AATA
EN
57752

DRAFT

1993 and 1994

Spring Snowmelt Runoff Survey

Prepared for
Los Alamos National Laboratories
Los Alamos, New Mexico

Prepared by
AATA International, Inc.
Fort Collins, Colorado

March 1995

7423

EXECUTIVE SUMMARY

The plateau region of New Mexico which characterizes the Los Alamos National Laboratory (LANL) environs is typically arid and does not support an abundance of aquatic ecosystems. Similar to other geographical regions, the aquatic systems are dependent upon annual precipitation patterns to regulate the extent and quality of aquatic resources. However, in the arid Southwest, annual precipitation patterns and events may play a more significant role in determining the extent and quality of aquatic ecosystems.

The spring snowmelt is a significant annual precipitation event that contributes to the development and status of aquatic systems at LANL. Many of the arroyos that drain the LANL property are ephemeral and support surface flow during the spring snowmelt period or immediately following intense summer rainstorms. This report presents the results of a two-year study conducted during May 3-7, 1993, and May 23-24, 1994, that evaluated the physical, chemical, and biological effects of snowmelt runoff in various reaches of the major arroyos and canyons draining LANL property. Significant findings from the study are presented below.

- Surface flows in the arroyos and drainage canyons on LANL property are dependent upon the snowmelt runoff. The surface flows from snowmelt runoff that entered LANL property during 1993 resulted from higher than normal snowpack. The 1994 surface flows from snowmelt runoff resulted from less than normal snowpack. During both runoff seasons, the surface waters infiltrated to subsurface water prior to reaching the Rio Grande. Only minimal amounts (less than 3.0 cfs) of flow were measured at the downstream boundary of LANL in Los Alamos Canyon and Pajarito Canyon in 1993, and less than 1.0 cfs was common at all sampling sites during 1994.

- The extent of downstream flow and surface flow duration of the spring snowmelt are dependent upon annual snowpack and seasonal temperatures. The downstream limit of surface flow was reduced during 1994. The surface flow is variable and related to differences in daytime and nighttime temperatures.

- Background water quality of snowmelt runoff exhibited low concentrations of total and dissolved metals and contaminants. No toxins, or toxic concentrations of water quality

parameters, were detected in surface waters flowing on LANL property. Differences in water quality for background (upstream of LANL property) and water quality within or downstream of LANL property were typical physico-chemical properties attributed to normal effects of existing wetlands and increased watershed drainage area. Water quality conditions that could be attributed to pollutants or contaminants from LANL discharge waters were not detected.

- Concentrations of total aluminum existed in background runoff waters (flowing onto LANL property) for the ephemeral reaches of Pajarito Canyon during 1993 which were above the State criteria for Livestock and Wildlife Watering. During 1994, total aluminum concentrations in all background waters were below the State criteria for Livestock and Wildlife Watering. However in 1993, total aluminum concentrations decreased to levels below the State criteria within Pajarito Canyon, and surface waters did not persist downstream of LANL property. The potential effects of total aluminum concentrations above the Livestock Watering standard are negligible because of the restricted use to livestock and the minimal flow duration. Bioavailable (dissolved) concentrations of aluminum were near or at detection levels and below all State water quality criteria.

- Perennial and ephemeral reaches investigated for Los Alamos Canyon, Pajarito Canyon, Water Canyon, Canyon de Valle, and Sandia Canyon during the course of this study exhibited physical and biological conditions of good to excellent quality for the physico-chemical and flow characteristics of the study sites. Although the physical attributes included a wide array of aquatic micro-habitats and riparian habitats common to undisturbed stream systems, these were not observed in any single site except where perennial waters existed above Los Alamos Reservoir in Los Alamos Canyon. During 1993 and 1994, the biological components of the drainage systems were limited primarily by surface flow. Provided with sufficient hydrology, the morphology of all canyons would become more complex and support lotic habitats containing pools, riffles, variable substrate types and habitats, and riparian cover.

- Macroinvertebrate and algae communities reflected good to excellent water quality for ephemeral stream conditions. Macroinvertebrate taxa present included a variety of taxa typical for a developing assemblage in first order streams following a period of desiccation. During 1993, a high abundance of EPT macroinvertebrate organisms, which are sensitive to organic pollution, were recorded from sites representing background conditions (waters flowing onto LANL property) in ephemeral (PJ-1) and perennial flow regimes (LA-1). These sensitive organisms continued to exhibit high relative abundance values at sites on LANL property where minimal physical and hydrologic conditions were present. The presence of the EPT organisms during 1994 was generally lower and attributed to limited habitat availability associated with low flows that reduced submerged substrate area and increased the frequency of desiccation.

- During 1993 and 1994, algae communities at the study sites on LANL property were dominated by diatoms representing forms typical of colonizing growth in cold, clear, unpolluted water conditions . The cold water macro-algae *Prasiola* was observed upstream of LANL property in Los Alamos Canyon during 1993 and 1994, and in Pajarito Canyon immediately above the Pajarito Wetland complex during 1993. This alga is found in cold waters where some available nutrients are available. Growths of *Prasiola* were not extensive, and the presence of this taxon at background water sites implies normal nutrient input from the surrounding watershed. The abundance of *Prasiola* was less in 1994. In general the biological samples from sites higher in the drainage, where flows were likely to be more consistent, generally exhibited higher richness, diversity and density than samples from reaches further downstream, where surface flows may have been more variable or interrupted by periods of desiccation.

- Fish were not observed or captured in the ephemeral reaches of the canyons on LANL property. Longnose dace (*Rhinichthys cataractae)* were the only fish observed at any study sites and were only observed during 1993. These fish were captured in Los Alamos Canyon within 0.5 mile of the confluence with the Rio Grande. Surface water at this site did not contain flow from LANL property, but consisted of treated effluent from the County Wastewater Treatment Facility. The longnose dace likely migrated upstream from the Rio Grande.

- The Pajarito Wetland complex and Sandia Wetland are important aquatic resources in a normally arid climate which provide valuable habitats for refugia and propagation of aquatic and semi-aquatic organisms, plus support to dependent terrestrial species. These important wetland areas are natural components of the local ecosystem which have been expanded by historical excavation (Pajarito Wetland complex) or supplemental sources of effluent water (Sandia Wetland).

- Sandia Wetland is being impacted by deposition of coarse mineral material from the Los Alamos County Landfill. Without preventative measures to eliminate further deposition in Sandia Wetland, the upper portion will continue to decrease in size and function.

- The Pajarito Wetlands are a mosaic of several islands of habitats ranging from open water, ponded aquatic systems to terrestrial grassy meadows. It is possible that the function of each type of habitat is greatly limited because the contiguous area of each habitat is minimal. The functional aspects of all the specialized habitats contained in the wetland may be improved by minor alteration of the surface topography to better manage the hydrology of this area.

TABLE OF CONTENTS

Executive Summary i

Table of Contents iv

1.0 Introduction 1
- 1.1 Significance of Snowmelt Study 1
- 1.2 Reasons for a Snowmelt Study 2
- 1.3 Expectations 3
- 1.4 Study Methods 5
  - 1.4.1 Water Quality 9
  - 1.4.2 Benthic Macroinvertebrates 13
  - 1.4.3 Periphyton 14
  - 1.4.4 Fish 15
  - 1.4.5 Wetlands 15
  - 1.4.6 Statistical Treatment 16

2.0 Results 18
- 2.1 Flow 18
- 2.3 Benthic Macroinvertebrates 32
- 2.4 Periphyton 46
- 2.5 Fish 53

3.0 General Discussion 54
- 3.1 Physical 54
- 3.2 Chemical 57
- 3.3 Biological 58
- 3.4 Overall Findings 60
  - 3.4.1 Healthy Conditions 60
  - 3.4.2 Unhealthy Conditions 62
- 3.5 Significant Positives 64
  - 3.5.1 Supporting Conditions 64
- 3.6 Significant Negatives 66
  - 3.6.1 Supporting Conditions 66
- 3.7 Overall Quality of Aquatic Systems Impacted by Snowmelt 67
  - 3.7.1 Excellent Quality 67
- 3.8 Corrective Actions 69

4.0 Canyon by Canyon Description 70

5.0 Pajarito Wetlands and Sandia Wetlands 75
5.1 General Wetland Descriptions 78
5.1.1 Sandia Wetland 78
5.1.2 Pajarito Wetland 80
5.2 Wetland Similarities 83
5.3 Wetland Differences 84

6.0 Conclusions 87
6.1 Canyons 87
6.2 Wetlands 90

7.0 References 92

Appendix I 93

Appendix II 94

LIST OF TABLES

Table 1.1 Sample collections for each sample location during spring 1993 and 1994 . . 11
Table 1.2 Water quality parameter laboratory methods and detection limits 12
Table 2.1 1993 Measured surface water flows at each study site 20
Table 2.2 1994 Measured surface water flows at each study site 24
Table 2.3 Field Determined Water Quality Parameters 26
Table 2.3 Field Determined Water Quality Parameters 30
Table 2.6 Macroinvertebrate community summary for Sandia Canyon 1993 34
Table 2.7 Macroinvertebrate community summary for Pajarito Canyon 1993 35
Table 2.8 Macroinvertebrate community summary for Water Canyon and Canyon de Valle 1993 36
Table 2.9 Macroinvertebrate community summary for Los Alamos Canyon 1994 41
Table 2.10 Macroinvertebrate community summary for Sandia Canyon 1994 42
Table 2.11 Macroinvertebrate community summary for Pajarito Canyon 1994 44
Table 2.13 Periphyton diatom community summary for Pajarito Canyon, Water Canyon, and Canyon de Valle, and Sandia Canyon 49
Table 2.14 Periphyton diatom community summary for Los Alamos Canyon 51
Table 2.15 Periphyton diatom community summary for Pajarito Canyon and Sandia Canyon 52
Table 5.1 Major Wetland Algae 77

LIST OF FIGURES

Figure 1. Map of Study Sites 7
Figure 2. 1993 Los Alamos Canyon Flow 19
Figure 3. 1993 Drainage Canyon Flow 21
Figure 4. 1994 Drainage Canyon Flow 23
Figure 5. Map of Sandia Canyon Wetland 79
Figure 6. Map of Pajarito Canyon Wetland Complex 82

1.0 INTRODUCTION

Maintenance of important ecological resources has been identified as a valuable asset for private, governmental, commercial, and industrial organizations. Recognition and awareness of the environment coupled with proactive management programs that enhance or maintain sensitive ecological systems is viewed as an asset within the arena of public scrutiny.

Los Alamos National Laboratory (LANL) has demonstrated a long-term dedication to preserving the natural environment surrounding the LANL property. The natural aquatic systems are an important component of the desert southwest environment that dominates the LANL geographical region. The biological communities that rely on aquatic systems extend beyond true aquatic communities to those assemblages of terrestrial and avian species that are dependent upon water for food or habitat.

1.1 SIGNIFICANCE OF SNOWMELT STUDY

The LANL property includes several dry arroyos and canyons that provide drainage from the Jemez Mountains and lands within the LANL boundary. These drainages have been historically considered ephemeral and typically contain water only during the spring as a result of winter snowmelt runoff or for short durations immediately following heavy rain events. The seasonal and annual variabilities in snowfall, spring temperatures, and rainfall patterns result in a corresponding variability of the hydrologic pattern in each of the LANL drainages. Understanding of the hydrodynamic variability and associated physical, chemical and biological fluctuations that likely occur is key to the identification and selection of management strategies that promote the health of the environment.

This report documents physical, chemical, and biological conditions observed in the canyons and arroyos of the LANL property for the snowmelt runoff period during May 3-7, 1993, and May

23-24, 1994. The runoff periods offered an excellent opportunity to evaluate runoff conditions because it represented a snowpack approximately 150% of average during 1993, and approximately 73% of average during 1994.

The objectives of the study were as follows:

- Characterize the hydrology (extent and magnitude) of snowmelt runoff.
- Characterize and document physical, chemical and biological attributes of the drainages on LANL property during the snowmelt runoff period.
- Determine the extent, if any, of fish migration from the Rio Grande into Los Alamos Canyon upstream from the confluence.

The physical, chemical and biological data collected in this study will provide valuable surface water quality information pertinent to the State of New Mexico Water Quality Standards (WQS) and the LANL National Pollutant Discharge Elimination System (NPDES) permit. Specifically, these data will provide the basis for conducting a Use Attainability Analysis (UAA) for the canyons draining the LANL facility and property. The role and importance of flow in tributary ephemeral stream reaches in regard to their effects on water quality in the perennial streams which serve as their receiving waters has yet to be adequately addressed in New Mexico's WQS.

1.2 Reasons for a Snowmelt Study

The application of protecting and maintaining the attainable uses and existing water quality standards for the receiving waters of the ephemeral streams has historically included ephemeral drainages from LANL in the NPDES permit issued by the EPA and certified by NMED per the provisions of Section 401 of the Clean Water Act. The attainable use of Livestock and Wildlife Watering was applied to ephemeral streams as a condition of State certification. Only during the snowmelt runoff period, and occasionally during periods immediately following significant storm events, are the conditions appropriate for surface water connection to perennial receiving waters

(Rio Grande). This receiving section of the Rio Grande is presently classified for use as Irrigation, Livestock Watering, Wildlife Habitat, Marginal Coldwater Fishery, Secondary Contact Recreation, and Warmwater Fishery (Section 2-111; WQCC 1995).

Typically, intense storm events do not support a long-standing hydrologic connection to the Rio Grande. Hydrologic models have shown that the results of a storm with sufficient intensity for uninterrupted runoff to reach the Rio Grande are typically less than 24 hours in duration. Under such conditions, it is likely that hydraulic energy associated with the storm event also alters the hydrologic, physical, and chemical conditions of the receiving waters reducing any effects from the LANL drainage.

However, during spring snowmelt conditions, the hydraulic energy is typically less, and surface water connection with the Rio Grande may not occur in most drainages, or persist for a period of up to three weeks when supplemented with discharge from the County Wastewater Treatment Facility in Los Alamos Canyon. Under spring runoff conditions the ephemeral streams draining LANL property develop a characteristic chemical, physical and biological profile. Presently, little is known about the interaction between the spring snowmelt hydrologic patterns and the physical, chemical, and biological conditions within the ephemeral reaches of the drainages from the LANL property.

Assessment of the hydrological conditions and ecological characteristics identified during the snowmelt period may facilitate determination of appropriate NPDES permit limits for the LANL facility.

1.3 EXPECTATIONS

Previous hydrologic or ecological studies have not been conducted in the drainages of LANL during the spring runoff period. A limited amount of information exists regarding the hydrologic

connection from LANL to the Rio Grande by surface waters. Information about surface water flow off LANL property and surface water connection to the Rio Grande has been primarily obtained from personal observations of LANL staff.

Ecological expectations for the ephemeral stream reaches containing snowmelt during early spring include the following.

Physical Attributes

- The arroyos draining LANL property were expected to contain flows much less than indicated by existing channel morphology. Stream channel morphology for the arroyos draining LANL is likely determined by very intense summer storms resulting in extensive erosion and deposition associated with short-term, high discharge levels. Runoff from snowmelt was anticipated to be less than characteristic for intense storm events.

- Flow was expected to show a diurnal pattern of higher flows during the late morning and afternoon in response to fluctuating cool night and warmer daytime temperatures. Daily net discharge was expected to be directly related to daytime temperature. Total flow and flow duration were anticipated to be dependent upon annual snowpack.

- Parameters such as total suspended solids (TSS), pH, conductivity, temperature, and alkalinity on LANL property were expected to be non-toxic and consistent with region-wide conditions during the snowmelt period.

- The spring snowmelt was expected to extend the downstream limit of surface water flow, and expand the winter limit of the wetland areas in Pajarito Canyon and Sandia Canyon. Increased water depth and surface area of standing water and slow draining waters were anticipated to occur in each wetland. However, the overall extent of wetland areas were not expected to change.

Chemical Attributes

- No chemical constituents were expected to occur within the stream channels or wetland areas at concentrations above a range typical for melted snow and local geology.

- No toxic chemicals, or toxic concentrations of chemicals, were expected to be present.

Biological Attributes

- Due to the anticipated short duration of surface water flow, biological development within the stream channels was expected to be minimal. Biological communities were expected to consist of thin films of algae and bacteria and early life stages of aquatic arthropod insects. Community level parameters such as richness, density, and diversity were expected to be low within the stream channels.

- The wetland algae and aquatic arthropod insect communities were expected to exhibit higher richness, density and diversity than observed from the stream channels.

- Fish were not expected to be observed within the LANL boundary. However, in the lower reaches of Los Alamos Canyon immediately upstream of the confluence with the Rio Grande, the opportunity of fish migration upstream into Los Alamos Canyon was considered possible. The extent of upstream migration was unknown.

- Evidence of use and visitation by terrestrial organisms such as birds and large and small mammals (including range cattle) was expected to be observed in and near the drainage channels and wetlands.

1.4 STUDY METHODS

Samples representing biological attributes, chemical characteristics, and physical properties were collected from May 4 - 7, 1993, and May 23 - 24, 1994, in canyons, arroyos and wetlands that drain LANL property. Sample site selection targeted three principal environments: *1)* locations that supported stream habitats flowing onto LANL property; *2)* wetlands within LANL property; and *3)* locations representing waters flowing off LANL property. Figure 1 shows sample sites in drainages and wetlands within the LANL boundary selected for study and locations of study sites outside the LANL boundary that were included in the two year study. A description for each study site is presented below.

Los Alamos Canyon

LA-1 Sampled in 1993 and 1994. Located outside of the LANL boundary approximately 400 meters upstream of Los Alamos Reservoir. This site exhibits perennial flow

and represented background water quality conditions flowing onto LANL property in Los Alamos Canyon.

LA-2 Sampled in 1993. Located approximately 50 meters below the Los Alamos Reservoir spillway. This site was used for flow measurements only.

LA-3 Sampled in 1993 and 1994. Sample reach located on south side of Los Alamos Canyon Rd. approximately 600 meters downstream of the Los Alamos Canyon ice rink where the stream channel crosses from the south to the north side of the road.

LA-4 Sampled in 1993. Sample reach located approximately 200 meters downstream of the TA-2 facility. Samples were taken in the channel from the south side of Los Alamos Canyon Rd.

LA-4.5 Sampled in 1994. Samples are each located approximately 1.0 km upstream of the USGS gaging station (LA-5) near the LANL boundary in lower Los Alamos Canyon.

LA-5 Sampled in 1993. No flow during May 23-24 1994. Sample reach located immediately below USGS gaging station. This sample site represents water flowing off of LANL property in Los Alamos Canyon.

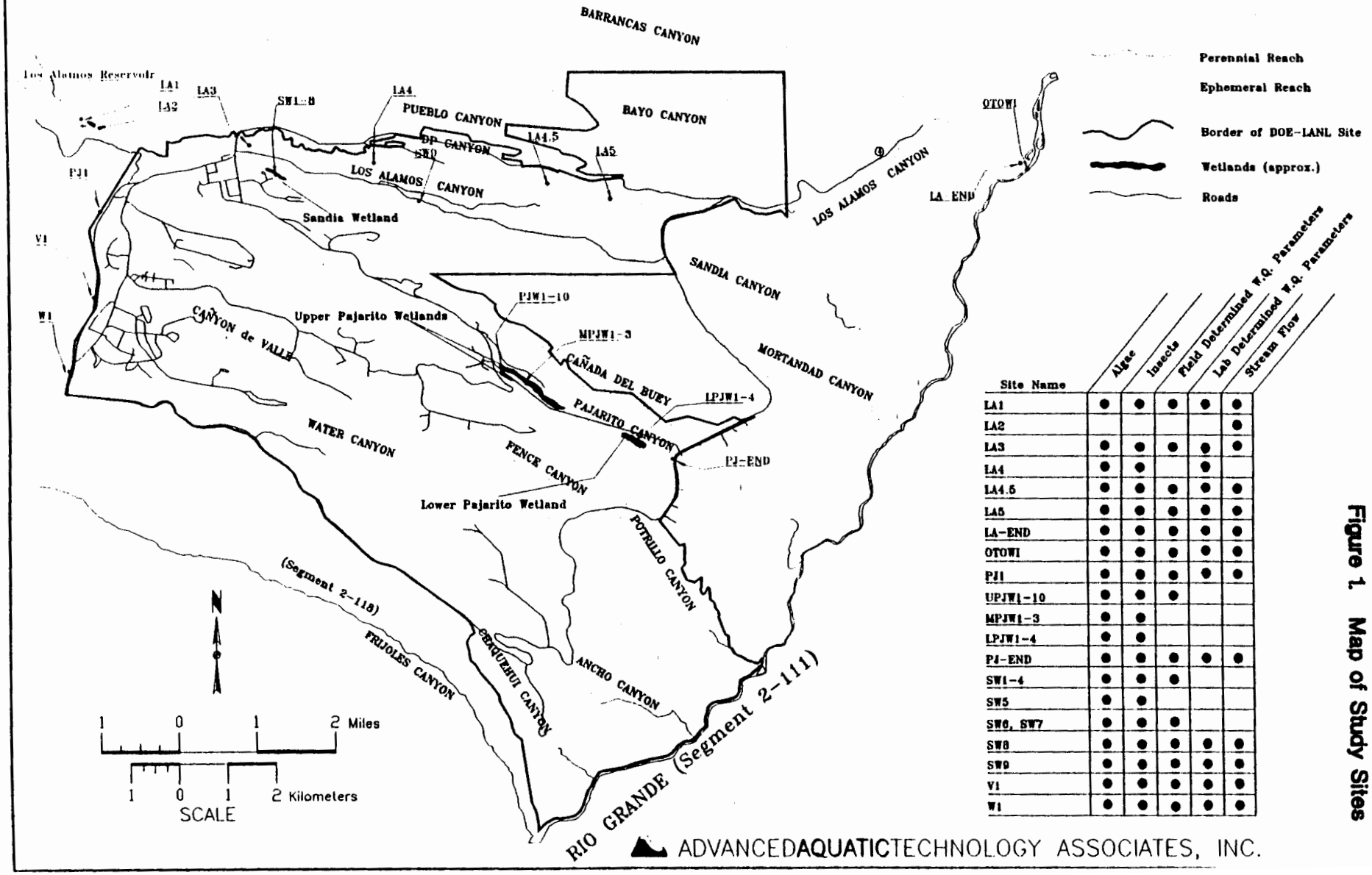
LA-End Sampled in 1993. Ground water seep flow at confluence with Rio Grande during May 23-24, 1994. Sample reach located in Los Alamos Canyon stream channel 50 meters upstream from the confluence with the Rio Grande at Otowi Bridge.

Pajarito Canyon

PI-1 Sampled in 1993 and 1994. Sample reach located upstream of Rte. 501 (East Jemez Rd.) approximately 200 meters. This sample site represented background water quality conditions from snowmelt onto LANL property.

PW-X Sampled in 1993. No flow during May 23-24, 1994. For sites located in upper Pajarito Wetland on the south side of the road below TA-18.

Los Alamos National Laboratory
Spring 1993 Sampling Locations



Site Name	Algae	Insects	Field Determined W.Q. Parameters	Lab Determined W.Q. Parameters	Stream Flow
LA1	●	●	●	●	●
LA2					●
LA3	●	●	●	●	●
LA4	●	●		●	
LA4.5	●	●	●	●	●
LA5	●	●	●	●	●
LA-END	●	●	●	●	●
OTOWI	●	●	●	●	●
PJ1	●	●	●	●	●
UPJW1-10	●	●	●		
MPJW1-3	●	●			
LPJW1-4	●	●			
PJ-END	●	●	●	●	●
SW1-4	●	●	●		
SW5	●	●			
SW6, SW7	●	●	●		
SW8	●	●	●	●	●
SW9	●	●	●	●	●
V1	●	●	●	●	●
W1	●	●	●	●	●

Figure 1. Map of Study Sites

MP-X — Sampled in 1993. For sites located in the middle Pajarito Wetland complex downstream of upper Pajarito Wetland and on the north side of the road below TA-18.

LP-X — Sampled in 1993. For sites located in the lower Pajarito Wetland complex located on the south side of the road below TA-18 and downstream of the middle Pajarito Wetland complex.

PI-End — Sampled in 1993. No flow during May 23-24, 1994. Sample site located at White Rock Rd. in Pajarito Canyon. This site represented flows off LANL property.

Canyon de Valle

V-1 — Sampled in 1993. No flow during May 23-24, 1994. Sample site located approximately 0.5 miles (800 meters) adjacent to the dirt access road off Rte. 501. Flow at the time of sampling did not extend to Rte. 501. This site represented water flowing onto LANL property.

Water Canyon

W-1 — Sampled in 1993. No flow during May 23-24, 1994. Sample reach located approximately 30 meters immediately upstream of Rd. 501. This site represented background water quality conditions from snowmelt flowing onto LANL property.

Sandia Canyon

SW-X — Sampled in 1993. Sites representing Sandia Canyon Wetland.

SW-8 — Sampled in 1993 and 1994. Sample site located approximately 30 meters downstream of Sandia Wetland within Sandia Canyon.

SW-9 — Sampled in 1994. Sample site immediately downstream of culvert at confluence of Sandia Canyon Rd. and Sandia Canyon approximately 5 km downstream of Sandia Wetland.

Otowi — Sampled in 1993 and 1994. Samples from the Rio Grande at Otowi Bridge.

During the 1993 sampling period, biological samples included benthic macroinvertebrates, periphyton (attached algae) in the drainage channels, and documentation of the dominant macrophyte plants in the wetlands. During the 1994 sampling period biological samples included benthic macroinvertebrates and periphyton in the drainages. During both sampling periods water quality analysis included laboratory and field determined water quality parameters, flow measurements and general habitat descriptions represented by physical characterization of each sample site. Not all canyons and arroyos that geographically exist upstream from LANL property contained water at the time of sampling, and not all canyons and arroyos that provide drainage from LANL property contained water downstream of the LANL boundary. Lack of surface waters flowing off LANL property in the downstream reaches of the drainages was more common during the 1994 sampling period.

Biological sampling collection methods and analyses were based on guidelines presented in *Rapid Bioassessment Protocols for Use in Streams and Rivers* (EPA, 1989). Interpretation of the field collected data and field observations utilized protocols and methods presented in *Technical Support Manual: Waterbody Surveys and Assessments for Conducting Use Attainability Analyses* (EPA, 1983), *Methods for Evaluating Stream, Riparian, and Biotic Conditions* (USDA, 1983), and *Methods for Evaluating Riparian Habitats With Applications to Management* (USDA, 1987). Standard collection and documentation protocols were followed for chemical and biological sampling. Specific collection techniques utilized for the chemical and biological components of the study are presented in the following sections. Table 1.1 shows the sample dates and collections for each sample site.

1.4.1 Water Quality

Selected water quality parameters were determined in the field at the time of biological sampling. Parameters and corresponding methods included:

- **pH**
  Measured with a Beckman Omega 10 series battery powered pH meter in standard units (s.u.).

- **Dissolved Oxygen**
  Measured with a Yellow Springs Instruments (YSI) Model 54A dissolved oxygen and temperature meter in milligrams per liter (mg/L).

- **Conductivity**
  Measured with a YSI Model 33 conductivity meter in micromhos per centimeter (μmhos/cm).

- **Alkalinity**
  Determined in the field by weak (O.1122 N) acid (H_2SO_4) titration and converted to mg/L $CaCO_3$ by calculation.

- **Temperature**
  Water and air temperature determined with a YSI Model 54A dissolved oxygen and temperature meter in °C.

- **Stream Flow**
  Calculated from total depth and current speed determined with a Marsh-McBirney, Inc. Flo-Mate 2000 portable flow meter with a top-setting rod positioned at selected intervals along a transect across the stream.

Water quality samples for laboratory analyses were collected in pre-washed sample containers supplied by the analytical laboratory, InterMountain Laboratories, Inc. (IML) in Sheridan, WY. Samples for total metals and nutrient analyses were collected and preserved in the field and immediately stored on ice in a cooler until shipment to IML. Dissolved metals samples were stored on ice immediately following collection and pressure filtered (0.45 μm filter) prior to preservation at the end of the daily field activities. All laboratory analysis samples were shipped overnight on ice to IML for analysis accompanied by standard Chain of Custody protocols. Biological samples were transported to AATA International Inc.'s main offices in Fort Collins Colorado by air with field personnel. All biological samples were checked for integrity prior to investigation. Benthic macroinvertebrate samples were delivered to a qualified taxonomist by AATA personnel. Algae samples were retained for analysis at AATA. Table 1.2 shows the method and detection limit for each laboratory-determined water quality parameter.

Table 1.1 Sample collections for each sample location during spring 1993 and 1994

SAMPLE DATES AND COLLECTIONS DURING SPRING 1993 - 1994

LOS ALAMOS NATIONAL LABORATORY

SAMPLE SITE[1] and YEAR	ALG[1]		MACRO[1]		FWQ[1]		LWQ[1]		FLOW[1]	
	93	94	93	94	93	94	93	94	93	94
Los Alamos Canyon LA-1	■	■	■	■	■	■	■	■	■	■
Los Alamos Canyon LA-2									■	
Los Alamos Canyon LA-3	■	■	■	■	■	■	■	■	■	■
Los Alamos Canyon LA-4	■		■				■			
Los Alamos Canyon LA-4.5	■	■	■	■	■	■	■	■	■	■
Los Alamos Canyon LA-5	■		■		■		■		■	
Los Alamos Canyon LA-End	■		■		■		■		■	
Otowi Bridge (Rio Grande)	■	■		■	■	■	■	■	■	■
Pajarito Canyon PJ-1	■	■	■	■	■	■	■	■	■	■
Upper Pajarito Wetland PW-1 to PW-10	■		■		■					
Middle Pajarito Wetland MP-1 to MP-3	■		■							
Lower Pajarito Wetland LP-1 to LP-4	■		■							
Pajarito Canyon PJ-End	■		■		■		■		■	
Sandia Wetland SW-1 to SW-4	■		■		■					
Sandia Wetland SW-5	■		■							
Sandia Wetland SW-6, SW-7	■		■		■					
Sandia Wetland SW-8	■	■	■	■	■	■	■	■	■	■
Sandia Wetland SW-9	■	■	■	■	■	■	■	■	■	■
Canyon de Valle V-1	■		■		■		■		■	
Water Canyon W-1	■		■		■		■		■	

1 ALG = periphyton; MACRO = macroinvertebrates and fish seining; FWQ = field water quality determinations; LWQ = laboratory water quality samples; FLOW = determination of hydrologic flow.

Table 1.2 Water quality parameter laboratory methods and detection limits

WATER QUALITY MONITORING PARAMETERS METHODS AND DETECTION LIMITS			
Parameter	Method	Detection Limit	Units
Lab pH	150.1	0.1	standard
Lab Conductivity @ 25° C	120.1	10	μmhos/cm
Total Suspended Solids	215.2	1.0	mg/L
Total Alkalinity as $CaCO_3$	310.1	1.0	mg/L
Bicarbonate as $CaCO_3$	310.1	1.0	mg/L
Carbonate as CO_2	310.1	1.0	mg/L
Hydroxide as OH^-	310.1	1.0	mg/L
Nitrate Nitrogen	353.3	0.01	mg/L
Total Kjeldahl Nitrogen	351.2	0.1	mg/L
Total Phosphorus	365.4	0.01	mg/L
Aluminum, dissolved Aluminum, total	3005/6010 3005/6010	0.1 0.1	mg/L mg/L
Arsenic, dissolved Arsenic, total	3020/7060 3020/7060	0.005 0.005	mg/L mg/L
Boron, dissolved Boron, total	3005/6010 3005/6010	0.01 0.01	mg/L mg/L
Cadmium, dissolved Cadmium, total	3020/7131 3020/7131	0.002 0.002	mg/L mg/L
Cobalt, dissolved Cobalt, total	3005/6010 3005/6010	0.02 0.02	mg/L mg/L
Copper, dissolved Copper, total	3005/6010 3005/6010	0.01 0.01	mg/L mg/L
Chromium, dissolved Chromium, total	3005/6010 3005/6010	0.02 0.02	mg/L mg/L
Lead, dissolved Lead, total	3020/7421 3020/7421	0.005 0.005	mg/L mg/L
Mercury, dissolved Mercury, total	7470 7420	0.001 0.001	mg/L mg/L
Vanadium, dissolved Vanadium, total	3005/6010 3005/6010	0.02 0.02	mg/L mg/L
Zinc, dissolved Zinc, total	3005/6010 3005/6010	0.01 0.01	mg/L mg/L

1.4.2 Benthic Macroinvertebrates

Benthic macroinvertebrate sample collection methods and analyses were based on guidelines presented in *Rapid Bioassessment Protocols for Use in Streams and Rivers* (EPA, 1989). Table 1.1 shows macroinvertebrate sampling locations and dates.

Benthic macroinvertebrates were collected with a standard 1.0 ft^2 Benthic Surber Sampler equipped with a 728 μm mesh net from substrates ranging from cobbles and mixed-sized gravel, to small gravel mixed with silts and organic debris. Mixed gravel and cobble substrates from riffles areas in flowing waters provide the best representation of benthic organisms and all efforts were made to select a mixed gravel substrate with physical characteristics common to all three sampling locations with respect to particle size, substrate depth, water depth, and current speed. Physical conditions among the sample sites varied widely with respect to substrate characteristic, flow, velocity and depth during 1993 and 1994, and well as between the two sampling years. Efforts were made to maximize organism retention and maintain standardized sampling among the sites. Sampling included disturbing the substrate within the confines of the Surber Sampler frame to a depth of approximately 5.0 cm for a period of three minutes. The 1993 macroinvertebrate samples consisted of three Surber samples composited to a single sample from each site. During the 1994 sampling period, three replicate benthic macroinvertebrate samples were taken at each sampling site, each replicate consisting of two or three Surber samples depending upon the amount of captured debris. The number of Surbers was recorded in order to determine organism density. Each sample was individually placed on a white tray and large debris was removed after being visually checked for organisms. The sample net was also visually inspected and all observed organisms retained. The entire sample was stored in a 1.0 L plastic wide-mouth sample container and preserved with 3% (vol:vol) formalin solution. Samples were delivered to AATA's Ecotoxicology Center (ETC) in Fort Collins, Colorado, for taxonomic identification and enumeration. All organisms collected for each replicate sample were identified at the lowest practical taxonomic level and counted. Identification and enumeration was done with the aid of an Olympus Zoom dissecting stereo-scope at 10X - 40X magnification.

1.4.3 Periphyton

Periphyton (attached algae) samples were collected from all available natural substrates such as rock, submerged plants and debris, and silts. A minimum of two periphyton samples were collected for analysis: 1) one sample to characterize major filamentous and colonial algae (non-diatom periphyton) and 2) one sample for diatom periphyton. Quantitative periphyton samples were not attempted because of the limited algal growth and development due to seasonal effects and the intermittent nature of many of the stream channels. Samples of periphyton material were stored in double Whirl-Pak sample bags and immediately preserved with 1-2 mL Lugol's solution. Periphyton samples were transported to AATA for analysis.

Subsamples of completely mixed periphyton samples were identified and enumerated in either a Palmer-Maloney counting chamber (volume 0.1 ml) or Sedgwick-Rafter counting chamber (volume 1.0 ml) at 400X total magnification. Counting chamber selection was dependent upon the abundance of large filamentous algal forms. Three replicate counts were made for each non-diatom periphyton collection. Depending upon the density of cells within the counting chamber, either a portion of the chamber or the entire chamber was viewed for enumeration and identification of algal taxa.

Diatom periphyton samples were analyzed for identification and relative abundance enumeration. Permanent diatom slides were prepared from 10 mL of completely mixed periphyton samples digested in 30 mL hydrogen peroxide (30%) and potassium dichromate (approximately 50 crystals). Residue from the digestion process was completely rinsed with deionized water. A suspension of cleaned residue was allowed to air dry on a microscope slide coverslip prior to permanent fixture with Hyrax mounting media. A minimum of 500 diatom frustules were identified and enumerated utilizing a Wild compound microscope at 1000X total magnification (oil immersion).

1.4.4 Fish

The presence of fish at each of the sampling locations was initially determined by observation. However, if suitable flow existed at the sample site, sampling for fish was conducted using a 5/8 inch mesh net. The net seine was rapidly dragged through the water in an upstream orientation between selected physical boundaries (log jams, small falls, or another field person) within the channel. The contents of the net seine were immediately inspected for fish following rapid removal from the water. A minimum of three net seine tows, or a total of approximately 100 feet, were sampled at each sample location which supported sufficient water and habitat to support fish regardless of observational information. In cases where fish were observed, seining activities were continued until the upstream boundary of fish occurrence was determined. With the exception of voucher specimens (preserved in 3% formalin solution), all fish captured were immediately returned to the water.

1.4.5 Wetlands

Sandia Wetland and the Pajarito Wetlands complex were examined for hydrological and general biological characterization. General plant associations were determined from the species and genus of predominant flora. Many of the encountered plants were not in flower at the time of sampling and therefore were identified only to the genus level. Species level identifications were determined whenever possible. Percent cover of the major plant associations was made based on a visual assessment of the percent area occupied relative to the whole wetland area. Maps were prepared to illustrate locations and extent of all major plant associations, physical features, and hydrologic patterns within each wetland area visited. Extensive mapping, detailed plant surveys, small mammal trapping and documentation of diel or nocturnal activity by large mammals and avifauna were not performed as part of this study. Comprehensive studies conducted previously by LANL staff have well documented the plant associations, mammal and avifauna presence, and ecological attributes of these wetlands.

Soils within the wetland areas were visually evaluated to determine their general classification and character. Soil structure, texture, composition, and a relative assessment of the degree of

saturation and level of oxidation were determined by digging shallow soil pits up to 1.5 feet in depth to examine the soil profile.

1.4.6 Statistical Treatment

Community structure parameters were determined for biological samples collected. Richness (the number of different taxa) was determined directly from sample identification. Diversity for benthic macroinvertebrates and diatom periphyton was measured by Simpson's Diversity Index (λ) and the Shannon-Weiner Diversity Index (H'). Both of these diversity indices consider the number of taxa and the abundance of each taxon present in the community. However, they are sensitive to different community structures. The numerical range for the Simpson Diversity Index is zero for maximum diversity (all members of the community with equal abundance) to 1.0 for no diversity, and shows greatest value change with differences in the number of dominant taxa regardless of their abundance. The Shannon-Weiner Diversity Index exhibits a zero value for no diversity and normally has an upper limit of about 4.0 for well developed, complex macroinvertebrate communities and about 4.5 for well-developed periphyton communities. The Shannon-Weiner Index shows the greatest changes in value with differences in total richness and relative abundance of dominant taxa. Hill's N1 is presented for the benthic macroinvertebrate and diatom periphyton communities because of the ease of interpretation for this index. Hill's N1 is calculated from Simpson's λ and represents the effective number of species that are abundant in the assemblage. Hill's N1 number when presented as a percent of richness allows a convenient interpretation of diversity for those who may not be familiar with the type of community under study (i.e. 70% indicates the majority of the taxa account for the majority of the individuals, compared to 20% which indicates few of the taxa account for the majority of the individuals).

The distribution of functional feeding groups was determined for the macroinvertebrate assemblage collected from each site. Functional feeding group assignments for each taxa followed the Water Quality Monitoring Protocols, Idaho Department of Health and Welfare, Division of Environmental Quality (Clark and Maret, 1991). The percent EPT (Ephemeroptera, Plecoptera, and Trichoptera) organisms was determined for each collection. The Ephemeroptera (mayflies),

Plecoptera (stoneflies), and Trichoptera (caddisflies) are considered pollution sensitive organisms and relative abundance of these organisms are good indicators of water quality.

Simpson's Diversity Index, the Shannon-Weiner Diversity Index, and Hill's N1 values were determined with Statistical Ecology software for the IBM-PC. Documentation and discussion on each of the indices employed in this study, including the use of the Statistical Ecology software, is presented in Ludwig and Reynolds (1988). Calculation of community metrics was performed by IBM-PC software supplied by the State of Idaho Department of Environmental Quality (DEQ) as documented in Clark and Maret (1991).

2.0 RESULTS

2.1 FLOW

1993

Flow in the canyons and arroyos included in the study was generally low. Measured flow at each of the study sites is listed in Table 2.1. Figure 2 shows measured flow in Los Alamos Canyon, and Figure 3 shows measured flow in Water Canyon, Canyon de Valle, Sandia Canyon, and Pajarito Canyon.

Flow at sample sites upstream of the LANL boundary decreased to very low, or non-existent, downstream of LANL property. Water flowing onto LANL property was observed in Los Alamos Canyon, Pajarito Canyon, Canyon de Valle, and Water Canyon. Measured flows onto LANL property ranged from an estimated 0.009 cubic feet/second (cfs) in Water Canyon upstream of West Jemez Rd. to 4.5 cfs in the perennial reach of Los Alamos Canyon upstream of Los Alamos Reservoir.

No surface flow was observed in Sandia Canyon, Mortandad Canyon, and Canada del Buey at the downstream border of LANL property. Flows of 2.8 cfs in Los Alamos Canyon at the USGS station, and 0.02 cfs in Pajarito Canyon downstream of Rte. 501 were the only locations where surface waters were observed downstream (flowing off) of LANL property.

At the time of the study, a flow of 3.8 cfs was measured in Los Alamos Canyon at the confluence with the Rio Grande. However, this hydrologic connection in Los Alamos Canyon was supported by discharge from the Los Alamos County Wastewater Treatment facility and was not continuous with surface flow from LANL property.

Figure 2. 1993 Los Alamos Canyon Flow

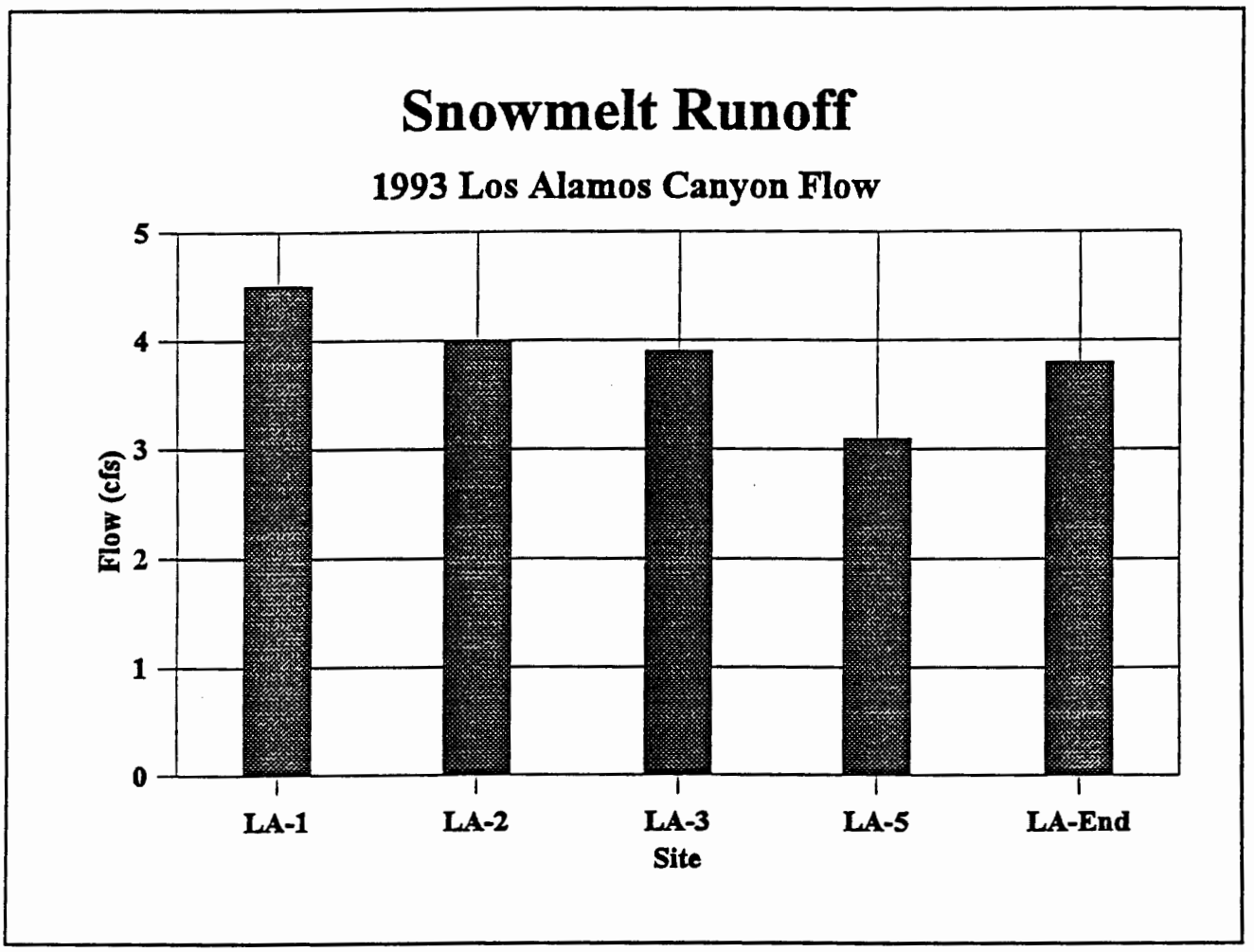
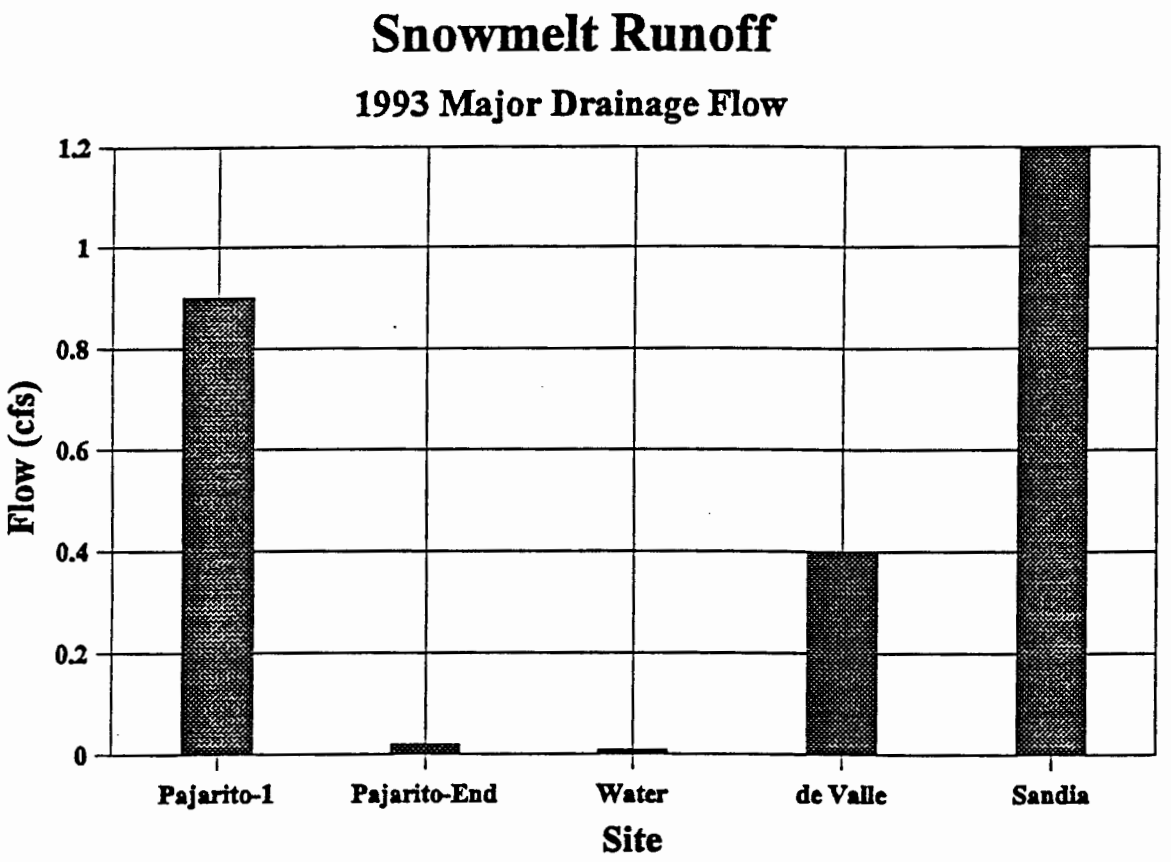


Table 2.1 1993 Measured surface water flows at each study site

SNOWMELT STUDY FLOW MEASUREMENTS MAY 1993	
Sample Site	**Flow (cfs)**
LA-1 Los Alamos Canyon above reservoir	4.5
LA-2 Los Alamos Canyon below reservoir	4.0
LA-3 Los Alamos Canyon below ice rink	3.9
LA-5 Los Alamos Canyon at USGS gage	3.1
LA-End Los Alamos Canyon at Rio Grande	3.8
PJ-1 Pajarito Canyon above State Rte. 501	0.9
PJ-End Pajarito Canyon below LANL boundary at Hwy. 4	0.02
W-1 Water Canyon 0.5 mi above Rte. 501	0.009
V-1 Canyon de Valle above Rte. 501	0.4
SW-8 Sandia Canyon below Sandia Wetland	1.2

Figure 3. 1993 Drainage Canyon Flow



1994

Flow onto LANL property existed in Pajarito Canyon (PJ-1) and Los Alamos Canyon (LA-1) during 1994. Surface flow onto LANL property did not exist in Water Canyon or Sandia Canyon as had occurred in 1993. Debris in the stream channels of Water Canyon and Sandia Canyon upstream of the LANL property, including easily removed dried shrub and oak leaves remaining from leaf fall indicated that in recent periods prior to the time of sampling there was no flow in these drainages.

Observed flow was less during 1994 than observed during 1993. Flows were measured in Los Alamos Canyon at LA-1 (upper Los Alamos Canyon flowing onto LANL property) LA-3 (ice rink area) and LA-4.5 (upstream of the USGS Station). All flows measured were less than 1.0 cfs and ranged from 0.12 cfs at LA-4.5 to 0.98 at LA-1. Figure 4 and Table 2.2 show the measured flows for the 1994 sampling period. Flow at PJ-1 was measured at 0.003 cfs immediately below the Parshall flume installed between the 1993 and 1994 sampling periods. The Parshall flume staff gage had a reading of 0.06 feet (0.7 inches) in depth. Flow from Sandia Wetland (SW-8) was measured at 0.69 cfs during 1994 compared to a measured value of 1.2 cfs during the 1993 sampling period. At the confluence of Los Alamos Canyon and the Rio Grande surface flow was supported by ground water seeps originating approximately 10.5 meters from the Rio Grande waters along the right bank of Los Alamos Canyon. Figure 4 and Table 2.2 show measured flows at the 1994 sample locations.

Figure 4. 1994 Drainage Canyon Flow

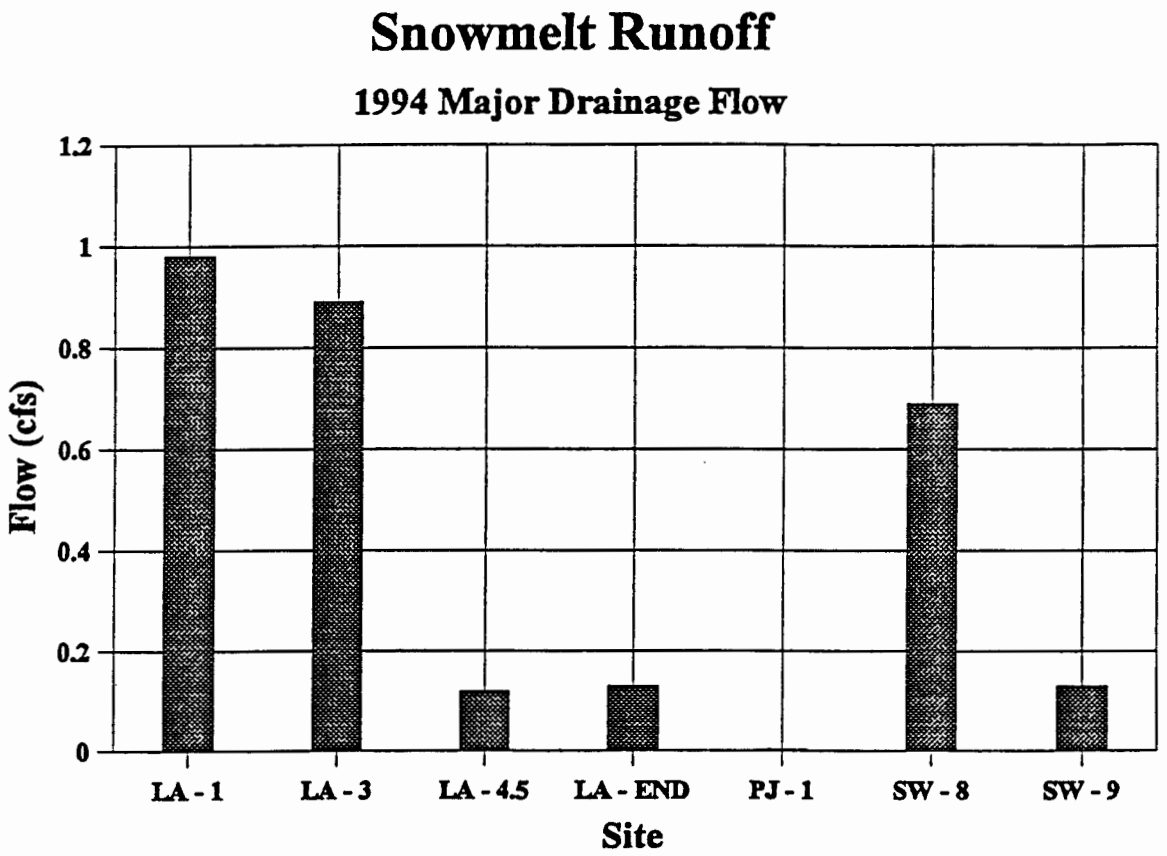


Table 2.2 1994 Measured surface water flows at each study site

SNOWMELT STUDY FLOW MEASUREMENTS MAY 1994	
Sample Site	Flow (cfs)
LA-1 Los Alamos Canyon above reservoir	0.98
LA-3 Los Alamos Canyon below ice rink	0.89
LA-4.5 Los Alamos Canyon approx. 1 km above USGS gage	0.12
LA-END Los Alamos Canyon at Rio Grande	0.13
PJ-1 Pajarito Canyon above State Rt. 501	0.003
SW-8 Sandia Canyon below Sandia Wetland	0.69
SW-9 Sandia Canyon at outlet of Sandia Canyon Rd. culvert	0.13

2.2 WATER QUALITY

1993

Field determined water quality parameters indicated conditions consistent with anticipated values for snowmelt runoff. Table 2.3 shows the field measured water quality parameters recorded for each sample location. Water temperatures ranged from 6.0 °C in Pajarito Canyon upstream West Jemez Rd. and the LANL property, to 18.0 °C in lower Pajarito Canyon downstream of the LANL boundary. Water temperatures were consistently lower than daytime air temperatures. Dissolved oxygen concentrations ranged from 6.6 mg/L in the upper portion of Sandia Wetland, to 10.4 mg/L in the perennial reach of Los Alamos Canyon above the Los Alamos Reservoir. Cold running waters with no apparent organic loads are typically near or above saturation for dissolved oxygen. Percent saturation for dissolved oxygen ranged from 84.7% at LA-End to 117% recorded at LA-1.

Recorded pH values from surface waters flowing onto LANL property exhibited a range of 6.9 s.u. in the perennial reaches of Los Alamos Canyon above Los Alamos Reservoir, to 7.3 s.u. for flow in upper Pajarito and upper Water Canyons. Values of 7.5 s.u. at the USGS station in Lower Los Alamos Canyon, and 7.9 s.u. in Lower Pajarito Canyon at Hwy. 4 were recorded for waters flowing off LANL property. Other pH values recorded reflected the immediate source of the water and included a value of 9.2 s.u. from residual flow in the stormwater discharge culvert at the head of Sandia Wetland, and values from 8.6 - 8.99 s.u. recorded from various locations in Sandia and Pajarito Wetlands.

Conductivity values showed a range of 40 μmhos/cm in upper Water Canyon to 80 μmhos/cm in upper Canyon de Valle for waters coming onto LANL property boundary. Conductivity for waters flowing off LANL property exhibited a range of 140 μmhos/cm in Los Alamos Canyon at the USGS station, and 335 μmhos/cm in Pajarito Canyon downstream of Hwy. 4. The highest conductivity (1,300 μmhos/cm) was recorded from residual flow in the stormwater culvert at the head of Sandia Wetland. However, conductivity decreased to 490 μmohs/cm in Sandia Canyon below Sandia Wetland.

Table 2.3 Field Determined Water Quality Parameters

FIELD DETERMINED WATER QUALITY PARAMETERS

SNOWMELT RUNOFF MAY 4-7, 1993

Site	Date	Air Temp. °C	Water Temp. °C	Dissolved Oxygen mg/L	pH s.u.	Conductivity µmhos/cm	Alkalinity mg/L $CaCO_3$	Flow cfs
LA-1	May 04	22.0	7.0	10.4	6.9	52	25.5	4.5
LA-2	May 04	NA	NA	NA	NA	NA	NA	4.0
LA-3	May 04	24.0	10.0	9.2	6.9	70	25.5	3.9
LA-4	May 04	26.0	NA	NA	NA	NA	NA	NA
LA-5	May 04	26.0	14.0	8.7	7.5	140	40.8	2.8
LA-End	May 07	19.0	15.0	7.5	8.2	240	81.6	3.8
Rio Grande	May 07	16.0	12.0	8.4	8.2	210	81.6	NA
PJ-1	May 05	9.0	6.0	10.0	7.3	50	30.6	0.9
PJ-End	May 06	NA	18.0	8.5	7.9	335	96.9	0.02
W-1	May 05	24.0	9.2	8.4	7.3	40	25.5	0.009
V-1	May 05	18.0	9.0	8.1	7.2	80	45.9	0.4
SW-1	May 06	22.0	16.0	6.6	9.2	1300	NA	NA
SW-2	May 06	22.0	14.0	7.0	8.5	380	NA	NA
SW-3	May 06	23.0	14.5	7.4	8.7	380	NA	NA
SW-4	May 06	23.0	15.5	7.4	8.8	390	NA	NA
SW-6	May 06	23.0	16.0	7.2	8.7	370	NA	NA
SW-7	May 06	22.0	15.5	7.2	8.6	470	NA	NA
SW-8	May 06	20.0	15.0	8.7	8.9	490	NA	1.2

Water quality parameters determined by laboratory analysis indicated low, or below detection limit concentrations, of general parameters in waters flowing onto LANL property. Laboratory analyses indicated that water quality conditions in Los Alamos Canyon at LA-5 (representing water flowing off LANL property) were equivalent to water quality at LA-1 (Los Alamos Canyon above LANL property). However, water downstream of the LANL property in Pajarito Canyon (PJ-End at Hwy. 4) exhibited higher values for hardness (calculated value of 66.8 mg/L $CaCO_3$) and conductivity (402 μmhos/cm) than values for hardness (calculated value of 22.1 mg/L $CaCO_3$) and conductivity (74 μmhos/cm) in Pajarito Canyon upstream of LANL property at PJ-1. Results of the laboratory analyses for each water quality sample are presented in Appendix I.

Laboratory water quality results indicated low concentrations of selected major nutrients (nitrate, total Kjeldahl nitrogen, and total phosphorus) in background water flowing onto LANL property. For water collected upstream of the LANL boundary, samples from W-1 in Water Canyon exhibited concentrations of 0.2 mg/L for total Kjeldahl nitrogen and 0.2 mg/L for total phosphorus. Nitrate was recorded from Los Alamos Canyon (LA-1) at a concentration of 0.18 mg/L nitrate-N (Appendix I). Concentrations of total nitrate, total Kjeldahl nitrogen, and total phosphorus in water samples representing surface water downstream of LANL property (sites PJ-End and LA-5) were equal to, or less than, concentrations recorded in water upstream of the LANL property.

The highest nutrient levels were observed in samples associated with treated effluent or highly organic wetlands such as Sandia Canyon immediately below Sandia Wetland (SW-8) and in Los Alamos Canyon at the confluence with the Rio Grande (LA-End). Total nitrate concentrations were 1.45 mg/L at SW-8 and 1.61 mg/L at LA-End. Total phosphorus concentrations were 2.78 mg/L at SW-8 and 0.66 mg/L at LA-End. Total Kjeldahl nitrogen concentrations were 0.8 mg/L at both SW-8 and LA-End sites.

Concentrations of total and dissolved metals were at or below detection limits except for individual concentrations of aluminum, boron, and zinc from various water quality samples (Appendix I).

A total aluminum concentration of 5.3 mg/L was recorded from Canyon de Valle. However, the dissolved fraction of 0.2 mg/L was not above the 1.7 mg/L standard for dissolved aluminum. Other total aluminum concentrations ranged from below the detection limit (≤0.1 mg/L) at LA-End to 3.5 mg/L total aluminum in Los Alamos Canyon at LA-4 below TA-2 and Pajarito Canyon at PJ-1 upstream of the LANL property. Dissolved aluminum ranged from below detection limits (≤0.1 mg/L) to 0.2 mg/L at many sites upstream of the LANL property and at LA-5 for waters flowing off LANL property in Los Alamos Canyon. Concentrations of boron ranged from below detection limits for both dissolved and total fractions (≤0.1 mg/L) to 0.7 mg/L dissolved boron and 0.8 mg/L total boron in Sandia Canyon at SW-8 immediately below the Sandia Wetland. The highest concentration of total boron detected in water samples collected upstream of the LANL boundary was 0.3 mg/L from W-1 in Water Canyon. Concentrations of total and dissolved zinc were at or below detection limits (≤0.01 mg/L) at all sample sites except in Sandia Canyon at SW-8 immediately below Sandia Wetland. Site SW-8 zinc concentrations were recorded at 0.06 mg/L dissolved zinc and 0.11 mg/L total zinc (Appendix I).

<u>1994</u>

Field determined water quality parameters during the 1994 sampling period were comparable with determinations measured during the 1993 sampling period. Table 2.4 shows the individual site results for each field determined water quality parameter for 1994. During 1994 pH (standard units) ranged from 7.17 (LA-3) to 8.33 (SW-9); alkalinity ranged from 33.1 mg/L $CaCO_3$ (LA-3 and PJ-1) to 188.7 mg/L $CaCO_3$ (LA-End); and dissolved oxygen ranged from 8.1 mg/L (LA-End) to 10.8 mg/L (LA-1). Measurements for pH, alkalinity, and dissolved oxygen were within the ranges observed in 1993.

Surface water temperatures ranged from 3.9 °C (LA-1) to 6.7 °C (LA-End) during the 1994 sampling period compared to a range of 6.0 °C (PJ-1) to 18.0 °C (PJ-End) during 1993. Water temperatures during the 1994 sampling period were lower and showed less variation in 1994 than those observed in 1993.

Field-determined conductivity in Los Alamos Canyon on LANL property (sites LA-3 and LA-4.5) was generally 75% higher in 1994 than was observed during 1993 at LA-3 and LA-5. Similar results were observed at LA-End, where conductivity was measured at 410 μmhos/cm in 1994 compared to 240 μmhos/cm in 1993. Conductivity in the Rio Grande at Otowi Bridge was lower (172 μmhos/cm) than was observed at the same site during 1993 (210 μmhos/cm). Conductivity values for water flowing onto LANL property at LA-1 and PJ-1 and in Sandia Canyon (SW-8) were comparable to 1993 values.

Table 2.3 Field Determined Water Quality Parameters

FIELD DETERMINED WATER QUALITY PARAMETERS SNOWMELT RUNOFF MAY 24, 1994							
Site	Date	Water Temp. °C	Dissolved Oxygen mg/L	pH s.u.	Conductivity µmhos/cm	Alkalinity mg/L $CaCO_3$	Flow cfs
LA - 1	May 24	3.9	10.8	7.45	59	25.5	0.98
LA - 3	May 24	5.0	9.9	7.17	126	33.1	0.89
LA - 4.5	May 24	6.2	8.9	7.54	245	47.9	0.12
LA - End	May 24	6.75	8.1	8.07	410	188.7	0.13
Rio Grande	May 24	5.8	9.5	8.03	172	72.4	NA
PJ - 1	May 24	3.95	10.32	7.16	51	33.1	.003
SW - 8	May 24	6.3	9.5	7.77	451	129.0	0.69
SW - 9	May 24	6.0	8.45	8.33	485	117.3	0.13

Laboratory analyses for water samples collected from the sampling sites during 1994 indicated low concentrations of major nutrients and metals in the surface waters. Results from InterMountain Labs (IML) are included in Appendix I and show that water quality conditions for waters flowing onto LANL property at LA-1 and PJ-1 during the 1994 sampling period were comparable to water quality conditions during 1993 the sampling period. The most notable difference includes a 50% reduction in TSS flowing onto LANL property (LA-1 and PJ-1). Other water quality constituents found in concentrations above the detection limit during 1993 in PJ-1 or LA-1 were again observed at nearly the same concentrations. However, the sample location for the parameters measured above the detection limit was switched between LA-1 and PJ-1. The 1993 and 1994 concentrations for total Kjeldahl nitrogen (TKN) and dissolved boron provide good examples of this variation (Appendix I).

TSS concentrations during the 1994 sampling period were below levels observed in 1993 at all sampling sites except the Rio Grande (Otowi). TSS in the Rio Grande was reported at 176 mg/L for the 1994 water quality sample compared to 69 mg/L TSS reported for the 1993 collection. All other water quality parameters at Otowi were comparable except total aluminum. The total aluminum concentration was higher in the Rio Grande in 1994 (4.6 mg/L) than during the 1993 sampling period (0.1 mg/L).

Sites within LANL property (LA-3, LA-4.5, and SW-8) generally showed lower concentrations for aluminum and higher concentrations for boron in the 1994 samples than were observed in the 1993 samples. 1994 concentrations for nitrate nitrogen (4.03 mg/L) and total phosphorus (3.27 mg/L) were higher than recorded during 1993 (1.45 mg/L nitrate nitrogen and 2.78 mg/L total phosphorus). During 1994 the laboratory and field determined water quality showed an increase in conductivity in Los Alamos Canyon at the LA-3 sampling location (below the ice rink). This same pattern was observed during May 1993.

2.3 BENTHIC MACROINVERTEBRATES

1993

A total of 23 different taxa were identified from the arroyo drainage benthic macroinvertebrate collections. The species observed represented several of the major groups of organisms commonly found in small first order and second order streams containing natural drainage waters. Species observed in Los Alamos Canyon at the confluence with the Rio Grande were representative of taxa that commonly occur in waters containing moderate amounts of available nutrients. Identified organisms included terrestrial and aquatic Oligochaeta (worms), aquatic beetles (Coleoptera), midges and true flies (Diptera), mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera). A listing of relative abundance and density for each identified organism for all sample sites is included in Appendix II.

Macroinvertebrate community richness (the total number of different taxa) ranged from a single taxa of beetle (*Agabus* sp.) in Pajarito Canyon at Hwy. 4 (site PJ-End) downstream of the LANL property to 13 taxa at LA-1 in Los Alamos Canyon (upstream of the Los Alamos boundary) and at LA-3 on LANL property. Macroinvertebrate density ranged from 3.6 organisms/m^2 in Pajarito Canyon at PJ-End to an estimated 2,760 organisms/m^2 in Los Alamos Canyon at LA-5 near the downstream boundary of the LANL property. Similar to LA-5, high density values of 2,194 organisms/m^2 were recorded in Los Alamos Canyon at LA-1, and 2,735 organisms/m^2 were recorded in Pajarito Canyon at PJ-1 (both sites upstream of LANL property).

Diversity values, as measured by the Shannon-Weiner Diversity Index (H'), range from no diversity (H'=0), reflected by the single species of beetle observed at PJ-End, to a moderately diverse community of H'=1.791, determined for LA-1 upstream of LANL property in Los Alamos Canyon. This value is considered to represent moderate diversity for the assemblage, as maximum diversity measured by the Shannon-Weiner Index for this richness would equal a value of 2.7 (abundance of all species identical). Hill's N1 for LA-1 indicates that one third (38.7%)

of the organisms are abundant and two thirds of the taxa are uncommon. Other community level descriptive parameters such as the number of dominant organisms expressed as a percent of richness (a useful alternative to a diversity measure), the number of dominant taxa, and community evenness, typically followed the patterns represented by richness, density, and Shannon-Weiner Diversity measures. Table 2.5 through Table 2.8 show the macroinvertebrate community summary statistics for each sample site.

Table 2.5 Macroinvertebrate community summary for Los Alamos Canyon 1993

MACROINVERTEBRATE COMMUNITY SUMMARY

MAY 1993

Parameter	Los Alamos Canyon Sites				
	LA1	LA3	LA4	LA5	End
Total Richness	15	13	5	4	4
Density (#/M^2)	2,194	1,235	1,872	2,760	1,185
Simpson's Diversity	0.24	0.27	0.82	0.76	0.91
Shannon-Weiner Diversity	1.77	1.59	0.41	0.49	0.23
Hill's Dominant Taxa N1	5.8	4.9	1.5	1.6	1.3
% Shredder Organisms	0	0	0	0	0
% Scraper Organisms	24.5	12.6	1.0	0	0
% Filterer Organisms	3.1	3.6	0	0	0
Scraper:Filterer Ratio	7.9	3.5	n/a	0	0
% EPT	56.7	98.5	3.6	2.9	0.2
% Chironomid	38.9	49.7	96.4	96.1	99
EPT:Chironomid	1.5	1.9	0.03	0.03	<0.01
BCI	74.3	83.4	106	106	107
Modified Hilsenhoff's Index	4.3	4.9	6.0	6.1	6.0

Table 2.6 Macroinvertebrate community summary for Sandia Canyon 1993

MACROINVERTEBRATE COMMUNITY SUMMARY MAY 1993		
Parameter	Sandia Canyon Sites	
	Sandia Wetland Inlet	Sandia Wetland Outlet
Total Richness	2	4
Density (#/M^2)	114	354
Simpson's Diversity	0.53	0.69
Shannon-Weiner Diversity	0.64	0.63
Hill's Dominant Taxa N1	1.9	1.9
% Shredder Organisms	0	0
% Scraper Organisms	0	0
% Filterer Organisms	0	4
Scraper:Filterer Ratio	0	0
% EPT	0	86.8
% Chironomid	100	9
EPT: Chironomid Ratio	0	9.6
BCI	110	107.6
Modified Hilsenhoff's Index	7.3	5.5

Table 2.7 Macroinvertebrate community summary for Pajarito Canyon 1993

MACROINVERTEBRATE COMMUNITY SUMMARY

MAY 1993

Parameter	Pajarito Canyon Sites	
	Pajarito Canyon (PJ1)	Pajarito Canyon End
Total Richness	6	1
Density (#/M^2)	2,735	3.6
Simpson's Diversity	0.29	1
Shannon-Weiner Diversity	1.43	0
Hill's Dominant Taxa N1	4.2	1
% Shredder Organisms	0	0
% Scraper Organisms	52.5	0
% Filterer Organisms	0	0
Scraper:Filterer Ratio	n/a	0
% EPT	83.6	0
% Chironomid	12.0	0
EPT:Chironomid Ratio	6.9	0
BCI	51.2	123.2
Modified Hilsenhoff's Index	4.0	11

Table 2.8 Macroinvertebrate community summary for Water Canyon and Canyon de Valle 1993

MACROINVERTEBRATE COMMUNITY SUMMARY MAY 1993		
	Canyon Headwater Sites	
Parameter	Water Canyon	Canyon de Valle
Total Richness	3	3
Density (#/M^2)	36	72
Simpson's Diversity	0.49	0.33
Shannon-Weiner Diversity	0.80	1.05
Hill's Dominant Taxa N1	2.2	2.9
% Shredder Organisms	0	0
% Scraper Organisms	0	0
% Filterer Organisms	90	20
Scraper:Filterer Ratio	0	0
% EPT	0	0
% Chironomid	10	80
EPT:Chironomid Ratio	0	0
BCI	120	114
Modified Hilsenhoff's Index	6	6.5

EPT (Ephemeroptera, Plecoptera, Trichoptera) species are generally considered sensitive to organic pollution and are commonly abundant in good to excellent water quality conditions. These sensitive species contributed a significant component of the macroinvertebrate community at background sites upstream of the LANL property. EPT organisms were also most apparent at LA-1, LA-3, PJ-1 and SW-8. The contribution of EPT organisms ranged from 0.0% - 3.6% at LA-4 and other sites characteristic of low flow or desiccation (sites LA-5, W-1, V-1 and PJ-End) compared to a range of 56% - 98% for sites LA-1, LA-3, and SW-8. Benthos at site LA-1

upstream of Los Alamos Reservoir exhibited relatively high density and supported species of great biomass (*Hesperoperla pacifica* and *Tipula* sp.) which suggests higher productivity at this site. Chemical data and analysis of the algae (discussed in Section 2.4) from LA-1 provide evidence that increased productivity at LA-1 may be attributed to higher concentrations of available nitrate nitrogen. The availability of nitrate nitrogen at this site did not appear to alter overall water quality as over 50% of the benthic community at LA-1 consisted of the sensitive EPT organisms.

Macroinvertebrate organisms that primarily use coarse particulate organic matter (CPOM) were absent from the collections. These organisms are typically abundant in forested headwater streams (where the primary source of organic material is provided from the surrounding terrestrial environment), and in-stream sources of organic material (periphyton, other macroinvertebrates) are limited by nutrient availability. The lack of shredders in headwater systems is common to disturbed watersheds or under highly variable flow regimes. Other selective feeding groups represented included scrapers, filterers and omnivores. Scrapers accounted for 24.5 % of the macroinvertebrates in the assemblage at LA-1 and decreased in a downstream pattern to be non-existent at LA-5 (Table 2.5). These organisms typically feed off periphytic algae growing within the stream. The highest percent abundance of scrapers (52.5%) were recorded from PJ-1 (Table 2.7). No scraper organisms were recorded from other sample sites. Filterer organisms, which feed or collect fine particulate matter usually transported in the water column, were poorly represented. Filter feeder organisms (*Eukeifferiella* sp.) collected immediately below the source waters discharged from the OS1 outfall in Sandia Canyon (site SW-1) were the only organisms and feeding strategy identified at this site, and accounted for 80% of the macroinvertebrates identified at V-1 (Canyon de Valle). Filter feeders within Sandia Canyon decreased to 4% abundance in samples collected from the outlet of Sandia Wetland at SW-8 (Table 2.6). Filter feeders in Los Alamos Canyon were only represented in samples from LA-1 and LA-3 and accounted for nearly equal proportion of the assemblage at 3.1% and 3.6% (Table 2.5). When combined, feeding groups identified as true omnivores, collector gatherers (generally omnivores),

and predators accounted for 10% at W-1, a total of 47.5% at PJ-1, and values of 96% at SW-8 and 100% at LA-End, PJ-End, and SW-1.

The percent Chironomid species in the macroinvertebrate assemblages ranged from a high of 100% at SW-1 for the two *Eukeifferiella* species collected to 0/0% at PJ-End below the Pajarito Wetland complex and V-1. The percent Chironomid increased in a downstream pattern within Los Alamos Canyon (Table 2.5) from 38.9% at LA-1 to 96.1% at LA-5 except at LA-End in the effluent-dominated waters of the County Wastewater Treatment Facility where 99% of the assemblage were chironomids. For waters flowing onto LANL property the proportion of chironomids ranged from a high of 80% at V-1 to a low of 10% at W-1 and 12.0% at PJ-1 in addition to LA-1 mentioned above.

Water quality rating metrics based on macroinvertebrate tolerance to organic pollution (modified Hilsonhoff's Index; Hilsenhoff 1987) showed that very good water quality (range 3.51-4.50) values were present for waters flowing onto LANL property at LA-1 and PJ-1. A very good water quality rating corresponds to possible slight organic pollution (Hilsenhoff 1987). Other waters flowing onto LANL property showed values of 6.5 at V-1 and 6.0 at W-1 for Hilsenhoff's Index. These values correspond to fairly poor water quality (range 6.51 - 7.50), defined by significant organic pollution for V-1 and fair water quality for W-1 defined by fairly significant organic pollution (Hilsenhoff 1987). Fairly poor water quality values for the Hilsenhoff Index were also recorded for SW-1 (7.3); fair water quality condition values were recorded for LA-5 (6.1) and LA-4 (6.0); and good water quality values were recorded for LA-3 (4.9) and SW-8 (5.5) (defined by Hilsenhoff as some organic pollution).

The BCI Index is a metric based on macroinvertebrate tolerance values to stress from pollution and habitat disturbance (Winget and Mangum, 1979). This index is interpreted by a comparison of index values to a predicted value based on physico-chemical attributes of the stream reach or a selected (sampled) macroinvertebrate reference condition index value. In general, BCI values above 85 indicate reference conditions are met, while values between 70 and 85 suggests some

loss of habitat quality, and scores below 70 suggest low habitat quality and/or degradation of water quality compared to the reference condition. The selection of appropriate reference conditions was based on sample location and collected macroinvertebrate assemblage, and comparison sites were selected on the basis of flow regime. (This will be further discussed in Section 3.0.) Using the BCI value from LA-1 as a reference condition for perennial waters flowing onto LANL, the BCI values indicate that *(1)* downstream at LA-3 the habitat quality is maintained and *(2)* there is no evidence of impacts to the macroinvertebrate assemblage. Site LA-1 was also used as the reference condition for SW-8 solely based on the likelihood that flow at SW-8 is continuous flow due to discharge from Sandia Wetland. The flow regimes at LA-4, LA-5 and PJ-End serve as a check on sensitivity of the BCI data with regards to the reference site. Since SW-8 flows originate from effluent-dominated waters, the BCI should indicate a change from reference conditions. BCI values indicated that the macroinvertebrate assemblage at SW-8 was negatively affected by habitat quality and possibly water quality. The mean BCI value for PJ-1, W-1 and V-1 (mean = 95.1) was used as the reference condition for ephemeral streams flowing onto LANL property. Based on comparisons to ephemeral sample sites within the LANL boundary, no impacts to the macroinvertebrate assemblage were determined for sites LA-4 and LA-5. In addition, habitat quality and possible water quality conditions may have negatively affected the macroinvertebrate assemblage at PJ-End. There was no appropriate reference site for comparison to the effluent-dominated waters at LA-End.

<u>1994</u>

During 1994, a total of 26 different benthic macroinvertebrate taxa were identified from the study site collections. Organisms representing the major groups of aquatic invertebrates were represented. A listing of relative percent abundance for the benthic macroinvertebrate taxa observed in the 1994 collections is presented in Appendix II. Three more taxa were observed in the 1994 collections than were identified in the 1993 collections. These figures combined total 32 different taxa identified for the two-year study period. Taxa identified in 1993, which were absent from the samples collected during May 1994, include *Isoperla* sp. (Plecoptera), *Agabus* sp. (Coleoptera), *Eukeifferiella potthasti*, *Hexatoma* sp., *Orthocladius* sp. and *Probezzia* sp. (Diptera).

Additional taxa observed from the 1994 benthic macroinvertebrate samples include *Limnodrilus* sp. (Oligochaeta), *Paraleptophlebia* sp. (Ephemeroptera), *Oligophlebodes* sp. and *Rhyacophila brunnea* (Trichoptera), *Hydaticus* sp. and *Optioservus* sp. (Coleoptera), *Antocha* sp., *Dicranota* sp., and *Hemerodromia* sp. (Diptera).

Benthic macroinvertebrate community descriptive statistics for the 1994 collections are presented in Table 2.9 for Los Alamos Canyon, Table 2.10 for Sandia Canyon, and Table 2.11 for Pajarito Canyon. The benthic communities generally exhibited low richness, density, and diversity for all sample sites.

Richness at LA-1 was equal between the two sampling years with 15 taxa identified. Richness was lower at LA-3 in 1994 (7 taxa) compared to 13 taxa in 1993, and higher at LA-4.5 (8 taxa) in 1994, compared to LA-5 with 4 taxa for 1993. Diversity was slightly higher for the 1994 collection at LA-1, lower at LA-3, and higher at LA-4.5 compared to the 1993 LA-5 collection. The 1994 samples exhibited a large decrease in density compared to 1993 collections. Density of organisms decreased by 95% (LA-4.5 versus LA-5) to 51% (LA-3) in 1994 compared to 1993 (Tables 2.9 and 2.5).

Table 2.9 Macroinvertebrate community summary for Los Alamos Canyon 1994

MACROINVERTEBRATE COMMUNITY SUMMARY MAY 1994 COLLECTIONS					
Parameter	Los Alamos Canyon Sites 1994 Collections				
	LA1	LA3	LA4.5	LA5	End
Total Richness	15	7	8	NA*	NA
Density (#/M^2)	339	579	107	NA	NA
Simpson's Diversity	0.13	0.55	0.20	NA	NA
Shannon-Weiner Diversity	2.26	0.85	1.66	NA	NA
Hill's Dominant Taxa N1	9.6	2.3	5.3	NA	NA
% Shredder Organisms	2	0	0	NA	NA
% Scraper Organisms	25.7	7.0	1.7	NA	NA
% Filterer Organisms	3.7	70.7	1.6	NA	NA
Scraper:Filterer Ratio	6.9	0.9	1.0	NA	NA
% EPT	62.7	28.6	31.8	NA	NA
% Chironomid	13.0	70.7	0	NA	NA
EPT:Chironomid Ratio	4.8	0.4	NA	NA	NA
BCI	64.5	94.1	87.9	NA	NA
Modified Hilsenhoff's Index	3.7	5.4	6.7	NA	NA

* No macroinvertebrate collections due to dry streambed conditions.

Taxonomic shifts in Los Alamos Canyon benthic macroinvertebrate assemblages at LA-1 between the two sample years included a reduction in the relative abundance of Plecoptera and Trichoptera and an increase in the relative abundance of Diptera. Downstream of LA-1, the assemblage of benthic macroinvertebrates generally shifted to a greater relative abundance of Diptera (Appendix II).

Sandia Wetland outlet (SW-8) exhibited the same richness of 4 benthic taxa for both sample periods. Diversity values were higher in 1994 than in 1993 and reflected a taxonomic shift from a dominance of the single taxon *Hesperophylax* sp. (Trichoptera) at 82.8% in 1993 to an assemblage dominated by the two taxa *Hesperophylax* sp. (39.7%) and terrestrial earthworms (46.5%) in 1994. In contrast to Los Alamos Canyon (and Pajarito Canyon discussed below), there were negligible differences in the density of benthic organisms at SW-8 between 1993 and 1994 (Table 2.10 and Table 2.6).

Table 2.10 Macroinvertebrate community summary for Sandia Canyon 1994

MACROINVERTEBRATE COMMUNITY SUMMARY MAY 1994 COLLECTIONS		
Parameter	**Sandia Canyon Sites 1994 Collections**	
	Sandia Wetland Outlet	**Sandia Wetland Culvert**
Total Richness	4	8
Density (#/M^2)	104	207
Simpson's Diversity	0.37	0.44
Shannon-Weiner Diversity	1.09	1.21
Hill's Dominant Taxa N1	2.9	3.4
% Shredder Organisms	0	0
% Scraper Organisms	0	0
% Filterer Organisms	0	0
Scraper:Filterer Ratio	0	0
% EPT	39.7	68.2
% Chironomid	0	39.4
EPT:Chironomid Ratio	NA	1.7
BCI	106	83.1
Modified Hilsenhoff's Index	5.5	5.4

Taxonomic richness in upper Pajarito Canyon at PJ-1 was lower in 1994 (2 taxa) than recorded in 1993 (6 taxa). The low richness observed in 1994 also reflected a major shift in taxonomic makeup of the assemblage to a dominance of *Eisenella tetraedra* and terrestrial earthworms (both Oligochaeta) from an assemblage dominated by three taxa of mayflies (Ephemeroptera) during the 1993 sample period (Appendix II). Differences in diversity values between the two sample periods were generally higher during 1994 even though richness values were lower. However, diversity measures for communities with low richness values are not typically as reliable as other community characteristics for comparisons or indicators of structure . Density of benthic organisms in 1994 was reduced to only 4% of the density of benthic organisms recorded in 1993 (Table 2.11 and Table 2.7).

Table 2.11 Macroinvertebrate community summary for Pajarito Canyon 1994

MACROINVERTEBRATE COMMUNITY SUMMARY MAY 1994 COLLECTIONS		
Parameter	Pajarito Canyon Sites 1994 Collections	
	Pajarito Canyon (PJ1)	Pajarito Canyon End
Total Richness	2	NA
Density (#/M^2)	107	NA
Simpson's Diversity	0.55	NA
Shannon-Weiner Diversity	0.64	NA
Hill's Dominant Taxa N1	1.8	NA
% Shredder Organisms	0	NA
% Scraper Organisms	0	NA
% Filterer Organisms	0	NA
Scraper:Filterer Ratio	0	NA
% EPT	0	NA
% Chironomid	0	NA
EPT:Chirnomid Ratio	0	NA
BCI	109	NA
Modified Hilsenhoff's Index	5.0	NA

NA No macroinvertebrate collections due to dry streambed conditions.

EPT organisms were present at all sampling sites except upper Pajarito Canyon at PJ-1. The range in percent abundance of EPT organisms for the remaining sample sites was from 31.8% at LA-4.5 to 68.2% at SW-9 in Sandia Canyon. In Los Alamos Canyon, EPT organisms were most abundant at LA-1 (62.7%) and least abundant at LA-3 (28.6%). This pattern is the same as demonstrated for richness and measures of diversity for the Los Alamos Canyon sites. In contrast to the 1993 collections where the highest percent abundance of 84% was recorded at PJ-1, there were no EPT organisms observed in the collections from PJ-1 in the 1994 samples.

Distribution of preferred feeding strategies in the macroinvertebrate assemblages indicated that similar to 1993 shredder organisms continued to be poorly represented at all the sampling sites. Shredder organisms (*Oligophlebodes* sp., Trichoptera) were recorded only at site LA-1 with a relative percent abundance of 2%. Scraper organisms were only observed in the samples from Los Alamos Canyon and showed a pattern of decreasing abundance downstream from 25.7% at LA-1 to 1.7% at LA-4.5. This same pattern for scrapers was observed in Los Alamos Canyon during the 1993 sampling period. Filterer organisms were also only observed in the collections from Los Alamos Canyon and showed a wide range from 1.6% at LA4.5 to 70.7% at LA-3. For waters flowing onto LANL property at LA-1, filterers accounted for 3.7% of the assemblage. Similar to the 1993 collections, there was a wide range in the proportion of omnivores, collector gatherers, and predators among the samples. Combined, these three groups accounted for 22.3% of the macroinvertebrate assemblage at LA-3 and 100% of the organisms collected from waters flowing onto LANL property at PJ-1 as well as collections from the Sandia Canyon sample sites (SW-8 and SW-9).

The percent chironomid specimens in the macroinvertebrate collections exhibited a wide range among sites and within drainages. For waters flowing onto LANL property, the percent chironomid organisms ranged from 0.0% at PJ-1 to 13% at LA-1. Downstream of LA-1 in Los Alamos Canyon, the proportion of chironomid organisms was 70.7% at LA-3 (the maximum observed during 1994) and 12.0 at LA-4.5. No chironomid organisms were observed in the macroinvertebrate samples from SW-8, but a total of 39.4% was accounted for in the SW-9 collections.

Hilsenhoff's Index values for the 1994 macroinvertebrate collections showed a value of 3.7 at LA-1 and 5.0 at PJ-1 for waters flowing onto LANL property. The Hilsenhoff Index value at LA-1 indicated very good water quality and possible slight organic pollution which was also indicated by the Hilsenhoff value from this site and from PJ-1 in 1993. The 1994 PJ-1 Hilsenhoff Index value of 5.0 corresponds to good water quality and suggests some organic pollution. Based on the Hilsenhoff Index, water quality conditions in Los Alamos Canyon below LA-1 were rated as

good (some organic pollution) at LA-3 with a value of 5.4, and fairly poor (significant organic pollution) at LA-5 with an index value of 6.7. Hilsenhoff Index values from samples collected in Sandia Canyon indicated that good water quality conditions existed at SW-8 (index = 5.5) and at SW-9 (index = 5.4).

The BCI quotients for the 1994 studies utilized the same reference site macroinvertebrate sample score and flow criteria as utilized for the 1993 analyses except for sites in Sandia Canyon. Since the 1994 samples sites included two locations in Sandia Canyon which are likely influenced by the same flow regime it was more appropriate and instructive to use SW-8 as representative of reference conditions for site SW-9. Based on the LA-1 reference condition BCI score, the final BCI value for LA-3 indicated the benthic community was negatively effected by habitat quality. Based on the BCI score for the PJ-1 reference condition, the final BCI value at site LA-4.5 indicated the macroinvertebrate assemblage was negatively effected by habitat quality and water quality conditions. Based on the SW-8 reference conditions the final BCI value for comparison between SW-8 and SW-9 indicated the macroinvertebrate assemblage may have been negatively effected by habitat quality.

2.4 PERIPHYTON

1993

The periphyton collected from the arroyos represented the common groups of freshwater algae including green algae (Chlorophyta), blue-green algae (Cyanophyta), euglenoids (Euglenophyta), a single member of the Cryptophyta (*Cryptomonas*), and a single yellow-green (Chrysophyta) taxon *Tribonema bombycinum* plus many species of diatoms (Bacillariophyta). Among the groups of algae, the diatoms were most diverse with 120 different species identified, followed by green algae, blue-green algae, and a few species representing each of the remaining groups. A total of 34 non-diatom forms of algae were identified. Large filamentous algae were not common in the arroyos, but accounted for a major component of the algal community in the wetlands. (Wetland

periphyton will be discussed in Section 5.0.) A listing of diatom algae and non-diatom algae identified from the collected samples from each study site is included in Appendix II.

Diatom growth was present as a thin film on rocks, gravel, sand, and pieces of submerged detritus and vegetation. The diatoms were a dominant component of the periphyton collections. Green algal masses (macroalgae) was not a dominant growth form in the arroyos. However, macroalgae were present in Los Alamos Canyon at LA-1 and LA-End and in Pajarito Canyon downstream of the LANL property (PJ-End). At LA-1, the macroalgae included the green alga *Prasiola crispa* which grows in an expanded flat sheet up to 1.5 cm in diameter. A few tufts of *Prasiola* attached to the downstream side of larger cobbles were also noticed in Pajarito Canyon in the arroyo adjacent to the upper Pajarito Wetland.

Extensive growth of two filamentous algae taxa contributed to the nearly 100% coverage of the substrate at LA-End near the confluence with the Rio Grande. The filamentous algae *Mougeotia* sp. and *Stigeoclonium stagnatile* dominated the lower Los Alamos Canyon channel at the LA-End sampling site. The blue-green filamentous algae *Phormidium tenue* and *Oscillatoria tenuis* were also common at LA-End. Blue-green algal forms were generally not a major component of the periphyton at any other study site. Other macroalgae present consisted of filaments of *Ulothrix zonata* (Chlorophyta), and the yellow green filamentous algae *Tribonema bombycinum*. These macroalgae were also common in the wetlands and often occurred in small dense growths.

With the exception of SW-8 which was immediately below a wetland, non-diatom algae was not common at the canyon sites. The highest richness of non-diatom algae at SW-8 was 15 taxa and was dominated by filamentous green algae taxa (*Mougeotia* sp., *Spyrogyra* sp., and *Zygnema* sp.). Highest richness of non-diatom taxa from sites not directly related to a wetland was 10 species recorded from LA-1, and decreasing richness was observed downstream in Los Alamos Canyon. Richness of non-diatom taxa was 4 taxa in upper Pajarito Canyon at PJ-1 and increased to a richness of 8 non-diatom taxa at PJ-End downstream of the LANL property. The diatom algae was used for community summary statistics because of the high richness and abundance values and

dominance of this group of algae at all sites. Diatom community descriptive statistics are summarized in Table 2.12 and Table 2.13 for stream channel study sites in Los Alamos Canyon, Water Canyon, Canyon de Valle, and Pajarito Canyon.

Table 2.12 Periphyton diatom community summary for Los Alamos Canyon

PERIPHYTON DIATOM COMMUNITY SUMMARY

MAY 1993

Parameter	Los Alamos Canyon Sites				
	LA1	LA3	LA4	LA5	End
Diatom Richness	36	32	36	34	24
Non-diatom Richness	10	7	3	2	9
Simpson's Diversity	0.10	0.13	0.11	0.07	0.13
Shannon-Weiner Diversity	2.83	2.61	2.74	2.96	2.36
Hill's Dominant Taxa N1	16.9	13.6	15.4	19.2	10.6
N1 as Percent of Richness	46.9	42.5	42.8	56.5	44.2
Evenness[1]	0.59	0.53	0.55	0.76	0.69

1 Evenness based on Hill's Modified Ratio.

Table 2.13
Periphyton diatom community summary
for Pajarito Canyon, Water Canyon, and Canyon de Valle, and Sandia Canyon

PERIPHYTON DIATOM COMMUNITY SUMMARY MAY 1993					
Parameter	**W-1**	**V-1**	**PJ-1**	**PJ-End**	**SW-8**
Diatom Richness	31	14	39	37	27
Non-diatom Richness	2	1	4	8	15
Simpson's Diversity	0.20	0.69	0.05	0.14	0.94
Shannon-Weiner Diversity	2.22	0.84	3.20	2.61	2.73
Hill's Dominant Taxa N1	9.2	2.3	24.6	13.7	15.3
N1 as Percent of Richness	29.7	16.4	62.1	37.0	56.6
Evenness[1]	0.50	1.46	0.80	0.49	0.67

1 Evenness based on Hill's Modified Ratio.

Analysis of the diatom community indicated that diatom species richness was relatively consistent between arroyo sites upstream and downstream of LANL except for site V-1 (Canyon de Valle) upstream of the LANL property. Site V-1 exhibited low richness, diversity, and a simple periphyton assemblage structure. Site V-1 richness was 14 diatom taxa compared to a range of 31 taxa at W-1 (upstream of the LANL boundary in Water Canyon) to 39 taxa at PJ-1 (upstream of the LANL boundary in Pajarito Canyon). Diversity values and richness measures were very consistent within Los Alamos Canyon Pajarito Canyon and Water Canyon sites. However, diversity and other structural measures indicated that the periphyton assemblage from V-1 was less diverse and dominated by only a few taxa (*Meridion circulare*, *M. circulare* var. *capitata*, and *Achnanthes lanceolata*) compared to nine dominant taxa and twice the richness at the second

lowest diverse site W-1. Site V-1 generally exhibited community structure parameters which were outside the range of values from other sample sites.

The most common diatom taxa for the Los Alamos Canyon sites and PJ-1 included varieties of *Achnanthes* and *Cocconeis* which are excellent colonizers, *Meridion circulare* which is a common cold, clean running water taxon, cool to cold water forms of *Fragilaria*, and forms of *Nitzschia* which can exist within fine silts and sandy substrates.

<u>1994</u>

Periphyton during the 1994 sampling period represented green, blue-green and yellow-green algae and diatoms. Richness and abundance was dominated by diatoms at all sampling sites. Non-diatom algae was visually scarce with respect to biomass at all sites except SW-8 where filamentous algae was visually present and contributed to a non-diatom richness of 15 taxa. Richness for non-diatom algae decreased from a total of 34 taxa (1993) to 19 taxa in the 1994 collections. Non-diatom algae richness ranged from 2 green algae taxa at LA-3 (*Chlamydomonas* sp. and *Oedogonium* sp.) and 1 green algae (*Chlorococcum humicola*) and 1 filamentous blue-green algae (*Lyngbya* sp.) at PJ-1, to 6 taxa at LA-1 (Appendix II).

Diatom periphyton richness at the sampling sites during 1994 was less than recorded in the 1993 collections at all sites except SW-8. Diatom richness ranged from 17 taxa identified from the SW-9 collection to 28 taxa identified in the LA-3 sample. Descriptive community statistics for the diatom periphyton assemblage collected from each sample site during 1994 are shown in Table 2.14 and Table 2.15. The list of taxa identified for the 1994 sampling period is presented in Appendix II.

Diatom periphyton samples from all sites in Los Alamos Canyon exhibited lower richness values than observed in 1993. Diversity values for the Los Alamos Canyon sites indicated that periphyton diversity increased at LA-1 and LA-4.5 and decreased at LA-3 (based on maximum possible Shannon-Weiner value). The measure of N1 as Percent of Richness closely follows the

relationships between maximum Shannon-Weiner value and actual Shannon-Weiner values. However, there was a steady decrease in contribution of non-diatom algae from upstream to downstream where only a single taxon of non-diatom algae (*Chlamydomonas* sp.) was collected (Table 2.14). The pattern of decreasing richness for non-diatom algae from upstream to downstream was comparable to collections observed during 1993 (Table 2.14 and Table 2.12).

Table 2.14 Periphyton diatom community summary for Los Alamos Canyon

PERIPHYTON DIATOM COMMUNITY SUMMARY MAY 1994					
	Los Alamos Canyon Sites				
Parameter	LA-1	LA-3	LA-4.5	LA-5	LA-End
Total Richness	26	28	21	N/A	N/A
Non-diatom Richness	6	2	1	N/A	N/A
Simpson's Diversity	0.12	0.25	0.13	N/A	N/A
Shannon-Weiner Diversity	2.62	2.25	2.40	N/A	N/A
Hill's Dominant Taxa N1	13.7	7.6	11.0	N/A	N/A
N1 as Percent of Richness	52.5	27.1	52.4	N/A	N/A
Evenness[1]	0.55	0.45	0.68	N/A	N/A

1 Evenness based on Hill's Modified Ratio.

Diatom periphyton community descriptive statistics show richness decreased from a total of 39 diatom taxa (1993) to 22 diatom taxa in 1994 in collections from upper Pajarito Canyon at PJ-1. Measures of diversity for PJ-1 were similarly lower in 1994 but were comparable to all other sample sites (Table 2.15 and Table 2.13). Richness and diversity immediately below Sandia Canyon Wetland at SW-8 showed little variation between the sample periods. Similar to patterns observed in Los Alamos Canyon, the downstream site in Sandia Canyon (SW-9) exhibited lower richness and measures of diversity than SW-8 (Table 2.15). Samples were not collected from SW-9 in Sandia Canyon during 1993.

Common diatom periphyton taxa observed in 1994 were similar to those observed in 1993 and included quick colonizing forms of *Achnanthes* and *Cocconeis*, *Fragilaria*, *Meridion circulare*, and *Nitzschia* species common to fine substrates. The most significant difference between the 1993 and 1994 diatom assemblages was the presence of the centric diatom *Stephanodiscus hantzschii* in Los Alamos Canyon at LA-3 and LA-4.5. This taxon is a common lentic (lakes) form and most likely indicates the influence of water from Los Alamos Reservoir.

Table 2.15 Periphyton diatom community summary for Pajarito Canyon and Sandia Canyon

PERIPHYTON DIATOM COMMUNITY SUMMARY

MAY 1994

Parameter	Canyon Sites			
	PJ-1	PJ-End	SW-8	SW-9
Total Richness	22	N/A	28	17
Non-diatom Richness	2	N/A	15	4
Simpson's Diversity	0.13	N/A	0.13	0.11
Shannon-Weiner Diversity	2.51	N/A	2.27	2.38
Hill's Dominant Taxa N1	12.2	N/A	9.7	10.8
N1 as Percent of Richness	55.8	N/A	34.6	63.6
Evenness[1]	0.59	N/A	0.74	0.79

1 Evenness based on Hill's Modified Ratio.

2.5 FISH

1993

Fish were observed and captured at one sampling location during the study. Longnose dace (*Rhinichthys cataractae*) were captured by net seine in Los Alamos Canyon at LA-End immediately upstream of the confluence with the Rio Grande. No other fish species were observed. Four specimens were retained for positive identification conducted by experts on Rio Grande fish at the Colorado State University Larval Fish Laboratory (Fort Collins, CO).

The extent of migration of longnose dace upstream in Los Alamos Canyon was determined by repeating 15 meter long net seines in an upstream manner at approximately 100 meters apart. No longnose dace were observed beyond a distance of 0.5 - 0.6 miles upstream of the Rio Grande. Habitat was critical to the success of capturing fish, and all attempts were made to seine through preferred areas which contained numerous, large (15 - 30 cm diameter) boulders that could be easily disrupted. It is possible that excessive algal growth and water quality could have contributed to limiting upstream migration in Los Alamos Canyon beyond this area.

1994

Fish surveys during 1994 consisted of visual observations only. No fish were observed at any study locations including the water resulting from groundwater seeps in Los Alamos Canyon at the confluence of the Rio Grande.

3.0 GENERAL DISCUSSION

3.1 PHYSICAL

During the 1993 sampling period, surface flow in channels upstream of the LANL boundary was observed in Los Alamos Canyon, Pajarito Canyon, and Water Canyon. Flow in Canyon de Valle terminated prior to reaching the LANL boundary. The Canyon de Valle stream channel downstream of where surface flow was observed (site PJ-1) was choked due to a wide variety and size range of leaves and forest litter including an assortment of established ground cover plants. This area was situated upstream of the LANL boundary and indicated that surface water in Canyon de Valle did not recently flow onto LANL property. Los Alamos Canyon drains the largest watershed area upstream of LANL property. The stream reach upstream of Los Alamos Reservoir is considered perennial, and the highest flow was measured in this reach (site LA-1).

The 1994 surface flows onto LANL property were only observed in Los Alamos Canyon (LA-1) and Pajarito Canyon (PJ-1). Site V-1 and W-1 contained debris such as dried leaves and twigs or new-growth grass indicating no surface flow had previously occurred in 1994.

Measured surface water flows during the two-year study suggest that bankfull conditions in the arroyos draining LANL are not characteristic of the spring runoff period. The 1992-1993 winter season produced near record snow water equivalent (SWE) measurements in almost every basin in New Mexico (USDA 1993). For the five-month period from March - July 1993, the *New Mexico Basin Outlook Report, March 1, 1993* (USDA 1993) reported a 90% chance of exceeding a volume of 6,500 acre feet (ac-ft) compared to a 30-yr average of 4,000 ac-ft in the Santa Fe River, and a 90% chance of exceeding 53,000 a compared to a 30-yr average of 43,000 ac-ft in the Jemez River. These data indicate that during the March - July 1993 period, the quantity of water due to snowmelt in the vicinity of LANL was 1.2 - 1.6 times higher than average. Similar

data for 1994 indicated that snowmelt in the vicinity of LANL was highly variable and ranged from 21% - 27% below average (USDA 1994).

Flow in the LANL arroyos is strongly influenced by ambient air temperature during the day and night and by the type and amount of precipitation. Proper evaluation of runoff within the arroyos surrounding the LANL property is best conducted with flow and duration data. Instantaneous flow in any of the arroyos studied may exhibit wide fluctuations from day to day depending on climatic conditions, and it is probable that mean flow during the entire spring period is relatively consistent from year to year. The differences in flow observed between 1993 and 1994 at the same sample sites are likely a result of ambient day and night temperatures. Evidence of this is demonstrated by the lower flows during 1994 and corresponding lower water temperatures observed in 1994.

Much of the surface flow in the arroyos draining the LANL property is dependent upon local geology interacting with saturated soils in the arroyo stream channels from elevated shallow groundwater levels. During wetter years, it is normal for the groundwater levels to be both higher and persistent longer than during dry years. For the ephemeral arroyos draining LANL property, differences between high and below normal spring runoff events are more likely to be expressed by the range and duration of surface water flow. The absence of flow during 1994 in Pajarito Canyon above and below the Pajarito Wetland complex and in Los Alamos Canyon at the USGS gage demonstrates the effects of groundwater levels.

Observations during the present study indicated that the range of flow for Canyon de Valle, Canyon del Buey, Water Canyon, Mortandad Canyon, and Sandia Canyon did not extend downstream beyond LANL's lower boundary. Flow in Pajarito Canyon and Los Alamos Canyon extended downstream beyond LANL property only during 1993. The range of off-site flow in Pajarito Canyon terminated approximately 20 meters below State Hwy. 4. The terminus of flow in Los Alamos Canyon was not observed. However, based on local geology and measured flow at LA-5, the range of surface flow in Los Alamos Canyon was expected to terminate a short

distance downstream from the boundary of LANL property and well upstream from the confluence of Pueblo Canyon. During 1994 when snowmelt runoff was estimated to be below average, surface flows in Los Alamos Canyon were absent nearly 1.0 km upstream of the lower LANL boundary and well above Pajarito Wetlands for Pajarito Canyon. It is anticipated that the range of surface flow from annual snowmelt runoff during average snowpack conditions may not extend beyond the LANL boundary.

Surface flow was present in Los Alamos Canyon at the confluence with the Rio Grande during both sampling periods. During 1993, the flow was dominated by treated effluent from the Los Alamos County Wastewater Treatment Facility. During 1994 there was no flow from the Los Alamos County Wastewater Treatment Facility that extended to the Rio Grande and the surface flows were supported by groundwater seeps in the Los Alamos Canyon stream channel approximately 10 - 15 meters from the Rio Grande. Based on field determined water quality parameters, it is likely that these seeps were a result of subsurface waters from the Los Alamos County Wastewater Treatment Facility and not subsurface Rio Grande water.

For waters flowing onto LANL property during 1993, Canyon de Valle exhibited the highest conductivity (162 μmhos/cm) and hardness (31 mg/L as $CaCO_3$). Pajarito Canyon contained the highest TSS (15 mg/L). For each arroyo, these values indicate clean water with little to no evidence of elevated chemical concentrations from natural or anthropogenic sources. TSS values are frequently dependent upon flow and substrate within the channel. Substrate material consisting of fine sand and silt was available for transport and is characteristic of the Pajarito Canyon and Canyon de Valle stream channels. During 1994 waters flowing onto LANL property in Pajarito Canyon and Los Alamos Canyon exhibited lower conductivity (82 μmhos/cm maximum) and TSS (6.0 mg/L) than in 1993. Again, these data suggest no chemical input from other than natural sources. Sufficient fine silts and sands were available in the substrates in upper Pajarito Canyon for transport downstream. However, the lower flow in 1994 (0.003 cfs) likely did not provide adequate hydrodynamic force for sediment transport. Substrate material for Los Alamos Canyon upstream of LANL property included sand deposits, sand as substrate armor to gravel and small

boulders, and sand trapped in moss growing on the surface of rocks and large debris. Similarly, the lower flow in 1994 reduced the concentration of TSS. The TSS potential in Water Canyon during 1993 was low because the substrate was dominated by established grasses and other ground cover plants. Although appropriate material was available to contribute to TSS in Canyon de Valle, insufficient hydrodynamic force due to low flow (0.009 cfs) prevented significant material transport.

A decrease of TSS was observed in water leaving LANL property during 1993 in Pajarito Canyon (1.0 mg/L at PJ-End) and likely resulted from a reduction in flow energy (0.02 cfs) and lack of material available for transport. The substrate was dominated by large woody debris and pea size gravel. TSS was higher for water in Los Alamos Canyon leaving LANL property (13 mg/L at LA-5) than was TSS upstream of Los Alamos Reservoir (7 mg/L) even though flow at LA-5 was less than that measured above Los Alamos Reservoir. During 1994 TSS measurements in Los Alamos Canyon were highest at LA-3 (4.0 mg/L) and equal to LA-1 at the terminus of surface flow (2.0 mg/L). TSS values for waters either flowing onto, or off LANL property pose no regulatory, water quality, or ecological concern.

3.2 CHEMICAL

Laboratory measured water quality parameters for snowmelt runoff waters flowing on LANL property indicated the absence of organic pollution and industrial contamination. Concentrations for most general parameters and trace metals were at or below detection limits as anticipated for natural snowmelt waters. Water flowing onto LANL property during 1993 in Canyon de Valle exhibited higher concentrations of aluminum (dissolved and total) than was observed from either Los Alamos Canyon or Water Canyon. Although Canyon de Valle is considered an ephemeral stream reach, a total aluminum concentration of 5.3 mg/L reported from Canyon de Valle is above livestock watering criteria for this element. Implications of this water quality criteria with respect to Canyon de Valle total aluminum concentrations will be discussed further in Section 3.2.2.

During 1994 the maximum total aluminum concentration for surface waters flowing onto LANL property was 1.4 mg/L (LA-1). No other water quality constituents from waters flowing onto LANL property exhibited an apparent regulatory or ecological concern.

3.3 BIOLOGICAL

Taxonomic assemblages and community structure for macroinvertebrates and algae collected from sites upstream of the LANL boundary reflected the flow conditions and characteristic of small headwater type streams. The consistently higher taxonomic richness for both benthic macroinvertebrates and algae in Los Alamos Canyon (LA-1) is most likely due to the perennial flow in this reach of Los Alamos Canyon. Stream reaches which are ephemeral cannot support an extensive algal flora or complex aquatic macroinvertebrate assemblage because there is often insufficient time for organism development. During above average snowmelt in 1993, LA-3 exhibited higher richness values than were observed at LA-4 or LA-5 in lower Los Alamos Canyon where surface flows were of shorter duration or were intermittent. In 1994 when snowmelt runoff was below average and flow was greatly reduced downstream of LA-1, the effects were observed at LA-3 where values for richness and other community structure characteristics were lower than 1993 values. In 1993, the aquatic macroinvertebrate assemblage in Pajarito Canyon exhibited the same pattern with respect to geographical location as was observed both algae and macroinvertebrates in Los Alamos Canyon during 1994. However, in Pajarito Canyon (1993), diatom algal richness was effectively equal and non-diatom algae richness was higher downstream of LANL property where low or intermittent flows would likely occur (PJ-End). The differences in macroinvertebrate and algal richness patterns observed in Pajarito Canyon during 1993 can be attributed to hydrological and biological effects of Pajarito Wetland. Insufficient flow existed in Pajarito Canyon during 1994 from which to observe a similar influence of the wetland complex. No wetland habitat exists between LA-1 and LA-5 in Los Alamos Canyon.

Pajarito Canyon upstream of LANL is ephemeral and aquatic habitats are short-lived. During the spring runoff period, macroinvertebrate assemblages may not have sufficient time to colonize or recruit a variety of organisms characteristic of a perennial stream reach. However, periphyton has the ability to withstand long periods of desiccation, and therefore, does not require as long of an extended period of flow for colonization or recruitment. Algal species richness (especially diatoms) would not necessarily be significantly reduced during short periods of desiccation.

During 1993, the waters downstream in Pajarito Canyon (PJ-End) exhibited only a single species of aquatic beetle (*Agabus* sp.) at an extremely low density (3.6 organisms/M^2), but exhibited a diatom richness equivalent to PJ-1 conditions and a non-diatom algal richness higher than PJ-1 conditions. Biologically, the macroinvertebrate and algal collections at PJ-End suggest that macroinvertebrate colonization does not occur, but periphyton community development is unaffected. The macroinvertebrate and algal communities that were observed at PJ-End could result from a diurnal hydrologic pattern resulting in daily, short-duration flows interrupted by a period of desiccation. During the night and early morning hours when flows in the arroyos are reduced due to cooler temperatures, the range of surface flow is correspondingly reduced. The macroinvertebrate collection at PJ-End was taken late in the afternoon, during a time when the range of surface flow would be extended farthest downstream. At the time of collection, the terminal end of surface flow was observed to be approximately an additional 20 meters downstream. Although variable in magnitude, a daytime increase in flow was observed in all stream channels under investigation and fluctuations in flow would correspond with fluctuations in the range of surface flow within the channels. Based on the lack of macroinvertebrates, the range of surface flow in Pajarito Canyon during the night and early morning hours was most likely upstream of PJ-End. *Agabus* sp. is typically not a fast developing or colonizing organism. This beetle would typically occur in slow or standing water with vegetation (wetland habitat) and was likely washed into the PJ-End site from the Pajarito Wetland complex (located upstream of PJ-End) during periods of high diurnal flow. During 1994, the only location sampled that provided an equivalent habitat for *Agabus* to exist was SW-8 immediately downstream of Sandia Wetland.

No specimens of *Agabus* were observed during 1994. It is possible that lower flows through the wetland were insufficient to transport this organism downstream to the sample site.

3.4 OVERALL FINDINGS

3.4.1 Healthy Conditions

Healthy physical, chemical, and biological conditions were observed in all the main channels of the arroyos and canyons of LANL property. Physical habitats in all stream channels consisted of a series of pools, riffles, undercut banks, extensive cover, and complex microhabitats characteristic of natural conditions consistent with local geology and regional topography. Extensive channelization, erosion, and deposition were minimal and typically limited to stream reaches near the terminus of runoff under low flow conditions at the time of the study. Bank side evidence indicated that erosion or deposition in these areas was likely the result of high energy, short-term spates following intense summer storms and not the result of snowmelt runoff.

Chemical analyses of the surface waters showed good to excellent water quality conditions in all canyons and wetlands investigated. With the exception of the total aluminum concentration in background waters collected upstream of LANL property in Canyon de Valle during 1993, no parameter concentrations were above established State water quality standards. Chemical constituents characteristically exhibited concentrations less than or equal to the analytical detection limit. The background concentration of total aluminum is further discussed in Section 3.2.2. No toxins or toxic concentrations of contaminants were detected at sites associated with wetlands (SW-8, PJ-End) or effluent-dominated waters (LA-End).

Biological collections of algae and macroinvertebrates were representative of the existing hydrology, physical characteristics, and water quality of the sample sites. Algae common to pristine waters were common at sites representing background conditions consistent with low nutrient availability, typical of headwater streams. For example, the flat, sheet-like *Prasiola crispa*

found at LA-1 typically occurs in alpine, cold water streams where there has been some enrichment from nitrogenous matter. The presence of this taxon at LA-1 corresponds with a concentration of 0.18 mg/L (1993) and 0.10 mg/L (1994) nitrate nitrogen, which was the highest recorded nitrate concentration among the sites that represent background conditions. Extensive plant and ground cover supported by well-developed organic soils characterizes the local riparian corridor at the LA-1 site and likely was the source of small amounts of nitrate which support this algal species. Availability of nitrate nitrogen would also contribute to the overall increased productivity and biomass observed in the benthic macroinvertebrate collections from this site. Algae observed during 1993 in samples from the wetlands depicted taxa and growth common to wetland habitats during early spring development. Similarly, high nutrient availability in Sandia Wetland due to Outfall 03F and in effluent-dominated water at LA-End supported algae characteristic of these conditions. Low algal species richness and community diversity were attributed to fluctuating hydrological conditions resulting in intermittent desiccation and low growth and not to toxic or poor water quality conditions.

Benthic macroinvertebrate collections reflected patterns similar to those demonstrated by the algae. Organism density, diversity, and richness were highest at sample locations where surface flow was longest. Fluctuating hydrological pattern, interrupted colonization periods, and desiccation reduced taxonomic richness to species with high colonization rates and resistance to drought. Differences in richness, diversity, and density of macroinvertebrates and algae between 1993 and 1994 sample sites in ephemeral reaches of Los Alamos Canyon and Pajarito Canyon provide good examples of the relationship between flow patterns and community development. EPT species (orders Ephemeroptera, Plecoptera, and Trichoptera), commonly recognized as sensitive to organic pollution, were not common where short-term flow and desiccation was characteristic. The shift toward a higher abundance of Diptera at LA-3 best demonstrates this effect. The EPT species contributed a significant component of the macroinvertebrate community (at study sites receiving long periods of sustained flow) and indicated high water quality conditions. Benthos at site LA-1 upstream of Los Alamos Reservoir exhibited high density, and species with high biomass were supported, reflecting the increase in overall productivity at this site. The condition

of the macroinvertebrate community at this site relative to other sample sites can be attributed to perennial flow and natural stimulation by higher nitrate nitrogen concentrations. The nitrate nitrogen concentrations do not reflect an abundance of nutrient availability as over 50% of the benthic community at site LA-1 consisted of EPT organisms. This is consistent with interpretations that water quality is good to excellent.

3.4.2 Unhealthy Conditions

Conditions which may be considered detrimental to existing ecological systems were limited to deposition of mineral material originating from the Los Alamos Canyon County Landfill into upper Sandia Canyon Wetland. Erosion and subsequent deposition of material from the landfill have resulted in channel formation which has altered hydrology within the wetland. Dystrophic, highly organic, saturated soils typical of wetlands support dense growths of obligate hydrophytic plants and exist opposite the landfill. However, these soils and plants in the wetland but were significantly reduced adjacent to the landfill boundary. Functional aspects of the upper Sandia Wetland have been significantly reduced in the region adjacent to the Los Alamos County Landfill. As an example, the extent of the Los Alamos County Landfill was greater in 1994 than was observed in 1993, and a greater amount of fine silts deposited in Sandia Canyon at the SW-8 sample site was visually apparent. As previously stated, this likely contributed to the observed decrease in macroinvertebrate richness in Sandia Canyon at site SW-8.

The highest concentration for any State regulated water quality parameter was exhibited by total aluminum in the surface waters of Canyon de Valle (site V-1) upstream of LANL (1993). Total aluminum concentration at V-1 was 5.3 mg/L. This sample site represents background conditions, and the total aluminum concentration was above the numerical limit for the designated use of Livestock Watering (5.0 mg/L). However, there is negligible ecological risk. Canyon de Valle upstream of LANL property is 1) considered an ephemeral stream which does not receive point or non-point source discharge to create a perennial flow and 2) not an area where livestock grazing in permitted. Bioavailable (dissolved) concentrations of aluminum at V-1 were 0.2 mg/L, well below the 1.7 mg/L target criteria for Wildlife Habitat. There was negligible risk of exposure to

existing concentrations of total or dissolved aluminum by livestock or wildlife on LANL property during 1993. There was no risk to exposure of elevated total or dissolved aluminum concentrations during 1994 as no chemical constituents were above existing or proposed water quality standards at any sample sites.

3.5 SIGNIFICANT POSITIVES

This study demonstrated that spring runoff is important to the continued development and existence of the aquatic systems surrounding the LANL property. In a geographical region characterized by minimal annual precipitation and dominated by typical desert conditions, the presence of aquatic habitats and systems are crucial to sustained plant, animal, and anthropogenic existence. This was demonstrated by differences between the projected snowmelt runoff between 1993 (above average) and 1994 (below average) and were reflected in flow patterns and the extent of development for the periphyton and benthic macroinvertebrate communities. The water quality of the snowmelt was characteristic of excellent water quality conditions consistent with most headwater streams and critical riparian and wetland habitats are replenished and expanded during periods of precipitation and snowmelt runoff. Negligible physical disturbance or pollution in the snowmelt runoff helped develop a suite of habitats which support a wide range of established plant and animal communities. These habitats are crucial to resident aquatic and terrestrial flora and fauna that directly and indirectly rely on availability of surface waters for continued growth and development.

3.5.1 Supporting Conditions

Existing conditions which support the high quality of the riparian and wetland aquatic systems can be characterized by minimal and infrequent disturbances of the natural ecological systems. Negligible physical disruption within the arroyos and wetlands is likely a direct consequence of the infrequent occurrence of natural events (i.e. intense storms) which are disruptive and is not a consequence of the limited access to LANL property by man or domesticated animals. Historical disturbance during construction and development of LANL likely resulted in the present day boundary of the Pajarito and Sandia wetlands. However, with the exception of portions of Sandia Wetland, there was little evidence of recent physical disturbances in the arroyos or wetlands from present day LANL operations which would significantly alter the aquatic resources. Physical perturbations in the arroyos and wetlands are largely a result of natural climatic events.

Good to excellent water quality for snowmelt waters flowing onto LANL property was demonstrated by low concentrations of nutrients and metals during projected runoff for above and below average conditions. Concentrations of chemical constituents for surface waters in the major arroyos were comparable to the expected water quality from snowmelt in north central New Mexico. The addition of treated effluent water from Outfall OS1 during 1993 altered natural water quality conditions in the upper portion of Sandia Wetland to an effluent-dominated system. However, the water quality and discharge from Outfall OS1 provide a nutrient source and hydrologic conditions which help sustain the Sandia Wetland habitat. It is likely that the rate of development and historical boundary of the Sandia Wetland have increased from the influence of Outfall OS1. The benefits to resident wildlife from wetland expansion and availability of water include increased habitat for forage, refugia, reproduction, and growth. The wetland also provides additional water treatment to the treated effluent water. The benefits are extended downstream of the Sandia Wetland into Sandia Canyon by extending the period of flow and distance of surface waters in the canyon.

The lack of physical disturbance and the absence of significant water pollution to aquatic systems associated with LANL contribute to favorable water quality conditions for biological development. The plateau regions of New Mexico support many environments ranging from montane to desert, each of which supports a wide array of terrestrial and aquatic organisms. Negligible physical and chemical disturbance, combined with the addition of high quality water to existing aquatic ecosystems, is beneficial to the non-impacted development of many fragile and unique ecological habitats on LANL property. The resulting highly diverse mosaic of well developed habitats support a wide range of resident fauna and flora likely not found in other plateau regions.

The study indicated that the quality of surface waters which may flow off LANL property was comparable to water quality conditions in the Rio Grande with respect to concentrations of trace metals. Only the effluent-dominated waters within Sandia Canyon (sites SW-8 and SW-9) exhibited concentrations of certain water quality parameters which were greater than detected in the Rio Grande. These parameters include pH, conductivity, alkalinity, nitrate nitrogen, TKN and

total phosphorus. However, it is very unlikely that surface flows in Sandia Canyon during spring snowmelt enter the Rio Grande. During both sampling years, the extent of surface flow in Sandia Canyon terminated well upstream of the junction of Sandia Canyon Road and State Hwy.#4. This is approximately 8 km (5 miles) from the Rio Grande, and even under extreme conditions of simultaneous snowmelt and heavy precipitation, it is unlikely surface waters from Sandia Canyon are maintained in the ephemeral reaches of Pueblo Canyon, and therefore do not enter the Rio Grande.

3.6 SIGNIFICANT NEGATIVES

The encroachment of mineral material from the Los Alamos County Landfill in the upper portion of Sandia Wetland is detrimental to the overall ecology of this aquatic resource at LANL. Erosion of the landfill material and subsequent deposition of various sized sediments in Sandia Wetland has reduced the wetland size, eliminated characteristic organic soils and soil development, promoted channelization, reduced hydraulic retention time, and decreased density of important wetland plants. Although discharge from the 0S1 outfall is obsolete under the current wastewater treatment scheme, Sandia Wetland will continue to be important by providing natural filtration for stormwater runoff water and other surface flow entering the wetland area. In addition, wetland ecosystems in the desert plateau are scarce, and therefore also play an important role in the propagation of terrestrial, semi-aquatic, and aquatic flora and fauna.

3.6.1 Supporting Conditions

Conditions that were observed which contribute to loss of habitat in Sandia Wetland include factors associated with the landfill and loss of a continuous source of water. Factors associated with the landfill included: *1)* slope instability, *2)* lack of erosion control practices (vegetation or contour grading), and *3)* lack of sediment transport control devices (silt fences, ditches, detention ponds, etc.) Implementation of standard Best Management Practices (BMP) would correct these

conditions. The lack of a continuous source of water resulting from the removal of the 0S1 outfall will contribute to a reduction in size and possible loss of the wetland habitat.

3.7 Overall Quality of Aquatic Systems Impacted by Snowmelt

3.7.1 Excellent Quality

The overall quality of the aquatic systems impacted by runoff from snowmelt was excellent. Physical conditions in the arroyos and wetlands typically include all the habitats common to the riparian corridor, running water (riffles, pools, undercut banks, cover, and a wide variety of substrate types and water depths), and wetlands (varying density and types of emergent vegetation, open water, dystrophic saturated soils, wide variety of temperatures and water depths). Chemical parameters indicated unpolluted, clean water quality conditions characteristic of uncontaminated snowmelt. The introduction of snowmelt to the canyons and wetlands on LANL property was beneficial to the existing aquatic habitats and established aquatic systems. Biological communities within the arroyos were positively impacted as snowmelt water re-established a normally absent ecosystem, and the presence of snowmelt runoff in the arroyos also provided opportunistic aquatic organisms to colonize and develop during the runoff period. Introduction of the snowmelt runoff waters to the wetlands promoted normal seasonal development of aquatic flora and fauna typical of wetland habitats and use by terrestrial organisms which are directly and indirectly dependent upon wetlands or stream ecosystems.

Based on chemistry alone, upper Pajarito Canyon (PJ-1) above the LANL boundary may be classified as excellent quality even though this site exhibited total aluminum concentration of 5.3 mg/L during 1993. This total aluminum concentration was above the State numerical limit of 5.0 mg/L total aluminum established for Livestock Watering. Other chemical and physical characteristics and biological collections at PJ-1 were consistent with excellent water quality conditions. As previously discussed, the bioavailable concentration of the dissolved fraction for aluminum in the water at PJ-1 during 1993 was well below any State water quality criteria. The

risk of exposure to livestock and wildlife is negligible considering the short flow duration, low concentrations, and the restrictions placed on livestock use. The concentration of total aluminum during 1994 was below the 5.0 mg/L Livestock Watering limit. Although 1993 was considered a wet year (above average runoff projection) and 1994 was considered a dry year (below average runoff projection), there is insufficient data to show that total aluminum concentrations at PJ-1` are higher during wet years.

3.8 CORRECTIVE ACTIONS

Detrimental effects to the aquatic biota from the snowmelt runoff were associated with natural hydraulics of the geological setting and the limitation of water supply from seasonal snowpack. During the period of study, negligible runoff was observed entering Sandia Wetland. However, it is likely that snowmelt runoff contributes water to the Sandia Wetland via the stormwater discharge. As discussed above in Section 3.4.1, the loss of the wetland habitat in Sandia Canyon may be significantly reduced by initiating any of several actions. These actions include: *1)* construction of an effective buffer strip or barrier to prevent further encroachment of sediments; *2)* alteration of channelized areas to significantly increase hydraulic residence time (ponding, contours, etc.); *3)* introduction of semi-aquatic grass species which will contribute to organic soil development and will be naturally replaced by wetland sedges and rushes as hydraulic residence time is increased; and *4)* initiation of cooperative management of the County Landfill facility. With respect to impacts on Sandia Canyon from snowmelt runoff via the stormwater discharge, the most beneficial course of action may be the disruption of the channelized streambed which would significantly increase hydraulic residence time.

4.0 CANYON BY CANYON DESCRIPTION

General physico-chemical features and important ecological attributes for each of the canyons investigated during the course of the study are presented below. Geographically, the canyons are situated in the Pajarito Plateau, and descriptions of surface and sub-surface geologic formations have been thoroughly discussed in many LANL reports and documents (see Purtymun 1974, Purtymun 1984, and ESG 1991). In general, all the canyons contained a wide variety of pools, riffles, and undercut banks associated with high quality substrate material forming excellent stream channel and riparian habitats.

Gross comparisons can only be made between the canyons draining LANL property and the Rio Grande. The Rio Grande contains a wide variety of pools, riffles, and occasional large debris dams along the banks which offer similar habitats as undercut banks providing excellent physical stream channel and riparian habitats. However, there is a difference in scale associated with the hydrology which separates the canyon systems and the Rio Grande. Independent of differences in water quality, the relationships between water depth, flow velocity, sediment transport, and substrate characteristics are not equal and result in different habitats suitable for each system. These physical differences alone preclude a strict comparison between the drainage canyons and the Rio Grande.

Los Alamos Canyon

Study sites in Los Alamos Canyon ranged from upstream of the western LANL boundary (LA-1) to the USGS gaging station near the eastern edge of LANL property (LA-5). An additional study site was located in Los Alamos Canyon at the confluence with the Rio Grande. Above the reservoir the stream bed material consisted of cobbles and angular rocks well embedded in sands and various sized gravel. Mean stream width was approximately 2.5 m (8 feet). Most submerged surfaces were covered with moss. Large rocks or felled trees created small falls, pools, dams,

and gravel/sand bars. Larger pine trees, various bushes, horsetails (*Equisetum*) and many grasses provided thick bank cover and riparian growth.

Downstream of Los Alamos Reservoir, channel width was highly variable, and the abundance of cobbles and angular rocks as well as the density of riparian growth generally decreased. Grasses dominated the bank and riparian growth in middle Los Alamos Canyon (LA-3 and LA-4). At site LA-5, sands and small gravel dominated the substrate, and outcrops of cobbles or rocks were sparse. Surface flow in Los Alamos Canyon between TA-2 and LA-5 generally decreased, but infiltration was variable depending upon the reach (losing or gaining).

At the confluence of Los Alamos Canyon and the Rio Grande, the stream bed consisted of noncohesive sands with sparse cobbles. Although surface flow was concentrated in one incised channel at the time of observation, the path of flow could have been in any one of several channels within the approximately 50 meter-wide stream bed. Channel selection in this section of Los Alamos Canyon is likely to occur immediately following summer storms and is not the result of spring snowmelt runoff.

Pajarito Canyon

The channel in Pajarito Canyon 30 meters upstream of Hwy. 510 was approximately 0.75 meter (2 feet) wide and passed through a typical montane area of pine and fir. Immediately upstream of Hwy. 510, the stream divided into many smaller, undefined channels within a grassy meadow. Within the pines, the streambed consisted of sands and gravel with deposits of pine needles and silt in dams created by outcrops of bedrock or felled trees that formed falls and occasional pools. Substrates in the grassy meadow were primarily silts, pine needles, and woody debris. Pajarito Canyon passed through a typical montane habitat of pine and fir with increasing outcrops of willows and grasses along the banks downstream of Hwy. 510 to Pajarito Wetlands below TA-18. Bed material consisted of sands, occasional isolated cobble outcrops embedded in sand, and well decomposed organic debris in the channel reach below TA-18.

Surface water in the main channel of Pajarito Canyon infiltrated the sandy bed material immediately adjacent to the upper Pajarito Wetland. The main channel alternated between diffuse and well defined as it passed through the Pajarito Wetland complex. Inflow from subsurface flows were most apparent in the middle Pajarito Wetland, and the stream channel was usually associated with stands of willow or cottonwoods. In the lower wetland, a more well defined channel existed than was observed in the middle portion of the wetland complex. A series of areas characterized by dense stands of sedges, rushes, and willows existed in the riparian corridor downstream to the LANL boundary. A few deep pools (1.0 meters) and a remnant check dam forming a large pool exist approximately 400 m above Hwy. 4. A salamander was observed (but quickly disappeared) in this large pool associated with the check dam. The pool associated with the check dam was the largest observed. However, several pools existed and formed a series of important aquatic habitats and refugia because of limited access due to the extremely dense cover of willows associated with this part of the wetland complex. Flow in the channel near Hwy. 4 was low, colored by tannins, and significantly slowed by dense stands of willow and grasses growing in the stream bed.

Canyon de Valle

Surface flow in Canyon de Valle terminated approximately 800 m upstream of West Jemez Rd. in a losing reach of the stream bed. Mean channel width was 1.0 m, although the average width of wetted substrate near the end of flow did not exceed 0.3 m. Substrates consisted of silt, sand, gravel, large boulders, and bedrock outcrops. The area can be characterized as a montane, pine/fir forest. General ground cover dominated the riparian zone, but bushes and tall grasses were occasionally present. Pine needles, small twigs, and branches formed occasional debris dams spanning the entire width of the channel. Hummocks of grass, established ground cover, and remnants of previous seasonal leaf fall were common in the Canyon de Valle channel approximately 250 meters downstream of the sample site. Remnants of leaf fall indicated that spring runoff did not reach the upstream LANL boundary during 1993. Established ground cover and grass hummocks are evidence that effects from spring snowmelt and summer storm event runoff is negligible. Canyon de Valle downstream to the point of confluence with Water Canyon on LANL property was not observed due to lack of flow.

Water Canyon

Water Canyon was investigated immediately above and below West Jemez Rd. Surface flow in Water Canyon 150 m above the road was contained in a single channel approximately 0.1 m in width, but low flow resulted in less than one-half of the channel being wet. The area was within a pine and fir dominated montane forest with grasses and typical ground cover dominating the riparian zone. Substrates were primarily silts and sands mixed with pine needles and twigs with occasional large angular rocks or debris forming falls, dams, and pools. Immediately above West Jemez Rd. the streambed opened into a grassy meadow where the single channel divided into many diffuse pathways. There was no distinct channel, and established grass or ground cover was nearly 100%. Flattened grass in many places within the meadow indicated that recent surface water flow was greater than observed during the study period, although insufficient in magnitude to establish a primary channel. Downstream of West Jemez Rd., the main channel was again distinct and more incised within a well established tall grass meadow in the forest surroundings. Surface flow infiltrated the sand substrates approximately 150 m downstream of the road. No further observations were made in Water Canyon.

Sandia Canyon

Surface flow in Sandia Canyon was supplied by discharge from the OS1 outfall and the stormwater conveyance culvert into Sandia Wetland which, in turn, drains into Sandia Canyon. However, this source of water will no longer enter the wetland. The Sandia Canyon channel immediately below the wetland is within a pine and fir forest containing occasional grassy meadows, rock outcrops, and steep canyon walls. The water quality of surface flows below Sandia Wetland correspond with the effluent-dominated nature of the water source. Expanses of flat bedrock interrupted by smaller deposits of sand and small gravel characterized the channel substrates within the meadow for the first 200 m downstream of Sandia Wetland. Farther downstream, large boulders, steep canyon walls, and dense growths of shrub oak, pine, and fir characterized the canyon. Channel habitat included many pools and riffles associated with undercut banks and flat streambeds. Substrates ranged from bedrock to gravel and sand

interspersed with deposits of silts and debris. As in most canyons observed within LANL property, Sandia Canyon supported excellent channel and riparian habitat.

5.0 PAJARITO WETLANDS AND SANDIA WETLANDS

The Sandia Canyon wetland and the Pajarito Wetland complex were visited to document and investigate hydrological and biological characteristics. Extensive mapping, detailed plant surveys, small mammal trapping, and documentation of diurnal or nocturnal activity by large animals and avifauna were not done as part of this study. Studies conducted previously by LANL staff have documented the plant associations, mammal and avifauna presence, and other ecological attributes of these wetlands in a report entitled *Wetland Characterization and Delineation Studies, Pajarito and Sandia Canyons* (currently in preparation).

Major plant associations were determined from the predominant flora observed during the study period. Many plants encountered were not in flower at the time of sampling. Percent cover of the major plant associations was made based on a visual assessment of the percent total area occupied relative to the entire wetland area. Maps were prepared to illustrate locations and extent of all major plant associations, physical features, and hydrologic patterns within each wetland area visited.

Soils within the wetland areas were visually evaluated to determine their general classification and character. Soil structure, texture, composition, and relative assessment of saturation and level of oxidation were determined by digging shallow soil pits up to 0.4 m in depth to view the soil profile.

Algal flora within the wetlands were collected and evaluated to determine a gross characterization of the microflora. Benthic macroinvertebrates were not sampled in the wetland areas. Adequate macroinvertebrate characterization would require an extensive sampling program because of the interactions between a large variety of substrates, hydrologic patterns, plant types, and physico-chemical properties typical of a wetland which creates a very complex series of micro-habitats. Secondly, a minimal number of specimens and representative species would be present during the

early spring runoff period. Benthic macroinvertebrate and algal samples from the stream channel downstream of Pajarito Wetland (PJ-End) and Sandia Wetland (SW-8) were collected and evaluated for species composition and community structure to determine biological effects of the wetlands on in-stream aquatic biota.

Filamentous algae and epiphytic (attached to plant material) diatoms dominated the algae in Sandia and Pajarito wetlands. Tangles of the filamentous green algal species *Spyrogyra*, *Mougeotia*, and *Zygnema* were widespread in both wetlands. Tufts of the yellow-green filamentous algae (Chrysophyta) *Tribonema bombycinum* were common in many places in the Pajarito Wetlands. In one short reach where Pajarito Creek converged to form a single channel, the filamentous *Hydrurus foetidus* (Chrysophyta) was abundant. Other common algal genera that characterized Pajarito Wetlands include the green algae *Tetraspora lubrica*, *Ulothrix zonata*, *Cosmarium*, *Scenedesmus*, *Closterium*, and the blue-green algae *Anabaena*. In Sandia Canyon, damp soil surfaces and vegetation within and adjacent to the many channels were colonized with the cellular green algae *Protococcus* (*Chlorococcum*). The occurrence of *Protococcus* appeared to diminish with distance from the OS1 outfall. Algal genera that characterize Sandia Wetland include *Stigeoclonium*, *Cladophora*, *Hyalotheca*, *Closterium*, and the blue-green algae *Oscillatoria*. Table 5.1 shows the relative dominance of the major algae observed in each wetland

Table 5.1 Major Wetland Algae

MAJOR WETLAND ALGAE		
Taxa	**Pajarito Wetlands**	**Sandia Wetland**
Chlorophyta		
Cladophora	present	common
Closterium	common	present
Cosmarium	common	present
Hyalotheca	not observed	common
Mougeotia	abundant, widespread	abundant, widespread
Protococcus	common	present
Scenedesmus	common	common
Spyrogyra	abundant, widespread	abundant, widespread
Stigeoclonium	present	common
Tetraspora	common	present
Ulothrix	abundant, widespread	common
Zygnema	abundant, widespread	abundant, widespread
Chrysophyta		
Hydrurus	dense patches	not observed
Tribonema	abundant	not common
Cyanophyta		
Anabaena	common	rare
Oscillatoria	present	common
Bacillariophyta (diatoms)	dominant, widespread	dominant, widespread

5.1 GENERAL WETLAND DESCRIPTIONS

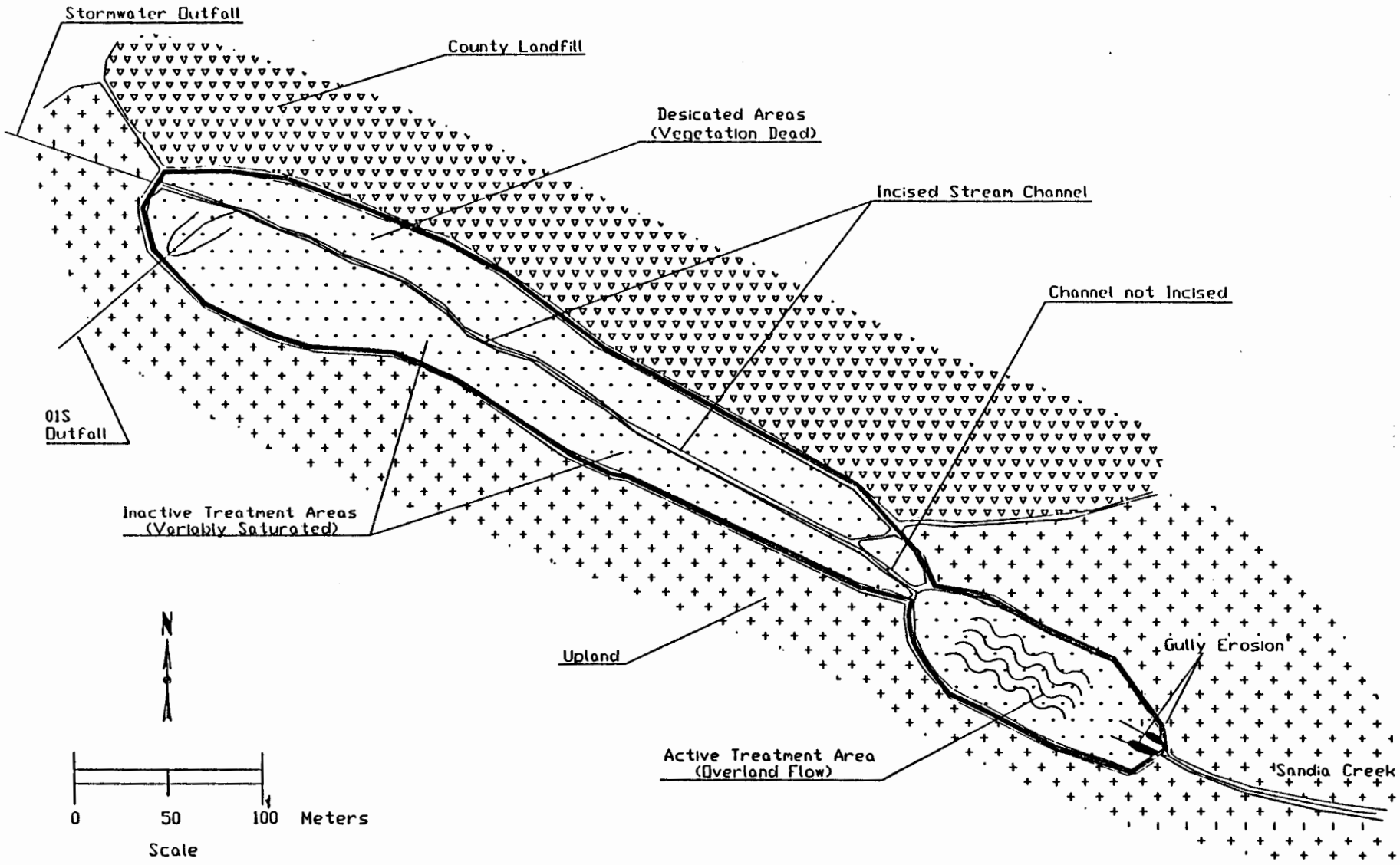
5.1.1 Sandia Wetland

Sandia Canyon Wetland is located in the upper Sandia Canyon area (LANL Technical Area 61), both adjacent to and parallel to the southern edge of the Los Alamos County Landfill. The upper end of the wetland begins in the area of the 13S outfall. The wetland is a large, nearly monotypic, cattail marsh with an incised channel situated near the geographical middle. The entire wetland area consists of multiple segments and is depicted in Figure 5.

Hydrologic inputs to the Sandia Wetland formerly included effluent-dominated water which originated from the O1S outfall and currently includes effluent from the TA3 steam plant, an asphalt plant, and stormwater runoff. During storm events, discharge from the outfall combines with runoff from developed and undeveloped LANL property and provides an intermittent source of water to the wetland. During the study periods, the stormwater discharge was negligible. It is also probable that the shallow groundwater in the vicinity of the wetland is a component of the hydrology. The extent of the groundwater was not determined during this study. The soils that make up the substrate were composed of a coarse mineral alluvium overlain in most areas by a 2 ft - 3 ft layer of organic soil. In areas where erosion had formed channels through the wetland, the organic layers were absent and exposed mineral soil dominated.

At the time of the study, deposition of mineral soils and gravel from the Los Alamos County Landfill reduced the surface area of upper Sandia Wetland. The area of deposition was characterized by an elevated plane of sands and gravel sparsely vegetated with cattails. New growth cattails common in other areas of the wetland were absent.

Los Alamos National Laboratory
Sandia Canyon Wetland



ADVANCEDAQUATICTECHNOLOGY ASSOCIATES, INC.

Figure 5. Map of Sandia Canyon Wetland

5.1.2 Pajarito Wetland

The Pajarito Canyon Wetland complex is located in the lower Pajarito Canyon from slightly below TA-18 to slightly above State Hwy 4. The entire complex is composed of several individual wetlands that occur on either side of the road that runs the length of the canyon. The Pajarito Wetland area is believed to be anthropogenically enhanced and each of the wetland areas occurs where previous excavation for gravel had lowered the original surface of the land and exposed the saturated alluvium. The hydrology for each wetland area was provided by a combination of surface flow in Pajarito Canyon and the underlying subsurface water.

The Pajarito Wetland complex can be divided into upper, middle, and lower wetland areas (Figure 6). The upper wetland area is the smallest (2-4 acres) and is located in TA-36 on the south side of the Pajarito Road below TA-18. The upper wetland appeared to be a former excavation site. Hydrology in this wetland area was provided by a combination of surface and sub-surface water. Soils in the Pajarito Canyon adjacent to, and south of, the wetland area consisted of very porous, gravelly alluvium that permitted the exchange of water between surface flows and the sub-surface water. Surface flow in the arroyo adjacent to the upper wetland was closely associated with the local sub-surface water and appeared to exchange freely between surface flow and sub-surface flow. Vegetation in the upper wetland was well established and consisted of a mixed assemblage of willows (*Salix* sp.) and cattails (*Typha* sp.) with sedges forming an understory or, in some locations, existing as a monospecies stand.

The middle Pajarito Wetland is located on the north side of Pajarito Rd. (TA-54) and extends from above the point where Pajarito Creek crosses the road to approximately 1 mile downstream. The middle wetland is hydrologically supported by a significant amount of sub-surface flow in addition to surface flow within Pajarito Creek. Vegetation in the middle wetland area consisted of more shrubby than in the upper area, but also supported large areas of sedges, rushes, grasses, and other herbaceous wetland and aquatic plants. Soils in this area were similar to those in the upper wetland area.

The lower Pajarito Wetland is located on the south side of Pajarito Road (TA-36) and begins at a point just below Building 36-117. The lower wetland was also fed by a combination of sub-surface and surface water flow. The predominant vegetation consisted of sedges, rushes, and other wetland grass species. Areas of willow and cattail were concentrated near the Pajarito Creek channel rather than widely dispersed across the wetland area.

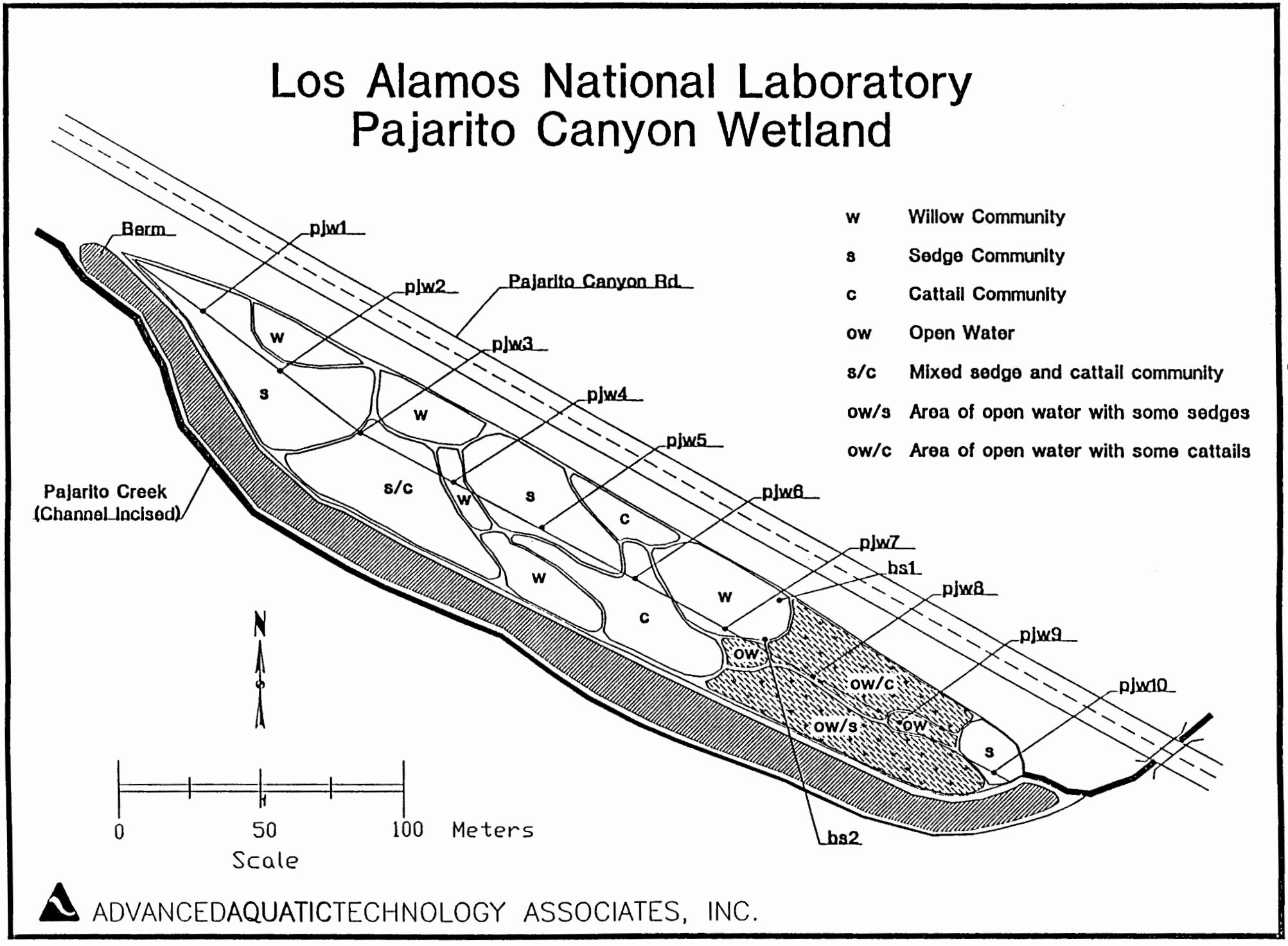


Figure 6. Map of Pajarito Canyon Wetland Complex

5.2 WETLAND SIMILARITIES

Several functional aspects of Sandia Wetland and the Pajarito Wetland complex were similar. Both wetlands provide an important aquatic habitat or "oasis" available to resident and migratory aquatic and terrestrial organisms within a typically arid regional environment. Since each wetland has been expanded by anthropogenic activities (occasional excavation or augmentation of hydrologic input), each wetland provides valuable plant and animal habitats that otherwise would be greatly reduced or absent. Wetland habitats provide a wide variety of species with a source of food and water and areas for habitation, growth, and reproduction. Since many species of plants specifically adapted for living in saturated soil conditions are only minimally represented in the arid environment of the Pajarito plateau, these two wetland areas comprise an important part of the total area of wetland ecotype in the region. Many of the wildlife species resident to the region use these wetlands as habitat that is intermediate to the wetter headwater areas and the riparian zone of major water resources.

Water quality functions that are provided by these areas include detention of runoff after storm events and during spring snowmelt periods, as well as filtration and transformation of sediments and other potential contaminants in the water. The potential for, and severity of, flooding can be reduced when stormwater is routed through wetland areas. Filtration and settling of contaminants occurs when stream flow rates decrease as detention time in the wetland increases. The capacity for these two areas to supply these functions is not currently maximized and could be improved with a minimum of planning and effort.

The Sandia and Pajarito wetlands may be functioning below their maximum capacity largely as a result of impacts to the hydrology within the wetland areas, and because of the semi-arid desert geographical setting. However, in a semi-arid desert type of setting including the Pajarito Plateau it is unlikely that wetland habitats ever function at maximum capacity for a significant period of time. The Sandia Wetland is impacted both by the rate of flow through the wetland, the

deposition of sediments, and overflow from the Los Alamos County Landfill. Unintentional deposition of sediments within the wetland combined with a reduction of source water from the inactivation of the OS1 outfall will contribute greatly to an ongoing degradation of the wetland's size, function, and hydrologic capacity. Reduction in wetland size and channelization of the hydrology in the wetland may be of sufficient magnitude to evaluate compliance with Section 404 of the Clean Water Act.

Impacts to the Pajarito Wetland are a result of historic excavation of gravel (reported to be during road construction) and the inadequate attention to the surface contours of the excavated areas. The removal of gravel may have sufficiently lowered the soil surface to enhance the emergence of alluvial ground water. The altered hydrology has changed the character and area of the natural wetland that most likely existed prior to construction. Failure to regrade the excavated area left the surface of the wetland uneven and has resulted in a mixture of island habitats which include open water, wetlands, and upland communities. The heterogeneous nature of the Pajarito Wetland complex may be beneficial in regards to supporting a highly diverse set of habitats. However, the individual islands may not be of sufficient contiguous size to adequately function as a specialized habitat or meet the desired objectives of the Pajarito Wetland area.

5.3 WETLAND DIFFERENCES

The character and diversity of the higher plant communities present in both of the wetland areas was the main difference between the Sandia and Pajarito wetland areas. Less apparent, but of critical importance, were differences in hydrology and anthropogenic impacts to the wetland environment. The principal important differences are described below.

- The Sandia Wetland supported a near monotypic population of cattail (*Typha latifolia*) with an understory of sedges (*Carex* sp.). Willow (*Salix*) and birch (*Betula*) shrubs occurring at the margins of the wetland in several areas.

- The Pajarito Wetland vegetation was composed of a mosaic of willows, cattails, sedges, rushes (*Juncus* sp.), and other shrubby and herbaceous wetland plants of less dominance. Some areas (islands) of the Pajarito wetland supported pure stands of sedges, rushes, and grasses or willows and other shrubs. These islands were indicative of variable levels and duration of saturation within the wetland.

- The upper portions of Sandia Wetland showed characteristics of erosion and channelization by high water flows and a reduction of wetland area by surface deposition of sands and gravel. High flows had eroded through the existing cattail root mass and the organic soil layer to expose the underlying mineral soil resulting in reduced saturation of the wetland area which contributed to further channelization and wetland reduction.

- Pajarito Wetland had few areas where water flow was concentrated in channels. Where flows are concentrated, the channels were typically intermittent and exhibited extensive braiding and meandering. A greater percentage of the water in the wetland was dispersed over a larger area and supported a wide range of functions and habitats not encountered in Sandia Wetland.

- Sandia Wetland was largely dependent upon the effluent discharged through Outfall O1S (1993), the steam plant discharge, and the stormwater runoff. The water in the wetland can be considered effluent-dominated since stormwater runoff does not provide a sustained source of water. Without the discharge from the steam plant, the size of the Sandia wetland would be considerably reduced, particularly since the channels that have formed allow a more rapid discharge of water from the wetland.

- Pajarito wetland received the majority of its water from subsurface flows and the saturated alluvium. Surface flows in Pajarito Canyon during 1993 terminated and joined sub-surface waters adjacent to the upper Pajarito Wetland. At the time of sampling in 1994 there was no flow in Pajarito Canyon immediately above the upper Pajarito Wetland and all water in the Pajarito Wetland complex was from sub-surface waters. Evidence in the stream channel above the wetland indicated no surface flows had existed prior to the 1994 field period. Surface flow to the wetland is highly variable compared to the relatively consistent volume of flow originating from effluent discharges to Sandia Wetland. This variation in flow likely contributes to the more variable character of the Pajarito wetland vegetation communities. Relationships between surface flow, sub-surface water, and size of functional wetland habitat between above average snowmelt runoff (1993) and below average snowmelt runoff (1994) were clearly evident during the study period.

- Sandia Wetland soils exhibited two distinctly different characteristics depending upon location within the wetland. Upper Sandia Wetland soils contained a surface layer of sands, gravel, and minimal organic material covering an unsaturated layer

of highly organic loam. The soils in the upper portion of Sandia Wetland have been altered by erosion and deposition of mineral material. The lower third of Sandia Wetland exhibited completely saturated, highly dystrophic organic soils with little to no sand, gravel, or other mineral materials.

- Pajarito Wetland soils consisted of a relatively homogeneous mixture of sands, gravel, and organic material. The proportion of sands to gravel did not vary appreciably and were the dominant component of the Pajarito Wetland soils. However, the relative amount of organic material varied and appeared to be higher in areas supporting a typical, saturated wetland or aquatic habitat.

6.0 CONCLUSIONS

6.1 CANYONS

The canyons associated with the LANL property exhibited physical, chemical, and biological conditions of excellent quality. Physical attributes included a wide array of aquatic micro-habitats and riparian habitats common to high quality, undisturbed, headwater streams. Provided with sufficient hydrology, the morphology of all canyons supported a variety of important biological habitats including pools, riffles, undercut banks, a range of substrate types, wetlands and riparian areas.

Evaluation of the hydrology associated with the canyons indicated spring snowmelt flows were typically less than bankfull conditions and contributed little to channel formation. Flow levels that have the potential to form or alter channel morphology most likely occur as a response to intense summer storm events. The downstream extent of surface waters from spring snowmelt reached the downstream boundary of LANL in Los Alamos Canyon and Pajarito Canyon. The lower flows and limited distance of surface waters indicate the importance of the spring snowmelt to recharge saturated soils in wetland areas, sub-surface water flow, and ground water systems. Background flow levels decreased to zero flow in all canyons except Pajarito and Los Alamos prior to leaving LANL property. No surface flows from LANL reached the Rio Grande. Flow generally decreased from the downstream extent of flow, and total discharge was dependent upon interactions between annual snowpack and seasonal variability of diurnal temperatures.

Snowmelt water quality showed no influence of significant contamination or pollution. Concentrations of most chemical constituents were near or at detection levels. Background water quality conditions generally persisted downstream in all canyons. Water quality conditions that were different than background were attributed to normal effects from wetlands, increased

watershed area, and local geology. Concentrations for total aluminum in waters flowing onto LANL property which were above State Livestock Watering limits were observed in Pajarito Canyon during 1993 only. Effects and potential impacts to livestock or wildlife from concentrations above the standard were determined to be negligible because of the limited exposure to livestock or wildlife, magnitude of concentration, inconsistent water quality conditions for this parameter (total aluminum was below the State criterion in 1994), and the bioavailable (dissolved) portion of aluminum which was well below any State criteria.

The macroinvertebrate and algae communities were present at all sample locations investigated during the two-year period. The assemblages of macroinvertebrates and periphyton included low richness and typical taxa that would be present during colonization and early development for small and first order ephemeral streams with minimal substrate complexity dominated by small gravel, sand, and low flows. A good representation of the EPT taxa which are sensitive to pollution were characteristic at sites which were selected to represent background conditions upstream of LANL property and at sites on LANL property. During 1993, a high abundance of EPT organisms was recorded from PJ-1, LA-1 and LA-3. During 1994 when the flow was reduced, a high abundance of organisms were observed only at LA-1. The lower flow conditions during 1994 certainly reduced the habitat available for macroinvertebrate colonization and development and also increased the frequency and duration of desiccation.

Under low flow conditions, effluent discharges related to LANL activities may be beneficial to the stream biota. The algal and macroinvertebrate assemblages at sites within the boundaries of LANL property where runoff gradually enters the shallow alluvium to become sub-surface water are dependent upon uninterrupted surface flow for development. Snowmelt runoff is supplemented by intermittent effluent release from LANL activities in many of the drainages. For years, with above average snowmelt runoff, the contribution of intermittent effluent discharges to the natural flows may be negligible. However, during below average runoff years when natural snowmelt surface flows may be interrupted due to variations in ambient daytime and night temperatures, the intermittent release of effluent waters may help reduce the frequency and

duration of desiccation. Low snowmelt runoff during 1994 likely contributed to a loss of habitat and variable flow conditions at LA-3 resulting in lower richness, density and diversity than observed at this site in 1993. It would be expected that this trend would continue downstream in Los Alamos Canyon under natural flow conditions. However, during 1994, richness was sustained and diversity values were higher at LA-4.5 than observed at LA-3, or at LA-4 and LA-5 during 1993. Supplemental discharge waters from the TA-2 facility under low natural flow conditions during 1994 may have been sufficient to support benthic macroinvertebrate development downstream.

Evaluation of selected macroinvertebrate community RBP protocol metrics, associated values, and final scores from comparisons to selected reference sites generally show that conditions on LANL property are moderately impaired (21% - 50%) to severely impaired (<17%). Tables that show selected RBP metric values, and scores for comparison sites for each sampling year are shown in Appendix II. The selected reference conditions for 1993 included *(1)* site LA-1 for perennial flow and *(2)* the mean of BCI values from PJ-1, W-1, and V-1 for ephemeral flow. During 1994, the selected reference conditions included *(1)* site LA-1 for perennial flow and *(2)* site PJ-1 for ephemeral flow. The choice of reference sites was based on flow regime and *a priori* water quality concerns. However, because of the differences in gradient, flow, and substrate characteristics between the reference sites and the study sites do not correspond with some of the underlying factors associated with some of the metrics and RBP protocol, caution regarding interpretation should be exercised. Inherent differences in the macroinvertebrate communities will be present due to physical differences in substrate structure and characteristics, differences in flow, and because the macroinvertebrate communities are in a developmental stage rather than established. Site LA-1, and SW-8 are likely to be the only sites that support an established macroinvertebrate community. For any single observation it may be more appropriate to utilize the BCI index to establish the potential at each site on it's own merits with respect to substrate and habitat availability, flow regime, and size. Use of the RBP methodology metrics and interpretation would increase in validity and usefulness when a more extensive database can be evaluated such as under long-term monitoring conditions. The biological conditions for

macroinvertebrates and periphyton correspond with the ephemeral, short-term nature of the flow regime and the limited array of physical characteristics for the geographical transition zone on the Pajarito Plateau.

Fish were not present in any of the canyons in the immediate area of LANL. The only fish observed were located in Los Alamos Canyon within 0.5 miles of the confluence with the Rio Grande during 1993. Surface flows at this site did not contain surface waters from LANL, but consisted of treated effluent from the County Wastewater Treatment facility. Longnose dace were captured and believed to have migrated 0.5 miles upstream from the Rio Grande.

6.2 WETLANDS

There are indications that portions of the Pajarito Wetland and the Sandia Wetland existed prior to the development of LANL and surrounding infrastructure. For example, the roadway through the Pajarito Wetland area raised above the surrounding terrain by excavating gravelly material from the adjacent surfaces suggests that the soils in the area were originally too wet to support a standard road base.

These wetland areas are natural components of the local ecosystem and are not solely artifacts of LANL activities. Wetlands play an important role in the character and ecology of the local landscape. Functions that wetland areas serve include provisions for wildlife habitat, maintenance of water quality, detention of stormwater runoff, and ground water recharge/discharge. The greatest functional attribute derived from these wetlands is the plant and animal habitat they provide. This is due particularly to the rarity with which wetlands occur on the landscape in the arid southwest. Additionally, the flood control and water quality functions these areas provide can be important in reducing potential effects of natural climatic events or land-use changes within the watershed.

Both the Sandia and Pajarito wetlands have been impacted by human activities in the area. Historical activities such as excavating and the addition of water have likely increased the original size of each wetland. The Sandia wetland is presently being negatively impacted by the ongoing deposition of fill material from the Los Alamos Landfill. Continuing deposition of sediments in the wetland, although an inadvertent result of the proximity of the landfill to the wetland, represents an encroachment onto the LANL property and a potential violation by Los Alamos County of Section 404 of the Clean Water Act. The range and quality of the services provided by the wetland are diminished as a result. Positive impacts to the wetlands can be initiated by regrading surface features to improve hydraulic retention time and further promote wide-spread sheet flow. This is particularly apparent in the upper portion of Sandia Wetland where erosion has created an incised single channel to convey water. The reduction of deposition of coarse mineral soils from the County Landfill in Sandia Wetland will greatly improve and restore wetland conditions. Increased habitat quality and greater efficiency of functional aspects of the wetland area can be gained from these activities.

7.0 REFERENCES

EPA. 1983. *Technical Support Manual: Waterbody Surveys and Assessments for Conducting Use Attainability Analyses.* US Environmental Protection Agency, Office of Water Regulations and Standards. Washington D.C.

EPA. 1989. *Rapid Bioassessment Protocols for Use in Streams and Rivers. Benthic Macroinvertebrates and Fish.* US Environmental Protection Agency. Office of Water. EPA/440/4-89/001.

ESG 1991. Environmental Surveillance at Los Alamos during 1990. Los Alamos National Laboratory, Environmental Surveillance Group. Report LA-12271-MS.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. The Great Lakes Entomologist. 20(1):31-39.

Hilsenhoff, W.L. 1988. Seasonal correction factors for the biotic index. The Great Lakes Entomologist. 21(1):9-13.

Purtymun, W.D. and S. Johansen. 1974. General geohydrology of the Pajarito Plateau. New Mexico Geological Society Guidebook. 25th Field Conference, Ghost Ranch, NM.

Purtymun, W.D. 1984. Hydrologic characteristics of the main aquifer in the Los Alamos area: Development of Groundwater Supplies. Los Alamos National Laboratory report LA-9957-MS.

USDA. 1983. *Methods for Evaluating Stream, Riparian, and Biotic Conditions.* US Department of Agriculture. Intermountain Forest and Range Experiment Station, Ogden, UT. General Technical Report INT-138.

USDA. 1987. *Methods for Evaluating Riparian Habitats with Applications to Management.* US Department of Agriculture, Intermountain Research Station. General Technical Report INT-221.

USDA. 1993. *New Mexico Basin Outlook Report March 1, 1993.* Soil Conservation Service. Albuquerque Office. Albuquerque, New Mexico.

USDA. 1994. Phone conversation with Soil Conservation Service Officer. Soil Conservation Service Albuquerque Office. Albuquerque, New Mexico.

Winget, R.N. and F.A. Mangum. 1979. *Biotic Condition Index: Integrated Biological, Physical and Chemical Stream Parameters for Management.* US Forest Service, Intermountain Region.

APPENDIX I

FIELD DATA SHEETS

LABORATORY ANALYSES

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/4/93 Collected By: Ellerbroek, Beeson, Stevens

Station Number: LA-1

Location: Los Alamos Creek above reservoir

Sample Collection Point: 100 - 150 yards above reservoir inflow

Weather: Slight breeze, partly cloudy

Time: 11:15 Elevation: 7800 ft.

Air Temp (°C): ~ 22 Water Temp (°C): 7°

Dissolved Oxygen (mg/L): 10.4 Saturation DO (mg/L): 8.86

pH: 6.89 Conductivity (µmhos/cm): 52

Alkalinity Titrant Normality: 0.102011 NaOH: _____ H2SO4: X

Buret finish: 34.5

Buret start: 34 Sample Volume: 100 ml

Difference: 0.5 ml

Periphyton: Collection method: Rock scrapes and grass squeezings.

Macroalgae % cover/comments: ~<5 filamentous mixed with vascular.

Macrophytes % cover/comments: Mostly horsetail, sphagnum, dogwood, geranium, strawberry.

Benthic Macroinvertebrates: Collection method: Surber method - 3 reps, 1 composite, #1 small angular gravels, #2 angular cobbles, #3 mix cobbles and gravel

Comments: Mayfly/blackfly larvae, #2 caddis, stoneflies, (large larvae body biomass), net spinning caddisflies.

Fish: Collection Method: 1/4" seine (100 ft). No fish.

Comments/observations: _____

Additional: Streambed consists of sand, gravel, cobble, and boulder.
Water shrew, garter snake (western terrestrial?), elk pellets

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/4/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: LA-3

Location: Los Alamos Canyon below Diamond bridge at point where stream crosses road.

Sample Collection Point: Just above where stream goes under road.

Weather: Overcast

Time: 2:30 Elevation: 7300 ft.

Air Temp (°C): 24° Water Temp (°C): 10°

Dissolved Oxygen (mg/L): 9.2 Saturation DO (mg/L): 8.43

pH: 6.94 Conductivity (µmhos/cm): 70

Alkalinity Titrant Normality: 0.102011 NaOH: _____ H2SO4: X

Buret finish: 41.4

Buret start: 41.9 Sample Volume: 100 ml

Difference: 0.5 ml

Periphyton: Collection method: Grass - squeezings - not much - no filamentous.

Macroalgae % cover/comments: No heavy diatom growth.

Macrophytes % cover/comments: None

Benthic Macroinvertebrates: Collection method: Surber sampler - 3 reps - 1 composite #1 - angular boulders (1), #2 - (2) angular boulders/large sand, #3 - angular boulders, large sand and gravels.

Comments: _____

Fish: Collection Method: 1/4" seine - 109 feet reach. No fish.

Comments/observations: _____

Additional: _____

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/4/93 Collected By: Beeson, Stevens, Ellerbroek

Station Number: LA-4

Location: Los Alamos Canyon below TA-2.

Sample Collection Point: Just downstream from 1st crossing (~ 50-100 yards).

Weather: Overcast

Time: 3:45 Elevation: 7100 ft.

Air Temp (°C): 26° Water Temp (°C): N/A

Dissolved Oxygen (mg/L): N/A Saturation DO (mg/L): _____

pH: N/A Conductivity (µmhos/cm): N/A

Alkalinity Titrant Normality: N/A NaOH: _____ H2SO4: _____

Buret finish: N/A

Buret start: _____ Sample Volume: _____

Difference: _____

Periphyton: Collection method: _____

Macroalgae % cover/comments: Squeeze samples - no filamentous.
Some diatoms (little slickness) but not enough to scrape off.

Macrophytes % cover/comments: None

Benthic Macroinvertebrates: Collection method: Surber sampler - 3 reps - 1 composite

Comments: #1 - angular cobbles, #2 - angular cobbles, #3 - angular cobbles
40% embeddedness (variable)

Fish: Collection Method: Did not seine; no fish observed.

Comments/observations: _____

Additional: _____

ADVANCED**AQUATIC** TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/4/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: LA-5

Location: Los Alamos Canyon below TA-2 at USGS station.

Sample Collection Point: Upstream and downstream of USGS station.

Weather: Sky darkening, no rain yet.

Time: 5:15 Elevation: 7000 ft.

Air Temp (°C): 26° Water Temp (°C): 14°

Dissolved Oxygen (mg/L): 8.7 Saturation DO (mg/L): 7.81

pH: 7.53 Conductivity (µmhos/cm): 140

Alkalinity Titrant Normality: 0.102011 NaOH: _____ H2SO4: X

Buret finish: 39.9

Buret start: 39.1 Sample Volume: 100 ml

Difference: 0.8

Periphyton: Collection method: Epipsamic - grass squeezings.

Macroalgae % cover/comments: 0% filamentous - some diatoms.

Macrophytes % cover/comments: 0%

Benthic Macroinvertebrates: Collection method: Surber sampler - 3 reps.

Comments: #1 - cobbles and large gravel, #2 - same, #3 - same, 70% embeddedness.

Fish: Collection Method: 1/4" seine for 100 feet - no fish.

Comments/observations: _____

Additional: Last site for today.

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/5/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: PJ-1

Location: Pajarito Canyon just above West Jemez Road.

Sample Collection Point: Where road first meets stream.

Weather: Overcast and chilly.

Time: 8:45 Elevation: 7700 ft.

Air Temp (°C): 9° Water Temp (°C): 6°

Dissolved Oxygen (mg/L): 10 Saturation DO (mg/L): 9.13

pH: 7.33 Conductivity (µmhos/cm): 50

Alkalinity Titrant Normality: 0.102011 NaOH: _____ H2SO4: X

Buret finish: 31.7

Buret start: 31.1 Sample Volume: 100 ml

Difference: 0.6

Periphyton: Collection method: Grab samples - epiphytes and epipsammon.

Macroalgae % cover/comments: No filamentous - stalked diatoms. (?)

Macrophytes % cover/comments: 0%

Benthic Macroinvertebrates: Collection method: Surber sampler - 3 reps

Comments: #1 and #2 large gravels and sand, few cobbles, some small cobbles
#3 same but with more large cobbles.

Fish: Collection Method: No fish observed.

Comments/observations: _____

Additional: First site of the day - not perennial.

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/5/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: W-1

Location: Water Canyon above West Jemez Road (~ 1/2 mile).

Sample Collection Point: Very shaded, not much light reaching stream.

Weather: Partly cloudy

Time: 2:30 Elevation: 7650 ft.

Air Temp (°C): 24° Water Temp (°C): 9.2°

Dissolved Oxygen (mg/L): 8.4 Saturation DO (mg/L): 8.45

pH: 7.3 Conductivity (µmhos/cm): 40

Alkalinity Titrant Normality: 0.102011 NaOH: _____ H2SO4: X

Buret finish: 30.7

Buret start: 30.2 Sample Volume: 100 ml

Difference: 0.5

Periphyton: Collection method: Grab - micro-sucker and tweezers!

Macroalgae % cover/comments: Limited to epiphytes growing on woody debris. No filamentous.

Macrophytes % cover/comments: None.

Benthic Macroinvertebrates: Collection method: Surber sampler - 3 reps - 1 composite.

Comments: 2 - 3" angular cobbles - embedded 70% with silts and fine sands - low richness and biomass.

Fish: Collection Method: No fish observed.

Comments/observations: _____

Additional: Flow <1.0 cfs estimated, no flow 500 yards downstream of sample location.

ADVANCED**AQUATIC** TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/5/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: V-1

Location: Canyon de Valle above road.

Sample Collection Point: At gate and just above.

Weather: Sprinkling, cool and breezy.

Time: 3:30 Elevation: 7600 ft.

Air Temp (°C): 18° Water Temp (°C): 9°

Dissolved Oxygen (mg/L): 8.1 Saturation DO (mg/L): 8.52

pH: 7.2 Conductivity (µmhos/cm): 80

Alkalinity Titrant Normality: 0.102011 NaOH: _____ H2SO4: X

Buret finish: 15.4

Buret start: 14.5 Sample Volume: 100 ml

Difference: 0.9

Periphyton: Collection method: Debris squeezings only - no heavy diatom growth.

Macroalgae % cover/comments: 0% filamentous.

Macrophytes % cover/comments: Grass - no true aquatics.

Benthic Macroinvertebrates: Collection method: Surber sampler - 3 reps - 1 composite.

Comments: Very angular cobbles - 40% embedded with pea gravel.

Fish: Collection Method: No fish observed.

Comments/observations: _____

Additional: Water cloudy with slight tannic color - looks like 4 - 5 days ago higher flows occurred.

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/6/93 Collected By: Ellerbroek, Beeson, Stevens

Station Number: SW-1

Location: At outfall above OS1 outfall (head of wetland).

Sample Collection Point: Pool at base of outflow (stormwater) from TA - 3.

Weather: Clear and breezy.

Time: 11:00 Elevation: 7250 ft.

Air Temp (°C): 22° Water Temp (°C): 16°

Dissolved Oxygen (mg/L): 6.6 Saturation DO (mg/L): 7.39

pH: 9.2 Conductivity (µmhos/cm): 1300

Alkalinity Titrant Normality: N/A NaOH: _____ H2SO4: _____

Buret finish: N/A

Buret start: _____ Sample Volume: _____

Difference: _____

Periphyton: Collection method: Grab - off silts.

Macroalgae % cover/comments: _____

Macrophytes % cover/comments: None.

Benthic Macroinvertebrates: Collection method: Grab

Comments: Chironomids on rock - also orange water mites (?).

Fish: Collection Method: No fish observed.

Comments/observations: _____

Additional: Lot of wildlife signs - elk scat, small mammal tracks, vegetation = cattails, Typha

Dave notes a residual chlorine type odor.

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/6/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: SW-2

Location: OS1 outfall

Sample Collection Point: At point where effluent stream joins streambed

Weather: Clear and breezy

Time: 11:05 Elevation: 7250 ft.

Air Temp (°C): 22° Water Temp (°C): 14°

Dissolved Oxygen (mg/L): 7.7 Saturation DO (mg/L): 7.72

pH: 8.5 Conductivity (µmhos/cm): 380

Alkalinity Titrant Normality: N/A NaOH: _____ H2SO4: _____

Buret finish: N/A

Buret start: _____ Sample Volume: _____

Difference: _____

Periphyton: Collection method: Grass squeezings - substrate scrapes

Macroalgae % cover/comments: 80 - 90% green coccoid

Macrophytes % cover/comments: Grasses

Benthic Macroinvertebrates: Collection method: Substrate disturbance with surber net

Comments: Pea size gravels - 1/2" water depth needed flushing into surber net

Fish: Collection Method: No fish observed

Comments/observations: _____

Additional: Lots of wildlife sign - elk scat, fox? tracks, small mammal tracks - Typha

Dave notes a residual chlorine type odor.

ADVANCED**AQUATIC** TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/6/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: SW-4

Location: Sandia Wetland

Sample Collection Point: ~600' below OS2 outfall in main channel at point where berm protruded from south

Weather: Clear and breezy

Time: 11:45 Elevation: 7200 ft.

Air Temp (°C): Water Temp (°C): 15.5

Dissolved Oxygen (mg/L): 7.4 Saturation DO (mg/L): 7.49

pH: 8.77 Conductivity (µmhos/cm): 390

Alkalinity Titrant Normality: NaOH: H2SO4:

Buret finish:

Buret start: Sample Volume:

Difference:

Periphyton: Collection method: Grab samples

Macroalgae % cover/comments: Green coccoid stuff similar to bank area at SW-3; Epiphytes on dead cattails.

Macrophytes % cover/comments: None in main channel; 90 - 100% outside stream channel

Benthic Macroinvertebrates: Collection method: None

Comments:

Fish: Collection Method: No fish observed.

Comments/observations:

Additional: Channel less incised (~ 1-1.5') - no overhanging banks - large sands, gravels and few cobbles - very embedded - Typha

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/6/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: SW-5

Location: ~ 900' downstream of OS1 outfall.

Sample Collection Point: Wetland area south of main channel at point across from short fat burned out tree.

Weather: _____

Time: _____ Elevation: 7200 ft.

Air Temp (°C): _____ Water Temp (°C): _____

Dissolved Oxygen (mg/L): _____ Saturation DO (mg/L): _____

pH: _____ Conductivity (µmhos/cm): _____

Alkalinity Titrant Normality: _____ NaOH: _____ H2SO4: _____

Buret finish: _____

Buret start: _____ Sample Volume: _____

Difference: _____

Periphyton: Collection method: Grab samples; rock scrapes.

Macroalgae % cover/comments: No filamentous; some green coccoid films.

Macrophytes % cover/comments: 90 - 100% outside streambed.

Benthic Macroinvertebrates: Collection method: None

Comments: _____

Fish: Collection Method: _____

Comments/observations: No fish observed.

Additional: Typha

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/6/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: SW-3

Location: Sandia Wetland

Sample Collection Point: 2300' below OS1 outfall on main channel

Weather: Clear and breezy

Time: 11:30 Elevation: 7200 ft.

Air Temp (°C): 23° Water Temp (°C): (1) 14.5° (2) 17.5°

Dissolved Oxygen (mg/L): (1) 7.4 (2) 8.8 Saturation DO (mg/L): (1) 7.65 (2) 7.18

pH: (1) 8.66 (2) 8.93 Conductivity (µmhos/cm): (1) 380 (2) 385

Alkalinity Titrant Normality: _____ NaOH: _____ H2SO4: _____

Buret finish: _____

Buret start: _____ Sample Volume: _____

Difference: _____

Periphyton: Collection method: Grab samples

Macroalgae % cover/comments: No filamentous - none of the green covering common on bank area at left

Macrophytes % cover/comments: None in streambed. Typha elsewhere.

Benthic Macroinvertebrates: Collection method: None

Comments: _____

Fish: Collection Method: No fish observed

Comments/observations: _____

Additional: #1 main channel, #2 on left bank above channel (south side) - Typha.

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/6/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: SW-6

Location: ~ 600' below SW-5

Sample Collection Point: At point where valley constricts , forming grassy area between 2 wetland sections.

Weather: Clear and breezy

Time: 12:20 Elevation: 7200 ft.

Air Temp (°C): 16° Water Temp (°C): 16°

Dissolved Oxygen (mg/L): 7.2 Saturation DO (mg/L): 7.41

pH: 8.69 Conductivity (µmhos/cm): 370

Alkalinity Titrant Normality: N/A NaOH: _____ H2SO4: _____

Buret finish: N/A

Buret start: _____ Sample Volume: _____

Difference: _____

Periphyton: Collection method: Grab samples; rock scrapes.

Macroalgae % cover/comments: Filamentous algae on bank vegetation.

Macrophytes % cover/comments: < 1% grasses in streambed.

Benthic Macroinvertebrates: Collection method: None

Comments: _____

Fish: Collection Method: No fish observed.

Comments/observations: _____

Additional: Site at transition between upstream cell and next downstream cell. Vegetation includes rushes, grasses, willows and some cattails. Unidentified wildlife scat, porcupine sighted. Channel substrates consists of large sands and pea gravel.

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/6/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: SW-7

Location: Sandia Canyon Wetland

Sample Collection Point: Middle of lower cell

Weather: Clear and breezy

Time: 12:35 Elevation: 7200 ft.

Air Temp (°C): Water Temp (°C): 15.5°

Dissolved Oxygen (mg/L): 7.2 Saturation DO (mg/L): 7.49

pH: 8.59 Conductivity (µmhos/cm): 470

Alkalinity Titrant Normality: NaOH: H2SO4:

Buret finish:

Buret start: Sample Volume:

Difference:

Periphyton: Collection method: Grab samples

Macroalgae % cover/comments: 50-60% cover filamentous algae in main channel, very anaerobic soils, lots of diatoms and algae.

Macrophytes % cover/comments: 90% Typha

Benthic Macroinvertebrates: Collection method: N/A

Comments: Well developed sediments approximately 12" in depth.

Fish: Collection Method: No fish observed

Comments/observations:

Additional: Even, well distributed flow - H_2S odors. Deep muck unlike above, larger substrate sizes not present. Very silty soil with large organic matter (OM) component, vegetation all cattails.

ADVANCED**AQUATIC** TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/6/93 Collected By: Stevens, Ellerbroek, Beeson

Station Number: SW-8

Location: Sandia Wetland below OS1 outfall

Sample Collection Point: Outlet of lower wetland cell

Weather: Clear and breezy

Time: 12:40 Elevation: 7200 ft.

Air Temp (°C): 20° Water Temp (°C): 15°

Dissolved Oxygen (mg/L): 8.7 Saturation DO (mg/L): 7.57

pH: 8.9 Conductivity (µmhos/cm): 490

Alkalinity Titrant Normality: _____ NaOH: _____ H2SO4: _____

Buret finish: _____

Buret start: _____ Sample Volume: _____

Difference: _____

Periphyton: Collection method: Grab samples; rock scrapes.

Macroalgae % cover/comments: More filamentous and general periphyton than seen previously. Appears to be more now than fall 1992.

Macrophytes % cover/comments: None in stream channel. Grasses and shrubs along banks.

Benthic Macroinvertebrates: Collection method: Surber

Comments: Substrate ranges from large boulder to pea size gravels among bedrock outcrops.

Fish: Collection Method: No fish observed

Comments/observations: _____

Additional: Substrate is bedrock, grasses in channel banks, channel incised 2-3', banks sloughing. Lizard spotted

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/7/93 Collected By: Stevens, Ellerbroek, Beeson, McInnis

Station Number: LA-End

Location: Lower Los Alamos just above confluence with Rio Grande.

Sample Collection Point: 25-50 yards above confluence

Weather: Partly cloudy and breezy

Time: 10:00 AM Elevation: 5400 ft.

Air Temp (°C): 19° Water Temp (°C): 15°

Dissolved Oxygen (mg/L): 7.5 Saturation DO (mg/L): 8.2

pH: 8.15 Conductivity (µmhos/cm): 240

Alkalinity Titrant Normality: 0.102011 NaOH: _____ H2SO4: X

Buret finish: 11.6

Buret start: 10.0 Sample Volume: 100 ml

Difference: 1.6

Periphyton: Collection method: Grab samples.

Macroalgae % cover/comments: Diatoms and filamentous algae collected from rocks 50% covered in slower water, overall 25% cover. Good diatom growth - filamentous algae to 10 cm long.

Macrophytes % cover/comments: None

Benthic Macroinvertebrates: Collection method: Surber

Comments: Angular cobbles to gravels substrates.

Fish: Collection Method: 1/4' seine.

Comments/observations: Fish observed and captured upstream to confluence with road to Espanola, New Mexico (single species).

Additional: Higher water at some other time, algae on adjacent plants. Fish captured approximately 2 miles upstream from confluence with Rio Grande.

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/7/93 Collected By: Stevens, Ellerbroek, Beeson, Janet McInnis

Station Number: OTOWI

Location: On Rio Grande above confluence with Los Alamos Canyon.

Sample Collection Point: 50 yards above confuence of Rio Grande with Los Alamos.

Weather: Partly cloudy, breezy

Time: 11:00 Elevation: 5400 ft.

Air Temp (°C): 16° Water Temp (°C): 12°

Dissolved Oxygen (mg/L): 8.4 Saturation DO (mg/L): 8.77

pH: 8.2 Conductivity (µmhos/cm): 210

Alkalinity Titrant Normality: 0.102011 NaOH: _____ H2SO4: X

Buret finish: 45.6

Buret start: 44.0 Sample Volume: 100 ml

Difference: 1.6

Periphyton: Collection method: None collected.

Macroalgae % cover/comments: _____

Macrophytes % cover/comments: None observed.

Benthic Macroinvertebrates: Collection method: None collected.

Comments: _____

Fish: Collection Method: No fish observed.

Comments/observations: _____

Additional: Water murky/muddy with silts.

ADVANCED**AQUATIC** TECHNOLOGY ASSOCIATES, INC.

Field Determined Water Quality Parameters
and
Biological Collections

Date: 5/6/93 Collected By: Ellerbroek, Beeson

Station Number: PJ - End

Location: Lower Pajarito Canyon below highway 4 (outside of boundary)

Sample Collection Point: Just below highway 4 at point where walking path crosses creek.

Weather: Clear and breezy

Time: 16:15 Elevation: 6400 ft.

Air Temp (°C): Water Temp (°C): 18.5°

Dissolved Oxygen (mg/L): 8.5 Saturation DO (mg/L): 7.29

pH: 7.94 Conductivity (µmhos/cm): 335

Alkalinity Titrant Normality: 0.102011 NaOH: H2SO4: X

Buret finish: 12.1

Buret start: 10.2 Sample Volume: 100 ml

Difference: 1.9

Periphyton: Collection method: Grab samples.

Macroalgae % cover/comments: 75% covered filamentous algae, ~25% embeddedness with silts and sands, algae old and new - mostly old. Substrate - gravels; pea size to 1".

Macrophytes % cover/comments: None

Benthic Macroinvertebrates: Collection method: Surber

Comments:

Fish: Collection Method: No fish observed.

Comments/observations:

Additional: Gravels and angular rocks/ cobbles, sediments and sediments/grass hummocks in channel, willows and grasses along banks. Banks soft.

ADVANCED**AQUATIC** TECHNOLOGY ASSOCIATES, INC.

Field Water Quality Parameters

Date: May 24, 1994 Time: 1000 Station Number: PJ-1

Location Description: Upper Pajarito Canyon

Describe Sample Collection Point: approx. 50 - 100 yds upstream of the paved road above the LANL property boundary.

Elevation (ft. MSL) 7700

Weather: Clear and cool

Air Temp: __ °C Water Temp: 3.95 °C

Dissolved Oxygen: 10.32 mg/L CalibrationTemp: 4.0 °C

Saturation DO: 9.8 mg/L pH: 7.16/7.10 pH units

Conductivity: 51 µmhos/cm

Alkalinity Titrant # 1 Normality: 0.0102 _____ NaOH __X__ H_2SO_4

Buret start: 0.0 mL
Buret finish: 6.5 mL
Difference: 6.5 mL

Sample Volume 100 mL
Total Alkalinity ___ mg/L

Alkalinity Titrant # 2 Normality: N/A _____NaOH _____ H_2SO_4

Buret start: _____mL
Buret finish: _____mL
Difference: _____mL

Sample Volume _____ mL
Total Alkalinity _____ mg/L

Collections:

X	Periphyton	Method: 3 general grab/squeeze
	Phytoplankton	Method:
X	Macroinvertebrates	Method: 2 Surber composite (3x)
	Zooplankton	Method:
X	Fish	Method: none oberserved
	Sediment	Method:
X	Other	Method: water quality

WQ Samples: Raw X Dissolved X Total X Other _____

Stream Gaging X cfs Photo Record _____

Remarks: Gaged flow immediately below Parshall flume. Gage = 0.06. No slime on rocks - took peripyton from silt surface and grass squeeze. Substrate mixed-sized gravels from pea size to large (2 in. diameter) embedded by silt, debris (pine needles, grasses, twigs).

Collected by: John Aronson, Dave Beeson, Mary Perkins, Bob Beery

Signed: _____

ADVANCEDAQUATICTECHNOLOGY ASSOCIATES, INC.

Field Water Quality Parameters

Date: May 24, 1994 **Time:** 1130 **Station Number:** LA-1

Location Description: Upper Los Alamos Canyon

Describe Sample Collection Point: 1/4 mile above Los Alamos Reservoir at first clearing from stream bed

Elevation (ft. MSL) 7800

Weather: Clear

Air Temp: __ °C **Water Temp:** 3.9 °C

Dissolved Oxygen: 10.8 mg/L **CalibrationTemp:** 4.0 °C

Saturation DO: 9.8 mg/L **pH:** 7.45 pH units

Conductivity: 59 µmhos/cm

Alkalinity Titrant # 1 Normality: 0.0102 _____ NaOH __X__ H_2SO_4

Buret start: 0.0 mL
Buret finish: 5.0 mL
Difference: 5.0 mL

Sample Volume 100 mL
Total Alkalinity ___ mg/L

Alkalinity Titrant # 2 Normality: N/A _____NaOH _____ H_2SO_4

Buret start: _____mL
Buret finish: _____mL
Difference: _____mL

Sample Volume _____ mL
Total Alkalinity _____ mg/L

Collections

X	Periphyton	Method: scrapes - split with State
	Phytoplankton	Method:
X	Macroinvertebrates	Method: 2 Surber composite (3x) split
	Zooplankton	Method:
X	Fish	Method: none oberserved
	Sediment	Method:
X	Other	Method: water quality

WQ Samples: Raw X Dissolved X Total X Other _____

Stream Gaging X cfs **Photo Record** _____

Remarks: Flow similar to 1994 (?) Flow gaged at section upstream of biological samples. Substrates embedded gravels and cobbles, some angular. Flow regime generally fast. Periphyton from rock scrapes, not real common - moss squeeze also. Noticed, *Prasilola*, debris indicated flow was higher recently.

Collected by: John Aronson, Dave Beeson, Mary Perkins, Bob Beery

Signed: _____

ADVANCEDAQUATICTECHNOLOGY ASSOCIATES, INC.

Field Water Quality Parameters

Date: May 24, 1994 Time: 1410 Station Number: LA-3

Location Description: Downstream of Los Alamos Canyon ice rink

Describe Sample Collection Point: along stream channel on the south side of the Canyon below the ice rink. Collected before creek goes under road.

Elevation (ft. MSL) 7300

Weather: Clear and sunny

Air Temp: __ °C Water Temp: 5.0 °C

Dissolved Oxygen: 9.9 mg/L

Saturation DO: 9.7 mg/L

Conductivity: 126 µmhos/cm

CalibrationTemp: 5.0 °C

pH: 7.17 pH units

Alkalinity Titrant # 1 Normality: 0.0102 _____ NaOH __X__ H_2SO_4

Buret start: 0.0 mL
Buret finish: 6.6 mL
Difference: 6.6 mL

Sample Volume 100 mL
Total Alkalinity ___ mg/L

Alkalinity Titrant # 2 Normality: 0.0102 _____NaOH __X__ H_2SO_4

Buret start: 0.0 mL
Buret finish: 6.4 mL
Difference: 6.4 mL

Sample Volume 100 mL
Total Alkalinity _____ mg/L

Collections:

X	Periphyton	Method: rock scrapes - silt and debris grabs
	Phytoplankton	Method:
X	Macroinvertebrates	Method: 2x Surber composite (3x)
	Zooplankton	Method:
X	Fish	Method: none oberserved
	Sediment	Method:
X	Other	Method: water quality

WQ Samples: Raw X Dissolved X Total X Other _____

Stream Gaging X cfs Photo Record _____

Remarks: Substrates large imbedded gravels to sand. Slightly cloudy water. No filamentous algae - substrates not slimy. Debris dams without algal growth.

Collected by: John Aronson, Dave Beeson, Bob Beery

Signed: _____

ADVANCEDAQUATICTECHNOLOGY ASSOCIATES, INC.

Field Water Quality Parameters

Date: May 24, 1994 Time: 1550 Station Number: LA-4.5

Location Description: Los Alamos Canyon approx. 1.0 km above USGS gage.

Describe Sample Collection Point: along dirt road access at end of surface flow. flow measured above terminus approx. 300 ft.

Elevation (ft. MSL) 7100

Weather: Clear

Air Temp: __ °C Water Temp: 6.2 °C

Dissolved Oxygen: 8.9 mg/L

Saturation DO: 9.6 mg/L

Conductivity: 245 µmhos/cm

CalibrationTemp: 6.2 °C

pH: 7.54 pH units

Alkalinity Titrant # 1 Normality: 0.0102 _____ NaOH __X__ H_2SO_4

Buret start: 0.0 mL
Buret finish: 7.4 mL
Difference: 7.4 mL

Sample Volume 100 mL
Total Alkalinity ___ mg/L

Alkalinity Titrant # 2 Normality: _____ _____NaOH ____ H_2SO_4

Buret start: ___ mL
Buret finish: ___ mL
Difference: ___ mL

Sample Volume ___ mL
Total Alkalinity _____ mg/L

Collections:

X	Periphyton	Method: silt scrape, rock scrape
	Phytoplankton	Method:
X	Macroinvertebrates	Method: Surber (2) composite (3x)
	Zooplankton	Method:
X	Fish	Method: none oberserved
	Sediment	Method:
X	Other	Method: water quality

WQ Samples: Raw X Dissolved X Total X Other _____

Stream Gaging X cfs Photo Record _____

Remarks: Sediments sand with occasional cobble outcrop. Macros from cobble areas. No visual algae. No slime on rocks. Difficult to get algae samples (mostly sand epiphytes).

Collected by: John Aronson, Dave Beeson, Bob Beery

Signed: _____

ADVANCEDAQUATICTECHNOLOGY ASSOCIATES, INC.

Field Water Quality Parameters

Date: May 24, 1994 **Time:** 1700 **Station Number:** SW-8

Location Description: Sandia Canyon at outlet of Sandia Wetland

Describe Sample Collection Point: 100 yds below outlet of Sandia Wetland in a meadow (grass)

Elevation (ft. MSL) 7200

Weather: Clear

Air Temp: __ °C **Water Temp:** 6.3 °C

Dissolved Oxygen: 9.5 mg/L **CalibrationTemp:** 6.3 °C

Saturation DO: 9.2 mg/L **pH:** 7.77 pH units

Conductivity: 451 µmhos/cm

Alkalinity Titrant # 1 Normality: 0.0102 _____ NaOH __X__ H_2SO_4

Buret start: 0.0 mL
Buret finish: 25.3 mL
Difference: 25.3 mL

Sample Volume 100 mL
Total Alkalinity ___ mg/L

Alkalinity Titrant # 2 Normality: _____ _____NaOH ____ H_2SO_4

Buret start: ___ mL
Buret finish: ___ mL
Difference: ___ mL

Sample Volume ___ mL
Total Alkalinity _____ mg/L

Collections:

X	Periphyton	Method: scrapes/squeeze from submerged grass
	Phytoplankton	Method:
X	Macroinvertebrates	Method: 2x Surber composite (3x)
	Zooplankton	Method:
X	Fish	Method: none oberserved
	Sediment	Method:
X	Other	Method: water quality

WQ Samples: Raw X Dissolved X Total X Other _____

Stream Gaging X cfs **Photo Record** _____

Remarks: Bedrock substrate with gravel outcrops and deposits. Much silt. Gaging on bedrock outcrop. Difficult to get algae, macros. Some debris in water - particulate organic. Slightly cloudy. Filamentous algae outcrops along bank only.

Collected by: John Aronson, Dave Beeson

Signed: _____

ADVANCEDAQUATICTECHNOLOGY ASSOCIATES, INC.

Field Water Quality Parameters

Date: May 24, 1994 **Time:** 1745 **Station Number:** SW-9

Location Description: Sandia Canyon at outlet of Sandia Canyon Road culvert

Describe Sample Collection Point: below culvert, approximately 30 feet

Elevation (ft. MSL) 7000

Weather: Cool

Air Temp: __ °C **Water Temp:** 6.0 °C

Dissolved Oxygen: 8.45 mg/L **CalibrationTemp:** 6.0 °C

Saturation DO: 9.3 mg/L **pH:** 8.33 pH units

Conductivity: 485 µmhos/cm

Alkalinity Titrant # 1 Normality: 0.0102 _____ NaOH __X__ H_2SO_4

Buret start: 0.0 mL
Buret finish: 1.1 mL Sample Volume 100 mL
Difference: 1.1 mL phenolphthalein Total Alkalinity ___ mg/L

Alkalinity Titrant # 2 Normality: as above _____NaOH ____ H_2SO_4

Buret start: 1.1 mL
Buret finish: 24.1 mL Sample Volume ___ mL
Difference: 23.0 mL Bromcresol Total Alkalinity _____ mg/L

Collections:

X	Periphyton	Method: silt, grass (submerged) collections
	Phytoplankton	Method:
X	Macroinvertebrates	Method: 2 Surber composite (3x)
	Zooplankton	Method:
X	Fish	Method: none oberserved
	Sediment	Method:
X	Other	Method: water quality

WQ Samples: Raw X Dissolved X Total X Other _____

Stream Gaging X cfs **Photo Record** _____

Remarks: Cloudy water, much silt over pea size gravels to cobbles. Gravels clean, cobbles silty. Lots of beetles. Algae, macros, difficult to sample. Flow low. Gaged at culvert, again below in channel.

Collected by: John Aronson, Dave Beeson

Signed: _____

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Field Water Quality Parameters

Date: May 24, 1994 **Time:** 1850 **Station Number:** Otowi

Location Description: Rio Grande at Otowi Bridge

Describe Sample Collection Point: along NW bank of Rio Grande upstream of confluence of Los Almos canyon.

Elevation (ft. MSL) 5400

Weather: Clear

Air Temp: __ °C **Water Temp:** 5.8 °C

Dissolved Oxygen: 9.5 mg/L **CalibrationTemp:** 5.8 °C

Saturation DO: 10.1 mg/L **pH:** 8.03, 8.05 pH units

Conductivity: 172 µmhos/cm

Alkalinity Titrant # 1 Normality: 0.0102 _____ NaOH __X__ H_2SO_4

Buret start: 0.0 mL
Buret finish: 14.2 mL Sample Volume 100 mL
Difference: 14.2 mL phenolpthalein Total Alkalinity ___ mg/L

Alkalinity Titrant # 2 Normality: N/A _____NaOH ____ H_2SO_4

Buret start: ___ mL
Buret finish: ___ mL Sample Volume ___ mL
Difference: ___ mL Bromcresal Total Alkalinity _____ mg/L

Collectons:

_____Periphyton Method:
_____Phytoplankton Method: _____
_____Macroinvertebrates Method:
_____Zooplankton Method: _____
_____Fish Method:
_____Sediment Method: _____
_____Other Method:

WQ Samples: Raw X_____ Dissolved ___X____ Total _X____ Other _____

Stream Gaging ___X____cfs **Photo Record** _____

Remarks: Flow not measured. Observed groundwater seep approx. 50 - 100 feet up channel in Los Alamos Canyon. Seep pH = 8.07; temp H_2O = 6.75; cond. = 410; D.O. = 8.1, Alk = 37.0 m/s. Flow in seep estimated at 1.3 ft/sec, 1" deep, 1' wide. Diptera (Simulidae) oberserved only.

Collected by: John Aronson, Dave Beeson

Signed: _____

ADVANCED**AQUATIC**TECHNOLOGY ASSOCIATES, INC.

Inter Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 8280

Client:	Advanced Aquatic Technology Associates		
Project ID:	LANL		
Sample ID:	W1	Date Reported:	05/[illegible]/93
Laboratory ID:	0193-01342	Date Sampled:	05/03/93
Sample Matrix:	Water	Time Sampled:	1430
Condition:	Cool/Intact	Date Received:	05/07/93

Parameter	Analytical Result	Units		Units
Lab pH	7.2	s.u.		
Lab Conductivity @ 25° C	55	umhos/cm		
Total Suspended Solids	1	mg/L		
Total Alkalinity as CaCO3	22	mg/L		
Bicarbonate as HCO3	27	mg/L	0.45	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.01	mg/L	<0.01	meq/L
Total Kjeldahl Nitrogen	0.2	mg/L		
Total Phosphorus	0.08	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.2	2.3	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	<0.01	0.03	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.02	<0.02	mg/L
Lead	<0.005	<0.005	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	<0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter-Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 828C

Client:	Advanced Aquatic Technology Associates		
Project ID:	LANL		
Sample ID:	PJ1	Date Reported:	05/27/93
Laboratory ID:	0193-01340	Date Sampled:	05/05/93
Sample Matrix:	Water	Time Sampled:	0900
Condition:	Cool/Intact	Date Received:	05/07/93

Parameter	Analytical Result	Units		Units
Lab pH	7.3	s.u.		
Lab Conductivity @ 25° C	74	umhos/cm		
Total Suspended Solids	15	mg/L		
Total Alkalinity as CaCO3	27	mg/L		
Bicarbonate as HCO3	33	mg/L	0.54	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.07	mg/L	<0.01	meq/L
Total Kjeldahl Nitrogen	<0.1	mg/L		
Total Phosphorus	<0.01	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.2	3.5	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	<0.01	0.02	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.02	<0.02	mg/L
Lead	<0.005	<0.005	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	<0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter·Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 8280

Client:	Advanced Aquatic Technology Associates		
Project ID:	LANL		
Sample ID:	V1	Date Reported:	05/ 3
Laboratory ID:	0193-01341	Date Sampled:	05/05/93
Sample Matrix:	Water	Time Sampled:	1525
Condition:	Cool/Intact	Date Received:	05/07/93

Parameter	Analytical Result	Units		Units
Lab pH	7.1	s.u.		
Lab Conductivity @ 25° C	162	umhos/cm		
Total Suspended Solids	1	mg/L		
Total Alkalinity as CaCO3	38	mg/L		
Bicarbonate as HCO3	47	mg/L	0.77	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	<0.01	mg/L	<0.01	meq/L
Total Kjeldahl Nitrogen	0.2	mg/L		
Total Phosphorus	0.02	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.2	5.3	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	<0.01	0.01	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.02	<0.02	mg/L
Lead	<0.005	<0.005	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter-Mountain Laboratories, Inc.

1633 Terra Aver
Sheridan, Wyoming 82

Client:	Advanced Aquatic Technology Associates		
Project ID:	LANL		
Sample ID:	LA1	Date Reported:	05/27/93
Laboratory ID:	0193-01336	Date Sampled:	05/04/93
Sample Matrix:	Water	Time Sampled:	1015
Condition:	Cool/Intact	Date Received:	05/07/93

Parameter	Analytical Result	Units		Units
Lab pH	7.1	s.u.		
Lab Conductivity @ 25° C	88	umhos/cm		
Total Suspended Solids	7	mg/L		
Total Alkalinity as CaCO3	22	mg/L		
Bicarbonate as HCO3	27	mg/L	0.44	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.18	mg/L	<0.01	meq/L
Total Kjeldahl Nitrogen	<0.1	mg/L		
Total Phosphorus	0.03	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.2	3.4	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.01	0.01	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.02	<0.02	mg/L
Lead	<0.005	<0.005	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	<0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter-Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 8280

Client:	Advanced Aquatic Technology Associates		
Project ID:	LANL		
Sample ID:	LA4	Date Reported:	05/[illegible]3
Laboratory ID:	0193-01338	Date Sampled:	05/04/93
Sample Matrix:	Water	Time Sampled:	1530
Condition:	Cool/Intact	Date Received:	05/07/93

Parameter	Analytical Result	Units		Units
Lab pH	7.4	s.u.		
Lab Conductivity @ 25° C	140	umhos/cm		
Total Suspended Solids	13	mg/L		
Total Alkalinity as CaCO3	17	mg/L		
Bicarbonate as HCO3	21	mg/L	0.35	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.04	mg/L	<0.01	meq/L
Total Kjeldahl Nitrogen	0.2	mg/L		
Total Phosphorus	0.10	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.1	3.4	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	<0.01	0.01	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.02	<0.02	mg/L
Lead	<0.005	<0.005	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by _____

Inter-Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 8280

Client:	Advanced Aquatic Technology Associates		
Project ID:	LANL		
Sample ID:	LA5	Date Reported:	05/27/93
Laboratory ID:	0193-01339	Date Sampled:	05/04/93
Sample Matrix:	Water	Time Sampled:	1645
Condition:	Cool/Intact	Date Received:	05/07/93

Parameter	Analytical Result	Units		Units
Lab pH	7.4	s.u.		
Lab Conductivity @ 25° C	180	umhos/cm		
Total Suspended Solids	13	mg/L		
Total Alkalinity as CaCO3	32	mg/L		
Bicarbonate as HCO3	39	mg/L	0.63	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	<0.01	mg/L	<0.01	meq/L
Total Kjeldahl Nitrogen	0.2	mg/L		
Total Phosphorus	0.02	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.2	3.0	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.02	0.03	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.02	<0.02	mg/L
Lead	<0.005	<0.005	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter-Mountain Laboratories, Inc.

1633 Terra Avenue
Sheridan, Wyoming 82801

Client:	Advanced Aquatic Technology Associates		
Project ID:	LANL		
Sample ID:	LA -End	Date Reported:	05/[illegible]
Laboratory ID:	0193-01372	Date Sampled:	05/07/93
Sample Matrix:	Water	Time Sampled:	1030
Condition:	Cool/Intact	Date Received:	05/10/93

Parameter	Analytical Result	Units		Units
Lab pH	7.2	s.u.		
Lab Conductivity @ 25° C	305	umhos/cm		
Total Suspended Solids	32	mg/L		
Total Alkalinity as CaCO3	79	mg/L		
Bicarbonate as HCO3	96	mg/L	1.58	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	1.61	mg/L	0.12	meq/L
Total Kjeldahl Nitrogen	0.8	mg/L		
Total Phosphorus	0.66	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.1	<0.1	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.07	0.05	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.02	<0.02	mg/L
Lead	<0.005	<0.005	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	<0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by _____

Inter Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 8280

Client:	Advanced Aquatic Technology Associates		
Project ID:	LANL		
Sample ID:	SW-8	Date Reported:	05/28/93
Laboratory ID:	0193-01375	Date Sampled:	05/06/93
Sample Matrix:	Water	Time Sampled:	1240
Condition:	Cool/Intact	Date Received:	05/10/93

Parameter	Analytical Result	Units		Units
Lab pH	7.7	s.u.		
Lab Conductivity @ 25° C	590	umhos/cm		
Total Suspended Solids	28	mg/L		
Total Alkalinity as CaCO3	138	mg/L		
Bicarbonate as HCO3	168	mg/L	2.75	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	1.45	mg/L	0.10	meq/L
Total Kjeldahl Nitrogen	0.8	mg/L		
Total Phosphorus	2.78	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	<0.1	0.7	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.07	0.08	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	0.01	mg/L
Chromium	<0.02	<0.02	mg/L
Lead	<0.005	<0.005	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	0.06	0.11	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter-Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 8280

Client:	Advanced Aquatic Technology Associates		
Project ID:	LANL		
Sample ID:	Pβ-End	Date Reported:	05/ 3
Laboratory ID:	0193-01374	Date Sampled:	05/06/93
Sample Matrix:	Water	Time Sampled:	1615
Condition:	Cool/Intact	Date Received:	05/10/93

Parameter	Analytical Result	Units		Units
Lab pH	7.6	s.u.		
Lab Conductivity @ 25° C	402	umhos/cm		
Total Suspended Solids	1	mg/L		
Total Alkalinity as CaCO3	82	mg/L		
Bicarbonate as HCO3	99	mg/L	1.63	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.00	mg/L	<0.01	meq/L
Total Kjeldahl Nitrogen	<0.1	mg/L		
Total Phosphorus	<0.01	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	<0.1	3.2	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.02	0.03	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.02	<0.02	mg/L
Lead	<0.005	<0.005	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Rocky Mountain Laboratories, Inc.
1633 Terra Avenue
Sheridan, Wyoming 82801

Client:	Advanced Aquatic Technology Associates		
Project ID:	LANL		
Sample ID:	OTOW1	Date Reported:	05/28/93
Laboratory ID:	0193-01373	Date Sampled:	05/07/93
Sample Matrix:	Water	Time Sampled:	1045
Condition:	Cool/Intact	Date Received:	05/10/93

Parameter	Analytical Result	Units		Units
Lab pH	7.8	s.u.		
Lab Conductivity @ 25° C	288	umhos/cm		
Total Suspended Solids	69	mg/L		
Total Alkalinity as CaCO3	82	mg/L		
Bicarbonate as HCO3	100	mg/L	1.64	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.02	mg/L	<0.01	meq/L
Total Kjeldahl Nitrogen	0.4	mg/L		
Total Phosphorus	0.12	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	<0.1	0.1	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.02	0.03	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.02	<0.02	mg/L
Lead	<0.005	<0.005	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter·Mountain Laboratories, Inc.

1633 Terra Aven
Sheridan, Wyoming 828

Client:	Advanced Aquatic Technology		
Project ID:	LANL		
Sample ID:	Upper Pajarito	Date Reported:	08/11/94
Laboratory ID:	0194-08687	Date Sampled:	05/24/94
Sample Matrix:	Water	Time Sampled:	0936
Condition:	Cool/Intact	Date Received:	05/26/94

Parameter	Analytical Result	Units		Units
Lab pH	7.1	s.u.		
Lab Conductivity @ 25° C	74	µmhos/cm		
Total Suspended Solids	6.0	mg/L		
Total Hardness as CaCO3	30	mg/L		
Total Alkalinity as CaCO3	30	mg/L		
Bicarbonate as HCO3	37	mg/L	0.60	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.10	mg/L		
Total Kjeldahl Nitrogen	0.37	mg/L		
Total Phosphorus	0.05	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.2	1.2	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.32	0.15	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	0.01	0.01	mg/L
Chromium	<0.01	<0.01	mg/L
Lead	<0.02	<0.02	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	<0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter-Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 8280

Client:	Advanced Aquatic Technology		
Project ID:	LANL		
Sample ID:	Upper Los Alamos	Date Reported:	08/11/94
Laboratory ID:	0194-08688	Date Sampled:	05/24/94
Sample Matrix:	Water	Time Sampled:	1130
Condition:	Cool/Intact	Date Received:	05/26/94

Parameter	Analytical Result	Units		Units
Lab pH	7.1	s.u.		
Lab Conductivity @ 25° C	82	µmhos/cm		
Total Suspended Solids	2.0	mg/L		
Total Hardness as CaCO3	28	mg/L		
Total Alkalinity as CaCO3	24	mg/L		
Bicarbonate as HCO3	29	mg/L	0.47	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.03	mg/L		
Total Kjeldahl Nitrogen	0.27	mg/L		
Total Phosphorus	0.07	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.2	1.4	mg/L
Arsenic	<0.005	0.009	mg/L
Boron	0.17	0.19	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	0.01	<0.01	mg/L
Lead	<0.02	<0.02	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	0.01	0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter-Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 8280

Client:	Advanced Aquatic Technology		
Project ID:	LANL		
Sample ID:	Ice Rink Los Alamos	Date Reported:	08/11/94
Laboratory ID:	0194-08689	Date Sampled:	05/24/94
Sample Matrix:	Water	Time Sampled:	1405
Condition:	Cool/Intact	Date Received:	05/26/94

Parameter	Analytical Result	Units		Units
Lab pH	7.2	s.u.		
Lab Conductivity @ 25° C	168	µmhos/cm		
Total Suspended Solids	4.0	mg/L		
Total Hardness as CaCO3	37	mg/L		
Total Alkalinity as CaCO3	31	mg/L		
Bicarbonate as HCO3	38	mg/L	0.62	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.05	mg/L		
Total Kjeldahl Nitrogen	0.36	mg/L		
Total Phosphorus	0.05	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.3	1.5	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.18	0.19	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.01	<0.01	mg/L
Lead	<0.02	<0.02	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	0.02	0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter·Mountain Laboratories, Inc.

1633 Terra Avenue
Sheridan, Wyoming 82801

Client:	Advanced Aquatic Technology		
Project ID:	LANL		
Sample ID:	Lower Los Alamos	Date Reported:	08/11/94
Laboratory ID:	0194-08690	Date Sampled:	05/24/94
Sample Matrix:	Water	Time Sampled:	1520
Condition:	Cool/Intact	Date Received:	05/26/94

Parameter	Analytical Result	Units		Units
Lab pH	7.3	s.u.		
Lab Conductivity @ 25° C	290	µmhos/cm		
Total Suspended Solids	2.0	mg/L		
Total Hardness as CaCO3	60	mg/L		
Total Alkalinity as CaCO3	43	mg/L		
Bicarbonate as HCO3	53	mg/L	0.86	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.03	mg/L		
Total Kjeldahl Nitrogen	0.84	mg/L		
Total Phosphorus	0.06	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.1	0.3	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.23	0.22	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.01	<0.01	mg/L
Lead	<0.02	<0.02	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	0.01	0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter-Mountain Laboratories, Inc.

1633 Terra Aven
Sheridan, Wyoming 828

Client:	Advanced Aquatic Technology		
Project ID:	LANL		
Sample ID:	Sandia Outlet	Date Reported:	08/11/94
Laboratory ID:	0194-08691	Date Sampled:	05/24/94
Sample Matrix:	Water	Time Sampled:	1700
Condition:	Cool/Intact	Date Received:	05/26/94

Parameter	Analytical Result	Units		Units
Lab pH	7.8	s.u.		
Lab Conductivity @ 25° C	516	µmhos/cm		
Total Suspended Solids	2.0	mg/L		
Total Hardness as CaCO3	78	mg/L		
Total Alkalinity as CaCO3	125	mg/L		
Bicarbonate as HCO3	153	mg/L	2.51	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	4.03	mg/L		
Total Kjeldahl Nitrogen	0.79	mg/L		
Total Phosphorus	3.28	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.1	0.4	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.15	0.21	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	0.01	mg/L
Chromium	<0.01	0.01	mg/L
Lead	<0.02	<0.02	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	0.03	0.07	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter-Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 828C

Client:	Advanced Aquatic Technology		
Project ID:	LANL		
Sample ID:	Sandia Culvert	Date Reported:	08/11/94
Laboratory ID:	0194-08692	Date Sampled:	05/24/94
Sample Matrix:	Water	Time Sampled:	1745
Condition:	Cool/Intact	Date Received:	05/26/94

Parameter	Analytical Result	Units		Units
Lab pH	8.1	s.u.		
Lab Conductivity @ 25° C	573	µmhos/cm		
Total Suspended Solids	2.0	mg/L		
Total Hardness as CaCO3	85	mg/L		
Total Alkalinity as CaCO3	118	mg/L		
Bicarbonate as HCO3	145	mg/L	2.37	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	2.13	mg/L		
Total Kjeldahl Nitrogen	0.48	mg/L		
Total Phosphorus	2.75	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.1	0.8	mg/L
Arsenic	0.005	0.005	mg/L
Boron	0.15	0.33	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	0.01	0.01	mg/L
Chromium	<0.01	0.01	mg/L
Lead	<0.02	<0.02	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	0.02	0.07	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter-Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 8280

Client:	Advanced Aquatic Technology		
Project ID:	LANL		
Sample ID:	Rio Grande	Date Reported:	08/11/
Laboratory ID:	0194-08693	Date Sampled:	05/24/94
Sample Matrix:	Water	Time Sampled:	1830
Condition:	Cool/Intact	Date Received:	05/26/94

Parameter	Analytical Result	Units		Units
Lab pH	7.8	s.u.		
Lab Conductivity @ 25° C	203	µmhos/cm		
Total Suspended Solids	176	mg/L		
Total Hardness as CaCO3	93	mg/L		
Total Alkalinity as CaCO3	69	mg/L		
Bicarbonate as HCO3	84	mg/L	1.38	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.07	mg/L		
Total Kjeldahl Nitrogen	0.38	mg/L		
Total Phosphorus	0.30	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.1	4.6	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.10	0.45	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	0.01	0.02	mg/L
Chromium	<0.01	0.01	mg/L
Lead	<0.02	<0.02	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	0.05	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed., 1989.

Reviewed by

Inter·Mountain Laboratories, Inc.

1633 Terra Avenu
Sheridan, Wyoming 828C

Client:	Advanced Aquatic Technology		
Project ID:	LANL		
Sample ID:	TA-16 Water Canyon	Date Reported:	08/11/94
Laboratory ID:	0194-08686	Date Sampled:	05/24/94
Sample Matrix:	Water	Time Sampled:	0915
Condition:	Cool/Intact	Date Received:	05/26/94

Parameter	Analytical Result	Units		Units
Lab pH	7.7	s.u.		
Lab Conductivity @ 25° C	72	µmhos/cm		
Total Suspended Solids	<1	mg/L		
Total Hardness as CaCO3	29	mg/L		
Total Alkalinity as CaCO3	31	mg/L		
Bicarbonate as HCO3	38	mg/L	0.62	meq/L
Carbonate as CO3	0.0	mg/L	0.00	meq/L
Hydroxide as OH	0.0	mg/L	0.00	meq/L
Nitrate Nitrogen	0.12	mg/L		
Total Kjeldahl Nitrogen	0.45	mg/L		
Total Phosphorus	<0.05	mg/L		

Trace Metals	Dissolved Concentrations	Total Concentrations	Units
Aluminum	0.3	0.9	mg/L
Arsenic	<0.005	<0.005	mg/L
Boron	0.08	0.16	mg/L
Cadmium	<0.002	<0.002	mg/L
Cobalt	<0.02	<0.02	mg/L
Copper	<0.01	<0.01	mg/L
Chromium	<0.01	<0.01	mg/L
Lead	<0.02	<0.02	mg/L
Mercury	<0.001	<0.001	mg/L
Selenium	<0.005	<0.005	mg/L
Vanadium	<0.02	<0.02	mg/L
Zinc	<0.01	<0.01	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Wastewater", 17th ed.; 1989.

Reviewed by

APPENDIX II

BIOLOGICAL DATA

Benthic Macroinvertebrates - May 1993						
Taxa	Los Alamos (LA1)			Los Alamos (LA3)		
	#/M^2	Tot.	Rel. %	#/M^2	Tot.	Rel. %
Diptera						
Ablabesmyia sp.						
Antocha sp.						
Cricotopus sp.	110.9	31	5.1	93.1	26	7.5
Dicranota sp.						
Eukeifferiella potthasti (group)	171.8	48	7.6	50.1	14	4.1
Eukeifferiella sp.						
Hemerodromia sp.						
Hexatoma sp.	14.3	4	0.7			
Orthocladius sp.	522.6	146	23.8	465.4	130	37.7
Pagastia sp.	50.1	14	2.3			
Procladius sp.						
Probezzia sp.				7.2	2	0.6
Simulium sp.	68.0	19	3.2	25.1	7	2.0
Tipula sp.	3.6	1	0.2			
Pelecypoda						
Pisidium sp.						
Total	2194.5	613	100	1235.1	345	100

Benthic Macroinvertebrates - May 1993						
	Los Alamos (LA1)			Los Alamos (LA3)		
Taxa	#/M²	Tot.	Rel.%	#/M²	Tot.	Rel.%
Oligochaeta						
Terrestrial earthworms						
Eisenella tetraedra						
Limnodrilus sp.						
Ephemeroptera						
Ameletus sp.						
Baetis sp.	690.9	193	31.5	400.9	112	32.5
Cinygmula sp.	60.8	17	2.7	3.6	1	0.3
Epeorus sp.	472.5	132	21.5	153.9	43	12.5
Paraleptophlebia sp.						
Plecoptera						
Hesperoperla pacifica	17.9	5	0.8	7.1	2	0.6
Isoperla sp.				10.7	3	0.9
Malenka sp.				10.7	3	0.9
Sweltsa sp.	7.1	2	0.3	3.6	1	0.3
Trichoptera						
Hesperophylax sp.						
Hydropsyche sp.				3.6	1	0.3
Oligophlebodes sp.						
Rhyacophila brunnea						
Coleoptera						
Agabus sp.						
Hydaticus sp.						
Narpus sp.	3.6	1	0.2			
Optioservus sp.						

Benthic Macroinvertebrates - 1993						
	Los Alamos (LA4)			Los Alamos (LA5)		
Taxa	#/M²	Tot.	Rel.%	#/M²	Tot.	Rel.%
Oligochaeta						
Terrestrial earthworms						
Eisenella tetraedra						
Limnodrilus sp.						
Ephemeroptera						
Ameletus sp.	3.6	1	0.2			
Baetis sp.	50.1	14	2.7			
Cinygmula sp.				82.3	23	3.0
Epeorus sp.	14.3	4	0.8			
Paraleptophlebia sp.						
Plecoptera						
Hesperoperla pacifica						
Isoperla sp.						
Malenka sp.						
Sweltsa sp.						
Trichoptera						
Hesperophylax sp.						
Hydropsyche sp.						
Oligophlebodes sp.						
Rhyacophila brunnea						
Coleoptera						
Agabus sp.				25.1	7	0.9
Hydaticus sp.						
Narpus sp.						
Optioservus sp.						

Benthic Macroinvertebrates - 1993						
	Los Alamos (LA4)			Los Alamos (LA5)		
Taxa	#/M²	Tot.	Rel. %	#/M²	Tot.	Rel.%
Diptera						
Ablabesmyia sp.						
Antocha sp.						
Cricotopus sp.						
Dicranota sp.						
Eukeifferiella potthasti (group)	114.5	32	6.1	254.1	71	9.2
Eukeifferiella sp.						
Hemerodromia sp.						
Hexatoma sp.						
Orthocladius sp.	1689.8	472	90.6	2398.6.	670	86.9
Pagastia sp.						
Procladius sp.						
Probezzia sp.						
Simulium sp.						
Tipula sp.						
Pelecypoda						
Pisidium sp.						
Total	1872.3	523	100	2760.2	771	100

Benthic Macroinvertebrates - May 1993						
	Sandia Wetland Inlet			Sandia Wetland Outlet		
Taxa	#/M^2	Tot.	Rel.%	#/M^2	Tot.	Rel.%
Oligochaeta						
Terrestrial earthworms						
Eisenella tetraedra						
Limnodrilus sp.						
Ephemeroptera						
Ameletus sp.						
Baetis sp.						
Cinygmula sp.						
Epeorus sp.						
Paraleptophlebia sp.						
Plecoptera						
Hesperoperla pacifica						
Isoperla sp.						
Malenka sp.						
Sweltsa sp.						
Trichoptera						
Hesperophylax sp.				293.5	82	82.8
Hydropsyche sp.				14.3	4	4.0
Oligophlebodes sp.						
Rhyacophila brunnea						
Coleoptera						
Agabus sp.				14.3	4	4.0
Hydaticus sp.						
Narpus sp.						
Optioservus sp.						

Benthic Macroinvertebrates - May 1993						
	Sandia Wetland Inlet			Sandia Wetland Outlet		
Taxa	#/M^2	Tot.	Rel.%	#/M^2	Tot.	Rel.%
Diptera						
Ablabesmyia sp.						
Antocha sp.						
Cricotopus sp.						
Dicranota sp.						
Eukeifferiella potthasti (group)	75.1	21	65.6			
Eukeifferiella sp.	39.3	11	34.4			
Hemerodromia sp.						
Hexatoma sp.						
Orthocladius sp.						
Pagastia sp.						
Procladius sp.				32.2	9	9.1
Probezzia sp.						
Simulium sp.						
Tipula sp.						
Pelecypoda						
Pisidium sp.						
Total	114.5	32	100	354.4	99	100

Benthic Macroinvertebrates - May 1993						
	Pajarito Canyon PJ1			Pajarito Canyon End		
Taxa	#/M²	Tot.	Rel.%	#/M²	Tot.	Rel%
Oligochaeta						
Terrestrial earthworms	96.6	27	3.5			
Eisenella tetraedra						
Limnodrilus sp.						
Ephemeroptera						
Ameletus sp.						
Baetis sp.	859.2	240	31.4			
Cinygmula sp.	1145.6	320	41.9			
Epeorus sp.	286.4	80	10.5			
Paraleptophlebia sp.						
Plecoptera						
Hesperoperla pacifica						
Isoperla sp.						
Malenka sp.						
Sweltsa sp.						
Trichoptera						
Hesperophylax sp.						
Hydropsyche sp.						
Oligophlebodes sp.						
Rhyacophila brunnea						
Coleoptera						
Agabus sp.				3.6	1	100
Hydaticus sp.						
Narpus sp.						
Optioservus sp.						

Benthic Macroinvertebrates - May 1993						
	Pajarito Canyon PJ1			Pajarito Canyon End		
Taxa	#/M^2	Tot.	Rel.%	#/M^2	Tot.	Rel.%
Diptera						
Ablabesmyia sp.						
Antocha sp.						
Cricotopus sp.						
Dicranota sp.						
Eukeifferiella potthasti (group)	204.1	57	7.5			
Eukeifferiella sp.						
Hemerodromia sp.						
Hexatoma sp.						
Orthocladius sp.						
Pagastia sp.	143.2	40	5.2			
Procladius sp.						
Probezzia sp.						
Simulium sp.						
Tipula sp.						
Pelecypoda						
Pisidium sp.						
Total	2735.1	764	100	3.6	1	100

Benthic Macroinvertebrates - May 1993						
	Water Canyon W1			Canyon de Valle V1		
Taxa	#/M²	Tot.	Rel.%	#/M²	Tot.	Rel%
Oligochaeta						
Terrestrial earthworms				14.3	4	20.0
Eisenella tetraedra	7.1	2	20.0			
Limnodrilus sp.						
Ephemeroptera						
Ameletus sp.						
Baetis sp.						
Cinygmula sp.						
Epeorus sp.						
Paraleptophlebia sp.						
Plecoptera						
Hesperoperla pacifica						
Isoperla sp.						
Malenka sp.						
Sweltsa sp.						
Trichoptera						
Hesperophylax sp.						
Hydropsyche sp.						
Oligophlebodes sp.						
Rhyacophila brunnea						
Coleoptera						
Agabus sp.						
Hydaticus sp.						
Narpus sp.						
Optioservus sp.						

Benthic Macroinvertebrates - May 1993						
	Water Canyon W1			Canyon de Valle V1		
Taxa	#/M²	Tot.	Rel.%	#/M²	Tot.	Rel.%
Diptera						
Ablabesmyia sp.						
Antocha sp.						
Cricotopus sp.						
Dicranota sp.						
Eukeifferiella potthasti (group)	3.6	1	10.0	25.0	7	35.0
Eukeifferiella sp.				32.2	9	45.0
Hemerodromia sp.						
Hexatoma sp.						
Orthocladius sp.						
Pagastia sp.						
Procladius sp.						
Probezzia sp.						
Simulium sp.	25.0	7	70.0			
Tipula sp.						
Pelecypoda						
Pisidium sp.						
Total Organisms	35.8	10	100	71.6	20	100

Los Alamos National Laboratory Spring Snowmelt - May 1993 Rapid Bioassessment Protocol Metric Data											
Parameter	**LA1**	**LA3**	**LA4**	**LA5**	**LA END**	**SW1**	**SW8**	**PJ1**	**PJ END**	**W1**	**V1**
Richness	15	13	5	4	4	2	4	6	1	3	3
Scraper:Filterer	7.9	3.5	N/A	0	0	0	0	N/A	0	0	0
EPT:Chironomid	1.5	1.9	0.03	0.03	<0.01	0	9.6	6.9	0	0	0
Shredder:Total	0	0	0	0	0	0	0	0	0	0	0
%Dominant Taxa	46.1	37.7	30.0	40.0	32.5	95.0	47.5	70.0	100	73.3	96.6
% EPT	56.7	98.5	2.9	2.9	0.2	0	86.8	83.6	0	0	0
Hilsenhoff Index	4.3	4.9	6.1	6.1	6.0	7.3	5.5	4.0	11	6.0	6.5

Los Alamos National Laboratory Spring Snowmelt - May 1993 Rapid Bioassessment Protocol Metric Scores											
Parameter	**LA1**	**LA3**	**LA4**	**LA5**	**LA END**	**SW1**	**SW8**	**PJ1**	**PJ END**	**W1**	**V1**
Reference Site	**None[2]**	**LA1**	**A[1]**	**A[1]**	**None[3]**	**None**	**LA1**	**None[2]**	**A[1]**	**None[2]**	**None[2]**
Richness	15	6	6	6	4	2	0	6	0	3	3
Scraper:Filterer	7.9	4	0	0	0	0	0	N/A	0	0	0
EPT:Chironomid	1.5	6	0	0	<0.01	0	0	6.9	0	0	0
Shredder:Total	0	0	0	0	0	0	0	0	0	0	0
%Dominant Taxa	46.1	2	2	2	32.5	95.0	0	70.0	0	73.3	96.6
% EPT	56.7	6	0	0	0.2	0	6	83.6	0	0	0
Hilsenhoff Index	4.3	6	6	6	6.0	7.3	4	4.0	2	6.0	6.5
Percent Score	**N/A**	**30**	**14**	**14**	**N/A**	**N/A**	**10**	**N/A**	**2**	**N/A**	**N/A**

1 Reference site values based on mean of PJ-1, W-1 and V-1 RBP values to represent background ephemeral conditions.
2 Used as Reference Site.
3 No appropriate Reference Site.

> 83%	Nonimpaired
54-79%	Slightly impaired
21-50%	Moderately impaired
<17%	Severely impaired

Benthic Macroinvertebrates - 1994						
	Los Alamos (LA1)			Los Alamos (LA3)		
Taxa	#/M²	Tot.	Rel.%	#/M²	Tot.	Rel.%
Oligochaeta						
Terrestrial earthworms						
Eisenella tetraedra						
Limnodrilus sp.						
Ephemeroptera						
Ameletus sp.	8.9	5	2.6	1.7	1	0.3
Baetis sp.	46.5	26	13.7	126.9	71	21.9
Cinygmula sp.	35.7	20	10.5			
Epeorus sp.	67.9	38	20.0	7.1	4	1.2
Paraleptophlebia sp.						
Plecoptera						
Hesperoperla pacifica	23.2	13	6,8			
Isoperla sp.						
Malenka sp.				1.7	1	0.3
Sweltsa sp.				28.6	16	4.9
Trichoptera						
Hesperophylax sp.	5.4	3	1.6			
Hydropsyche sp.	10.7	6	3.2			
Oligophlebodes sp.	10.7	6	3.2			
Rhyacophila brunnea	3.6	2	1.1			
Coleoptera						
Agabus sp.						
Hydaticus sp.						
Narpus sp.	8.9	5	2.6			
Optioservus sp.	33.9	19	10.0			

Benthic Macroinvertebrates - 1994						
	Los Alamos (LA1)			Los Alamos (LA3)		
Taxa	#/M²	Tot.	Rel. %	#/M²	Tot.	Rel.%
Diptera						
Ablabesmyia sp.						
Antocha sp.	1.7	1	0.5			
Cricotopus sp.						
Dicranota sp.				3.6	2	0.6
Eukeifferiella potthasti (group)	69.7	39	20.5			
Eukeifferiella sp.						
Hemerodromia sp.						
Hexatoma sp.						
Orthocladius sp.						
Pagastia sp.						
Procladius sp.						
Probezzia sp.						
Simulium sp.	8.9	5	2.6	409.5	229	70.7
Tipula sp.	3.6	2	1.1			
Pelecypoda						
Pisidium sp.						
Total	339.8	190	100	579.4	324	100

Benthic Macroinvertebrates - 1994						
	Los Alamos (LA4.5)			Pajarito Canyon (PJ1)		
Taxa	#/M²	Tot.	Rel.%	#/M²	Tot.	Rel.%
Oligochaeta						
Terrestrial earthworms				71.5	40	70
Eisenella tetraedra				35.8	20	30
Limnodrilus sp.	14.3	8	13.3			
Ephemeroptera						
Ameletus sp.	1.7	1	1.7			
Baetis sp.	28.6	16	26.7			
Cinygmula sp.						
Epeorus sp.						
Paraleptophlebia sp.	1.7	1	1.7			
Plecoptera						
Hesperoperla pacifica						
Isoperla sp.						
Malenka sp.						
Sweltsa sp.						
Trichoptera						
Hesperophylax sp.						
Hydropsyche sp.						
Oligophlebodes sp.						
Rhyacophila brunnea						
Coleoptera						
Agabus sp.						
Hydaticus sp.	25.0	14	25.9			
Narpus sp.						
Optioservus sp.						

Benthic Macroinvertebrates - 1994						
	Los Alamos (LA4.5)			Pajarito Canyon (PJ1)		
Taxa	#/M²	Tot.	Rel.%	#/M²	Tot.	Rel. %
Diptera						
Ablabesmyia sp.						
Antocha sp.						
Cricotopus sp.	28.6	16	29.8			
Dicranota sp.						
Eukeifferiella potthasti (group)						
Eukeifferiella sp.						
Hemerodromia sp.						
Hexatoma sp.						
Orthocladius sp.						
Pagastia sp.						
Procladius sp.						
Probezzia sp.						
Simulium sp.	5.4	3	1.6			
Tipula sp.						
Pelecypoda						
Pisidium sp.						
Total	107.2	60	100	107.2	60	100

Benthic Macroinvertebrates - 1994						
	Sandia Wetland Outlet			Sandia Rd. Culvert		
Taxa	#/M²	Tot.	Rel.%	#/M²	Tot.	Rel.%
Oligochaeta						
Terrestrial earthworms	48.2	27	46.5	30.3	17	14.7
Eisenella tetraedra						
Limnodrilus sp.						
Ephemeroptera						
Ameletus sp.						
Baetis sp.				135.1	75	64.7
Cinygmula sp.						
Epeorus sp.						
Paraleptophlebia sp.						
Plecoptera						
Hesperoperla pacifica						
Isoperla sp.						
Malenka sp.						
Sweltsa sp.						
Trichoptera						
Hesperophylax sp.	41.0	23	39.7			
Hydropsyche sp.				7.0	4	3.5
Oligophlebodes sp.						
Rhyacophila brunnea						
Coleoptera						
Agabus sp.						
Hydaticus sp.	8.6	5	8.6	14.6	8	6.9
Narpus sp.						
Optioservus sp.						

Benthic Macroinvertebrates - 1994						
	Sandia Wetland Outlet			Sandia Rd. Culvert		
Taxa	#/M²	Tot.	Rel.%	#/M²	Totl	Rel.%
Diptera						
Ablabesmyia sp.						
Antocha sp.						
Cricotopus sp.				1.6	1	0.8
Dicranota sp.						
Eukeifferiella potthasti (group)						
Eukeifferiella sp.				1.6	1	0.8
Hemerodromia sp.	5.4	3	5.2			
Hexatoma sp.						
Orthocladius sp.						
Pagastia sp.				7.0	4	3.5
Procladius sp.				32.4	6	5.2
Probezzia sp.						
Simulium sp.						
Tipula sp.						
Pelecypoda						
Pisidium sp.						
Total	103.7	58	100	207.4	116	100

Los Alamos National Laboratory Spring Snowmelt - May 1994 Rapid Bioassessment Protocol Metric Data						
Parameter	**LA1**	**LA3**	**LA4.5**	**SW8**	**SW9**	**PJ1**
Richness	15	7	8	4	8	2
Scraper:Filterer	6.9	0.9	1.0	0	0	0
EPT:Chironomid	4.8	0.4	N/A	0	1.7	0
Shredder:Total	0.03	0	0	0	0	0
%Dominant Taxa	64.1	32.8	66.2	74.0	42.5	94.0
% EPT	62.7	28.6	31.8	39.7	68.2	0
Hilsenhoff Index	3.7	5.4	6.7	5.5	5.4	5.0

Los Alamos National Laboratory Spring Snowmelt - May 1994 Rapid Bioassessment Protocol Metric Scores						
Parameter	**LA1**	**LA3**	**LA4.5**	**SW8**	**SW9**	**PJ1**
Reference Site	**None[1]**	**LA1**	**PJ1**	**None[1]**	**SW8**	**None[1]**
Richness	15	2	6	4	6	2
Scraper:Filterer	6.9	0	0	0	0	0
EPT:Chironomid	4.8	0	0	0	0	0
Shredder:Total	0.03	0	0	0	0	0
%Dominant Taxa	64.1	0	0	74.0	0	94.0
% EPT	62.7	2	0	39.7	6	0
Hilsenhoff Index	3.7	2	6	5.5	6	5.0
Percent Score	**N/A**	**6**	**12**	**N/A**	**18**	**N/A**

1 Used as Reference Site

Periphyton Taxonomic Listing
Los Alamos National Laboratory
May 4-7, 1993

Taxa	W-1[a]	V-1	PJ-1	PJ-End[b]
Bacillariophyta (Diatoms)	3[1]	3	5,5	5,5
Chlorophyta				
Chlamydomonas sp1			1	
Chlamydomonas sp2				
Chlorococcum humicola			1	
Closterium moniliferum			3	
Closterium sp1			1	3
Closterium sp2				3
Cosmarium sp1				3
Cosmarium sp2				1
Euastrum				1
Mougeotia				
Oedogonium				
Oocystis				
Phacotus lenticularis				
Prasiola				
Scenedesmus bijuga alternans				
Scenedesmus obliquus				1
Stigeoclonium stagnatile				
Tetraspora lubrica				
Tetraspora				
Ulothrix				3
Cyanophyta				
Anabaena	1			1
Chroococcus varius				
Lyngbya aerugineo-caerulea		1		
Lyngbya sp1				
Microcystis aeruginosa				
Microspora				
Oscillatoria tenuis				
Oscillatoria sp1				
Phormidium tenue	1			
Synechococcus				
Euglenophyta				
Euglena				
Trachelomonas				

Periphyton Taxonomic Listing Los Alamos National Laboratory May 4-7, 1993				
Taxa	**W-1[a]**	**V-1**	**PJ-1**	**PJ-End[b]**
Cryptophyta *Cryptomonas*				
Chrysophyta *Tribonema bombycinum*				5,3
General Comments				
No. Composite Samples	1	1	2	1
Pine pollen	yes	yes	yes	
Fontinalis (aquatic moss)	5,5	5		
Non-diatom algae generally rare	yes	yes		
Silt and sediments	yes	yes	yes	yes
Ciliates				yes
Algae generally rare	yes	yes	yes	

1 Scale: 5,5 Domanant; 5,3 Abundant; 5,1 Common; 3 Occasional; 1 Rare.
a Collection site at upstream LANL boundary.
b Collection site at downstream LANL boundary.

Periphyton Taxonomic Listing
Los Alamos National Laboratory
May 4-7, 1993

	Los Alamos LA-1[a]	Los Alamos LA-3	Los Alamos LA-4	Los Alamos LA-5[c]	Los Alamos Otowi[b]
Bacillariophyta					
Diatoms	5[1]	5,5	2	3	5,3
Chlorophyta					
Chlamydomonas sp1	1	1			
Chlamydomonas sp2	1	1			
Chlorococcum humicola	1				1
Closterium moniliferum					
Closterium sp1	3			1	1
Closterium sp2			1		
Cosmarium sp1	1				
Cosmarium sp2	1				
Euastrum					
Mougeotia					1
Oedogonium	5,3				
Oocystis		1			
Phacotus lenticularis					
Prasiola	5,5				
Scenedesmus bijuga alternans					
Scenedesmus obliquus					
Stigeoclonium stagnatile					5,5
Tetraspora lubrica					
Tetraspora					
Ulothrix					
Cyanophyta					
Anabaena					
Chroococcus varius	1				
Lyngbya aerugineo-caerulea					
Lyngbya sp1	1	1			
Microcystis aeruginosa					5,1
Microspora			1		
Oscillatoria tenuis					3
Oscillatoria sp1		3			3
Phormidium tenue					5,2
Synechococcus		3			

Periphyton Taxonomic Listing Los Alamos National Laboratory May 4-7, 1993					
	Los Alamos LA-1	Los Alamos LA-3	Los Alamos LA-4	Los Alamos LA-5	Los Alamos Otowi
Euglenophyta					
Euglena					1
Trachelomonas			1		
Cryptophyta					
Cryptomonas		1			
Chrysophyta					
Tribonema bombycinum					
General Comments					
No. Composite Samples	3	4	1	2	5
Pine pollen	yes		yes		
Fontinalis (aquatic moss)	yes		yes		
Non-diatom algae generally rare		yes	yes	yes	
Silt and sediments			yes	yes	
Ciliates		yes			yes
Algae generally rare	yes	yes	yes	yes	

1 Scale: 5,5 Domanant; 5,3 Abundant; 5,1 Common; 3 Occasional; 1 Rare.
a Collection site at upstream LANL boundary.
b Collection site in Los Alamos Canyon at Rio Grande.
c Collection site near LANL boundary at USGS station.

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance - May 1993					
Taxa	PJ-1	PJ-End	V-1	W-1	SW-8
Achnanthes exigua var. *constricta*					
lanceolata var. *capitata*					
lanceolata var. *dubia*	5.0		1.0	9.8	5.4
lanceolata var. *haynaldii*				0.9	
lanceolata	12.7	1.8	3.7	3.0	
lanceolata var. *ventricosa*	6.8				3.6
lemmermanni					
linearis var. *curta*					2.0
marginulata				0.4	
minutissima var. *cryptocephala*	0.3	0.3			
minutissima	1.4	1.8			2.7
Amphora ovalis var. *affinis*		0.6			0.2
ovalis					5.0
perpusilla					3.3
Anomoeoneis vitrea					0.2
Caloneis alpestris	0.3				
ventricosa var. *truncatula*		0.6			
Cocconeis hustedtii					
placentula var. *euglypta*	5.0				
placentula var. *lineata*	4.5			0.4	
Cyclotella stelligera					
meneghiniana		0.5			
Cymbella angustata					
minuta					5.8
minuta var. *pseudogracilis*					1.0
sinuata	0.3				

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance - May 1993					
Taxa	**PJ-1**	**PJ-End**	**V-1**	**W-1**	**SW-8**
Diatoma hiamale var. *mesodon*	1.5			3.4	
Diploneis ostracodarum	0.1				
Epithemia turgida					
turgida var. *westermannii*	0.3	0.3			
Eunotia incisa					
pectinalis var. *minor*					
Fragilaria brevistriata					4.2
construens	3.9		1.2		
construens var. *venter*	0.3	1.0			
pinnata					
vaucheriae	6.6	13.9	0.2	6.0	
virescens		3.5			
Frustulia vulgaris	0.6				
Gomphonema *acuminatum* var. *pusilla*				0.4	
angustatum	3.6	0.6			0.2
angustatum var. *intermedia*					
dichotomum	0.3				
intricatum				1.3	
parvulum	0.6			0.4	2.1
Hantzschia amphioxys	0.3		1.2	0.9	
amphioxys var. *capitata*			0.1		
Melosira islandica					
italica				0.2	
varians					
Meridion circulare var. *capitata*			5.0	27.4	

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance - May 1993					
Taxa	PJ-1	PJ-End	V-1	W-1	SW-8
Meridion circulare	5.7	0.5	82.5	26.8	
Navicula acceptata					
accomoda					
acicularis		0.1			
angusta					
arvensis					
atomus			1.7	0.4	
cinta var. *leptocephala*					
cryptocephala	1.4	0.6			
cryptocephala var. *veneta*					0.7
fennica				0.4	
halophila					
halophila var. *tenuirostris*					
heurfleri					
insociabilis					
krasskei				2.1	
laevissima					0.8
lanceolata	2.0	1.0			
minima	2.5	0.3	0.8	0.4	2.1
minuscula					
minusculus var. *upsaliensis*					
mutica var. *cohnii*				4.7	
mutica			0.8		
notha					
pupula var. *elliptica*				0.4	
pupula					

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance - May 1993					
Taxa	PJ-1	PJ-End	V-1	W-1	SW-8
Navicula pupula var. *rectangularis*		0.2			
pseudoexilissima	3.6	1.0			
radiosa var. *intermedia*	0.1				
radiosa var. *tenella*	0.3				
sabiniana	3.1				
seminulum	0.8				2.5
subbacillum			0.4		
subtilissima				0.4	
symmetrica		0.3			
tripunctata		0.3			
unknown WC1-1				1.1	
unknown WC1-2				1.9	
unknown WC1-3				1.1	
yorkensis		0.3			
Neidium affine				0.6	
Nitzschia acicularis		0.6			
amphibia		0.3			20.4
delicatissima	0.7	2.6			
dissipata	0.3	0.6			3.9
fonticola	3.4	3.5	0.4		4.1
frustulum	2.9	4.0	0.8		
kutzingiana				0.6	16.5
linearis	2.5	0.3			2.1
palea	4.7	2.1			2.0
pusilla			0.4		
romana					

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance - May 1993					
Taxa	**PJ-1**	**PJ-End**	**V-1**	**W-1**	**SW-8**
Pinnularia borealis var. *rectangularis*				0.9	
microstauron					0.2
subcapitata		0.6			
Rhoicosphenia curvata	3.2	0.3			
Rhopalodia gibba		0.6			
Stuaroneis pheonicenteron					0.2
smithii					
Stenopteropbia intermedia				1.7	
Surirella angustata					0.4
ovata var. *crumena*					
ovata	5.3				7.9
pinnata	1.7	0.2		0.9	
Synedra delicatissima		11.2			
rumpens var. *fragilariodes*		0.3			
rumpens	1.4			0.4	
tenera		4.5			
ulna var. *radians*		7.0			
ulna var. *subaequalis*		31.8			
ulna				0.6	

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance -May 1993					
Taxa	**LA-1**	**LA-3**	**LA-4**	**LA-5**	**LA-End**
Achnanthes exigua var. *constricta*					0.4
lanceolata var. *capitata*	1.0	0.4	1.0	1.9	
lanceolata var. *dubia*	16.7	8.3	7.1	13.5	1.1
lanceolata var. *haynaldii*					
lanceolata	11.6	9.6	9.1	5.2	0.8
lanceolata var. *ventricosa*	3.3	3.8	3.7	4.6	0.4
lemmermanni					2.8
linearis var. *curta*					
marginulata					
minutissima var. *cryptocephala*			1.0		
minutissima				0.3	
Amphora ovalis var. *affinis*					
ovalis					
perpusilla	0.8		1.0		
Anomoneis vitrea					
Caloneis alpestris				0.3	
ventricosa var. *truncatula*					
Cocconeis hustedtii			0.6	0.5	
placentula var. *euglypta*		1.9	0.8	0.6	
placentula var. *lineata*	1.3				
Cyclotella stelligera		0.8	0.3		
meneghiniana					
Cymbella angustata		0.4	1.0		
minuta		0.4	0.6	0.3	
minuta var. *pseudogracilis*					
sinuata	0.3	1.1	0.6	3.2	0.8

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance - May 1993					
Taxa	LA-1	LA-3	LA-4	LA-5	LA-End
Diatoma hiamale var. *mesodon*	3.5	0.8			
Diploneis ostracodarum					
Epithemia turgida			0.3		
turgida var. *westermannii*					
Eunotia incisa		0.8			
pectinalis var. *minor*	0.3				
Fragilaria brevistriata					
construens	0.3				
construens var. *venter*	0.7		1.3	0.3	
pinnata			0.3		
vaucheriae	2.3	4.7	4.5	7.3	6.6
virescens					
Frustulia vulgaris					
Gomphonema acuminatum var. *pusilla*					
angustatum				0.6	0.8
angustatum var. *intermedia*			0.3		
dichotomum					
intricatum					
parvulum	0.7				5.1
Hantzschia amphioxys		0.4		0.3	
amphioxys var. *capitata*					
Melosira islandica		0.4	0.7		
italica					
varians		0.2			
Meridion circulare var. *capitata*		0.9			

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance - May 1993					
Taxa	**LA-1**	**LA-3**	**LA-4**	**LA-5**	**LA-End**
Meridion circulare	1.8	1.1	1.0	0.3	
Navicula acceptata	0.3		2.9	2.2	8.4
accomoda					20.4
acicularis					
angusta			1.0		
Navicula arvensis	0.7	12.6	2.7	6.8	0.4
atomus					
cinta var. *leptocephala*					0.4
cryptocephala					
cryptocephala var. *veneta*	1.8	0.4	1.3		
fennica					
halophila					5.1
halophila var. *tenuirostris*	0.2	0.4	0.3	1.3	
heurfleri	6.8	1.9			
insociabilis				0.6	
krasskei					
laevissima					
lanceolata	2.8	1.9			
minima	4.0	3.0	3.8	4.0	
minuscula					13.3
minusculus var. *upsaliensis*				0.3	
mutica var. *cohnii*					
mutica		0.4		0.6	
notha	0.2			0.3	
pupula var. *elliptica*					
pupula			0.3		

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance - May 1993					
Taxa	**LA-1**	**LA-3**	**LA-4**	**LA-5**	**LA-End**
Navicula pupula var. *rectangularis*					1.3
pseudoexilissima	20.7	30.1	26.8	10.0	
radiosa var. *intermedia*					
radiosa var. *tenella*	1.2		0.3		
sabiniana	2.8	0.8			
seminulum					1.7
subbacillum					
subtilissima					
symmetrica					
tripunctata					
unknown WC1-1					
unknown WC1-2					
unknown WC1-3					
yorkensis					
Neidium affine					
Nitzschia acicularis					
amphibia					
delicatissima	1.0				
dissipata	0.7	1.9	0.3	1.3	0.2
fonticola	2.3	4.0	12.7	6.8	
frustulum	1.3	1.5	2.2	9.0	
kutzingiana					4.9
linearis	0.5	1.1	0.5	2.1	0.4
palea					23.2
pusilla	3.7	3.0	4.8	27.3	
romana				1.9	

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance - May 1993					
Taxa	**LA-1**	**LA-3**	**LA-4**	**LA-5**	**LA-End**
Pinnularia borealis var. *rectangularis*					
microstauron	0.3			0.3	
subcapitata					
Rhoicosphenia curvata	1.3	0.8	1.3	0.6	
Rhopalodia gibba					
Stauroneis phoenicenteron					
smithii	0.3				
Stenopteropbia intermedia					
Surirella angustata					0.2
ovata var. *crumena*					0.2
ovata	0.3	0.8	3.8	8.6	1.5
pinnata					
Synedra delicatissima					
rumpens var. *fragilariodes*					
rumpens					
tenera					
ulna var. *radians*					
ulna var. *subaequalis*					
ulna	0.2		0.3	0.6	

Periphyton Taxonomic Listing
Los Alamos National Laboratory
May 24, 1994

	LA-1[a]	LA-3	LA-4.5	PJ-1	SW-8	SW-9
Bacillariophyta						
Diatoms	5,3[1]	5,1	3	3	5,5	3
Chlorophyta						
Chlamydomonas sp1	1	3	1		5,5	
Chlamydomonas sp2						
Chlorococcum humicola				3	3	
Closterium moniliferum					1	
Closterium sp1						
Closterium sp2						
Cosmarium sp1					3	
Cosmarium sp2					1	
Euastrum						
Mougeotia					5,1	
Oedogonium	3	1				
Oocystis						
Phacotus lenticularis						
Prasiola	5,1					
Scenedesmus bijuga alternans					1	
Scenedesmus obliquus						
Stigeoclonium stagnatile					5,5	
Tetraspora lubrica						
Tetraspora						
Ulothrix	3				1	
Cyanophyta						
Anabaena						
Chroococcus varius	1				3	
Lyngbya aerugineo-caerulea	1				3	
Lyngbya sp1				1		
Microcystis aeruginosa					3	
Microspora						
Oscillatoria tenuis					5,1	
Oscillatoria sp1						
Phormidium tenue						
Synechococcus						

Periphyton Taxonomic Listing
Los Alamos National Laboratory
May 24, 1994

	LA-1	LA-3	LA-4.5	PJ-1	SW-8	SW-9
Euglenophyta						
Euglena					1	
Trachelomonas						
Cryptophyta						
Cryptomonas						
Chrysophyta						
Tribonema bombycinum					1	
General Comments						
No. Composite Samples	3	3	3	3	3	3
Pine pollen	yes	yes		yes	yes	
Fontinalis (aquatic moss)	yes					yes
Non-diatom algae generally rare	yes	yes	yes	yes		yes
Silt and sediments		yes	yes	yes	yes	
Ciliates					yes	
Algae generally rare	yes	yes	yes	yes		yes

1 Scale: 5,5 Domanant; 5,3 Abundant; 5,1 Common; 3 Occasional; 1 Rare.
a Collection site at upstream LANL boundary.
b Collection site approximately 1.0 km upstream of the LANL boundary.
c Collection site located at juncture of Sandia Canyon and Sandia Canyon Road.

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance May 1994			
Taxa	**Los Alamos LA-1**	**Los Alamos LA-3**	**Los Alamos LA-4.5**
Achnanthes affinis	0.3		
exigua		0.4	
hauckiana		2.1	
lanceolata var. *dubia*	30.4	21.9	11.1
lanceolata var. *hayanaldii*	2.0	1.7	
lanceolata		0.8	
marginulata var. *helvetica*			1.8
minutissima	2.7	1.7	1.3
Amphora perpusilla	2.1		
Cocconeis placentula var. *euglypta*	1.7		
placentula var. *lineata*		0.4	2.7
Cymbella microcephala		0.4	0.3
minuta	2.4		
sinuata		0.8	
Diatoma hiamale var. *mesodon*	0.3	0.4	
Eunotia perminuta		0.4	
Fragilaria construens var. *venter*	1.1		
vaucheriae	1.2	0.8	2.3
Gomphonema angustatum var. *intermedia*			
unknown PJ1	1.1	0.4	
Meridion circulare var. *capitata*		2.1	
circulare	1.9	0.4	1.5
Navicula cryptocephala	9.4	0.4	1.8
halophila var. *tenuirostris*	2.6		0.3

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance May 1994			
Taxa	**Los Alamos LA-1**	**Los Alamos LA-3**	**Los Alamos LA-4.5**
minima	7.0	5.1	6.3
mutica var. *cohnii*		0.4	
pelliculosa	7.3	3.2	11.3
radiosa	0.6		
radiosa var. *tenella*	0.3		
reinhardtii var. *elliptica*			0.3
secura	0.9	4.4	2.8
seminulum	4.9		3.5
subtilissima	2.1		
unknown WC1-1			0.3
Nitzschia amphibia		0.4	
delicatissima			0.5
dissipata		1.5	
fonticola	3.5		7.6
frustulum	2.3	3.4	3.7
kutzingiana	7.9		12.9
linearis	2.1	0.6	0.7
paleacea			
Rhoicosphenia curvata	2.0	0.4	
Stephanodiscus hantzschii		44.3	26.9
Surirella angustata			
ovata			
Synedra delicatissima		0.4	

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance May 1994			
Taxa	Sandia SW-8	Sandia SW-9	Pajarito PJ-1
Achnanthes affinis			
Achnanthes exigua		0.3	
hauckiana	0.3		
lanceolata var. *dubia*	21.3	8.0	30.2
lanceolata var. *haynaldii*		3.3	
lanceolata			
marginulata var. *helvetica*			
minutissima		0.4	5.2
unknown SW-1	0.3		
Amphora perpusilla	0.2		0.8
Cocconeis placentula var. *euglypta*	3.6		
placentula var. *lineata*	0.3		
Cymbella microcephala			
minuta			2.4
sinuata			
Diatoma hiamale var. *mesodon*			
Eunotia perminuta			
Fragilaria construens var. *venter*			
vaucheriae	5.6	2.0	2.6
Gomphonema angustatum var. *intermedia*	0.3		1.5
parvulum	0.8		1.3
unknown PJ1			1.5
Meridion circulare var. *capitata*			
circulare			1.1
Navicula cryptocephala		1.8	0.8
halophila var. *tenuirostris*	0.3	0.4	

Los Alamos National Laboratory Periphyton Diatoms Relative Percent Abundance May 1994			
Taxa	**Sandia SW-8**	**Sandia SW-9**	**Pajarito PJ-1**
minima	2.1	10.7	7.6
mutica var. *cohnii*	0.6		
pelliculosa	18.4	6.6	2.6
radiosa			
radiosa var. *tenella*			
reinhardtii var. *elliptica*			
secura	0.3	0.8	1.1
seminulum	4.9	7.9	2.9
subtilissima			
unknown WC1-1			
Nitzschia amphibia	1.1		
delicatissima			0.7
dissipata	0.3		
fonticola			2.7
frustulum	5.3	11.5	10.9
kutzingiana	13.6	18.2	5.8
linearis	1.8	2.9	
paleacea	15.9	18.6	8.3
Rhoicosphenia curvata	0.6		0.3
Stephanodiscus hantzschii			
Surirella angustata			4.2
ovata	5.7	3.1	5.4
Synedra delicatissima			