functioning** characteristics are bank stability, pool quality, and riffle sediment content.

The riffle habitat in Reach 10 is **properly functioning** for relative sediment content with 10.9% fines (see Table 48).

Table 48. Summary of riffle habitat characteristics including substrate composition in Reach 10.

Riffle Habitat Summary						
Reach	Number of Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
10	11	367	15.4	0.9	1.7	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
10	10.9	25.5	38.2	24.6	0.9	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool development is **not properly functioning**. The desirable pool content is greater than or equal to 30% of the stream habitat length (see Table 37). Reach 10 contains 8.1% pool habitat. Pool quality, measured by residual depth, is **properly functioning** (see Table 49).

The density of large woody debris in Reach 10 is **at risk** when compared to the matrix standard. The 21 pieces of wood in the reach creates a density of 25.0 pieces per mile (see Table 50). The desirable density is greater than 30 pieces per mile. Much of the LWD in this reach has been caught in or incorporated into beaver dams.

Table 49. Summary of pool habitat characteristics including substrate composition of 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	7	56.1	17.5	3.2	0.9	2.3	8.3	7	8.3	3	3.6
Properly Functioning Indicators	-	-	-	-	-	≥1 ft	-	-	-	-	-

Substrate Summary								
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total	
	10	41.4	10.0	24.3	15.7	8.6	100.0	

Bankfull width-to-depth ratio, 10:1, is outside the expected range for the related Rosgen stream classification and is therefore **not properly functioning** (see Table 50). This could be related to surveyor error and should have further investigation.

Table 50. Habitat characteristics for Reach 10 of the Pecos River.

[redacted]

Reach	[redacted]

[redacted]

Reach 11: Short bedrock canyon below Beatty's Creek

Reach 11 begins with a change in valley morphology from an open valley to a tight bedrock canyon. This reach was surveyed on August 17th, 2002. Beginning at an elevation of 9240 ft (T19N, R13E, Sec. 7), Reach 11 ends 0.4 miles upstream at the confluence with Beatty's Creek and a change in valley morphology, 9300 ft (T19N, R13E, Sec. 6). The average gradient is 2.8% with a mapped sinuosity of 1.1. The Rosgen channel type is B2 with a boulder-dominated substrate.

Reach 11 begins with a tight bedrock canyon after the open meadows of Reach 10. The geomorphology of Reach 11 is similar to that of Reach 9 except shorter and tighter. Deep pool habitat and rock banks dominate this reach with bedrock walls as tight as 6 feet wide (see Photo 51), offering opportunities for barrier development. Rock fall from the bedrock walls, steep canyon and rockslides supply much of the substrate in the reach. Toward the end of the reach the canyon began to widen, while the stream stayed along the left canyon wall. At the end of the reach and the confluence with Beatty's Creek, the right bank was flat while the left bank was against a steep canyon wall. The steep nature of the canyon does not allow stock access.

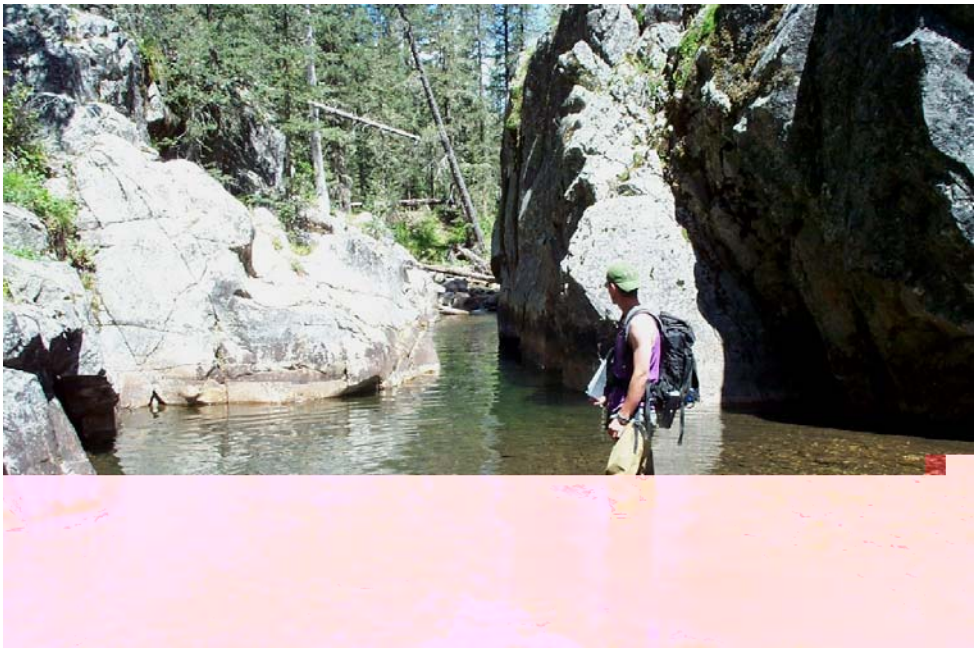

Photo 55. Reach 11, NSO 337, P105. A constriction of the bedrock canyon (17 Aug 2002).

The riparian vegetation of Reach 11 was conifer dominated with some alder. Due to the steep nature of the canyon, many conifers have fallen into the Pecos, a source of large woody debris.

No official trail access approaches this reach. The closest access to this reach is provided by Trails # 25 and 249, which parallel the river from several hundred feet above. At the upper end of the reach an unofficial trail accesses a dispersed campsite on the right bank. This campsite is within the Beatty's Creek area where camping is prohibited. The campsite appears to be well used and consists of a fire ring and several downed trees used for benches and fire fuel. This campsite decreases bank stability and riparian vegetation on the right bank. There is also a manmade cobble dam attempting to increase the volume of a pool within the canyon.

Water temperatures are measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings are taken in the water column. Two (2) temperatures were taken during the survey of Reach 11. The highest temperature was 51°F at 11:30 and the lowest, 49°F at 11:00.

Habitat Characteristics

0.4 stream miles (2,162 ft) of Reach 11 are divided into 17 NSOs. Eight (8) NSOs are pool habitat and comprise 15.0 % of the stream habitat. 6 riffle habitats consist of 85.5 % of the stream habitat. Three (3) tributary habitats are in the reach (see Table 51). This reach is under the recommended 0.5-mile minimum for a reach, so ocular estimates are not statistically valid.

Table 51. Summary of Reach 11 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	8	324	15.0	15.0	>30%
Riffle	6	1838	85.0	85.0	-
Culvert	0	0	0	0	-
Tributary	3	NA	NA	NA	-
Falls	0	0	0	0	-
Side Channel	0	0	NA	0	-
Total	17	2,162	100.0	100.0	-

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

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 11 contains not properly functioning, at risk and properly functioning characteristics. The parameters that are **not properly functioning** include pool development and the bankfull width-to-depth ratio. Large woody debris content is **at risk.** The **properly functioning** characteristics are bank stability, pool quality, and riffle sediment content.

The riffle habitat in Reach 11 is **properly functioning** for relative sediment content with 11.3% fines (see Table 52).

Table 52. Summary of riffle habitat characteristics including substrate composition in Reach 11.

Riffle Habitat Summary						
Reach	Number of Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
11	6	229.8	18.5	1.0	2.1	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
11	11.3	17.5	27.5	30.0	13.8	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool development is **not properly functioning**. The desirable pool content is greater than or equal to 30% of the stream habitat length (see Table 51). Reach 11 contains 15.0 % pool habitat. Pool quality, measured by residual depth, is **properly functioning** (see Table 53).

Table 53. Summary of pool habitat characteristics including substrate composition of 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	8	54.0	16.0	3.4	0.9	2.5	14.7	6	14.7	3	7.3
Properly Functioning Indicators	-	-	-	-	-	≥1 ft	-	-	-	-	-

Substrate Summary							
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total	
11	15.0	20.0	31.7	13.3	20.0	100.0	

Large woody debris density in Reach 11 is **at risk** when compared to the matrix standard. The 11 pieces of wood in the reach create a density of 26.9 pieces per mile (see Table 54). The desirable density is greater than 30 pieces per mile.

Table 54. Habitat characteristics for Reach 11 of the Pecos River.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
11	1.3:1	11:1	26.9	50	1.2
Properly Functioning Indicators	-	12-30:1	>30	-	<10

The bankfull width-to-depth ratio, 11:1, is outside the expected range for the related Rosgen stream classification and thus is **not properly functioning** (see Table 54). This is possibly due to surveyor error related to the tight nature of the floodplain. Further investigations should be conducted.

Bank stability is **properly functioning**. 50 feet of bank is unstable in the reach. The length of unstable bank is 1.2 % of the stream habitat (see Table 54).

Recommendations

The management recommendations of this reach focus around the dispersed camping site. The camping restrictions need to be enforced at the site using a sign or other educational means. The site should also be obliterated and rehabilitated to its natural condition. The Respect the Rio Campaign could be utilized to help the public understand the camping restrictions.

Reach 12: Beatty's Creek to Rito del Padre

Reach 12 begins just above the confluence with Beatty's Creek, 9,300 feet (T19N, R13E, Sec. 6) and ends 0.8 mi. upstream at the confluence with Rito del Padre 9,420 feet (T20N, R13E, Sec. 31). Surveyed on August 17, 2002, this reach is exploited by heavy recreational use. The average gradient is 2.9% with a mapped sinuosity of 1.0. The Rosgen channel type is B2 with a boulder-dominated substrate.

Photo 56. Looking up the open valley of Reach 12 from the top of a bedrock canyon wall of Reach 11 (Sutherland 1975). The Rito del Padre drainage is in the background. Compare this photo to Photo 22 (page 46). Note that the tree centered here in the foreground has since died.

The geomorphology of Reach 12 is a broader canyon than the previous reach. The valley opened up from the previous tight canyon in Reach 11 to a grassy slope on the left bank and a steep forested slope on the right bank, which is dominant for most of the reach (see Photo 56).

The anthropogenic effects on Reach 12 include multiple campsites on both banks with associated impacts. Although the land throughout this entire reach is closed to camping, multiple established campsites with signs of recent use were scattered throughout the reach. Stream related impacts from the campsites include eroded banks and trampled upland and riparian vegetation in proximity to fire rings. Heavy trampling around several trees demonstrated evidence of horses tied to trees for long periods of time.

Although this area is closed to stock use, cattle impacts are apparent. On several occasions cattle were observed grazing in the Beatty's Cabin area. Stock related impacts include decreased bank stability, several areas with trails crossing the river, and trampled vegetation. The decreased bank stability stemmed from both riparian zone grazing and stream crossings. The trampled vegetation was especially obvious near Tributary #26 (NSO 347).

The six tributaries or Reach 12 include three seeps, two springs and one stream. The three seeps and two springs were all very low flow, each contributing an estimated 1% or less to the main channel. Temperature of the seeps and spring ranged from 48 to 68°F. The stream tributary, Rito del Padre, contributed more than half of the flow of the main channel (estimated 60%) and ended the reach. The temperature of Rito del Padre was 56°F at 1730, the same temperature as the Pecos.

Twenty-one (21) pieces of large woody debris were observed in the reach. Several pools were formed by pieces of wood with one pool formed by a logjam. The relative number of woody debris in the reach was 62% small, 29% medium and 9% large.

Dominant riparian vegetation is willow mixed with grasses. The upland vegetation consists of conifer and grasses. The willow riparian vegetation showed signs of grazing with decreased density. Upland vegetation was primarily conifer on the right bank with grass on the left bank.

Water temperatures are measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings are taken in the water column. Two (2) temperatures were taken during the survey of Reach 12. Both main channel temperatures were 56°F at 16:40 and 17:25.

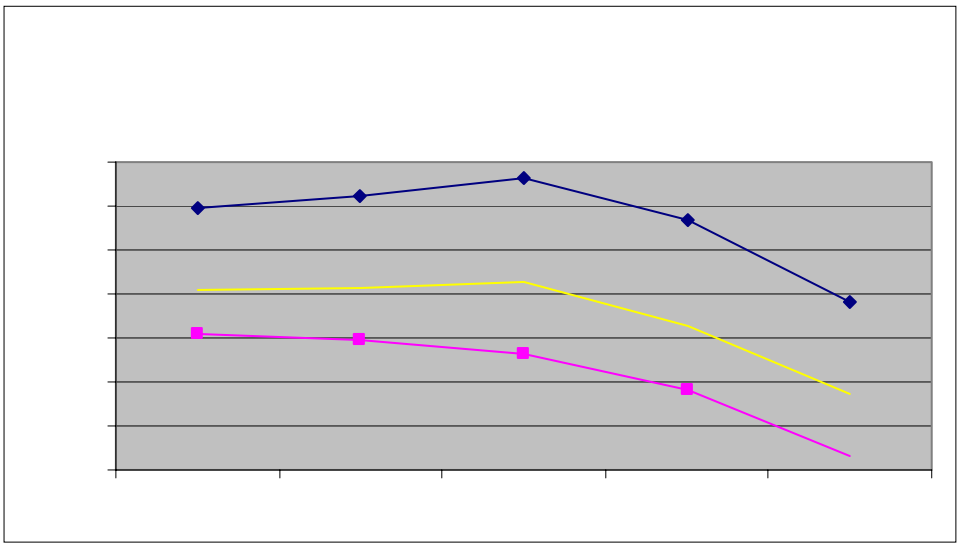

Table 55. Summary of Reach 12 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	4	178	4.4	4.0	>30%
Riffle	3	3,913	95.6	87.5	-
Culvert	0	0	0	0	-
Tributary	6	NA	NA	NA	-
Falls	0	0	0	0	-
Side Channel	2	380	NA	8.5	-
Total	15	4,471	100.0	100.0	-

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

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 12 contains not properly functioning, and properly functioning characteristics. The parameters that are **not properly functioning** include pool development, large woody debris density, and bankfull width-to-depth ratio. **Properly functioning** characteristics are bank stability, pool quality, and riffle sediment content.

The riffle habitat in Reach 12 is **properly functioning** for relative sediment content with 10.1% fines (see Table 56).

Table 56. Summary of riffle habitat characteristics including substrate composition in Reach 12.

Riffle Habitat Summary						
Reach	Number of Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
12	3	1304.3	11.7	0.9	1.9	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble			

Table 57. Summary of pool habitat characteristics including substrate composition of 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	4	44.6	15.3	2.4	1.1	1.3	5.2	4	5.2	0	0
Properly Functioning Indicators	-	-	-	-	-	≥1 ft	-	-	-	-	-

Substrate Summary								
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total	
	12	27.5	15.0	35.0	22.5	0.0	100.0	

Bankfull width-to-depth ratio, 11:1, is outside the expected range for the related Rosgen stream classification and is therefore **not properly functioning** (see Table 58). This is possibly due to surveyor error and should be investigated further.

Table 58. Habitat characteristics for Reach 12 of the Pecos River.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
12	1.3:1	11:1	10.3	140	1.7
Properly Functioning Indicators	-	12-30:1	>30	-	<10

Bank stability is **properly functioning**. 140 feet of bank is unstable in the reach. The length of unstable bank is 1.7 % of the stream habitat (see Table 58).

Recommendations

Management recommendations for this reach include enforcement of the "no camping" status of the area and harder enforcement of grazing regulations along the riparian zone. The primary degrading factor in Reach 12 is the high recreational use of the area. If the "no camping" regulation was enforced, many of the impacts seen in this reach would be reduced. Increased enforcement of the reach's grazing restrictions would also improve the fisheries and riparian habitat. This could include riparian fencing or improvement to current fencing scheme, increased range rider activity in the area or altering set herding routes.

Reach 13: Rito del Padre to Jarosa Creek

Reach 13 begins just above the confluence with Rito del Padre 9,420 feet (T20N, R13E, Sec. 31) and ends 2.86 miles upstream at the confluence with Jarosa Creek 10,200 feet at a significant change in flow (T20N, R13E, Sec. 28). Surveyed from August 18th to the 28th, 2002, this reach is in a canyon with an established stock trail off the left bank. The average gradient is 5.1% with a mapped sinuosity of 1.1. The Rosgen channel type is A2 for with a cobble-dominated substrate.

Anthropogenic impacts included one large established campsite and several smaller sties. The only large established camping area was toward the beginning of the reach, just outside the boundary fence of the Beatty's Creek area on the left bank, just before Trail #24 climbs away from the Pecos River. This campsite included an established fire ring, trampled vegetation, river access trails decreasing bank stability and other degradation. Several other campsites were observed upstream in the canyon section with much less use and associated impact. These smaller sites are likely associated with stock trails that parallel and crisscross the reach.

Photo 57. Reach 13, NSO 360, R191. Stock caused bank instability at a campsite near beginning of the reach (18 Aug 2002).

Stock impacts on this area were primarily related to campsites and trails paralleling and crossing the Pecos River. One significant trail follows the left bank, beginning where Trail #24 climbs away from the river. This dispersed trail receives significant use and in some areas demonstrates increased erosion, decreased bank stability and trampled upland vegetation. This trail also causes severe impacts to several small tributaries, increasing sediment inputs to the river. Several other less established trails connect to this trail crossing the river, possibly leading up to Hamilton Mesa. The trail crossings decreased riparian vegetation density and bank stability, degrading fisheries habitat.

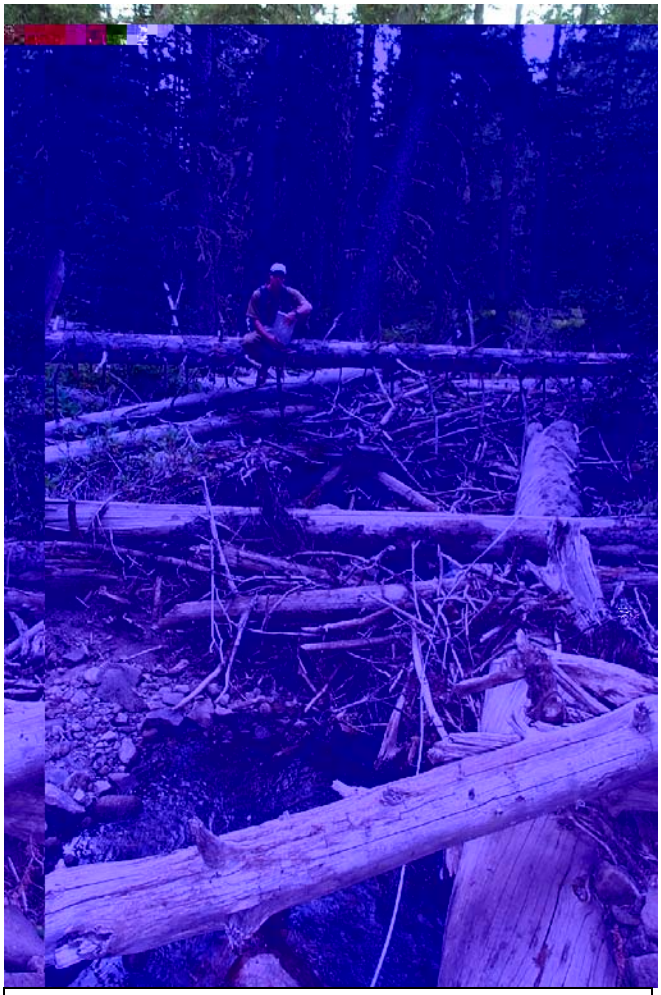

Photo 58. Reach 13, NSO 468, R233. A typical site where LWD density is over 42 pieces per mile (27 Aug 2002).

Twenty-three (23) tributaries were observed in Reach 13, consisting primarily of seeps with some springs and one stream. With an average of just over 8 tributaries per mile, this reach contained a high tributary density, which is related to nearing the headwaters. One stream, Jarosa Creek, at the top of the reach contributed an estimated 52% of the main channel flow. The significant reduction in flow above the tributary required a reach break.

High density of large woody debris in Reach 13 was related to the forested canyon morphology of the reach. Multiple debris jams and other wood was scattered through the reach influencing habitat formation. Channel dynamics, including side channel and pool formation, appeared to be influenced by woody debris.

Four (4) natural special case habitats are included in Reach 13, one falls and three chute habitats. The falls habitat had a plunge over 11 feet into a 6-foot deep pool below. This falls is a possible fish migration barrier and could easily be modified into a fortified barrier. The chute habitats are not significant enough to stop upstream fish migration. Two of the chute habitats contain 6-foot drops with the third dropping 3 feet over bedrock.

Observed vegetation included willow dominated riparian. Upland vegetation consisted of alternating conifer and mixed grasses. The riparian zone contained areas of thick willow with many areas with growth over the entire channel. Upland vegetation had areas of thick-forested slopes full of mixed conifer and areas of open grassland. The forested areas were a source of woody debris to the stream.

Reach 13 contained nine (9) side channels. Many of the side channels were created by debris jams in the river creating a dynamic system, and increasing fish habitat. Willow and conifer vegetation dominated side channel islands.

Many fish were observed throughout the reach. Rainbow trout are the dominant species with some brown trout. It is also possible that some cut-bows were observed. All size classes of fish were observed.

Photo 59. Reach 13, NSO 379, P114. Damon Goodman with a typical pool. The inset photo is a closeup of a six-inch rainbow trout inhabiting the pool (18 Aug 2002).

Habitat Characteristics

2.9 stream miles (15,181 ft) of Reach 13 are divided into 114 NSOs. Thirty-nine (39) NSOs are pool habitat and comprise 6.4 % of the stream habitat. 48 riffle habitats consist of 93.1 % of the stream habitat. 23 tributaries and 4 falls are in the reach (see Table 59).

Table 59. Summary of Reach 13 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	39	971	6.4	6.4[1]	-
Riffle	48	14,128	93.1	93.1	-
Culvert	0	0	0	0	-
Tributary	23	NA	NA	NA	-
Falls	4	82	0.5	0.5	-
Side Channel	0	0	NA	8.5	-
Total	114	15,181	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.
[1]Pool development applicable only to 3rd order streams and higher.

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 13 contains only **properly functioning** characteristics. The characteristics that are evaluated in Reach 13 include large woody debris density, bank stability, pool quality, riffle sediment content and bankfull width-to-depth ratio. Pool development is not evaluated in streams that are smaller than 3rd order. The Pecos River from Reach 13 to the headwaters is smaller than a 3rd order stream.

The riffle habitat in Reach 13 is **properly functioning** for relative sediment content with 10.2% fines (see Table 60).

Table 60. Summary of riffle habitat characteristics including substrate composition in Reach 13.

Riffle Habitat Summary						
Reach	Number of Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
13	48	294	10.6	0.8	1.5	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
13	10.2	17.9	31.1	32.3	8.5	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool quality is **properly functioning** in Reach 13. Pool quality, as determined by residual pool depth, is twice as deep as the "greater than or equal to 1 foot" properly functioning indicator.

Table 61. Summary of pool habitat characteristics including substrate composition of Reach 13.

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
13	39	24.9	10.7	2.5	0.6	2.0	13.6	39	13.6	6	2.1
Properly Functioning Indicators	-	-	-	-	-	≥1 ft	-	-	-	-	-

Substrate Summary							
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
	13	22.6	16.6	24.1	18.5	18.2	100.0

Large woody debris density in Reach 13 is **properly functioning**. The 121 pieces of wood in the reach creates a density of 42.1 pieces per mile (see Table 62). Reach 13 has the highest density of LWD on the Pecos River. Only Reaches 13 and 14 are properly functioning for LWD density on the Pecos River.

Bankfull width-to-depth ratio, 5:1, is within the expected range for the related Rosgen stream classification and is therefore **properly functioning** (see Table 62).

Table 62. Habitat characteristics for Reach 13 of the Pecos River.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
13	1:1.2	5:1	42.1	615	2.0
Properly Functioning Indicators	-	<12:1	>30	-	<10

Bank stability is **properly functioning** in Reach 13. 615 feet of bank is unstable in the reach. The length of unstable bank is 2.0 % of the stream habitat (see Table 62).

Recommendations

Photo 60. Reach 13, NSO 425, F3. The falls could be used to extend the Rio Grande cutthroat trout population 1.3 miles down from Pecos Falls (19 Aug 2002).

Management recommendations include further reconnaissance of the falls habitat. It is possible that the falls habitat could be used to extend the current range of Rio Grande cutthroat trout by 1.3 miles, which would include expanding occupation in Jarosa Creek. It is possible that the falls feature is currently a barrier and if not, it could be easily modified by obstructing the pool at its base. This falls habitat is the easiest first stage to extend RGCT populations in the Pecos River.

The stock trail that parallels most of the reach and several large, established campsites along the left bank should also be managed. The stock trail should be eliminated and Trail #24 should be the primary route utilized by the range rider to move cattle to the Pecos Headwaters grazing area. Designated trail use would minimize dispersed impacts on the watershed. The large established campsites where Trail #24 breaks off from the Pecos should be relocated and the area rehabilitated. With decreased use of the camping site, riparian vegetation and streambank condition could recover.

Reach 14: Jarosa Creek to Pecos Falls

Reach 14 begins above the confluence with Jarosa Creek 10,200 feet (T20N, R13E, Sec. 28) and ends 0.6 miles upstream at the top of Pecos Falls 10,420 ft (T20N, R13E, Sec. 22) due to a significant fish migration barrier and change in geomorphology. Surveyed from August 28th to the 29th, 2002, this reach is in a broad canyon type system. average gradient is 7.5% (high value artially due to 85-foot elevation change at Pecos Falls) with a mapped sinuosity of 1.2. The Rosgen

Trail #24 p ximity to ecos Falls, very few signs of anthropogenic impacts were witnessed in Reach 14. With exception ar

Three small seeps and one large spring enter the Pecos River in Reach 14. The small seeps contribute 1% or less to the flow of the main channel. The seeps ranged in temperature from 49° to 53° F. A large spring entered the Pecos River on the left bank contributing an estimated 5% of the main channel flow. The temperature was 52° F at 1420. This spring was unique due to the fact that it lacked any sort of drainage and dropped steeply from the left canyon. The flow seemed to be undirected with no secured drainage, instead the water poured over the soil, creating a 16-foot wide spring (see Photo 58). When exploring the spring, it appeared to form at a group of thick grasses several hundred feet from the river.

Photo 62. Reach 14, NSO 502, T57. An unusual spring in Reach 14 that lacked a defined channel (28 Aug 2002).

Pecos Falls is the only falls habitat in the reach. Pecos Falls is the most significant falls habitat on the entire Pecos River and is the current barrier used to protect an upstream population of Rio Grande Cutthroat Trout (*Salmo clarki virginalis*). The falls drops approximately 85 vertical feet over 189 ft, stepping down an area of jointed Precambrian quartzite (Sutherland 1975). A historic channel is just to the left of the current falls with a more vertical drop (see Photo 63). The reason for the channel shift is not apparent.

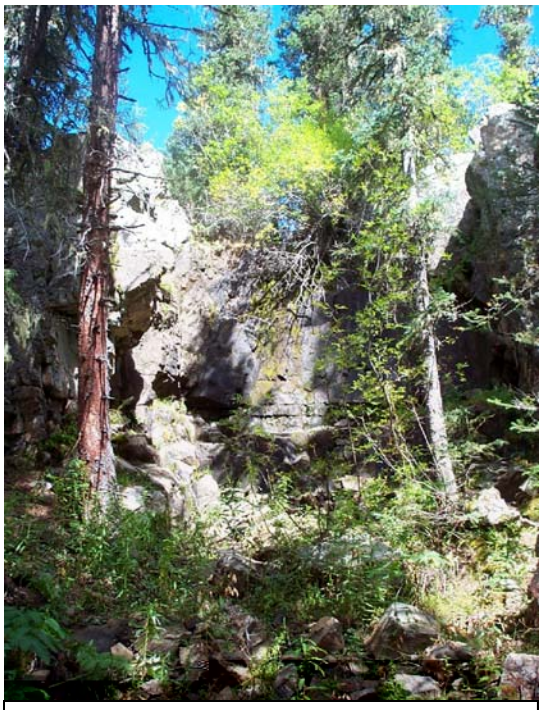

Photo 63. A historic channel of Pecos Falls located just to the left of the current channel (29 Aug 2002).

Two logjams were located near the beginning of Reach 14. The first logjam produced a small pool just upstream of the jam. The second created several dry side channels around the channel-spanning LWD jam.

Thick willows dominated the riparian vegetation. Many of the willows overgrew the stream, improving fish habitat by providing increased shading, bank stability and cover from predators. Upland vegetation includes mixed conifers.

Many fish were observed including brown trout, rainbows and possibly RGCT and cut-bows. Size classes of fish ranged from juvenile to adult fish.

Habitat Characteristics

0.6 stream miles (3,118 ft) of Reach 14 are divided into 25 NSOs. Eight (8) NSOs are pool habitat and comprise 3.7 % of the stream habitat. 9 riffle habitats consist of 87.0 % of the stream habitat. 4 tributaries and 3 side channels are in the reach.

Table 63. Summary of Reach 14 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	8	119	3.8	3.7[1]	-
Riffle	9	2,810	90.1	87.0	-
Culvert	0	0	0	0	-
Tributary	4	NA	NA	NA	-
Falls	1	189	6.1	5.9	-
Side Channel	3	112	NA	3.5	-
Total	25	3,230	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.
[1]Pool development applicable only to 3rd order streams and higher.

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 14 contains only **properly functioning** characteristics. The characteristics that are evaluated in Reach 14 include large woody debris density, bank stability, pool quality, riffle sediment content and bankfull width-to-depth ratio. Pool development is not evaluated in streams that are smaller than 3rd order. The Pecos River from Reach 13 to the headwaters is smaller than a 3rd order stream.

Riffle habitat in Reach 14 is **properly functioning** for relative sediment content with 16.7% fines (see Table 64).

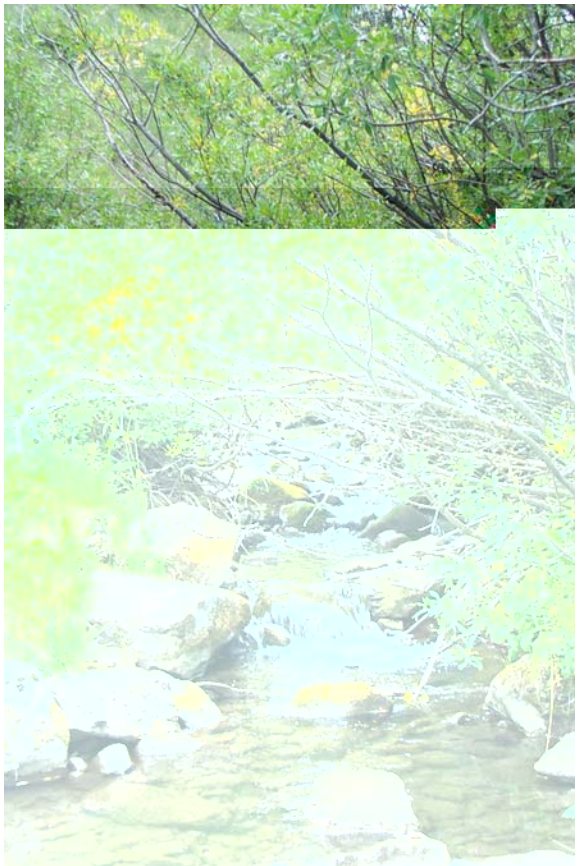

Photo 64. Reach 14, NSO 492, R242. Typical riffle habitat with overhanging willow (28 Aug 2002).

Table 64. Summary of riffle habitat characteristics including substrate composition in Reach 14.

Riffle Habitat Summary						
Reach	Number of Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
14	9	312.2	9.8[1]	0.7	1.5	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
14	16.7	25.6	28.9	28.9	0.0	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

[1] Average width is surveyor estimation and not a corrected value in Reach 14.

Pool quality is **properly functioning** in Reach 14. Pool quality, as determined by residual pool depth, is above "greater than or equal to 1 foot" (see Table 65).

Large woody debris density in Reach 14 is **properly functioning**. The 19 pieces of wood in the reach creates a density of 32.2 pieces per mile (see Table 66).

Table 65. Summary of pool habitat characteristics including substrate composition of Reach 14.

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
14	8	14.9	9.9	1.9	0.5	1.4	13.5	6	10.2	0	0
Properly Functioning Indicators	-	-	-	-	-	≥1 ft	-	-	-	-	-

Substrate Summary							
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
	14	41.3	17.5	17.5	21.3	2.5	100.0

Bankfull width-to-depth ratio, 9:1, is within the expected range for the related Rosgen stream classification and is therefore **properly functioning**. (see Table 66).

Table 66. Habitat characteristics for Reach 14 of the Pecos River.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
14	1:1.1	9:1	32.2	55	0.9
Properly Functioning Indicators	-	<12:1	>30	-	<10

Bank stability is **properly functioning** in Reach 14. 55 feet of bank is unstable in the reach. The length of unstable bank is 0.9 % of the stream habitat (see Table 66).

Recommendations

There are no management recommendations for this reach.

Reach 15: Pecos Falls to the Headwaters

Reach 15 begins at the top of Pecos Falls 10,420 ft (T20N, R13E, Sec. 22) and ends 4.6 miles upstream at the headwaters 11,700 ft (T20N, R13E, Sec. 10). This reach was surveyed from August 29th through August 30th, 2002. The average gradient is 5.3% with a mapped sinuosity of 1.83. The Rosgen channel type is A4 with sand dominated substrate.

Due to the rapidly changing characteristics of headwaters streams, this reach is particularly diverse. Habitat, flow regime, and other characteristics change dramatically throughout the reach. The valley morphology of this reach is similar to a wide staircase surrounded by steep ridges. The valley floor alternates between grassy meadow and steep gradient riffle. Above the valley floor tall ridges, between 400 and 1000 feet, tower above both banks of the river. The enclosed "stair-step" pattern

pe42 0 0 12 408.92s.67093 538.08052 Tm(t)Tj12 010 1 0 07.07093 538.0805s Tm(t)Tj12 0106h2 721.07093 5

Several groups of cattle were observed grazing in this area during the survey (see Photo 18), as well as a few elk herds. Also one large mud pit was observed off of the left bank of the river, possibly due to cattle access. Stock utilization was observed just above the exclosure fence, but decreased above that.

Photo 66. Reach 15, NSO 541, R259. Bank instability likely caused by stock use (29 Aug 2002).

ontributed significantly to the main channel flow. Four tributaries contributed 40% of the main channel flow (relative to where the tributary enters the river) and several others contributed 15 to 0%. Due to the high number and significant flow input of these tributaries the Pecos River reduced

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atches.

orested areas were dominated by conifer es

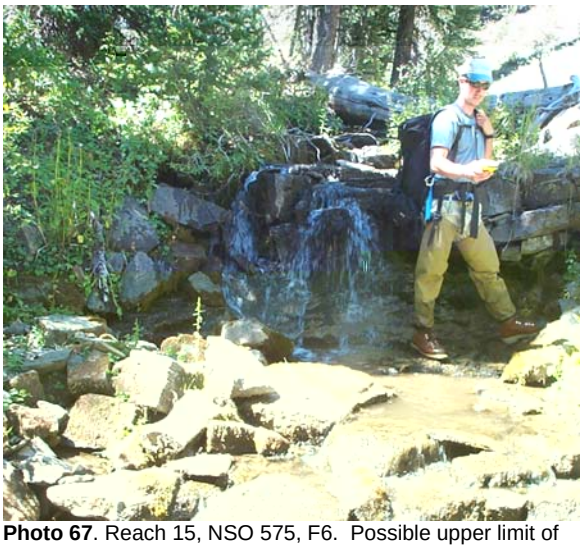


Photo 67. Reach 15, NSO 575, F6. Possible upper limit of RGCT (30 Aug 2002).

Identifying the Pecos River became difficult towards the headwaters. Lack of detail in field maps and large tributaries, contributing almost equal flow made the differentiation between tributaries and the main channel difficult. The method used to identify the main channel in the headwaters area was to follow the highest flow to its source. It is possible that this was not the longest channel. At the source the stream was formed by five (5) separate springs emerging across a slope separated by approximately 10 feet each, which come together to form the Pecos River.

A combination of time constraints and remote location of the site caused information gathering above the falls habitat in Reach 15 to be of a lower quality than the previous surveying. Much of the habitat that was classified as riffle was in fact pool. When analyzing habitat characteristics of this section, the pool-to-riffle ratio was excluded from both the reach and river summaries.

Photo 68. Reach 15, NSO 598, R280. Murray Boatright celebrates the end of survey and terminus of the Pecos River (30 Aug 2002).

Habitat Characteristics

4.6 stream miles (24,127 ft) of Reach 15 are divided into 93 NSOs. Twenty-six (26) NSOs are pool habitat and comprise 2.3 % of the stream habitat. 35 riffle habitats consist of 96.4 % of the stream habitat. 27 tributaries, one falls and 3 side channels are in the reach (see Table 67).

Table 67. Summary of Reach 15 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	26	556	2.3	2.3[1]	-
Riffle	35	23,555	97.6	96.4	-
Culvert	0	0	0	0	-
Tributary	27	NA	NA	NA	-
Falls	1	16	0.1	0.1	-
Side Channel	4	301	NA	0.1	-
Total	93	24,428	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.
[1]Pool development applicable only to 3rd order streams and higher.

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 15 contains both properly functioning and not properly functioning characteristics. Characteristics that are **not properly functioning** include large woody debris density and riffle sediment content. **Properly functioning** characteristics include bank stability, pool quality, and bankfull width-to-depth ratio. Pool development is not evaluated in streams that are smaller than 3rd order. The Pecos River from Reach 13 to the headwaters is smaller than a 3rd order stream.

The riffle habitat in Reach 14 is **not properly functioning** for relative sediment content with 28.8 % fines (see Table 68). This may be within the natural range of variability given the smaller size of the watershed and geological source material.

Table 68. Summary of riffle habitat characteristics including substrate composition in Reach 15.

Riffle Habitat Summary						
Reach	Number of Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
15	35	673	5.4	0.5	1.2	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
15	28.8	29.7	27.9	11.5	2.1	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool quality is **properly functioning** in Reach 15. Pool quality, as determined by residual pool depth, is above “greater than or equal to 1 foot” (see Table 69).

Table 69. Summary of pool habitat characteristics including substrate composition of Reach 15.

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
15	26	21.4	5.2	1.7	0.3	1.3	5.7	22	4.8	0	0
Properly Functioning Indicators	-	-	-	-	-	≥1 ft	-	-	-	-	-

Substrate Summary								
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total	
	15	44.8	24.0	18.4	6.0	6.8	100.0	

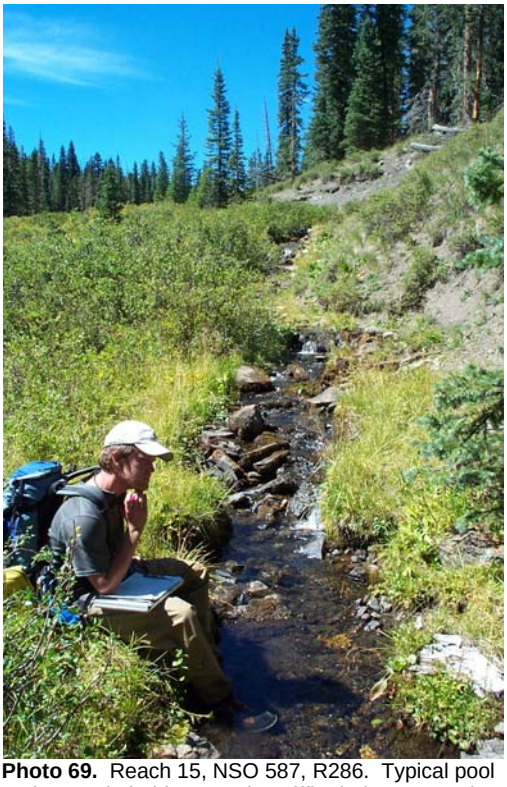


Photo 69. Reach 15, NSO 587, R286. Typical pool and cascade habitat noted as riffle during survey (30 Aug 2002)

Large woody debris in Reach 15 is **not properly functioning**. 28 pieces of wood in the reach creates a density of 6.1 pieces per mile (see Table 70).

Table 70. Habitat characteristics for Reach 15 of the Pecos River.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
15	NA[1]	2.7:1	6.1	1,530	3.2
Properly Functioning Indicators	-	<12:1	>30	-	<10

[1]Pool to riffle ratio is not applicable in Reach 15 due to lack of survey accuracy.

Bankfull width-to-depth ratio, 3:1, is within the expected range for the related Rosgen stream classification and is therefore **properly functioning** (see Table 70).

Bank stability is not evaluated in reaches with a gradient over 4%. Reach 15 has a gradient of 6.1% and had only 3.2% unstable bank.

Recommendations

Recommendations for management of Reach 15 include the construction of a bridge crossing at Trail #239, reduction of stock impacts below the exclosure fence and an upper limits survey for Rio Grande cutthroat trout. The significant widening at Trail #239 (Gascon Trail) crossing should be mitigated (see Photo 65) with the construction of a bridge for both human and stock use. Stock impacts below the exclosure fence could be mitigated by construction of riparian fencing and/or the reduction of the number of cattle and time spent grazing in this area. The exclosure fence should be checked for breeches and repaired accordingly. An upper limit survey for RGCT should investigate both above and below the falls habitat to get a better idea if the falls is a fish migration barrier. The survey should also include a population study to better understand the current range and population density of RGCT, including the assortment of tributaries in Reach 15.

APPENDIX A:
Supporting Information

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

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

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

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

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

Tributaries

Table 3. Information summary of the tributaries to Pecos River.

Reach Number	NSO Number	Habitat Number	Bank	Type	Name	% Flow*	Date (2002)	Time	Trib Temp (°F)	Stream Temp (°F)	Comments
6	41	T1	Right	Stream	Rio Mora	40	4 Jul	1550	60	59	Heavy recreational impacts from state owned campground
6	42	T2	Left	Stream		<1	4 Jul	1635	54	59	
7	108	T3	Left	Spring		1	23 Jul	1730	46	57	Very clear with veg covering flow in spots
7	114	T4	Left	Spring		<1	24 Jul	1215	61	57	Spring probably from Cowles Ponds se

Reach Number	NSO Number	Habitat Number	Bank	Type	Name	% Flow*	Date (2002)	Time	Trib Temp (°F)	Stream Temp (°F)	Comments
12	348	T27	Left	Seep		<1	17 Aug	1510	68	59	Low gradient
12	349	T28	Right	Seep		<1	17 Aug	1530	48	59	Very small
12	355	T29	Right	Seep		<1	17 Aug	1700	53	56	Low gradient
12	357	T30	Left	Stream	Rito del Padre	60	17 Aug	1730	56	56	Drainage includes the Truchas and Chimayosos Peaks; large pool formed by confluence
13	366	T31	Right	Seep		<1	18 Aug				Too shallow to get temp reading
13	367	T32	Right	Seep		<1	18 Aug	1130	45	49	Flows into side channel
13	368	T33	Right	Seep		<1	18 Aug	1130	49	49	Seeps out of side channel island
13	369	T34	Left	Seep		<1	18 Aug	1145	47	49	
13	370	T35	Right	Seep		<1	18 Aug	1150	49	49	
13	375	T36	Right	Seep		<1	18 Aug	1210	48	49	
13	378	T37	Right	Seep		<1	18 Aug	1235	50	49	
13	386	T38	Right	Seep		<1	18 Aug	1405	48		Flows into side channel
13	390	T39	Right	Seep		<1	18 Aug				Too shallow to get temp reading
13	391	T40	Right	Stream		<1	18 Aug	1445	48		Spring is also source; subterranean for two feet near mouth; fish trapped in isolated pool
13	392	T41	Right	Seep		<1	18 Aug	1500	50		Cattle damage noted
13	394	T42	Right	Seep		<1	18 Aug	1515	46	52	Steep; multiple braids at confluence with 10' fan
13	404	T43	Left	Seep		<1	18 Aug	1605	56	52	Steep
13	409	T44	Right	Spring		<1	18 Aug	1700	41	53	Steep
13	422	T45	Left	Seep		<1	27 Aug	1050	48	45	Steep
13	424	T46	Right	Seep		<1	27 Aug	1145	43	49	
13	441	T47	Right	Seep		<1	27 Aug	1415	50	52	
13	444	T48	Right	Seep		<1	27 Aug				Too shallow to get temp reading
13	450	T49	Right	Seep		<1	27 Aug	1510	47	53	
13	458	T50	Right	Seep		<1	27 Aug	1630	53	54	
13	467	T51	Left	Seep		<1	27 Aug	1720	48	54	
13	469	T52	Right	Seep		<1	27 Aug	1735	48	54	
13	480	T53	Left	Stream	Jarosa Creek	25	28 Aug	1130	49	49	Marks end of Reach 13; very steep gradient
14	482	T54	Right	Seep		<1	28 Aug	1205	49	49	
14	498	T55	Left	Seep		<1	28 Aug	1345	57	53	Two mouths; steep gradient
14	501	T56	Left	Seep		<1	28 Aug	1400	53	53	
14	502	T57	Left	Spring		5	28 Aug	1410	52	53	Overland flow with no incised channel
15	508	T58	Left	Stream		<1	29 Aug	1205	51	51	
15	512	T59	Left	Stream		<1	29 Aug	1240	59	58	
15	518	T60		Stream		<1	29 Aug	1305	59	58	Two mouths
15	519	T61	Left	Seep		<1	29 Aug	1320	60	58	3 sources

Reach Number	NSO Number	Habitat Number	Bank	Type	Name	% Flow*	Date (2002)	Time	Trib Temp (°F)	Stream Temp (°F)	Comments
15	538	T65	Right	Spring		<1	29 Aug	1615	65	65	
15	539	T66	Right	Stream							

APPENDIX B:
Pool Volume Proof

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

Area of an Ellipe

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

$$3.14159265358979323 \cdot 12385$$

or π*b*a

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

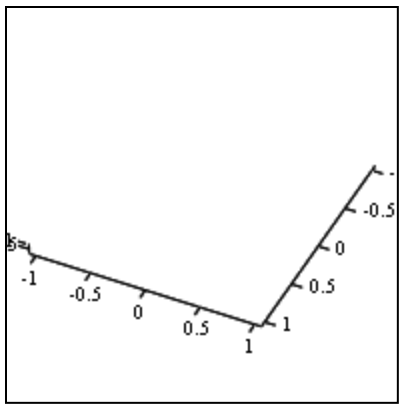
$$\int_{-a}^{a} \int_{-b\cdot\frac{\left(a^2-x^2\right)^{.5}}{a}}^{b\cdot\frac{\left(a^2-x^2\right)^{.5}}{a}} \int_{0}^{h\cdot\left[\left(\frac{x^2}{a^2}\right)+\left(\frac{y^2}{b^2}\right)\right]} 1\,dz\,dy\,dx \rightarrow$$

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

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

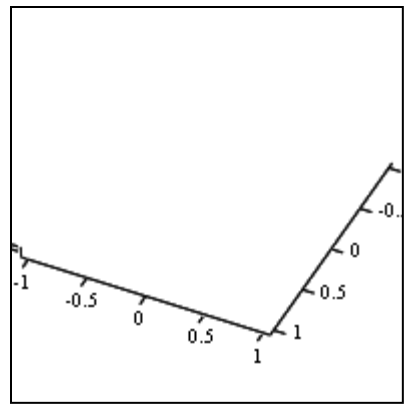
$$f(x,y) := \left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2$$

Surface Plot **Contour Plot**



x = 0

f

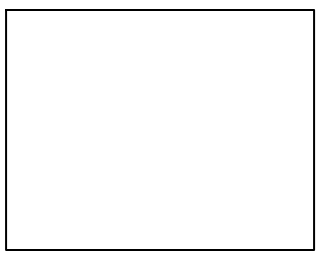


y = 0

f

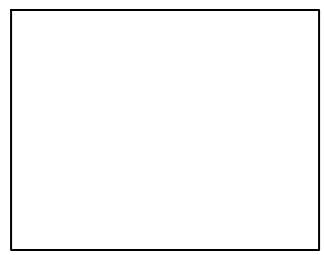
Cross Sections (2-D)

$f(0,y)$



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

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

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The Crew (L to R): Sarah Eddy, Murray Boatright, Damon Goodman (team leader)

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