GALLINAS WATERSHED THINNING MONITORING
Final Report

Prepared by
Surface Water Quality Bureau
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Cover: Gallinas River below the USGS gage at Montezuma, NM

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AP	Assessment Protocol
C	Celsius
cfs	cubic feet per second
CWA	Clean Water Act
CWAL	Coldwater Aquatic Life
ELS	Early Life Stage
DO	Dissolved Oxygen
GIS	Geographic Information Systems
HQCWAL	High Quality Cold Water Aquatic Life
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
OLS	Other Life Stage
QAPP	Quality Assurance Project Plan
SoC	Species of Concern
STORET	EPA's Storage and Retrieval System
SWQB	Surface Water Quality Bureau
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WQS	Water Quality Standards
WUI	Wildland – Urban Interface

1.0 Executive Summary

The Gallinas River watershed, located near Las Vegas New Mexico, is currently the focus of a wildland/urban interface (WUI) forest thinning project undertaken by the Santa Fe National Forest and the City of Las Vegas. During 2007 the Monitoring and Assessment Section of the Surface Water Quality Bureau of the New Mexico Environment Department conducted a water quality and biological assessment survey designed to capture the impacts, if any, of thinning activities in the watershed. This effort was continued in 2008 and 2009 in anticipation of forest thinning activities.

Initially four study sites were established; three stations on the Gallinas River proper and one station on El Porvenir Creek. In 2008 two additional stations were added: Gallinas River at forest boundary and El Porvenir Creek at Christian Camp. Both are stations used during past SWQB water quality surveys, allowing comparison of past and present data. Both also provide separation of federal and private land uses. Sampling at stream stations was conducted on a monthly basis from May through September during 2007. Sampling was reduced to five events in 2008 due to SWQB resource limitations. During 2009 sampling was further reduced to three events due to an apparent lack of significant forest thinning activity in the watershed. Water chemistry sampling at survey stations included total nutrients, and major anions and cations. Temperature was monitored by six water-deployed and four air-deployed recording thermographs. In addition, biological and geomorphological assessments were conducted at selected stations. All sampling methods were in accordance with the Standard Operating Procedures for Data collection (NMED, 2007a) *Quality Assurance Project Plan for Water Quality Management Programs* (NMED, 2007b, 2008 and 2009a).

Examination of chemical, biological and hydrological data over the course of three years found no indications of damage to water quality in either the Gallinas River or El Porvenir Creek as a result of this watershed rehabilitation project. Those parameters that were seen to exceed criteria, temperature and turbidity, are known to have been problems prior to the start of forest thinning projects.

This project was funded by a grant from the U.S. Environmental Protection Agency.

2.0 Introduction

The Gallinas watershed affords a relatively cool summer climate and snowy winter conditions supporting activities such as hiking, mountain biking, camping, fishing, and hunting as well as cross country skiing and other winter sports. Ranching and irrigated agriculture are additional water uses and contributors to the local economies. The City of Las Vegas, NM, relies heavily on the Gallinas River for its drinking water supply.

Due to the risk of wildfire, the City of Las Vegas and the Santa Fe National Forest, Pecos / Las Vegas Ranger District, have embarked on programs of forest rehabilitation. These projects involve extensive programs of thinning, burning and logging which have the potential to impact water quality. In an effort to monitor these impacts, if any, the Surface Water Quality Bureau (SWQB) of the New Mexico Environment Department (NMED) has undertaken a multiyear effort to assess the condition of the Gallinas River within and below the treatment areas.

The upper Gallinas watershed (US Geological Survey [USGS] Hydrologic Unit Code 13060001) is located in San Miguel County, NM on the east slopes of the Sangre de Christo Mountains (**Figure 1**). The upper Gallinas watershed encompasses approximately 84 square miles (218 km^2). The Gallinas River originates at about 9800 ft (or ~3,000 m) on the southeast slopes of Elk Mountain. The upper Gallinas watershed includes three smaller, perennial, sub-watersheds, Burro, Trout Springs and El Porvenir Creeks. The Burro and El Porvenir sub-watersheds join the Gallinas from the northwest and are planned receive varying degrees of treatment as part of the overall thinning project. Trout Springs joins the Gallinas on private land from the south just below the village of Gallinas. Flows (stream discharge) of the Gallinas River during the survey period are derived from USGS gage number 08380500 (Gallinas Creek near Montezuma, NM), and are graphically represented and compared to long-term mean flows in **Figure 2**, below.

The upper Gallinas watershed is contained within the Southern Rockies Level III Ecoregion 21; it contains the following Level IV Ecoregions: 21b-Crystalline Subalpine Forests, 21c-Crystalline Mid-Elevation Forests, 21e-Sedimentary Subalpine Forests and 21f-Sedimentary Mid-Elevation Forests (Griffith, G.E. et al., 2006). Several species within this watershed are listed as threatened or endangered by State or Federal agencies, or identified as species of concern by non-governmental conservation groups.

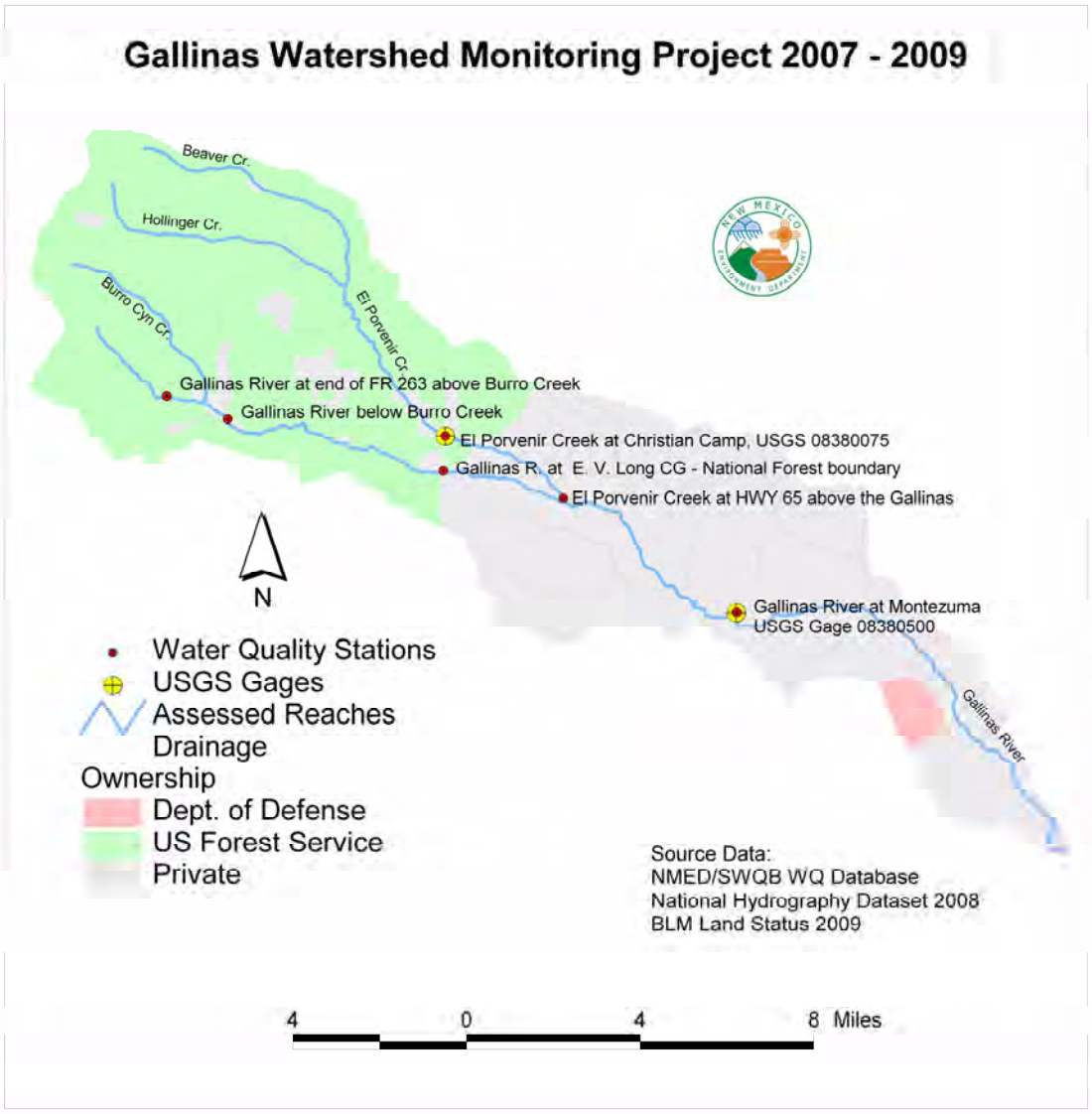

Figure 1. Map of Study Area

Photo 1. Thinned ponderosa forest above the Gallinas River.

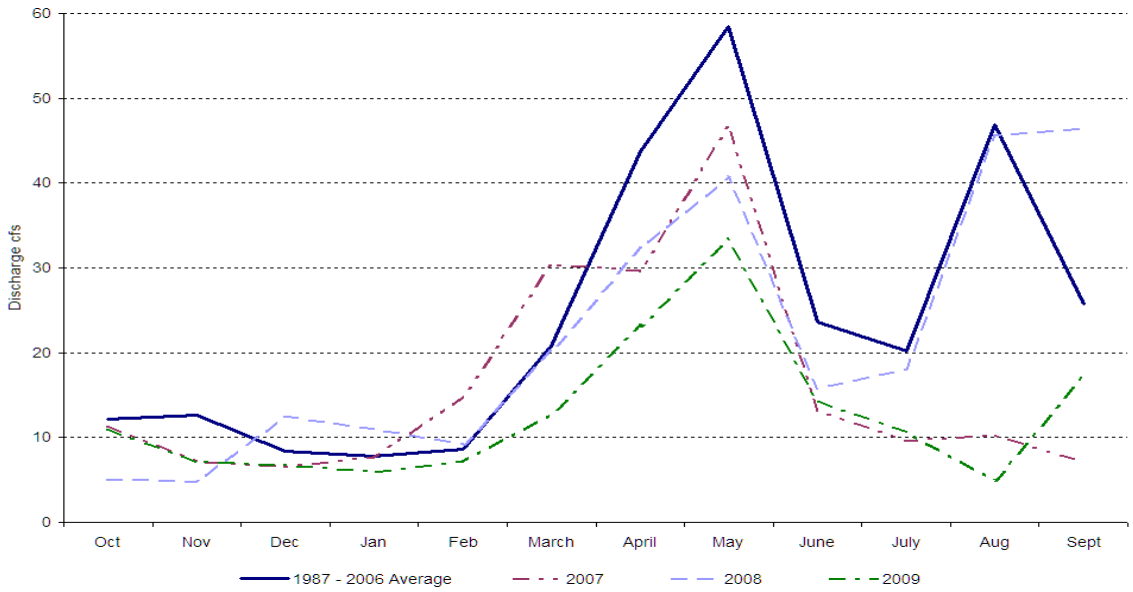

Figure 2. Mean monthly discharge of the Gallinas River in cfs (cubic feet per second). The graph compares the long-term historical average with values from water years 2007, 2008 and 2009. Data are from USGS Gage 08380500, Gallinas Creek near Montezuma, NM.

Photo 2. Thinning adjacent to the riparian. A number of spruce trees in this area have apparently drowned, possibly due to rising ground water from downstream beaver activity.

3.0 Water Quality Standards

The water quality standards for the upper Gallinas watershed fall within segment 20.6.4.215 NMAC (NMAC, 2007). For this segment, the WQS state:

20.6.4.215 PECOS RIVER BASIN - Perennial reaches of the Gallinas river and all its tributaries above the diversion for the Las Vegas municipal reservoir and perennial reaches of Tecolote creek and its perennial tributaries.

A. Designated Uses: domestic water supply, high quality coldwater aquatic life, irrigation, livestock watering, wildlife habitat, municipal and industrial water supply and secondary contact.

B. Criteria:
(1) In any single sample: specific conductance 300 μmhos/cm or less except specific conductance 450 μmhos/cm or less in Wright Canyon creek, pH within the range of 6.6 to 8.8 and temperature 20°C (68°F) or less. The use-specific numeric criteria set forth in

20.6.4.900 NMAC are applicable to the designated uses listed above in Subsection A of this section.
(2) The monthly geometric mean of E. coli bacteria 126 cfu/100 mL or less; single sample 235 cfu/100 mL or less (see Subsection B of 20.6.4.14 NMAC).
[20.6.4.215 NMAC - Rp 20 NMAC 6.1.2212, 10-12-00; A, 05-23-05]

A summary of the current status of support or non-support of the designated uses for this watershed is provided in **Table 1**. Presently the only approved TMDL within the Gallinas River watershed is for temperature (**Table 2**). The TMDL may be found at: http://www.nmenv.state.nm.us/SWQB/Pecos/Upper/index.html

Table 1. Summary of water quality assessment from the 2010 Integrated List (NMED/SWQB, 2010)

Assessment Unit	Domestic Water Supply	H Q Cold Water Aquatic Life	Irrigation	Livestock Watering	Municipal Water Supply	Secondary Contact	Wildlife Habitat
Gallinas River (Las Vegas Diversion to SFNF boundary)	FS	NS	FS	FS	FS	NA	FS
Gallinas River (SFNF boundary to headwaters)	FS	FS	FS	FS	NA	NA	FS
Porvenir Creek (Gallinas River to SFNF boundary)	FS	NS	FS	FS	FS	NA	FS
Porvenir Creek (SFNF boundary to headwaters)	NA	NA	NA	NA	NA	NA	NA

FS: Full Support; NS: Non-Support; NA: Not Assessed.

Table 2. Approved TMDLs for the Gallinas Watershed.

Waterbody	Watershed	Pollutant TMDL
Gallinas River	Pecos Headwaters	Temperature http://www.nmenv.state.nm.us/SWQB/Pecos/Upper/index.html

4.0 Methods

All water quality sampling, benthic macroinvertebrate collection, riparian habitat analysis, and fluvial geomorphologic measurements were in accordance with relevant portions of the SWQB's *Quality Assurance Project Plan for Water Quality Management Programs* (QAPP) (NMED/SWQB, 2007b, 2008, 2009a) and *Standard Operating Procedures for Data Collection* (NMED/SWQB, 2007a). The macroinvertebrate and habitat methods employed are the same as the USEPA's Environmental Monitoring and Assessment Program (Peck et al., 2003).

5.0 Sampling Summary

In 2007 samples were collected at four stations, three on the Gallinas and one on El Porvenir in 2007 (stations 1, 2, 5 and 6). During 2008 and 2009, samples were collected at six sampling sites during the survey period, four stations on the Gallinas River and two stations on El Porvenir Creek. The STORET identification codes and location descriptions of sampling stations selected for this survey are provided in **Table 3**. Sampling at stream stations was conducted on a monthly basis from May through September in 2007, in May, June, July and October in 2008, and seasonally (spring, summer and fall) in 2009. The start of sampling was delayed until May by snow in the upper watershed.

Table 3. Survey Stations and STORET Codes

SITE #	STATION	LATITUDE	LONGITUDE	STORET_ID	RATIONALE
1	GALLINAS RIVER AT THE END OF FOREST ROUTE 263	35.722139	-105.497333	50Gallin141.9	Upstream reference. Below uppermost area of treatment
2	Gallinas River below Burro Creek	35.716600	-105.487400	50Gallin140.8	Burro Cr. (No Access) will receive extensive treatment. Station monitors potential impacts.
3	Gallinas @ NF boundary	35° 41.905	-105°25.094	50Gallin131.8	Provides comparison between USFS and private lands.
4	El Porvenir @ Christian Camp	35° 42.649	-105°24.854	50ElPorv004.8	Upstream reference. Provides comparison between USFS and private lands
5	El Porvenir Creek at HWY 65 above the Gallinas	35.690000	-105.375833	50ElPorv000.1	Subject to treatment on Forest Service lands and logging on private land.
6	Gallinas River at Montezuma, USGS Gage 08380500	35.651944	-105.318333	50Gallin119.7	Monitors water quality immediately above the Las Vegas municipal diversion.

A listing of parameter suites sampled at each station in the various assessment units can be found in **Table 4**. The number of times each parameter (or suite of parameters) was sampled is indicated. Field data include temperature, specific conductance, pH, dissolved oxygen, and turbidity. In the case of stream discharge, some of the data may be estimated

or calculated. Due to the volume of data collected during this survey, it will not be included in this report. Those persons requiring a complete dataset or data from a specific site should contact the Surface Water Quality Bureau or search EPA's STORET database at: http://www.epa.gov/STORET.

Table 4. Sampling Summary.

Assessment Units / Stations	Ions	Nutrients	Macroinvertebrates	Thermograph	Discharge	EMAP	Sonde Deployment	Field Data
Gallinas River (SFNF Boundary to Headwaters)								
GALLINAS RIVER AT THE END OF FOREST ROUTE 263	13	13	x	x*	13			13
Gallinas River below Burro Creek	13	13	x	x	13	1		13
Gallinas @ NF bnd	7	7		x*	7			7
Gallinas River (Las Vegas Diversion to SFNF Boundary)								
Gallinas River at Montezuma, USGS Gage 08380500 -	13	13	x	x*	13	2	x	13
El Porvenir Cr (SFNF boundary to headwaters)								
El Porvenir @ Christian Camp	7	7		x	7			7
El Porvenir Cr (Gallinas R. to SFNF boundary)								
El Porvenir Creek at HWY 65 above the Gallinas-	13	13	x	x*	13	1	x	13

* Water plus air thermographs.

6.0 Water Quality Assessment

6.1 Water Quality Standards Exceedences

The following discussion includes information pertaining to all exceedences of water quality standards (NMAC, 2007) found during the watershed survey. The purpose of this section is to provide the reader with information on where within the watershed current water quality standards are not being met. For many water quality parameters, the State of New Mexico has adopted numeric water quality criteria. However, for some parameters (*e.g.*, plant nutrients, stream bottom deposits) only narrative standards exist.

Water quality criteria exceedences are evaluated to determine if the waterbody is impaired, that is to say, not-supporting its designated use. It should be noted that a single sample that exceeds a given criterion may or may not generate a violation of standards, triggering an impairment listing. In New Mexico, surface water data are assessed for designated use attainment status for both numeric and narrative water quality standards according to the SWQB *Assessment Protocol* (AP) (NMED/SWQB 2009). The purpose of the AP is to detail the decision process that the SWQB employs to determine whether or not designated uses are being attained in surface waters of the state. Thus, the AP covers the decision making process for both listing and de-listing. The AP is an evolving

document and the current protocol may vary from the procedures in place at the time these assessments were performed.

Final assessment determinations depend on the overall amount and type of data available during the assessment process (Refer to the *Assessment Protocol* NMED/SWQB, 2009) for additional information on the assessment process). When available, outside sources of data that meet quality assurance requirements are combined with data collected by SWQB during watershed surveys to determine final impairment status. Final designated use impairment status is housed in the Assessment Database (ADB) and is reported in the biennial *State of New Mexico Integrated Clean Water Act §303(d)/ §305(b) Report ("Integrated Report")* (NMED/SWQB 2010).

6.1.1 Physicochemical Data

Physicochemical water quality samples and sampling frequencies are provided in Table 3. When a survey is completed, all data are checked against Quality Assurance/Quality Control (QA/QC) measures identified in the QAPP before assessing to determine if designated uses are being met.

Extensive sampling for major ions, nutrients, and field parameters (temperature, dissolved oxygen, pH, turbidity and specific conductance) found exceedences of only the HQCWAL temperature criterion (20° C) at stations Gallinas River at Montezuma, USGS Gage 08380500 and El Porvenir Creek at HWY 65 above the Gallinas. These exceedences of criteria associated with the high quality aquatic life designated use are consistent with the historical finding of non-support of that use in these assessment units. There were no exceedences of any kind on Santa Fe National Forest lands. Details are discussed in section 7.0.

6.1.2 Data from Continuous Monitoring Devices

Large data sets generated from continuous monitoring devices attached to data loggers (e.g., sondes and thermographs) are assessed according to protocols developed specifically for such datasets. This is because, unlike grab sample data, it is not reasonable to list as not supporting on the basis of one or a few exceedences out of several hundred or thousand data points. The pH and temperature assessment protocols are tied to the criteria in the *State of New Mexico Standards for Interstate and Intrastate Surface Waters* (NMAC, 2007). Dissolved oxygen assessment criteria are linked to season (i.e., if early life stages of fish are likely present) and designated use (coldwater or warmwater aquatic life use). Further details of large data set assessment procedures are available in the appendices of the *Assessment Protocol*. (NMED/SWQB 2009)

Temperature data loggers (thermographs) were deployed at four stations in the upper Gallinas watershed in 2007 and six stations in 2008 and 2009. Additionally, four

thermographs were deployed in the air to determine the effect of air temperature on water temperature. The thermographs were programmed to record hourly. The water thermograph at station El Porvenir @ Christian Camp and the air thermograph at station Gallinas @ NF bnd were stolen in 2009. **Table 5** summarizes these datasets. In addition, a single multi-parameter data logger (sonde) was deployed at station Gallinas River at Montezuma, USGS Gage 08380500 in 2007 and two more at stations Gallinas River at Montezuma, USGS Gage 08380500 and El Porvenir Creek at HWY 65 above the Gallinas in 2009 to evaluate pH and DO. **Tables 6a and 6b** summarize these data.

Table 5. Summary of Thermograph Data.

Assessment Unit / Station Name		**Data Collection Interval**	**WQS Temperature Criterion (°C)**	**Maximum Recorded Temperati (°C)**	**Total # of Data Points**	**# / % of Exceedences**
Gallinas River (SFNF Boundary to Headwaters) GALLINAS RIVER AT THE END OF FOREST ROUTE 263	**2007**	07/03/2007 – 11/01/2007	≤ 20	15.915	2014	0 / 0%
	2008	06/19/2008 – 9/18/2008	≤ 20	14.697	2185	0 / 0%
	2009	06/19/2009 – 10/9/200	≤ 20	17.106	2688	0 / 0%
Gallinas River (SFNF Boundary to Headwaters) Gallinas R. below Burro Creek	**2007**	07/03/2007 – 11/01/2007	≤ 20	19.508	2015	0 / 0%
	2008	06/19/2008 – 9/18/2008	≤ 20	17.748	2185	0 / 0%
	2009	06/19/2009 – 10/9/2009	≤ 20	19.651	2687	0 / 0%
Gallinas River (SFNF Boundary to Headwaters) Gallinas @ NF bnd	**2008**	06/19/2008 – 9/18/2008	≤ 20	19.674	2184	0 / 0%
	2009	06/19/2009 – 10/9/2009	≤ 20	22.058	10754	95 / 0.9%
Gallinas River (Las Vegas Diversion to SFNF Boundary) Gallinas River at Montezuma, USGS Gage 08380500	**2007**	07/03/2007 – 11/01/2007	≤ 20	26.207	2927	16 / 0.6%

Table 5. Summary of Thermograph Data, cont.

Assessment Unit / Station Name	Data Collection Interval	WQS Temperature Criterion (°C)	Maximum Recorded Temperature (°C)	Total # of Data Points	# / % of Exceedences
Gallinas River at Montezuma, USGS Gage 08380500 **2008**	06/19/2008 – 9/18/2008	≤ 20	23.833	2333	160 / 6.9%
2009	06/19/2009 – 10/9/200	≤ 20	25.744	2691	426 / 15.86%
El Porvenir Cr. (SFNF boundary to headwaters) / El Porvenir Cr. @ Christian Camp **2008**	06/19/2008 – 9/18/2008	≤ 20	19.008	2183	0 / 0%
El Porvenir Cr. (Gallinas R. to SFNF boundary) / El Porvenir Creek at HWY 65 above the Gallinas **2007**	07/03/2007 – 11/01/2007	≤ 20	24.581	2014	10 / 0.5%
2008	06/19/2008 – 9/18/2008	≤ 20	23.761	2184	84 / 3.85%
2009	06/19/2009 – 10/9/200	≤ 20	24.146	2689	158 / 5.88%

Table 6a. Summary of pH Data Collected from Sondes.

Assessment Unit Station Name	**Designated Use**	**Criterion SU**	**Deployment Dates**	**Min/Max SU**	**Number/% Exceedences**	**Magnitude Violation**	**Frequency Violation**
Gallinas River (Las Vegas Diversion to SFNF Boundary) / Gallinas River at Montezuma, USGS Gage 08380500 **2007**	HQCW AL	6.6 – 8.8	8/16 – 8/23	8.23 – 8.90	0 / 0	0	0

Table 6a. Summary of pH Data Collected from Sondes, cont.

Assessment Unit Station Name	Designated Use	Criterion SU	Deployment Dates	Min/Max SU	Number/% Exceedences	Magnitude Violation	Frequency Violation
Gallinas River (Las Vegas Diversion to SFNF Boundary) / Gallinas River at Montezuma, USGS Gage 08380500 **2009**	HQCWAL	6.6 – 8.8	9/2 – 9/9	7.89 – 8.4	0 / 0	0	0
El Porvenir Cr (Gallinas R. to SFNF Boundary) El Porvenir Creek at HWY 65 above the Gallinas **2009**	HQCWAL	6.6 – 8.8	9/2 – 9/9	7.96 – 8.61	0 / 0	0	0

Table 6b. Summary of DO Data Collected from Sondes.

Assessment Unit Station Name	Designated Use	WQS Criterion (mg/L)	Deployment Dates	Min/Max Conc. (mg/L)	Min Sat. (% local)	Combined Conc./Sat. Exceedences (# / % / >3 hrs)	% Sat Exceedences (# / % / >3 hrs)
Gallinas River (Las Vegas Diversion to SFNF Boundary) / Gallinas River at Montezuma, USGS Gage 08380500 **2007**	HQCWAL	≥ 6.0	8/16 – 8/23	7.18 / 9.44	103.2%	0/0/0	0/0/0
Gallinas River (Las Vegas Diversion to SFNF Boundary) / Gallinas River at Montezuma, USGS Gage 08380500 **2009**	HQCWAL	≥ 6.0	9/2 – 9/9	6.99 – 9.31	93.6%	0/0/0	0/0/0
El Porvenir Cr (Gallinas R to SFNF Boundary) El Porvenir Creek at HWY 65 above the Gallinas **2009**	HQCWAL	≥ 6.0	9/2 – 9/9	7.29 – 9.56	96.4%	0/0/0	0/0/0

6.1.3 Macroinvertebrate Data

The macroinvertebrate community is generally the first to show a response to certain stressors such as the fine sediment that settles to the bottom of the channel. By collecting data on the macroinvertebrate communities that are present in a stream reach SWQB can identify changes that indicate stress on the community. Depending on the ecoregion of the study site, this can be done by utilizing either the Rapid Bioassessment Protocol (RBP) or Mountain Stream Condition Index (M-SCI) as described in SWQB's main assessment protocol. Application of the biological assessment or degree of impairment is a percentage comparison of the sum of selected metric scores at the study site compared to a reference site or condition. For example, when the macroinvertebrate community at a study site in ecoregion 23 (AZ/NM Mountains) has an M-SCI score less than 56.70% of the reference condition, it can be concluded that there is stress on that community and it would be deemed impaired (i.e. non-support) (**Table 7**).

Table 7. Biological Integrity Attainment Matrix using M-SCI1 for AZ/NM Mountain Sites

	Biological Condition Category[2]
> 78.36%	**Very Good (Full Support)**
78.35 – 56.70%	**Good (Full Support)**
56.69 – 37.20%	**Fair (Non-Support)**
37.19 – 18.90%	**Poor (Non-Support)**
< 18.89%	**Very Poor (Non-Support)**

1. M-SCI Index and percentages based on Jacobi, *et al.* (2006)
2. New Mexico has combined the "very good" and "good" categories into "Full Support," while the remaining categories define "Non-Support."

Macroinvertebrate and were collected at 3 sites during the course of this study and one addition site in the watershed in 2004. Three out of the four study sites had biological assessment scores in the "very good" to "good" range whereas one site was in the "fair" range indicating the biological community in that reach is stressed.(**Table 8**).

Table 8. Macroinvertebrate evaluations for the Gallinas River and El Porvenir Creek watersheds

Stations	Collection Date	Biological Index Score
Gallinas River below Burro Creek	**15 Aug 2007**	**70.08***
Gallinas @ NF boundary	**27 Sept 2004**	**84.29***
Gallinas River at Montezuma, USGS Gage 08380500	**1 Sept 2009**	**67.66***
El Porvenir Creek at HWY 65 above the Gallinas	**2 Sept 2009**	**52.51***

* Mountain – Stream Condition Index (M-SCI) is used to assess AZ/NM Mountain sites.
+ Raw percent values of ≤20% fines at a study site should be evaluated as "Full Support."
FS = Fully Supporting

6.1.4 Physical Habitat

It is essential to characterize the physical habitat in order to relate stream biological condition to land use impacts and potential anthropogenic disturbances. The physical habitat components most directly impacting aquatic communities are the stream geomorphology (physical structure), the riparian corridor that supports and protects aquatic life, and the composition of the substrate where the aquatic communities live. Streams existing in similar landscapes express similar compositions of these three attributes and can be compared to a reference site within that group. A reference site is a stream reach that has been exposed to the least amount of human disturbance within a certain landscape.

Environmental Monitoring and Assessment Program (EMAP; Peck *et al.* 2006) surveys were conducted to collect data for sedimentation/siltation impairment determinations. **Table 9** describes the watershed size, elevation, and ecoregion of each station where an EMAP survey was conducted. These are the minimal data necessary to categorize the sites by landscape.

Table 9. Watershed Characteristics of Study Sites

Station Name	Watershed Area in km^2 (mi^2)	Elevation in meters (feet)	Omernick Ecoregion
Gallinas River below Burro Creek	36 (14)	2564 (8412)	Southern Rockies
Gallinas River at Montezuma, USGS Gage 08380500	197 (76)	2132 (6995)	Southern Rockies
El Porvenir Creek at HWY 65 above the Gallinas	67 (26)	2216 (7270)	Southern Rockies

Substrate Composition

The size of sediment within a stream system is one of the most important physical attributes in determining the health of aquatic communities. There are two components to sediment load that impact aquatic life: suspended load and bed load. Suspended load is quantified through the measurement of turbidity and total suspended solids. Bed load describes the particles that settle to or roll along the bottom (saltation) of the channel. Larger bed load particles provide increased interstitial space between particles, thus allowing for different aquatic communities than those found among small particles with little or no space. The size of sediment within a stream has a natural progression from course, large particles in sections at high elevation with smaller watershed size gradually decreasing to sand in low elevation streams with large watersheds. Therefore, to determine whether a stream exhibits an unnaturally fine bed load, knowledge of the location of the stream segment within the watershed is necessary. Particles smaller than 2 millimeters are considered "fines", and "percent fines" are considered for assessment of New Mexico's narrative sediment standard (see 20.6.4.13(A) NMAC). Percent fines is calculated by adding the % sand and % silt-clay fractions (**Table 10**). Other metrics in **Table 10** describe the size classes found in the reach, the size of the median of the cumulative frequency distribution (D50), and the mean embeddedness, which is how much of the particles were surrounded by fines.

Table 10. Substrate Composition Data from the Gallinas River

Station Name	D50 (mm)	D84 (mm)	% Fines (>2mm)	Mean % Embeddedness
Gallinas River at Montezuma, USGS Gage 08380500 – 2007	*106*	*211*	*6%*	**46**
Gallinas River below Burro Creek	40*	566*	20%*	**50**
Gallinas River at Montezuma, USGS Gage 08380500 – 2009	74	161	4%	**40**
El Porvenir Creek at HWY 65 above the Gallinas-	118	256	5%	**44**

* Data from this site was collected from multiple habitats whereas the other sites were sampled from only riffles, as such the data from this site should not be directly compared to the other sites in this study. This site also exhibits a significant number of large boulders which were likely added to the stream bed through non-fluvial processes (e.g. road construction and mechanical erosion) and explain the large D84 value.

Geomorphology

Quantitatively identifying the current structure of a stream channel allows for a determination of the amount and variation of habitat available for aquatic communities. A natural, undisturbed stream system maintains equilibrium with the amount of water and sediment that it transports, allowing that system to remain stable. Human impacts may alter the equilibrium of a stream, causing the stream to actively attempt to restore this balance. As the stream attempts to restore equilibrium, it may cause damage to the adjacent riparian habitat or the aquatic communities within the channel. **Table 11**

provides a comparison of the geomorphic parameters collected at the reference reaches and study reaches during the EMAP surveys.

Riparian Health

The riparian area is the corridor of vegetation surrounding the stream that provides many beneficial functions to the stream channel. Although there are many benefits to a diverse and healthy riparian area, the most direct effects are shade, soil stability, and organic inputs providing food for the aquatic communities. Two qualitative assessments were performed to provide general information on the health of the habitat and structure of the stream: the Rapid Geomorphic Assessment (RGA) and the Rapid Habitat Assessment (RHA). These observational assessments combined with the quantitative canopy measurements (**Table 12**) provide an indication of riparian health.

Table 11. Geomorphic Data for the Gallinas River

Station Name	Slope (%)	Bankfull Width (m)	Bankfull Height (m)	Width-Depth Ratio
Gallinas River at Montezuma, USGS Gage 08380500 – 2007	1.55	7.9	0.7	11.6
Gallinas River below Burro Creek	3.62	4.6	0.4	10.4
Gallinas River at Montezuma, USGS Gage 08380500 - 2009	1.5	7.1	0.4	17.9
El Porvenir Creek at HWY 65 above the Gallinas	1.07	5.7	0.3	19.2

Table 12. Riparian Cover and Qualitative Scores for the Gallinas River

Station Name	Riparian Canopy Cover (% cover)	RGA[1] Stability Score (0-36)	RHA[2] Habitat Score (0-200)
Gallinas River at Montezuma, USGS Gage 08380500 - 2007	50	*n/a*	181
Gallinas River below Burro Creek	72	n/a/	187
Gallinas River at Montezuma, USGS Gage 08380500 - 2009	58	3	171
El Porvenir Creek at HWY 65 above the Gallinas	88	2	153

1. The Rapid Geomorphic Assessment is used to identify stable reaches and the destabilizing processes that are active in the reach. A channel stability score is determined by observing a number of channel characteristics and the stage of channel evolution based on the National Sedimentation Lab empirical model (Simon 1989). **Lower scores indicate a more stable channel**.
2. The Rapid Habitat Assessment (Barbour, *et al.* 1999) provides a qualitative aquatic habitat score that is based primarily on observation of the quality and diversity of in stream habitats. **Higher scores indicate better habitat quality**.

7.0 Discussion

As noted above, extensive sampling for major ions, nutrients, biological indicators (aquatic invertebrates, and algae/periphyton) and field parameters found exceedences only for temperature and turbidity (discussed below). Elevated water temperature not only stresses aquatic communities directly by decreasing dissolved oxygen concentration in the water but indirectly by increasing the metabolic rates of fish, particularly salmonids, thereby increasing food and oxygen requirements.

Stations El Porvenir Creek at HWY 65 above the Gallinas and Gallinas River at Montezuma, USGS Gage 08380500 consistently exceeded the temperature criterion. This finding is consistent with historical data and a previous assessment of non-support of the high quality cold water aquatic life designated use due to elevated temperature (Hopkins, 2004). A TMDL for temperature was approved by EPA for these assessment units in September of 2005 (see **Table 4**). Assessment of temperature data from 2007 and 2008 resulted in the Assessment Units for the Gallinas River and El Porvenir Creek being split at the Santa Fe National Forest boundary to reflect the lack of temperature exceedences on Forest lands (NMED/SWQB 2010).

While neither station Gallinas River at end of Forest Road 263 or Gallinas River below Burro Creek exceeded the HQCWAL temperature criterion of 20˚ C, a noticeable and consistent increase in temperature was observed below Burro Creek (**Figure 3**). These stations are only 1.5 miles apart. This increase was 2.10˚ C or 14.75% of the average temperature and 3.59˚ C or 22.60% of the maximum temperature). This increase in temperature is, probably, due to the fact that Burro Creek and the Gallinas River above their confluence both pass through a series of small, shallow impoundments (including those related to a beaver colony on the Gallinas) where long retention times and a lack of shade allows for increased solar heating. The diurnal swing in water temperature from coldest (early morning) to warmest (mid afternoon) at the two stations demonstrates the sensitivity of streams to inputs of solar energy. Excessive thinning of riparian areas could trigger temperature exceedences that would impair the aquatic life use. Re-establishment of woody riparian vegetation in areas where it has been removed and implementation of measures to lower the width / depth ratio, narrowing and deepening the channel, would improve the temperature regime in both watersheds.

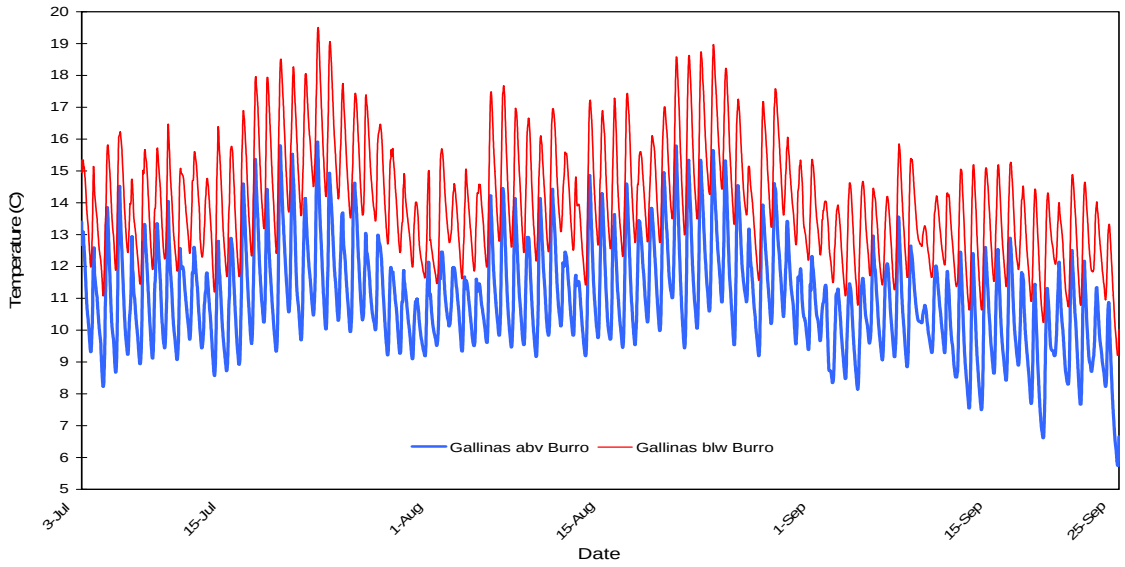

Figure 3. Comparison of water temperature in the Gallinas River above and below Burro Creek.

In general, concentrations of selected parameters that were found at concentrations above the level of detection *e.g.* total phosphorus (TP), total Kjehldal nitrogen (TKN), total suspended solids (TSS) and total dissolved solids (TDS), increased in a down stream direction. There were slight increases of nutrient indicators (TKN and TP) over time (2007 to 2009). TDS and TSS remained flat or declined slightly over time. All stations returned a spike in TP on July 17 2008, apparently in response to a precipitation event. There were two minor detections of ammonia at stations Gallinas River at SFNF boundary (0.14 mg/l SDL = 0.1 mg/l) and Gallinas River at Montezuma (0.15 mg/l, SDL = 0.1 mg/l). While these detections were two orders of magnitude below their respective criteria, the fact that they occurred at these locations given the low nitrate, TP and TKN and high dissolved oxygen levels is anomalous. In general, ammonia should not be found under these conditions.

Instantaneous sampling of field parameters found three exceedences of the turbidity criterion (10 NTU) at station Gallinas River at Montezuma, USGS Gage 08380500 and one at station El Porvenir Creek at HWY 65. While two exceedences of a criterion can trigger a listing, examination of macroinvertebrate data collected in 2007 as required by the Interim Turbidity Assessment Protocol (Appendix H of NMED/SWQB 2009) indicate Full Support despite these exceedences at Montezuma. Potential sources of turbidity are numerous, but in the Gallinas watershed unimproved roads, both public and private, and erosion of unprotected stream banks are the principal causes. Runoff from trails can also be a factor. Proper implementation of Best Management Practices could alleviate or even eliminate turbidity issues.

Examination of chemical, biological and hydrological data over the course of three years found no indications of damage to water quality in either the Gallinas River or El

Porvenir Creek as a result of this watershed rehabilitation project. Those parameters that were seen to exceed criteria, temperature and turbidity, are known to have been problems prior to the start of forest thinning projects.

8.0 REFERENCES

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