HYDROGEOLOGICAL CHARACTERIZATION OF DREDGE MATERIALS AND FLUVIALLY DEPOSITED TAILINGS AT CATALDO MISSION FLATS COEUR D'ALENE RIVER, IDAHO.

A Thesis

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AUTHORIZATION TO SUBMIT THESIS

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ABSTRACT

The hydrogeologic system in the vicinity of the Cataldo Mission Flats, Kootenai County, Idaho, on the Coeur d'Alene River was investigated during the period June 1997 through March 1998. Along this reach, cadmium, lead, and zinc concentrations in soil and pore water are known to be elevated as a result of historic mining activity within the Coeur d'Alene watershed. In order to identify sources of heavy metals release to the river, a conceptual hydrogeological model and metals loading analyses were completed along the subject reach. Based on the results of the hydrogeologic investigation completed at 23 groundwater and 16 surface water sites, the dredge materials constitute a perched water table system that show little, if any, connection to the Coeur d'Alene River.

Based on the results of an approximate loading analysis (using USGS gaged flows and water sampling) on six sections along the reach, no significant increases or decreases in dissolved cadmium, lead, or zinc loadings were identified. These results indicate that no significant inflows of impacted groundwater containing high levels of heavy metals can be identified along the Cataldo Mission Flats reach. From a remedial perspective, this suggests that large-scale excavation of the dredged materials along this reach is not necessary and that attention should be focused on remediation and stabilization of impacted and erodible material, which has the potential to be suspended during high flow times.

Based on these results, it is recommended that in areas where erodible and impacted dredged materials have been identified, which are not well vegetated, these materials should be stabilized by armoring or using heavy metals-tolerant vegetation. Where a riparian environment is established over impacted dredge materials, these bank areas should be stabilized so as to promote continual development of the riparian zone and minimize resuspension of the sediments and destruction of the riparian zone during high flow events. An additional recommendation is that a similar multi-location loading study of dissolved and suspended metals be repeated during high flow when bank sediments are being resuspended by erosion to identify specific locations of sediment loading.

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CHAPTER 1

INTRODUCTION

Statement of Problem

Water quality throughout the Coeur d'Alene River basin has been impaired due to historical mining activity. The deposition of mill tailings throughout the course of the Coeur d'Alene River is a result of the mine waste disposal practices since the late 1880's (Ellis, 1940). The tailings, containing heavy metals, have been eroded from disposal sites and redeposited along the bed, banks, and floodplains of the Coeur d'Alene River.

The Cataldo Mission Flats lie west of the confluence of the North and South Forks of the Coeur d'Alene River. The area is bounded on the south by the river and by topographic bedrock highs on the north, east, and west (Figure 1). Beginning in the late 1930's and continuing into the 1960's, tailings and sediments were dredged out of the Coeur d'Alene River and placed on the Cataldo Mission Flats (Galbraith, 1971).

Water samples taken from the Coeur d'Alene River indicate a significant increase in heavy metals loading occurs near the Cataldo Mission Flats area (SCS, 1994). Two mechanisms have been identified as likely sources for the metal loading over this reach; 1) the erosion of banks and riverbed deposits during high flow periods and 2) the discharge of metals into the river from groundwater seeps. This thesis, along with a model study of the Flats (Wakefield, 2001), is an assessment of the groundwater flow through the dredge materials at the Mission Flats site and the associated metals loading to this reach of the Coeur d'Alene River.

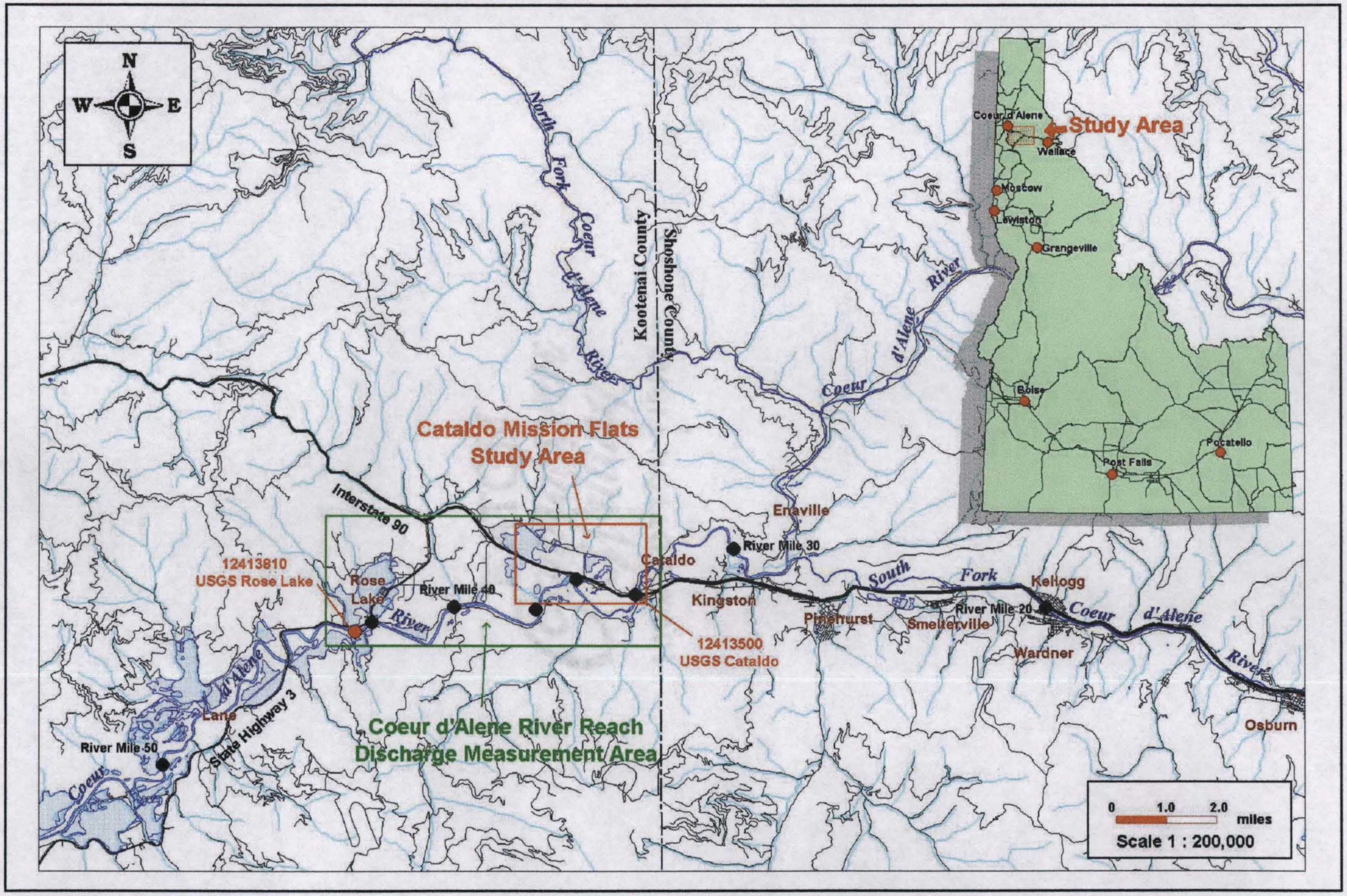

Figure 1. Location of the Cataldo Mission Flats study area.

Purpose and Objectives

The purpose of this research is to develop a better understanding of groundwater movement through the Cataldo Mission Flats dredge materials in support of continued understanding of the water quality impacts to the Coeur d'Alene River. The general objective is to estimate groundwater flow and resultant metals loading through the Cataldo Mission Flats dredge materials and describe the impacts on the water quality in the Coeur d'Alene River.

Specific objectives include:

1. Assemble and review literature on groundwater and surface water conditions within the Cataldo Mission Flats area of the main stem Coeur d'Alene River.
2. Describe the regional hydrogeological setting.
3. Compile, present, and evaluate data on water elevations and water quality data collected from piezometers, selected wetlands, streams, and the Coeur d'Alene River at Cataldo Mission Flats.
4. Use the existing numerical model, water level data, and water quality data to develop a hydrogeological conceptual model of the groundwater flow system including dredge materials at the Cataldo Mission Flats and interpret what this model means with respect to metals loading in the Coeur d'Alene River.
5. Present conclusions and recommendations.

Previous Investigations

Historic groundwater investigations in the Cataldo Mission Flats area were done by Galbraith (1971) and Norbeck (1974). Galbraith (1971) presents a hydrogeological conceptual model for the groundwater flow system through the dredge materials and suggests that there is a westward groundwater gradient between the dredge materials and the wetlands. Norbeck (1974) investigates the water table configuration and tailings distribution along the Coeur d'Alene River including the area near Cataldo Mission Flats. Grant (1952) reports on the history and operation of the dredge at Cataldo Mission Flats

More recent studies reflect the renewed interest in the site. McCulley, Frick, and Gilman (1996) and the Soil Conservation Service (SCS, 1994) report on the water quality of groundwater and surface water along the in the vicinity of Cataldo Mission Flats. Paulson (1996) and the Idaho Department of Environmental Quality (IDEQ, 1998) report on potential metal loading mechanisms occurring at the Cataldo Mission Flats area.

Studies in other parts of the Coeur d'Alene River basin contain information pertinent to the Cataldo Mission Flats study area. Dames & Moore (1991), Mabes (1977), Morilla (1975), and Swanson (1992) report on the hydraulic characteristics, water table configuration and tailings distribution in the Smelterville Flats area located in the South Fork portion of the Coeur d'Alene basin. Dames & Moore (1991) describe the mass balance of metals transported by groundwater into the South Fork of the Coeur d'Alene River from the Smelterville Flats tailings deposits. Mabes (1977) considers different methodologies for determining hydraulic characteristics of groundwater flow through mine tailings. Morilla (1975) suggests that the two major controls on a groundwater mound beneath the Page tailing pile are the quantity of infiltrating precipitation and the position and behavior of the local water table. Swanson (1992) studies the effects on groundwater quality in a perched system where an alluvial clay aquitard underlies mine wastes. Additional studies of importance on the groundwater and mine wastes at the Smelterville Flats site include Kunkel (1993), Marcy (1979), Norton (1980), and Swope (1990). Kunkel (1993) examines the transport of oxidation mine wastes via infiltration of precipitation at the Smelterville Flats. Marcy (1979) investigates the chemistry of shallow groundwater and mine waste. Norton (1980) concludes that metal concentration in mine tailings is higher for finer size fractions of the sediments. Swope (1990) describes correlations for zinc concentrations and field parameters of pH and specific conductivity.

Surface water investigations on the Coeur d'Alene River provide information on water quality, flow rate, and sediment load pertinent to the Cataldo Mission Flats area. These include reports by IDEQ (1998), McCulley, Frick, and Gilman (1996), SCS (1994), and the U.S. Geological Survey (1999). Marshall (1992) and Reece and others (1978) provide information on metal pollution of surface waters in the South Fork of the Coeur d'Alene River relevant to the Cataldo Mission Flats area. Neufield (1987), Rabe and Bauer (1977), and Skille and others (1983) report on heavy metals in lakes of the Coeur d'Alene River Valley with analogous implications to the Cataldo Mission Flats area. Hobbs and others (1965) provides discussion on the geology of the area.

CHAPTER 2

GEOLOGIC SETTING

Introduction

Discussion of the geology of the Cataldo Mission Flats is based on data collected as part of this study, from Galbraith (1971), from McCulley, Frick, and Gilman (1996), and from Wakefield (2001). Additional data were provided from the Idaho Department of Environmental Quality (IDEQ, 1998) and from the United States Geological Survey (USGS, 2003). The objectives of this section are the following: 1) present a description of the Cataldo Mission Flats area, and 2) discuss the geographic and geologic setting of the Flats.

General Description of the Cataldo Mission Flats Area

The Cataldo Mission Flats area is a wide section of the valley floor located within the lower Coeur d'Alene River basin northern Idaho. The Flats lie west of the confluence of the North and South Forks of the Coeur d'Alene River at river mile 36 and are bounded on the south by the river and by topographic bedrock highs on the north, east, and west (Figure 1). The Flats were formed as an alternating fluvian and lacustrian sediment deposition area associated with ancestral levels of Coeur d'Alene Lake. The thickness of native sediments ranges from zero along the margin to more than 120 feet (depth of the deepest well).

Historic mining activities in the Silver Valley along the South Fork Coeur d'Alene River from the late 1800's until the 1960's resulted in the discharge of mine tailings directly into the Coeur d'Alene River. The tailings and native sediments tended to accumulate near the Cataldo Mission Flats area where there is a change in river gradient. The accumulation of sediments, mainly tailings, caused flooding and river navigation problems. The dredging of tailings-rich sediments from the Coeur d'Alene River at this location began in the late 1930's and continued into the 1960's (Galbraith, 1971). The tailings were removed from the river and hydraulically placed on the low-lying alluvial sediments. The Flats dredge materials were deposited across an area situated northwest of the Old Mission State Park and on both sides of I-90 (Figure 2).

Elevations at the Flats range from 2127 feet at the western edge of the site near the large wetlands, to 2151 feet at the northeastern edge of the dredge materials on the north side of Interstate 90. The mountains surrounding the Flats rise to 6800 feet (Hobbs and others, 1965). Vegetation on the Flats dredge materials is sparse and consists of Redtop, some pine trees along the river, and various types of bullbrush (Galbraith, 1971). Vegetation is thicker in areas of shallow groundwater flow and in areas outside the Flats dredge materials.

Description of the Cataldo Mission Flats Dredge Materials

The Cataldo Mission Flats dredge materials reach maximum depths of nearly 40 feet and cover an area of approximately 6,000,000 square feet. The dredge materials decrease in thickness as they fan out to the west with coarser materials forming higher elevations and fines extending northwest. The dredge materials are bounded by wetlands consisting of

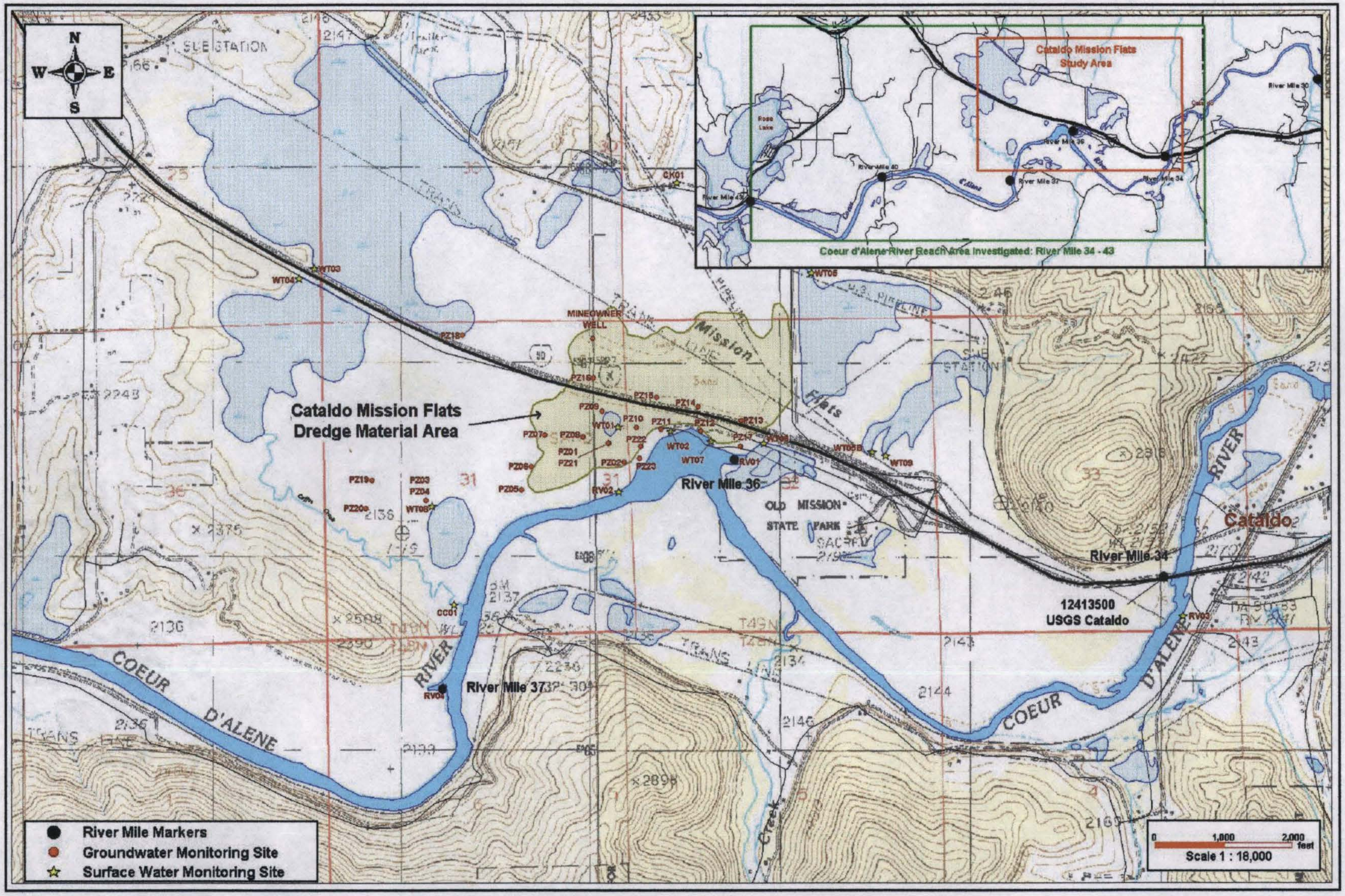

Figure 2. Cataldo Mission Flats study area.

marshlands and shallow lakes to the north, east, and west (Galbraith, 1979). The Coeur d'Alene River bounds the dredge materials on the south.

The terms "Cataldo Mission Flats," "Cataldo Flats," "Flats," "Cataldo Mission Flats dredge materials," "Flats dredge materials," and "dredge materials" are used interchangeably in this report. These terms describe the combination of dredge tailings and natural fluvially transported sediments that had settled out at this location in the Coeur d'Alene River and were subsequently emplaced on the floodplain sediments at the Cataldo Mission Flats. The terms "numerical model of the Cataldo Mission Flats," "Flats model," and "numerical model" also are used interchangeably in this report. They describe the supporting groundwater model of the Flats study conducted by Wakefield (2001).

Hydrologic Setting

The Coeur d'Alene River flows from the confluence of the North and South Forks of the Coeur d'Alene River near Enaville, Idaho westward to its discharge in Coeur d'Alene Lake near Harrison, Idaho (Figure 1). The Coeur d'Alene River flows through a floodplain that ranges from one-quarter to three-quarters mile in width. The floodplain is bound by the Coeur d'Alene Mountains to the north and the St. Joe Mountains to the south. The gradient of the Coeur d'Alene River from the confluence to Cataldo, Idaho is 0.075% allowing transport of gravel-sized sediments (Box and others, 1994). The river gradient decreases to 0.045% west of Cataldo as it approaches the Flats (Box and others, 1994). Below the Flats, the river's gradient is minimal (0.005%) allowing the transport of only sand-sized and smaller particles resulting in a much higher flood-flow gradient from Dudley, Idaho to Coeur d'Alene Lake (Box and others, 1994).

Several small south-flowing creeks replenish the wetlands located on the north of the Mission Flats. The creeks contain sediments comprised of fines from the Belt Supergroup, which form the northern boundary of the dredge materials. The absence of mines along these streams suggests that there is a low probability of elevated background levels of heavy metals entering the northern wetlands.

The hydrology of the Coeur d'Alene River basin was changed when the Post Falls Dam was constructed to control water level on Coeur d'Alene Lake in 1906. The dam is used to hold the summer lake level to 2128 feet elevation. This resulted in the lake backwater extending to the Cataldo Mission Flats area. The dam lowers the lake level to 2121 feet in September, in preparation for spring runoff during the annual Coeur d'Alene Lake drawdown beginning September to December.

Streamflows are seasonably variable; areas along the main stem are often flooded during the spring months, while some of the smaller tributaries go dry during the late summer. High water flows rates occur in spring due to mountain snowmelt and low flows occur in the fall primarily driven by groundwater discharge (Mink, 1971; Hobbs and others, 1965).

Geologic Setting

The Coeur d'Alene River basin consists of narrow valleys underlain by metamorphic rocks and filled with lacustrian and fluvial sediments. Rocks of the Precambrian Belt

Supergroup, composed of fine-grained argillites and quartzites with smaller amounts of carbonate-bearing dolomitic rocks, form most of the hills and underlie the valley sediments. Younger intrusive rocks cut the Belt rocks. Tertiary Columbia River Basalt extends from Coeur d'Alene Lake 10 miles up the Coeur d'Alene River valley (Hobbs and others, 1965). Faulting is common and complex with the Osborne Fault being the major fault in the area. The major mineral deposits within the Coeur d'Alene basin are associated with the Osborne Fault.

The river valleys are partially filled with glacio-fluvial gravels and lacustrine clay deposits. Hobbs and others, (1965) present evidence of damming of the Coeur d'Alene River at the Purcell Trench east of Spokane, Washington during Pleistocene glaciation. The alluvial sediments and glacio-fluvial deposits comprise the major hydrostratigraphic units beneath the Cataldo Mission Flats. Fluvial sediments consisting of natural materials reworked with mine tailings dominate the Coeur d'Alene River banks. Dredged materials overlie these sediments and cover an area of approximately 6,000,000 square feet with thicknesses up to 40 feet on the Flats. Norbeck (1974) described the area near Cataldo Mission Flats as consisting of clay, silt, and very fine sands with most water wells penetrating gravel layers.

Climate

Climate in the Coeur d'Alene River basin is seasonal with temperate to warm temperatures in the summer. Winter temperatures range from above freezing to zero degrees F in winter. Precipitation averages 30 to 40 inches per year with the greatest amount falling as snow during winter. Mean monthly precipitation recorded at Enaville, Idaho, the closest weather station, ranges from under one inch in July to over five inches in February. Annual snowfall at Enaville is about 60 inches, 60 percent of which falls in December and January (National Weather Service, 1999).

CHAPTER 3

FIELD DATA COLLECTION PROGRAM

Introduction

In June 1997, fieldwork began to collect hydrogeologic data for a coordinated research effort for this project and for Wakefield (2001). Fieldwork necessary for these projects included installation of piezometers, measurement of groundwater and surface water heads, and collection of water quality samples. Wakefield (2001) constructed a numerical model of the shallow aquifer in the dredge materials and surrounding area at Cataldo Mission Flats to study and simulate groundwater behavior.

Construction of Shallow Wells

Piezometers PZ01 through PZ23 were installed into the Cataldo Mission Flats for water level measurement and water quality sampling (Figure 3). The area distribution of piezometers was selected to illustrate the groundwater gradient and to observe selected heavy metals concentration. Completion data for the piezometers in the Mission Flats is presented in Table 1. Water level measurements for the piezometers and selected surface water bodies are presented in Appendix A.

The piezometers were installed manually to cause the least disturbance to the dredge materials' surface. Piezometers PZ01 and PZ02 were constructed with 2-¼ inch ID stainless steel casing and screened intervals 2.5 feet long with size 20 (0.020 inches) slots located

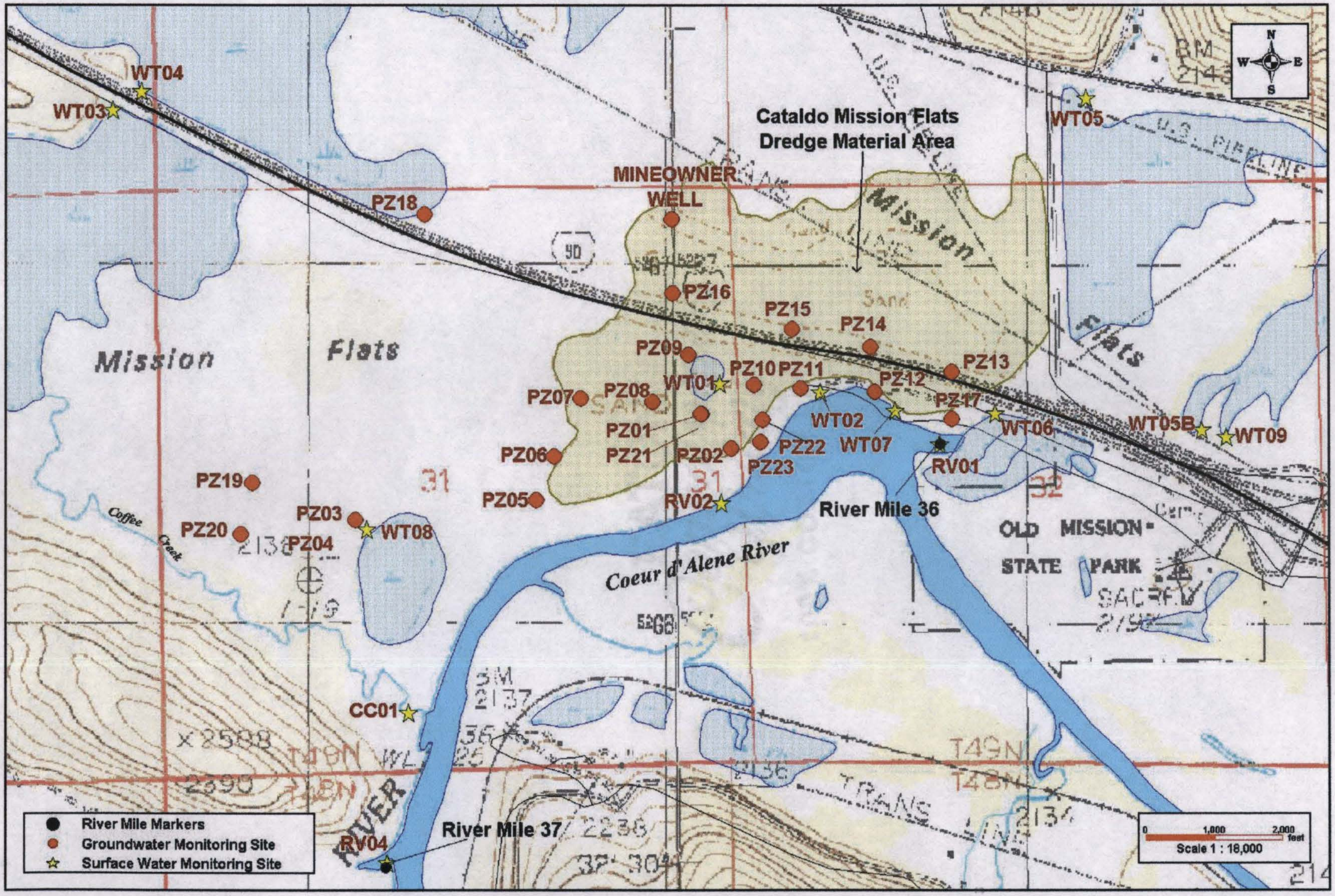

Figure 3. Groundwater and surface water measurement locations at Cataldo Mission Flats.

Piezometer	Location		Casing Elevation[1]	Piezometer	Screened	Seal	Sand Pack	Construction
	Long. (W)	Lat. (N)	(ft)	Depth[2] (ft)	Interval[2] (ft)	Interval[2] (ft)	Interval[2] (ft)	Type
PZ01	116 22 26.7	47 33 10.7	2152.07	14.60	12.10 -14.60	0 - 5 (approx)	None	A
PZ02	116 22 22.8	47 33 7.6	2141.50	10.80	8.30 - 10.80	0 - 4 (approx)	None	B
PZ03	116 23 13.1	47 33 1.4	2139.76	12.80	8.55 - 12.45	0 - 2; 5 - 8	8.00 - 12.80	C
PZ04	116 23 13.1	47 33 1.4	2139.93	5.40	1.15 - 5.05	0 - 2.00	2.00 - 5.00	C
PZ05	116 22 48.8	47 33 3.1	2143.26	12.75	8.50 - 12.40	0 - 5.80	Little to none	C
PZ06	116 22 46.3	47 33 7.0	2144.70	13.70	9.45 - 13.35	0 - 2.83	None	C
PZ07	116 22 42.7	47 33 12.2	2146.40	13.60	9.35 -13.25	0 - 4.50	None	C
PZ08	116 22 33.2	47 33 11.8	2149.40	14.40	10.15 - 14.05	0 - 6.00	None	C
PZ09	116 22 28.4	47 33 16.0	2151.24	15.85	11.60 - 15.50	0 - 5.83	None	C
PZ10	116 22 19.7	47 33 13.3	2146.24	13.90	9.65 - 13.55	0 - 2.50	None	C
PZ11	116 22 13.6	47 33 12.9	2140.69	12.70	8.45 - 12.35	0 - 5.00	None	C
PZ12	116 22 3.7	47 33 12.6	2142.86	12.80	8.55 - 12.45	0 - 2.70	None	C
PZ13	116 21 53.4	47 33 14.3	2147.32	14.05	9.80 - 13.70	0 - 4.30	None	C
PZ14	116 22 4.2	47 33 16.7	2151.77	15.70	11.45 - 15.35	0 - 6.50	None	C
PZ15	116 22 14.6	47 33 18.3	2147.55	12.65	8.40 -12.30	0 - 3.80	None	C
PZ16	116 22 30.4	47 33 21.6	2147.83	13.45	9.20 - 13.10	0 - 3.00	None	C
PZ17	116 21 53.5	47 33 10.1	2139.83	15.85	11.60 - 15.50	0 - 6.20	6.20 - 11.40	C
PZ18	116 23 3.3	47 33 29.0	2134.38	15.20	10.95 - 14.85	0 - 3.90	3.90 - 13.90	C
PZ19	116 23 26.9	47 33 4.8	2136.54	17.30	13.05 - 16.95	0 - 5.75	5.75 - 8.00	C
PZ20	116 23 28.4	47 33 0.2	2138.15	17.10	12.85 - 16.75	0 - 5.30	5.30 - 8.40	C
PZ21	116 22 26.8	47 33 10.7	2150.80	14.40	10.15 - 14.05	0 - 4.20	4.20 - 7.55	C
PZ22	116 22 18.6	47 33 10.2	2126.65	15.80	11.55 - 15.45	0 - 12.83	12.83 - 15.80	C
PZ23	116 22 18.9	47 33 10.2	2138.32	15.45	11.20 - 15.10	0 - 7.40	7.40 - 11.90	C

Type A Construction: 2.25-inch diameter stainless steel casing & screened section; uppermost 4.60 feet section consisting of 2-inch. ID PVC.

Type B Construction: Entire piezometer casing & screened section consists of 2.25-inch diameter stainless steel.

Type C Construction: Entire piezometer consists of 3/4-inch ID schedule 40 PVC. Hand cut perforations wrapped with 0.05-inch mesh screen.

[1] Elevations for all piezometers, except PZ22, surveyed to top of casing; PZ22 elevation is ground elevation. For ground elevation at PZ01 and PZ02, subtract 2.52 feet and 1.68 feet from the casing elevation; for all other piezometers subtract 1.0 foot from the casing elevation. Surveying was done using Leica Rapid-Static GPS equipment.

[2] Measurements are depths below ground surface.

Table 1. Construction data for piezometers installed at the Cataldo Mission Flats (from Wakefield, 2001).

approximately 0.5 feet from the bottom of the casing. Piezometers PZ03 through PZ23 were constructed of ¾ inch ID schedule 40 PVC with 3.9 feet long, slot 20 (0.020 inches) screened intervals covered by mesh screen.

The piezometers were hand-augured approximately 10 feet into the dredge materials until saturation no longer allowed the core to be removed. Piezometers PZ01 and PZ02 were installed using steel casing with a disposable HDPE drivepoint that was then driven another five feet deeper into the dredge materials to insure that the screened interval would be in the saturated zone. Piezometers PZ03 through PZ23 were installed by driving drill casing, fitted with an HDPE disposable drive point, into the augered hole approximately 10 feet below the water table. Piezometer casing sections were joined by couplers with PVC cement to obtain the desired length including screen. The completed piezometer was then inserted into the drill casing. The drill casing was then removed leaving the piezometer and drive point in the ground. Sand was added when the screened interval was not completely in contact with saturated sediments. Bentonite pellets were placed from the saturated interval to the annulus to prevent preferential downward movement of water. Sediment samples were collected at discrete sampling intervals from selected piezometers for grain size analysis.

Selection of Surface Water Sites

Surface water locations were selected to determine water quality and hydraulic heads. A total of sixteen surface water sites were chosen in the Mission Flats area (Figure 3). Surface water sites included four sites on the Coeur d' Alene River (RV01-RV04) one upstream from, one downstream from, and two adjacent to the Flats study area. Other surface water sites comprised two seeps within the dredge pile (WT02 and WT07), eight sites in the wetland lakes in the Flats (WT01, WT03, WT04, WT05, WT05B, WT06, WT08 and WT09), and two sites in local streams (Hayden Creek, CK01; and Coffee Creek, CC01).

Discharge data for the two river stations and two seep sites were obtained by two different methods (Figure 3). Discharge measurements were obtained for USGS gaging stations upstream of the Flats near Cataldo (station 12413500) and downstream of the Flats near Rose Lake (station 12413810). Discharge measurements from the two seeps (WT02 and WT07) were field estimated using a stopwatch to measure the time it took to fill a five-gallon bucket. The Cataldo Mission Flats numerical model provided additional discharge information for the seeps (Wakefield, 2001). No discharge measurement was made at Hayden Creek (CK01)).

Water Level Data Collection

Water level measurements were taken at both groundwater and surface water locations at the Cataldo Mission Flats area from July 1997 through December 1998 by Wakefield (2001). The groundwater (red circle) and surface water (yellow star) measurement locations are shown in Figure 3.

Groundwater level measurements began on a weekly basis in July 1997 after the completion of the first 17 piezometers. The groundwater measurement program was expanded in September 1997 when piezometers PZ18, PZ19, and PZ20 were added and again in March 1998 with PZ21, PZ22, and PZ23. Weekly groundwater measurements continued on all 23 piezometers until July 1998, when the measurement frequency decreased to once every two weeks, except for PZ06, PZ07, PZ08, PZ09, PZ14, and PZ16, which were discontinued because of limited access. From November 1998 to December 1998, bi-weekly measurements were taken only in piezometers PZ02, PZ11, and PZ17 because of their proximity to the Coeur d'Alene River.

Surface water elevation measurements coincided with the piezometer measurements at three locations. Stream gage height measurements were taken at wetland location, WT03, and Coffee Creek Bridge, CC01, by Wakefield (2001). The USGS provided stream gage height and discharge measurements of the Coeur d'Alene River upstream of the Flats area near Cataldo (station 12413500) and downstream of the Flats near Rose Lake (station 12413810). Note that gaging instrumentation accuracy is limited to ± 10%.

Water Quality Data Collection

Water quality samples were collected and field filtered (0.45-micron Millipore (μm)) and then transported to the University of Idaho's Analytical Laboratory for analysis of selected analytes from thirty-eight sites at the Cataldo Mission Flats area (Figure 3). Samples were collected for this study during the months of June through September 1997, and February and March 1998. Table 2 lists the elements included in the analysis and the maximum concentration limits (MCLs) (USEPA, 2002).

Twenty-three groundwater sites were sampled from piezometers installed for this study and Wakefield (2001) (Figure 3). Sixteen surface sites were sampled including four sites on the Coeur d'Alene River one upstream from (RV03), one downstream from (RV04), and two within the Cataldo Flats (RV01 and RV02) (Figure 3). Other surface water sites

Chemical	Units	Maximum Contaminant Level Classification	Maximum Contaminant Level
Aluminum	mg/L	Secondary MCL[2]	0.005 - 0.2 mg/L
Arsenic	mg/L	Primary MCL[1]	0.01 mg/L as of 01/23/06
Barium	mg/L	Primary MCL[1]	2.0 mg/L
Berylium	mg/L	Primary MCL[1]	0.004 mg/L
Cadmium	mg/L	Primary MCL[1]	0.005 mg/L
Calcium	mg/L	No MCL, No Action Level	
Chloride	mg/L	Secondary MCL[2]	250 mg/L
Chromium	mg/L	Primary MCL[1]	0.1 mg/L
Cobalt	mg/L	No MCL, No Action Level	
Copper[3]	mg/L	Secondary MCL[3]	1.0 - 1.3 mg/L
Iron	mg/L	Secondary MCL[2]	0.3 mg/L
Lead[3]	mg/L	Secondary MCL[3]	0.015 mg/L
Magnesium	mg/L	No MCL, No Action Level	
Manganese	mg/L	Secondary MCL[2]	0.05 mg/L
Molybdenum	mg/L	No MCL, No Action Level	
Nickel	mg/L	Primary MCL[1]	0.1 mg/L
Potassium	mg/L	No MCL, No Action Level	
Silicon	mg/L	No MCL, No Action Level	
Silver	mg/L	Secondary MCL[2]	0.1 mg/L
Sodium	mg/L	No MCL, No Action Level	
Sulfate	mg/L	Secondary MCL[2]	250 mg/L
Vanadium	mg/L	No MCL, No Action Level	
Zinc	mg/L	Secondary MCL[2]	5.0 mg/L
Temerature	Celsius	No MCL, No Action Level	
Conductivity	m/v	No MCL, No Action Level	
pH	pH	Secondary MCL[2]	6.5 - 8.5
Alkalinity	mg/L	No MCL, No Action Level	

[1] The U.S. Environmental Protection Agency established Maximum Contaminant Levels (MCLs) for contaminants as part of the Federal Safe Drinking Water Act (SDWA). The MCL is the maximum allowed concentrations of a particular contaminant in drinking water for public water systems. Detection of these contaminants in public drinking water supplies at or below the MCL is associated with little or no risk. For more information about drinking water MCLs please refer to the Code of Federal Regulations, 40 CFR Part 141.

[2] The U.S. Environmental Protection Agency established Secondary Maximum Contaminant Levels (MCLs) for contaminants as part of the Federal Safe Drinking Water Act (SDWA). These regulations control contaminants in drinking water that primarily affect the aesthetic qualities relating to the public acceptance of drinking water. At considerably higher concentrations of these contaminants, health implications may also exist as well as aesthetic degradation. The regulations are not Federally enforceable but are intended as guidelines for the States.

[3] Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

Table 2. Elements included in the analysis and the maximum concentration limits (MCLs) (EPA, 2002).

comprised two seeps within the dredge materials (WT02 and WT07), eight sites in the wetland lakes in the Flats (WT01, WT03, WT04, WT05, WT05B, WT06, WT08, and WT09), and one site in each of the creeks (Hayden, CK01 and Coffee, CC01) (Figure 3).

Groundwater samples were collected using a Wattera manual pump. The piezometers were purged of three well volumes of water prior to sampling to insure that water samples were from the formation and not residual water. Water was collected into two pre-cleaned high-density polyethylene (HDPE) bottles, one each for cation and anion analysis. The samples were refrigerated or kept ice-covered in a cooler until analyzed.

In addition, the temperature, conductivity, pH, and Eh of each sample was measured in the field using a YSI model 3500 multifunction water quality monitor. The YSI-3520 conductivity cell was equilibrated in YSI conductivity calibrator solution, the YSI-3530 pH electrode was calibrated with 4.00 and 7.00 buffer solutions, and the YSI-3540 Eh probe was calibrated using a 0.1 M potassium ferrocyanide and 0.5 M potassium ferricyanide solution.

Water quality samples collected in June, August, and September 1997 and February and March 1998 were field filtered and acidified at the Cataldo Mission Flats site. The July 1997 water quality samples were filtered and acidified in the laboratory within 24 hours of collection. The pre-cleaned filters were 0.45μm filters, and preservation of the cation sample was accomplished with concentrated Seastar Ultra-pure concentrated nitric acid to a $\mathrm{pH} < 2$.

All chemical analyses were performed at the University of Idaho's Analytical Laboratory. Environmental Protection Agency (EPA) method 200.7 was followed for determination of cadmium and zinc by inductively coupled plasma (ICP) atomic emission spectrometry (AES) using a Perkin Elmer P40 spectrometer. Detection limits by this method are 0.0023 mg/L for cadmium and 0.0025 mg/L for zinc. Lead concentrations were determined using EPA method 239.2 by graphite furnace atomic absorption spectrometry (GFAAS) using a Perkin Elmer 5100 spectrometer with a detection limit for lead of 2.9 μg/L. Alkalinity was determined by potentiometric titration using 1.5 N sulfuric acid and EPA method 310.1 for which the low detection limit is 2.0 mg/L. Inorganic anion determinations were by ion chromatography using EPA method 300.0 and a Dionex 100 ion chromatograph.

Dissolved cadmium, lead, and zinc concentration data were combined with discharge data to compute instantaneous loads of cadmium, zinc, and lead at four sites on the Coeur d'Alene River and two seep sites (WT02 and WT07). The river sites included two upstream sites, RV03 from this study and USGS site #12413500 at Cataldo (Figure 2), and two downstream sites, RV04 from this study (Figure 2) and USGS site #12413810 at Rose Lake (Figure 1). Instantaneous loads, in pounds per day, were computed by multiplying the following four variables: instantaneous discharge, in cubic feet per second; constituent concentration, in milligrams per liter; a conversion factor of 0.0027 to convert flow and concentration units; and a conversion factor of 2,000 to convert tons to pounds.

<u>Other Data Collection</u>

Hydraulic conductivity of the dredge materials was determined for this study and Wakefield (2001). Grain size analysis using standard shaker and sieves was performed on sediment samples from selected piezometers. An aquifer test was conducted on the dredge materials to support hydraulic conductivity values derived from the grain size analysis.

Hydraulic conductivity estimates of the sediment samples were calculated with the

Hazen equation: $K = C\,(d_{10})^2$

K is Hydraulic conductivity (cm/sec)

d_{10} is the effective grain size (cm)

C is a coefficient ranging from 40 to 150 depending on sediment type

The effective grain size was converted to centimeters required by the equation, and resulting hydraulic conductivities converted to feet/day for this study. The coefficient C ranges from 40 to 80 for fine, poorly sorted sands, to 120 to 150 for coarse, well-sorted sands. Appendix B presents a summary of the effective grain size, uniformity coefficients, and hydraulic conductivity estimates of the Flats dredge materials. Grain size analysis curves are presented in Wakefield (2001).

Sediment samples collected during piezometer installation at the Mission Flats found that the dredge materials consist mostly of well sorted silty to fine sands and some poorly sorted silts and silty sands with an average effective grain size of 0.0020 inches. Fetter (1994) reports the Hazen equation is intended for sands with an effective grain size ranging from 0.004 to 0.12 inches. However, Mabes (1977) compares several equations that estimate hydraulic conductivity to laboratory values using samples from mine tailings in the Bunker Hill Central Impoundment Area (CIA). The CIA samples contained sediments within the fine sand to silt range, comparable to the sediments from the Flats. Mabes (1977) found that the Hazen equation estimates were closer to the laboratory values of hydraulic conductivity than the other equations. The hydraulic conductivity range for the Flats sediment samples was found to be 5 to 27 feet/day.

An aquifer test was conducted on September 15, 1998 on the Flats dredge materials to support hydraulic conductivity estimates. Piezometer PZ01 operated as the pumping well while PZ21, located five feet from PZ01 and completed to a similar depth of 14 feet, served as the observation well. Duration of the aquifer test was 190 minutes. Time, drawdown, and pump discharge data are presented in Wakefield (2001). Data from the aquifer test were analyzed with the program PUMPTEST®. The dredge materials have an estimated hydraulic conductivity range of 0.04 to 26 feet/day. This value is consistent with hydraulic conductivity estimates of the tailings using the Hazen equation (Appendix B, piezometer PZ14). Storage coefficients were 0.007 for early time and 0.05 for the late time.

Global positioning system (GPS) equipment was used to determine horizontal location and vertical elevation of piezometers and selected surface water sites at the Flats. Location and elevation information was obtained using *Leica System 300 Rapid-Static Global Positioning System* equipment. Accuracy limits of this equipment are ± 0.07 feet in the horizontal (longitude and latitude) directions and ± 0.13 feet in the vertical (elevation) direction.

The National Oceanic and Atmospheric Administration (NOAA) (1999) provided precipitation data for this study. Precipitation data in the analysis represent the total precipitation from daily records recorded at Enaville, Idaho, approximately 10 miles east of Cataldo Mission Flats. Daily data not available from Enaville were obtained from Kellogg, Idaho, located approximately seven miles east of Enaville. The precipitation patterns at the Cataldo Mission Flats are comparable to Enaville and Kellogg with prevailing winds driving rapid moving weather systems between Lolo Pass to the east and Fourth of July Pass to the west. Precipitation data are presented in Appendix C.

CHAPTER 4

PRESENTATION AND ANALYSIS OF WATER LEVEL DATA

Introduction

This chapter includes a presentation and analysis of water level data from the Cataldo Mission Flats study. The collected field data and geologic properties were integrated to create a hydrogeologic conceptual model of the shallow aquifer at Cataldo Mission Flats. Important data listed by Wakefield (2001) for model construction included physical boundaries, topographic data, aquifer geologic composition for hydraulic conductivity distributions, precipitation and evapotranspiration rates, water table contour maps, groundwater and surface water hydrographs, and identification of groundwater recharge and discharge areas. The conceptual model serves as a simplified representation so that the groundwater system can be analyzed.

The data presented are from this study and from Wakefield (2001). Additional data were provided from the National Oceanic and Atmospheric Administration (NOAA) and from the U.S. Geological Survey (USGS).

Site Stratigraphy

The Cataldo Mission Flats are located in an area of the Coeur d'Alene River characterized by low energy featuring relatively flat topography and river gradients. This low-energy environment typically results in deposition of finer-grain sediments. The borehole log from the Mine Owners' Association well drilled in May 1998 provided information on sediment distribution (Figure 4).

The Mine Owner's Well has a total depth of 110 feet and is located 650 feet north of piezometer PZ16 at the northwestern corner of the dredge materials. The borehole log from the Mine Owner's Well indicates that a 67-foot thick clay confining layer separates the dredge materials from the underlying fluvial sediments. Wakefield (2001) concluded that PZ16 and the Mine Owner's Well are completed in two different aquifers. That conclusion was extended to propose that all PZ piezometers in this study were completed in a higher aquifer that the Mine Owner's Well.

The distribution of the piezometer network at the Flats was chosen to determine the vertical and horizontal extend of the dredge materials. Wakefield (2001) produced conceptual cross-section stratigraphic models of cross-section A-A' (Figure 5) and B-B' (Figure 6). Cross sections A-A' and B-B' for the Flats are shown in plan view in Figure 4.

Sediment samples were collected during piezometer installation. The sediment samples showed that the piezometers located within the dredge materials (PZ01, PZ02, PZ05-PZ16, PZ21, and PZ23) consist mostly of well-sorted silty to fine sands and some poorly-sorted silts and silty sands (Table 3). The sediment samples from the piezometers located outside the dredge materials, in the fluvial sediments (PZ03, PZ04, PZ17-PZ20, and PZ22), contain more fine-grain silts, with some silty to fine sands (Table 3). Hydrogeologic properties of the sediments including horizontal and vertical hydraulic conductivity, porosity, specific yield and specific storage are presented in Table 3.

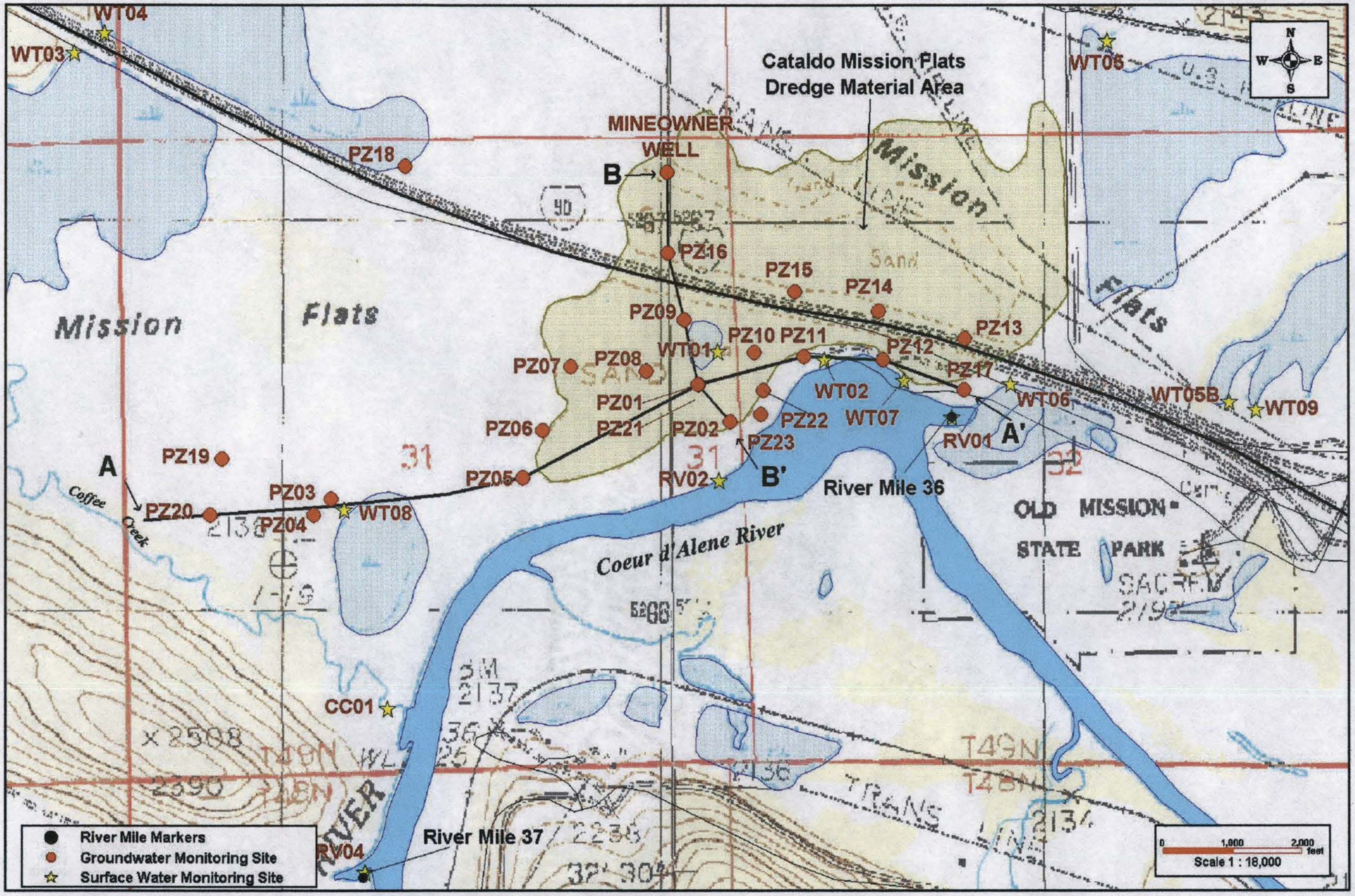

Figure 4. Locations of conceptual cross sections A-A' and B-B' at Cataldo Mission Flats.

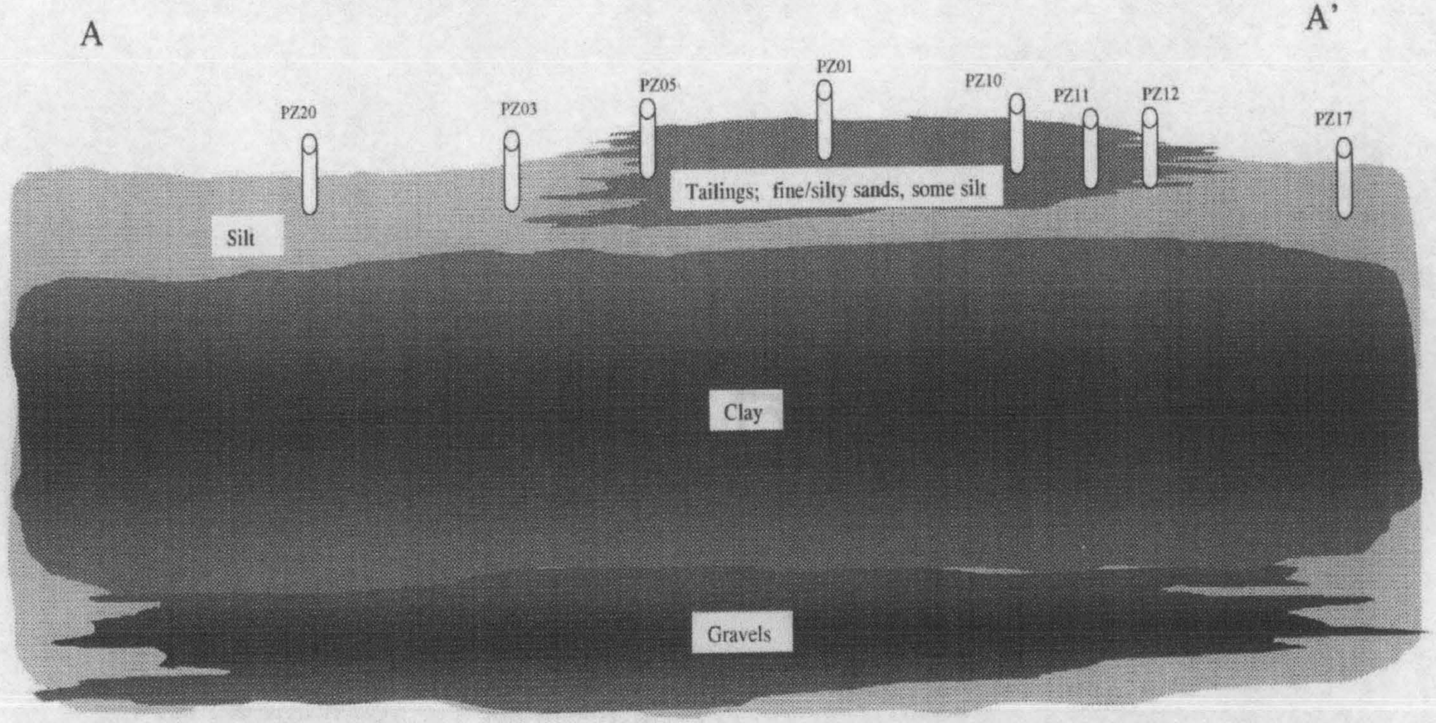

Figure 5. Conceptual cross section A-A' (from Figure 4) of Cataldo Mission Flats (from Wakefield, 2001).

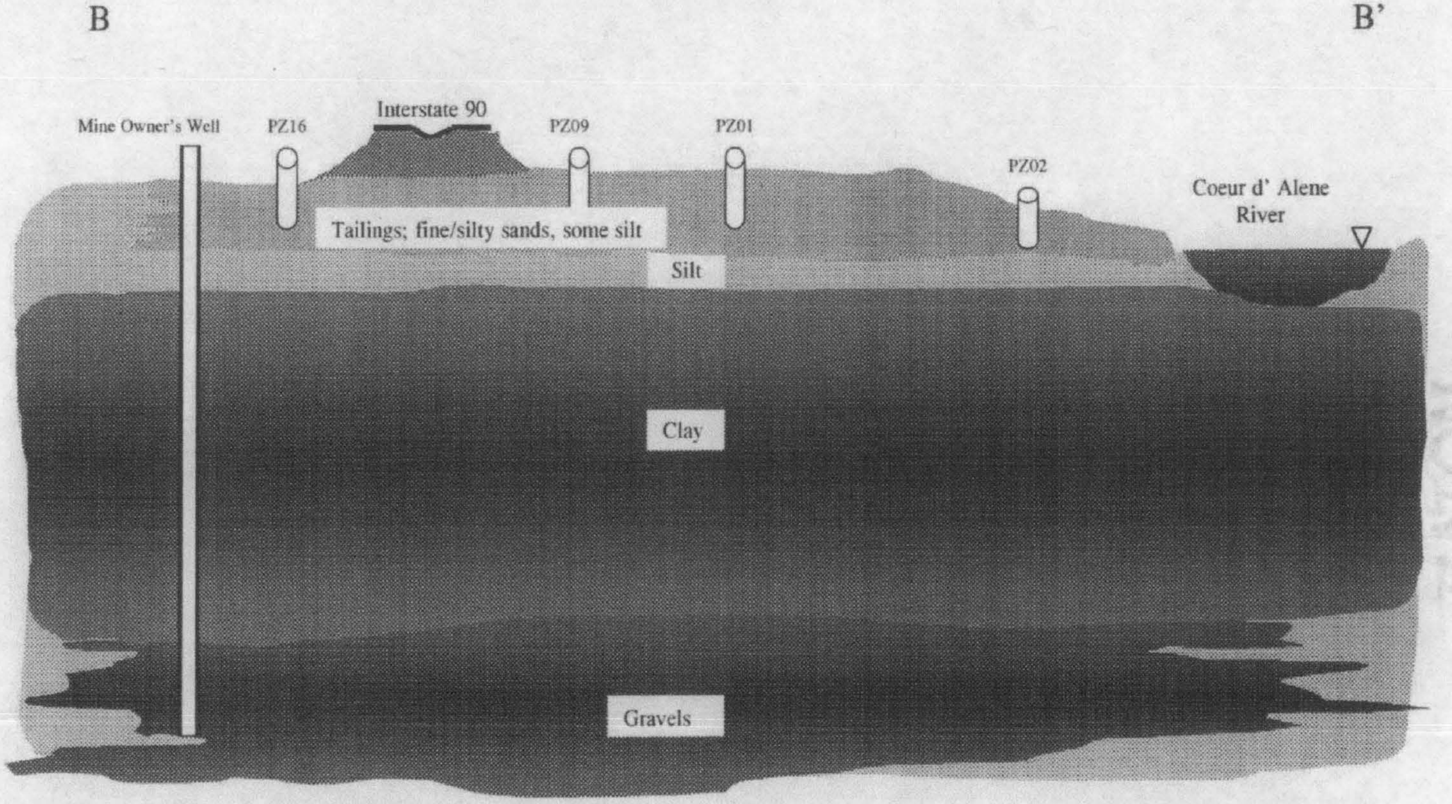

Figure 6. Conceptual cross section B-B’ (from Figure 4) of Cataldo Mission Flats (from Wakefield, 2001).

HYDRAULIC PROPERTY	REFERENCE	SEDIMENT					
		Gravel	Fine Sand	Silty Sand	Silt	Clay	Shale
Horizontal Hydraulic Conductivity (ft./day)	Anderson & Woessner (1992)	5.0×10^{2} to 1.0×10^{4}	1.0×10^{-1} to 3.0×10^{1}	2.0×10^{-2} to 6.0×10^{1}	4.0×10^{-3} to 1.0×10^{1}	1.0×10^{-7} to 1.0×10^{-3}	1.0×10^{-7} to 5.0×10^{-4}
	Freeze & Cherry (1979)	2.8×10^{2} to 2.8×10^{5}	8.5×10^{-3} to 2.8×10^{3}	2.3×10^{-2} to 2.3×10^{2}	5.7×10^{-4} to 5.7×10^{0}	2.0×10^{-7} to 5.7×10^{-4}	2.8×10^{-8} to 2.8×10^{-4}
	Hazen Equation[1]	—	1.6×10^{1} to 2.7×10^{1}	4.0×10^{-1} to 1.5×10^{1}	4.0×10^{-2} to 3.0×10^{-1}	—	—
Vertical Hydraulic Conductivity (ft./day)	Estimated[2]	2.8×10^{1} to 1.4×10^{5}	8.5×10^{-2} to 1.4×10^{3}	2.3×10^{-3} to 1.1×10^{2}	5.7×10^{-5} to 5.0×10^{0}	1.0×10^{-8} to 5.0×10^{-4}	7.0×10^{-9} to 2.5×10^{-4}
Porosity	Driscoll (1986)	0.25 - 0.40	0.25 - 0.40	0.25 - 0.50	0.35 - 0.50	0.45 - 0.55	0.0 - 0.10
	Freeze & Cherry (1979)	0.25 - 0.40	0.25 - 0.50	0.25 - 0.50	0.35 - 0.50	0.40 - 0.70	0.0 - 0.10
Effective Porosity	Estimated[3]	0.20 - 0.35	0.20 - 0.35	0.20 - 0.45	0.10 - 0.40	0.05 - 0.25	0.0 - 0.10
Specific Yield	Anderson & Woessner (1992)	0.13 - 0.44	0.01 - 0.46	0.01 - 0.46	0.01 - 0.39	0.01 - 0.18	No value listed
	Fetter (1994); Driscoll (1986)	0.12 - 0.35	0.10 - 0.28	0.03 - 0.28	0.03 - 0.19	0.0 - 0.05	0.005 - 0.05
	Aquifer Test (1998)	-	-	0.05	-	-	-
Specific Storage ($ft.^{-1}$)	Anderson & Woessner (1992)[4]	1.5×10^{-5} to 3.0×10^{-5}	1.5×10^{-4} to 3.0×10^{-4}	1.9×10^{-4} to 2.2×10^{-3}	2.4×10^{-4} to 4.2×10^{-3}	2.8×10^{-4} to 6.1×10^{-3}	Less than 1.0×10^{-6}

[1] Range of values from Chapter 3, Table 2

[2] Freeze and Cherry (1979) report studies with horizontal to vertical conductivity ratios between 2 and 10 for fluvial deposits.

[3] Effective porosity estimates based on porosity actually available for water flow

[4] Values for silty sand and silt are estimated, others are from listed reference.

Table 3. Ranges of hydrogeologic property values for sediments at Cataldo Mission Flats (from Wakefield, 2001).

Groundwater Flow Patterns and Gradients

Spatial and temporal groundwater flow patterns and gradients for the Cataldo Mission Flats dredge materials and fluvial sediments were determined from water level measurements taken during the study period from July 1, 1997 to December 31, 1998 by Wakefield (2001). Piezometers were completed to similar depths throughout the Flats, the depth to water was measured, and the water table referenced to sea level to contour the data. Wakefield (2001) produced water table contour maps for the Flats numerical model using the MODFLOW program on measurement dates November 19, 1997, March 13,1998, May 29, 1998, and July 10, 1998 (Figures 7 - 10). Figure 11 is a composite hydrograph illustrating groundwater levels, surface water stage, and precipitation data at the Cataldo Mission Flats for the study period.

Spatial Trends in Water Level Data

Spatial trends in groundwater flow at the Cataldo Mission Flats were determined from the water table contour maps (Figures 7-10) and the composite water level hydrograph (Figure 11). A review of the water table contour maps and composite hydrograph, done for this research, generally agrees with Wakefield's (2001) observations that groundwater follows a northeast to southwest direction with groundwater discharge into the Coeur d'Alene River where the river bends and that the horizontal gradient follows the surface topography.

The steepness of the water table contours between the dredge materials and the river indicates the dredge materials and fluvial sediments have low permeability (Figures 7-10).

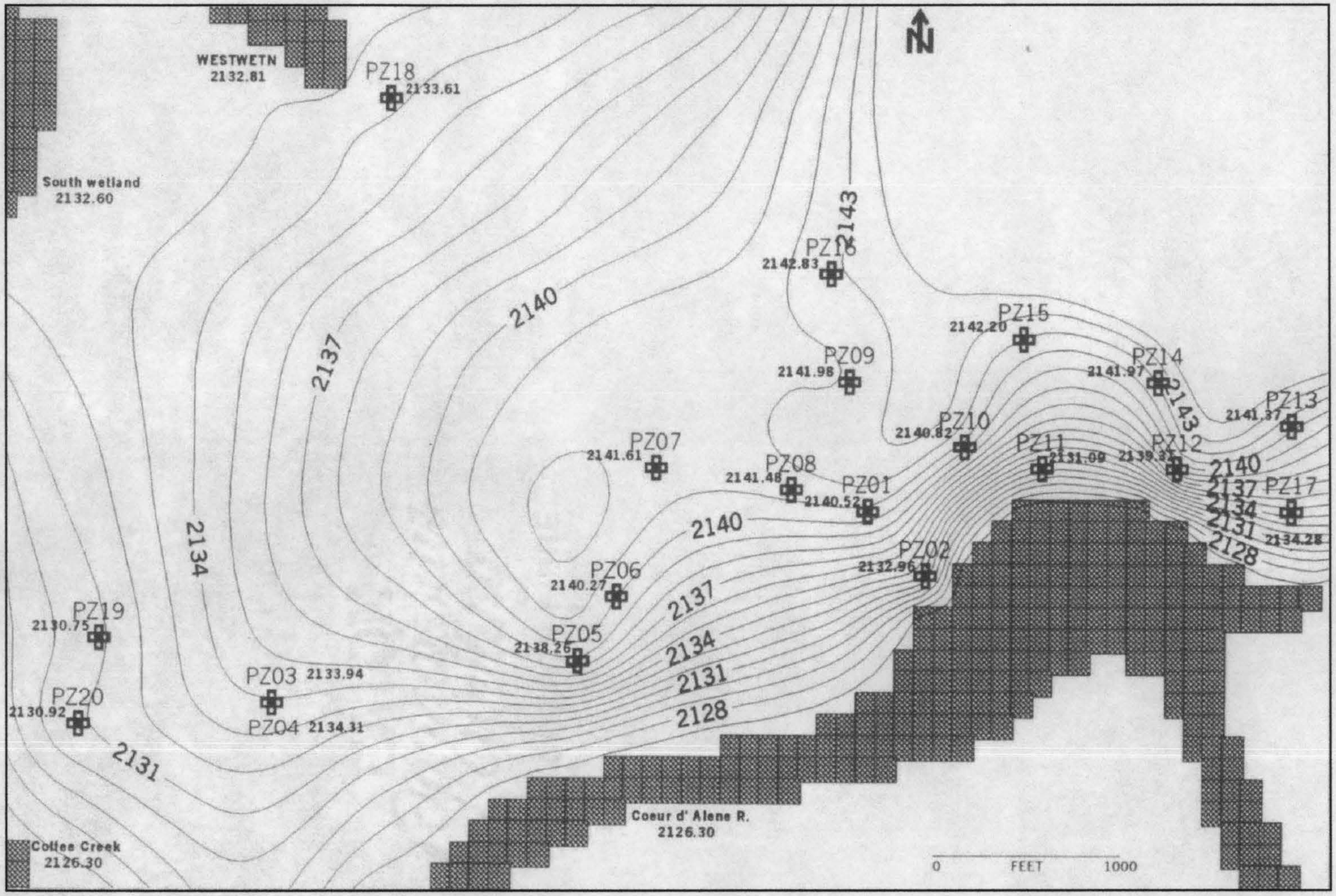

Figure 7. Groundwater and surface water heads and contours on measurement date November 19, 1997 at Cataldo Mission Flats (all measurements in feet, one-foot contour intervals) (from Wakefield, 2001).

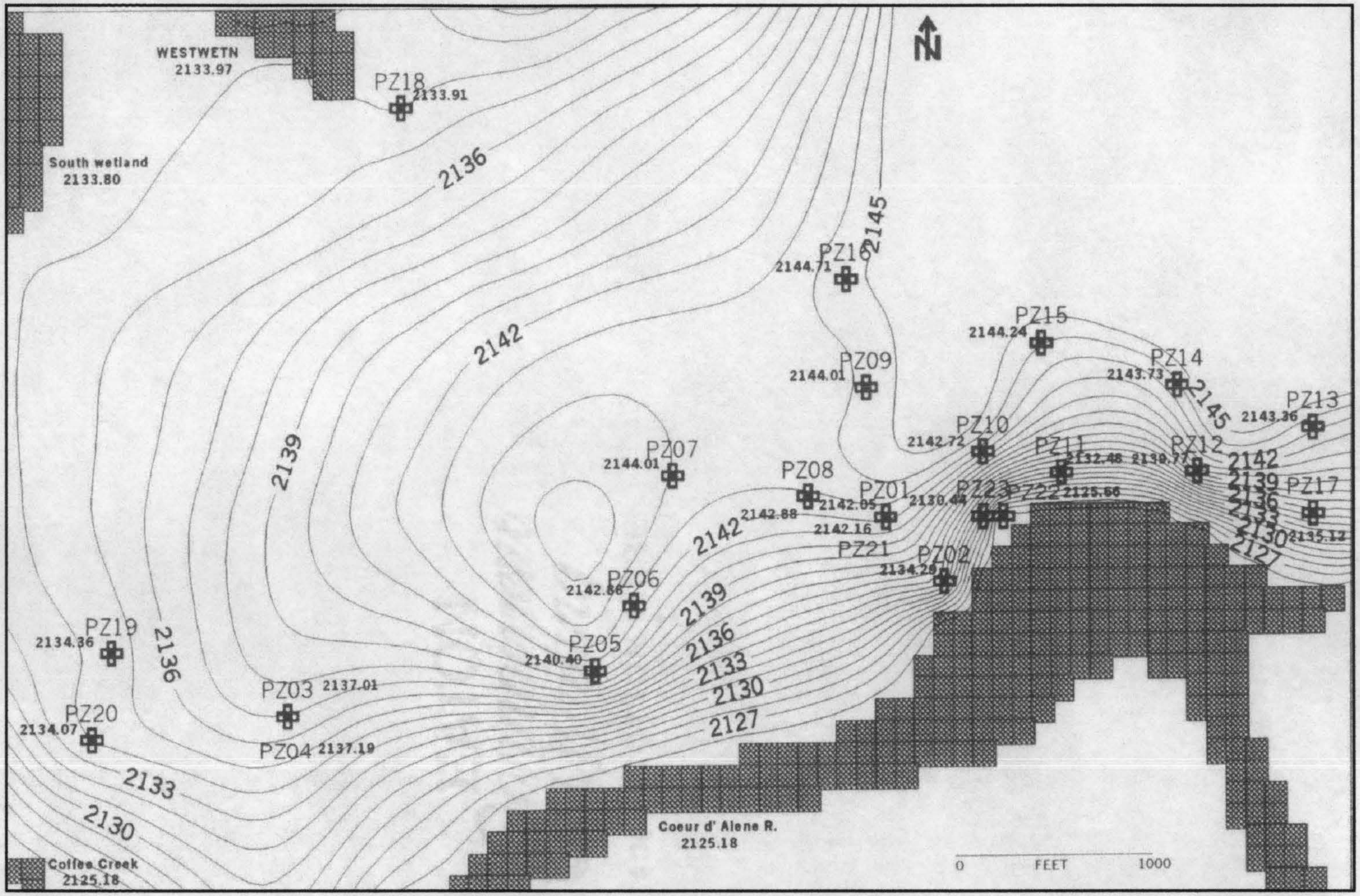

Figure 8. Groundwater and surface water heads and contours on measurement date March 13, 1998 at Cataldo Mission Flats (all measurements in feet, one-foot contour intervals) (from Wakefield, 2001).

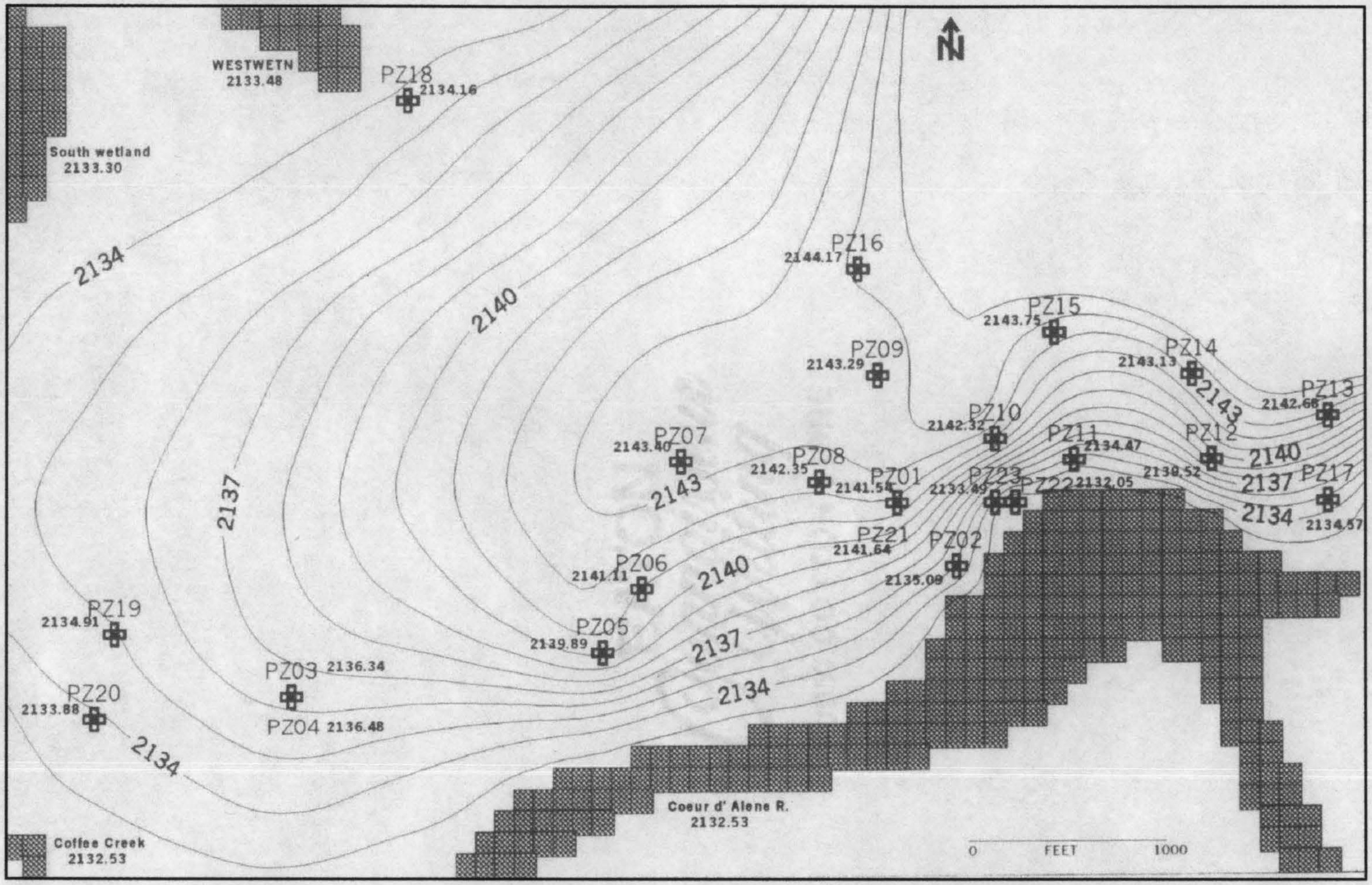

Figure 9. Groundwater and surface water heads and contours on measurement date May 29, 1998 at Cataldo Mission Flats (all measurements in feet, one-foot contour intervals) (from Wakefield, 2001).

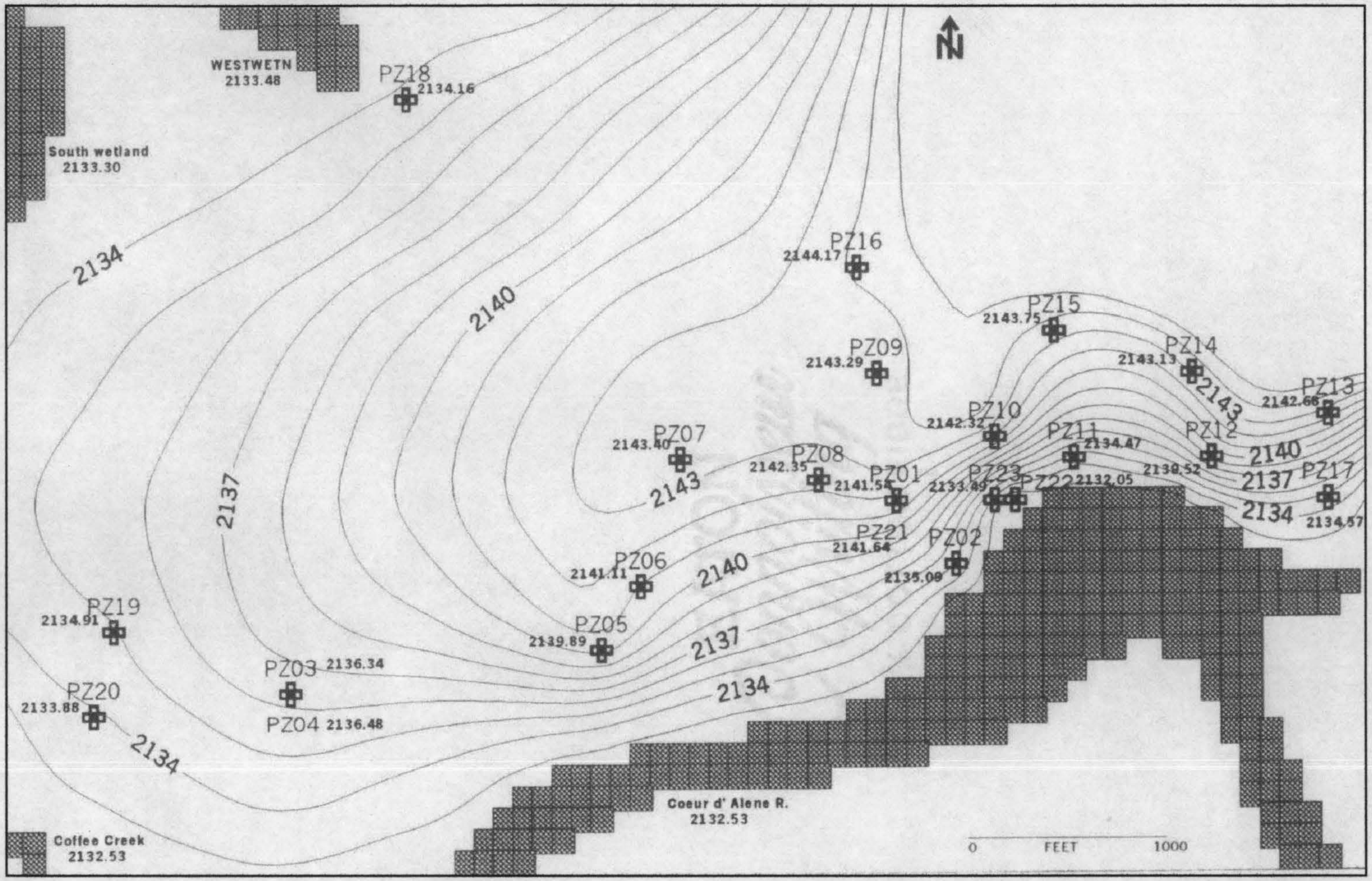

Figure 10. Groundwater and surface water heads and contours on measurement date July 10, 1998 at Cataldo Mission Flats (all measurements in feet, one-foot contour intervals) (from Wakefield, 2001).

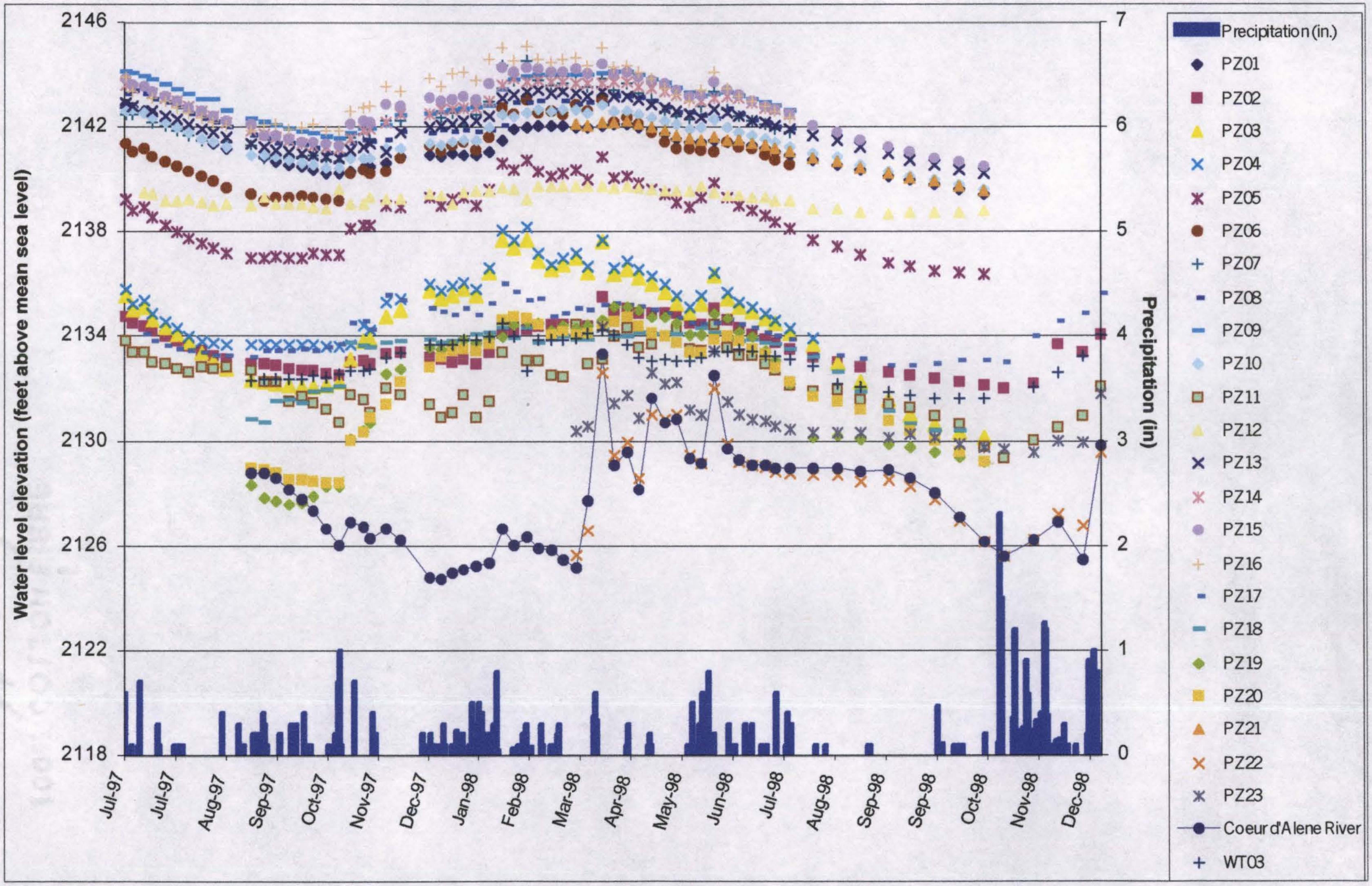

Figure 11. Composite groundwater and surface water hydrographs at Cataldo Mission Flats for the measurement period July 1997 – December 1998.

As shown in Figures 7-10, water levels in piezometers developed in the dredge materials (PZ01, PZ02, PZ05–PZ16, and PZ21), in piezometers developed in the fluvial sediments (PZ03, PZ04, and PZ18–PZ20), and in both wetlands (South wetland and WESTWETN) are always higher than the water level of the Coeur d'Alene River at Coffee Creek. This pattern is also shown in the composite hydrograph (Figure 11).

The composite hydrograph (Figure 11) and low permeability of the dredge materials and fluvial sediments (Appendix B) indicate that the dredge materials and fluvial sediments constitute a perched water table system. As shown in Figures 7-10, the steep horizontal gradient shown in the water table contours, as the dredge materials approach the Coeur d'Alene River, also suggest the interpretation that the dredge materials and fluvial sediments comprise a perched water table system.

Temporal Trends in Water Level Data

The Coeur d'Alene River system experienced an exceptionally high water event during 1997. The USGS (2003) calculates monthly mean streamflow records for the Coeur d'Alene River system based on historical data from 1911 to present day. Records indicate that the 1997 monthly mean streamflow exceeded the 1911 to 2001 mean of monthly streamflow nearly every month in 1997, except February, November, and December (USGS, 2003). Table 4 compares the 1911 to 2001 mean of monthly streamflow to the 1997 monthly mean streamflow at the USGS stream gage site (#12413500) located at Cataldo, Idaho, approximately two miles upstream from the Cataldo Mission Flats.

USGS Site 12413500 at Cataldo Bridge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean of Monthly Streamflows 1911-2001	1,836	2,572	3,333	7,286	6,951	2,684	908	483	417	569	1,340	1,986
1997 Monthly Mean Streamflow (cfs)	4,139	2,542	5,296	9,050	13,690	4,704	1,381	623	531	693	1,253	1,009
Comparison of 1997 Monthly Mean Streamflow to Mean of Monthly Streamflow 1911-2001 (percent)	225%	99%	159%	124%	197%	175%	152%	129%	127%	122%	94%	51%

Table 4. Comparison of 1997 monthly mean streamflow to the 1911-2001 mean of monthly streamflow at the USGS Gage Site # 12413500 near Cataldo, Idaho (USGS, 2003).

River stage variations (represented by Coeur d'Alene River) in the Coeur d'Alene River appear to have negligible impact on groundwater levels in the remaining piezometers (Figure 11). As the river stage declined in the fall months of 1997 and 1998 (due to the annual Coeur d'Alene Lake drawdown) most of the piezometers in the dredge materials show increasing groundwater levels during the time period. Conversely, groundwater levels decreased during late spring and summer of 1998, even though the Coeur d'Alene River was at a constant river stage of about 2128 feet during that period (Figure 11). As shown in Figure 11, the Cataldo Mission Flats dredge materials and fluvial sediments respond primarily to precipitation during the late winter and spring, and show little or no influence from the Coeur d'Alene River.

Recharge Trends in Water Level Data

Recharge to the Flats dredge materials and fluvial sediments appears to be predominated by precipitation and infiltration in the summer and fall, rather than horizontal groundwater movement from the Coeur d'Alene River or the wetlands and streams to the north (Figure 11). This recharge pattern further indicates that the Flats constitute a perched system with significantly greater recharge occurring in the dredge materials than the surrounding fluvial sediments due to the sparse vegetation and coarser sediments of the dredge materials.

The annual average recharge rate for the dredge materials and fluvial sediments was obtained by subtracting the annual estimated evapotranspiration rate (24 inches/year) from the annual average precipitation rate (25 inches/year) for a net recharge of 1 inch/year

(Wakefield, 2001). This "annual average" approach does not take into account the effects of extreme conditions. If the annual precipitation rate increases significantly with an average evapotranspiration rate or if the Cataldo Mission Flats were completely inundated by an extreme flood event, net recharge rate would probably exceed 1 inch/year. Conversely, if the annual precipitation rate was average with higher-than-average temperature for a sustained period, the evapotranspiration rate would most likely increase, resulting in a net decrease in recharge.

Calculated and Observed Groundwater Discharge from Riverbank to River

Groundwater discharge from the Cataldo Mission Flats dredge materials to the Coeur d'Alene River was observed in the field at various locations. Discharge, in the form of seeps from the riverbank, was observed near piezometers PZ22 and PZ23, in compact red-brown sands containing gravel and cobbles, characteristic of tailings impacted material. During low-water periods, culverts were observed discharging water from sites WT02, located near PZ11, and WT07, located between PZ12 and PZ17. Red-brown stained slimes, characteristic of tailings impacted material, were observed on the riverbank below the culvert discharge points. Field estimated discharge rates for the combined flow from seeps and culverts ranged from 10 to 50 gallons per minute (gpm). The Flats numerical model estimated that total groundwater discharge to the Coeur d'Alene River over the reach of interest ranged from 1.4 to 7.8 gpm (Wakefield, 2001).

Bank Storage Trends in Water Level Data

Bank storage occurs when a rapid rise in river stage causes water to move from the river into the riverbanks caused by storm precipitation, rapid snowmelt, or, in the case of the Cataldo Mission Flats, by backwater effects from a downstream dam (Post Falls Dam). Most of the volume of river water entering the riverbanks returns to the river within a few days or weeks (Winter, 1998). The 1997 high water event resulted in the Coeur d'Alene River overtopping the banks and floodplain at the Flats on several occasions (Zilka, 2001). When this occurs, widespread recharge to the water table can take place throughout the flooded area and increase the total bank storage capacity.

Bank storage at the Flats was investigated by Wakefield (2001). Groundwater levels were measured in five piezometers (PZ02, PZ11, PZ17, PZ22, and PZ23) all located within 100 feet from the Coeur d'Alene River (Figure 4). River stage measurements were recorded from the confluence of Coffee Creek and the Coeur d'Alene River by Wakefield (2001). Figure 12 compares the Coeur d'Alene River stage to the hydrographs for piezometers PZ02, PZ11, PZ02, PZ22, and PZ23 during the period July 1997 through December 1998.

Piezometer PZ22 shows marked river influence upon groundwater levels, exactly tracking surface water. Piezometer PZ23 may exhibit slight river influence. All remaining piezometers (PZ01 – PZ21) exhibited no river influence. PZ22 was constructed in the river channel sediments and, most likely, below the dredge materials where the remaining piezometers were developed. The lack of river influence with groundwater levels for the remaining piezometers is further evidence that the dredge materials and fluvial sediments constitute a perched water table system that is not connected to the Coeur d'Alene River.

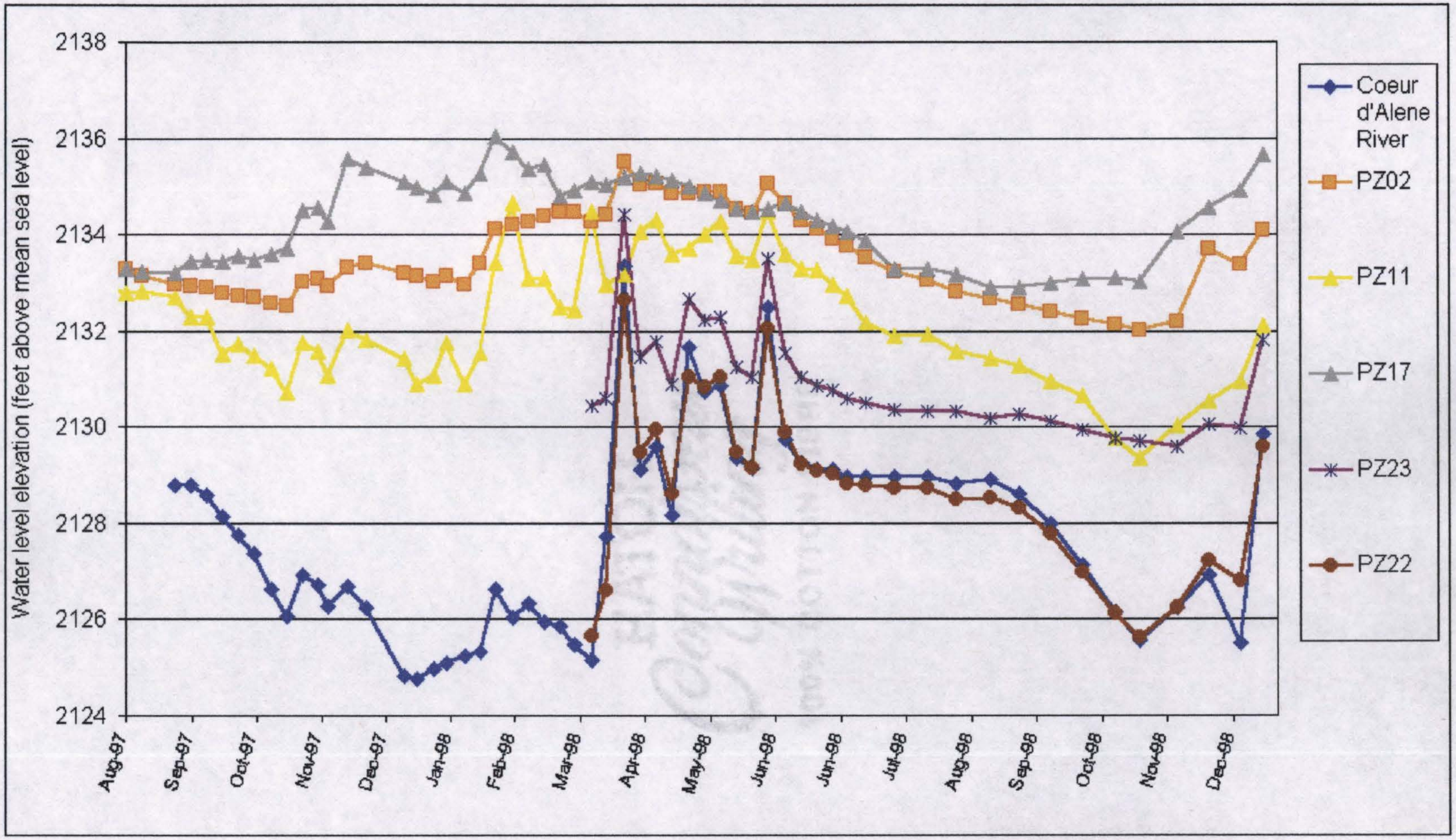

Figure 12. Comparison of Coeur d'Alene River stage to hydrographs for piezometers PZ02, PZ11, PZ17, PZ22, and PZ23.

CHAPTER 5

PRESENTATION AND ANALYSIS OF WATER QUALITY DATA

Introduction

This chapter includes a presentation of surface water and groundwater quality data and an analysis of metals loadings for the Cataldo Mission Flats study. The data presented are from this study and the U.S. Geological Survey (USGS). The water quality analysis was limited to dissolved cadmium, lead, and zinc, the principal dissolved metals of concern in the Coeur d'Alene River system. Water quality data sampling trips were taken on June 1997, July 1997, August 1997, September 1997, February 1998, and March 1998.

Dissolved cadmium, lead and zinc concentrations recorded from groundwater and surface water sampling sites in this study are presented in Appendix D. Graphs presenting dissolved metals concentrations plotted versus sampling site locations for each sampling trip are included in Appendix E. Maps representing the spatial distribution of dissolved metals concentrations for the September 15, 1997 and the February 23-24, 1998 (including March 6, 1998) sampling trips are presented in Appendix F.

Temporal Trends in Water Quality Data

Water quality samples were collected at the Cataldo Mission Flats during six sampling trips from June 1997 through March 1998. Two groundwater sites and six surface water sites were sampled for the June 15, 1997 sampling trip, conducted during the installation of the piezometer field and a sustained high-flow event in the Coeur d'Alene River. One groundwater site and ten surface water sites were sampled on July 13, 1997, conducted during near the end of the sustained high-flow event. Nine groundwater and six surface water sites were sampled for the August 12, 1997 sampling trip, conducted at low-flow conditions during summer-level (2125 feet elevation) lake stage for Coeur d'Alene Lake. The final, and most comprehensive sampling trip for 1997, was performed on September 15, 1997, with samples collected from all groundwater sites, except PZ04 and PZ16, eleven surface water sites, and after about two months of low-flow conditions during summer-level lake stage.

The February 23-24, 1998 sampling trip included all groundwater sites, except PZ12 and PZ18, eleven surface water sites, and was conducted near the recession end of a rain-on-snow event in the Coeur d'Alene River and after six months of low-level lake stage. The final sampling trip of March 6, 1998 included piezometers PZ12, PZ18, and three additional piezometers (PZ21, PZ22, and PZ23) installed for this study and Wakefield (2001).

Temporal Trends in Dissolved Cadmium Data

As shown in the table (Appendix D1) and graph (Appendix E1), concentrations of dissolved cadmium in groundwater ranged from 0.0027 to 0.46 mg/L. All groundwater sites, except piezometers PZ05 and PZ06, had concentrations of dissolved cadmium greater than the Maximum Contaminant Level (MCL) of 0.005 mg/L (Table 2). Cadmium shows no significant temporal trend in groundwater.

Concentrations of dissolved cadmium in surface water ranged from 0.0023 to 0.023 mg/L, as shown in the table (Appendix D1) and graph (Appendix E2). All surface water sites had concentrations of dissolved cadmium greater than the MCL (0.005 mg/L). Cadmium shows an overall temporal trend of increasing concentrations in surface water, except in seep sites, WT02 and WT07, which show a slight temporal trend of decreasing concentration.

Temporal Trends in Dissolved Lead Data

As shown in the table (Appendix D2) and graph (Appendix E3), concentrations of dissolved lead in groundwater ranged from 0.0040 to 0.39 mg/l. Dissolved lead concentrations in piezometers PZ01, PZ09, PZ10, PZ11, PZ14, and PZ21 were greater than the MCL (0.015 mg/L). Dissolved lead shows no significant temporal trend in groundwater. Concentrations of dissolved lead in surface water ranged from 0.0015 to 0.025 mg/L, as shown in the table (Appendix D2) and graph (Appendix E4). Dissolved lead concentrations greater than the MCL were detected in one Coeur d'Alene River site (RV01), Coffee Creek (CC01), and three wetland sites (WT05, WT06, and WT09). Dissolved lead shows no significant temporal trend in surface water.

Temporal Trends in Dissolved Zinc Data

Dissolved zinc concentrations in groundwater are shown in the table (Appendix D3) and graph (Appendix E5). Groundwater concentrations of dissolved zinc ranged from 0.0037 to 150.0 mg/l. Dissolved zinc concentrations greater than the MCL (5.0 mg/L) were detected in all piezometers, except PZ03, PZ05, PZ06, PZ18, PZ19, and PZ20. Zinc shows no significant temporal trend in groundwater.

As shown in the table (Appendix D3) and graph (Appendix E6), concentrations of dissolved zinc in surface water ranged from 0.005 to 50.0 mg/L. Dissolved zinc concentrations greater than the MCL were detected in one Coeur d'Alene River site (RV01), one wetland site (WT01) and both seep sites (WT02 and WT07). Zinc shows an overall temporal trend of increasing concentrations in seep sites WT02 (10 times greater than the MCL) and WT07 (4 times greater than the MCL). Concentrations of dissolved zinc in WT02 and WT07 are similar to the contaminated groundwater near the center of the dredge materials.

Spatial Trends in Water Quality Data

The spatial trends for dissolved metals concentrations are presented in plan-view maps in Appendix F. Dissolved cadmium, lead, and zinc concentrations are shown for sampling trips conducted on September 15, 1997 and February 23-24, 1998 (including March 6, 1998), the most comprehensive sampling trips taken during this study. Surface water sampling locations are designated with a star, while a circle designated groundwater sampling locations. Six different colors were used to illustrate the sampling results at each site. Black indicates no sample taken, white indicates sample taken but concentration was below laboratory detection limits, blue indicates the sample was below the constituent's Maximum Contaminant Level (MCL) (Table 2), green indicates the sample was as much as three times greater than the constituent's MCL, yellow indicates that the sample was between three times and ten times the constituent's MCL, and red indicates that the sample was greater than ten times the constituent's MCL.

Dissolved cadmium concentrations are shown in plan-view for the September 15, 1997 sampling trip in Appendix F1 and for the February 23-24, 1998 (including March 6, 1998) sampling trip in Appendix F2. Concentrations of dissolved lead for the September 15, 1997 sampling trip are presented in Appendix F3 and for the February 23-24, 1998 (including March 6, 1998) sampling trip in Appendix F4. Dissolved zinc concentrations are shown in the plan-view for the September 15, 1997 in Appendix F5 and for the February 23-24, 1998 (including March 6, 1998) sampling trip in Appendix F6.

Concentrations of dissolved cadmium, lead, and zinc in groundwater within the study area are high and locally variable. The highest concentrations of dissolved cadmium, lead, and zinc (greater than ten times the MCLs) in groundwater occur near the center of the dredge materials in the vicinity of PZ01, PZ02, PZ07, PZ09 - PZ16, and PZ17. Concentrations of dissolved cadmium, lead, and zinc at or below the MCLs occurred near sites PZ03 - PZ06, PZ08, PZ15, and PZ18 where the dredge materials are thin or not present.

Dissolved concentrations of cadmium, lead, and zinc in the wetland, creek, and river surface water sites were generally lower than those in the groundwater sampled in the majority of piezometers in the dredge materials. Nearly all of the surface water sites had concentrations of cadmium, lead, and zinc at or below the MCLs, with the exception of the two seeps, WT02 and WT07. Concentrations of dissolved cadmium and zinc at WT02 and WT07 are similar to the contaminated groundwater near the center of the dredge materials.

Metals Loading Analysis in Surface Water Quality Data

An analysis of dissolved cadmium, lead, and zinc loadings provides a more accurate picture of changes occurring along a specific reach of a river than concentrations alone since it expresses the mass of the dissolved metals. Concentrations can be misleading since inflow of contaminated water to the river system will have significant impact on river concentrations only if the volume of the inflow is comparable to the volume of the river.

Dissolved cadmium, zinc, and lead concentration data from this study and a USGS study were used for the metals loading analysis (Woods, 2002). USGS personnel conducted metals loading studies on a nine-mile reach of the Coeur d'Alene River (river mile 34 to 43) on June 5, 1997, February 4-6, and March 10, 1998 (Figure 13). This reach includes the Cataldo Mission Flats study area. The USGS sampling dates bracket sampling trips made for this study conducted on June 15, 1997 and February 23, 1998.

For this study, loadings were estimated by multiplying the dissolved cadmium, lead, and zinc concentrations by the flows recorded by the USGS at the nearest applicable gaging station on the sampling date. Gaging stations at Cataldo (#12413500), two miles upstream from the Cataldo Mission Flats, and at Rose Lake (#12413810), six miles downstream on the date closest to the sampling date were used for this analysis. Since the flows are not specific to the sampled section for this study, the loadings are approximate. However gross trends can be identified and the information can also be compared to the results of the USGS study.

A compilation of the analytical results and an estimate of dissolved cadmium, lead, and zinc loadings for this study are compiled in Table 5. Note that on Table 5, by subtracting the loadings estimated at the Rose Lake gaging station (#12413810) from the loadings

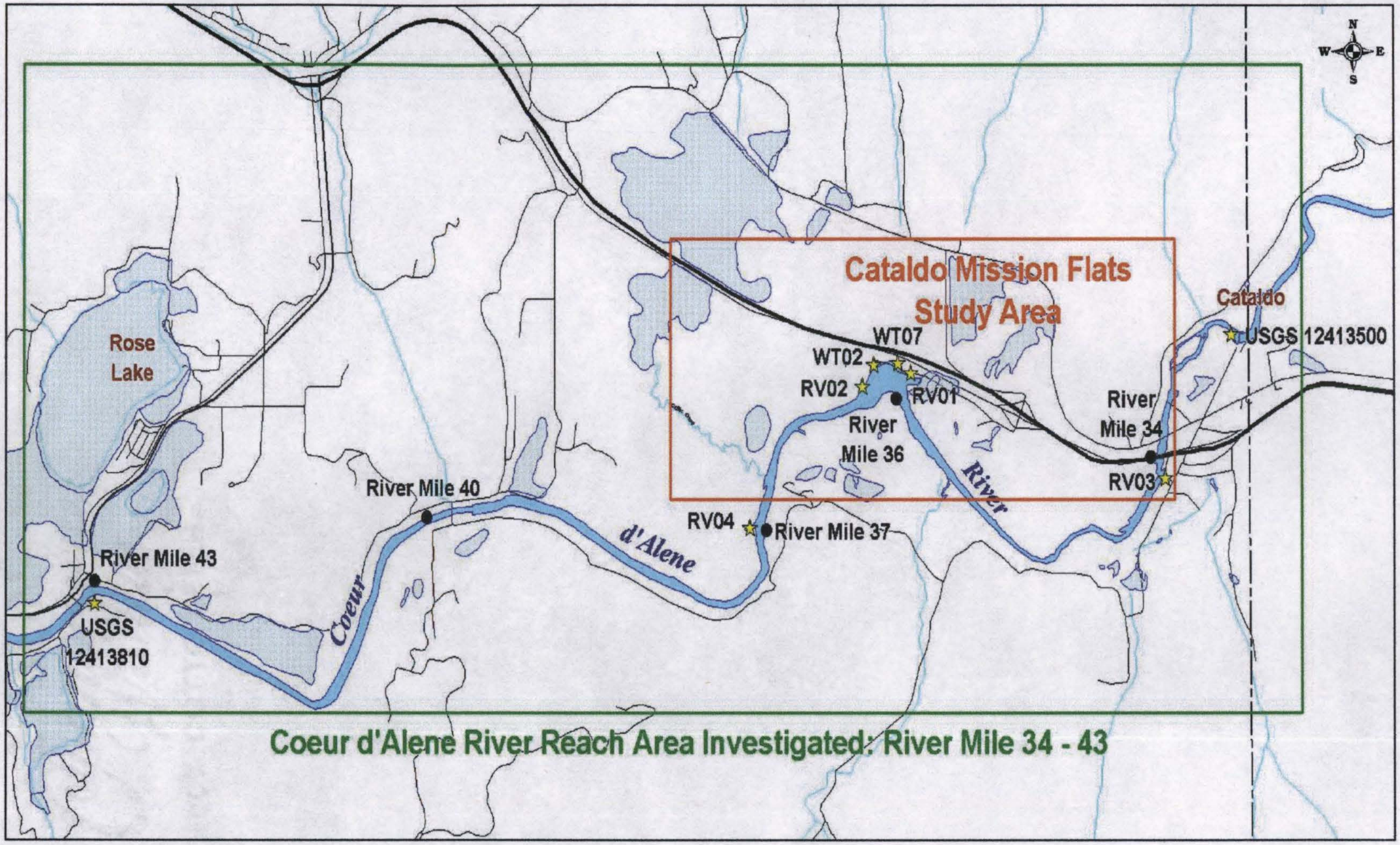

Figure 13. Coeur d'Alene River Reach Area of Investigation from River Mile 34 to River Mile 37 during the period June 1997 to March 1998 for the Cataldo Mission Flats Study.

estimated at the Cataldo gaging station (#12413500), the changes in metals loading for the Cataldo Mission Flats reach can be assessed for the USGS (Woods, 2002) data on June 5, 1997, February 4-6, 1998, and March 10, 1998.

Loading estimates for this study can be assessed by subtracting the loadings estimated at Coeur d'Alene River site RV01 from the loadings estimated at Coeur d'Alene River site RV02 on June 15, 1997, and by subtracting the loadings estimated for Coeur d'Alene River site RV03 from the loadings estimated at Coeur d'Alene River site RV04 on February 23, 1998 (Table 5). Site RV03 is located 2 miles upstream of the Flats study area, RV01 and RV02 are located within the Flats, and RV04 is located at the downstream boundary of the Flats. For these four sites, the discharge measurements used to calculate dissolved cadmium, lead, and zinc loadings were taken from the Cataldo gage (#12413500) on the sampling date.

Dissolved cadmium, lead, and zinc loadings from bank discharge were calculated by using a seep discharge rate of 10 gallons per minute (.003 cfs) derived from the Cataldo Mission Flats numerical model (Wakefield, 2001). The estimated loadings that can be attributed to bank discharge are presented in Table 5 for seep sites WT02 (Bank discharge using east seep concentration) and WT07 (Bank discharge using west seep concentration). The bank discharge loadings can be compared to the results of the river loading analysis to determine the influence from groundwater seeps in this reach of the river (Table 5).

Since there is at least a 10% error in the velocity measurements inherent to using gaged data, a ± 10% margin of error should be assumed. Note that errors associated with laboratory analyses, which are typically about ± 5% should also be assumed.

Date	Identifier		Discharge	Cadmium		Lead		Zinc	
	Site number	Physical Location	Discharge (cfs)	Dissolved Concentration (mg/L)	Load (pounds per day)	Dissolved Concentration (mg/L)	Load (pounds per day)	Dissolved Concentration (mg/L)	Load (pounds per day)
06/05/97	12413500	CDR @ USGS Gage Site at Cataldo Bridge	7670	0.0011	45	0.0018	75	0.23	9568
06/05/97	12413810	CDR @ USGS Gage Site at Rose Lake	7870	0.0011	45	0.0041	174	0.223	9477
06/15/97	RV01	CDR @ Cataldo Mission Flats	4250	0.0053	122	0.018	413	0.43	9869
06/15/97	WT02	Bank Discharge Using East Seep Concentration	0.003	0.02	0.0003	BDL	BDL	50	0.015
06/15/97	RV02	CDR @ Mid-Cataldo Mission Flats	4250	0.0049	112	0.005	115	0.25	5738
02/04/98	12413810	CDR @ USGS Gage Site at Rose Lake	1980	0.002	21	0.0011	12	0.31	3304
02/06/98	12413500	CDR @ USGS Gage Site at Cataldo Bridge	1940	0.0027	28	0.0013	14	0.36	3803
02/23/98	RV03	CDR @ Cataldo Campground	2270	0.0081	99	BDL	BDL	0.26	3187
02/23/98	RV01	CDR @ Cataldo Mission Flats	2270	0.0088	108	BDL	BDL	0.53	6497
02/23/98	WT07	Bank Discharge Using West Seep Concentration	0.003	0.01	0.0002	BDL	BDL	22	0.36
02/23/98	WT02	Bank Discharge Using East Seep Concentration	0.003	0.018	0.0003	BDL	BDL	49	0.8
02/23/98	RV02	CDR @ Mid-Cataldo Mission Flats	2270	0.0085	104	BDL	BDL	0.72	8826
02/23/98	RV04	CDR @ Coffee Creek Confluence	2270	0.01	123	BDL	BDL	0.31	3800
03/10/98	12413500	CDR @ USGS Gage Site at Cataldo Bridge	1510	0.0026	21	0.0011	9	0.375	3058
03/10/98	12413810	CDR @ USGS Gage Site at Rose Lake	1690	0.0022	20	0.0016	15	0.349	3185

* Estimated discharge rate of 0.003 cfs (from culverts at sites WT02 and WT07) based on field observations and the Flats numerical model estimates.

Table 5. Concentrations and instantaneous loads of cadmium, lead, and zinc measured on June 5, 1997, June 15, 1997, February 4, 1998, February 23, 1998, and March 10, 1998 at eight water quality stations on the Coeur d'Alene River near Cataldo Mission Flats.

Dissolved Cadmium, Lead, and Zinc Loading Trends

As indicated on Table 5, the USGS data for the June 5, 1997 sampling event showed an increase in dissolved lead loading, a decrease in dissolved zinc loading, and no change in dissolved cadmium loading over the Flats reach. Discharge increased through the reach from Cataldo to Rose Lake (Table 5).

The June 15, 1997 data for this study may not be directly comparable because RV01 is in a backwater zone and RV02 is in a relatively stagnant zone away from the main channel of the Coeur d'Alene River. Comparing the June 5, 1997 USGS sampling trip to the June 15 1997 sampling trip for this study, discharge at Cataldo was about 55% lower, however, lead loading was nearly 450% higher and zinc loading was about 3% higher (Table 5). The bank discharge from the east seep, WT02, had an estimated dissolved zinc load of 50 pounds per day (lbs/day) and was within the measurement error band of ± 5% to 10% and probably not significant (Table 5).

The USGS sampling event for February 1998 occurred on two different days, February 4th and 6th. As indicated on Table 5, dissolved cadmium, lead, and zinc loading showed an overall trend of increasing over the Flats reach. The results for this sampling event may not be directly comparable because the sampling does not provide metals loadings data for the same day discharge showed a decreasing trend from Cataldo to Rose Lake. The discharge data recorded from Cataldo to Rose Lake for both the June 5, 1997 and March 10, 1998 shows an increasing discharge trend, suggesting that the loadings data is not comparable for this sampling event (Table 5).

The February 23, 1998 sampling trip was the most complete metals loadings analysis conducted for this study. For this analysis, discharge was assumed constant, due to the nearly flat gradient of the Coeur d'Alene River over the three-mile reach from RV03 to RV04 (Table 5). As indicated on Table 5, dissolved cadmium and zinc loadings showed an overall trend of increasing over the Flats reach from site RV03 to RV04. Dissolved lead was below detection limits. Cadmium and zinc loadings also showed an increase from site RV01 to RV02; however, loading analysis data for RV01 and RV02 may not be directly comparable because of their locations, as explained previously in this study. Dissolved zinc loadings from bank discharge at seep sites, WT02 and WT07, were estimated at 49 and 22 lbs/day, respectively (Table 5).

Loading estimates for the March 10, 1998 USGS sampling trips indicate that, dissolved lead and zinc loadings showed an increased, while dissolved cadmium loadings remained nearly constant, as shown in (Table 5). Discharge increased through the reach from Cataldo to Rose Lake (Table 5).

Dissolved cadmium, lead, and zinc loadings estimated during this study period indicated both increasing and, in some instances, decreasing trends over the Cataldo Mission Flats reach of the Coeur d'Alene River. However, if a 10% margin of error is assumed, the loadings along this reach are within the error band for water quality analysis; therefore, the differences dissolved cadmium, lead and zinc loading are not significant.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Introduction

The hydrogeologic system in the vicinity of the Cataldo Mission Flats, Kootenai County, Idaho, on the Coeur d'Alene River was investigated. Groundwater and surface water levels as well as water quality were monitored and interpreted to test the hypothesis that heavy metals release to the Coeur d'Alene River occurs via inflow of impacted groundwater or directly from erosion of the impacted bank sediments.

The subject reach includes the Coeur d'Alene River from Cataldo, river mile 34, to Rose Lake, river mile 37 (Figure 13). Along this reach, cadmium, lead, and zinc concentrations in soil and pore water are known to be elevated due to release of these heavy metals from the dredge materials and tailings-impacted fluvial sediments, which have been deposited within the banks of the river as a result of historic mining activity within the Coeur d'Alene watershed.

In order to identify sources of heavy metals release to the river, a hydrogeologic investigation was completed and a conceptual hydrogeologic model was developed for the Cataldo Mission Flats dredge materials. The Flats numerical model, created by Wakefield (2001), supplements the water quality analysis presented in this study by providing recharge estimates and groundwater discharge estimates from the dredge materials into the Coeur d'Alene River.

Conclusion

Based on the results of the conceptual hydrogeological model analysis completed at twenty-three groundwater sites and sixteen surface water sites during the period June 1997 through March 1998, the dredge materials and fluvial sediments constitute a perched water table system that shows little, if any, connection to the Coeur d'Alene River.

Reasons for this conclusion are:

- Low permeability of the dredge materials and fluvial sediments.
- Water levels in the piezometers developed in the dredge materials and fluvial sediments are always higher than the water level of the Coeur d'Alene River.
- Water levels in the both wetlands are always higher than the water level of the Coeur d'Alene River.
- Water levels in the dredge materials respond mainly to recharge from precipitation and removal of water through evapotranspiration, indicating an unconfined system.
- Groundwater levels in nearly all the piezometers exhibited no river influence.
- The highest concentrations of dissolved cadmium, lead, and zinc occur in contaminated groundwater near the center of the dredge materials.
- Concentrations of dissolved cadmium and zinc at seep sites are similar to the contaminated groundwater near the center of the dredge materials.
- Dissolved metals concentrations in surface water are always lower than dissolved metals concentrations in groundwater.

In order to identify sources of heavy metal release to the river, loading analyses were completed along the subject reach. Metals loadings analysis provides a means of determining if the mass of a constituent within the river flow changes with distance along the reach. If changes in mass can be identified, this indicates that additional mass of the constituent is entering the flow either from groundwater or surface water source or from erosion of riverbank sediments.

Based on the results of an approximate loading analysis (using USGS gaged flows and water sampling) on six sections along the reach during the period June 1997 through March 1998, no significant increases or decreases in dissolved cadmium, lead, or zinc loadings were identified during three low-flow events and one high-flow event (conducted by USGS personnel on June 5, 1997).

These results indicate that no significant inflows of impacted groundwater containing high levels of heavy metals can be identified along the Cataldo Mission Flats reach. From a remedial perspective, this suggests that large-scale excavation of the dredged materials along this reach is not necessary and that attention should be focused on remediation and stabilization of impacted and erodible material, which has the potential to be suspended during high flow times.

Recommendations

- Based on these results, it is recommended that in areas where erodible and impacted dredged materials have been identified, which are not well vegetated, these materials should be stabilized by armoring or using heavy metals-tolerant vegetation.

- Where a riparian environment is established over impacted dredge materials, these bank areas should be stabilized so as to promote continual development of the riparian zone and minimize resuspension of the sediments and destruction of the riparian zone during high flow events.
- An additional recommendation is that a similar multi-location loading study of dissolved and suspended metals be repeated during high flow when bank sediments are being resuspended by erosion to identify specific locations of sediment loading.

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APPENDICIES

APPENDIX A

RECORD OF GROUNDWATER HEADS AND SURFACE WATER ELEVATIONS BY MEASUREMENT DATE

DATE	PZ01	PZ02	PZ03	PZ04	PZ05	PZ06	PZ07	PZ08	PZ09	PZ10	PZ11	PZ12	PZ13	PZ14	PZ15	PZ16	PZ17	PZ18	PZ19	PZ20	PZ21	PZ22	PZ23	Coeur d'Alene River	WT03
07/02/97	2142.9	2134.7	2135.6	2135.8	2139.2	2141.4	2142.5	2143.2	2144.2	2142.6	2133.9		2143.0	2143.6	2143.9	2143.9									
07/06/97	2142.8	2134.5	2135.0	2135.3	2138.8	2141.1	2142.5	2143.4	2144.1	2142.7	2133.4		2142.8	2143.5	2143.6	2143.4									
07/12/97	2142.6	2134.4	2135.1	2135.4	2138.9	2141.2	2142.6	2143.3	2143.9	2142.6	2133.4	2139.5			2143.6		2134.1								
07/17/97	2142.5	2134.2	2134.7	2134.9	2138.6	2140.9	2142.2	2143.1	2143.8	2142.4	2133.0	2139.4	2142.6	2143.3	2143.4	2143.1	2133.8								
07/24/97	2142.3	2134.0	2134.3	2134.6	2138.3	2140.7	2142.0	2142.9	2143.6	2142.2	2132.9	2139.2	2142.5	2143.1	2143.2	2143.0	2133.7								
07/30/97	2142.0	2133.8	2134.1	2134.3	2138.0	2140.5	2141.9	2142.7	2143.5	2142.0	2132.8	2139.2	2142.3	2143.0	2143.0	2142.7	2133.5								
08/06/97	2141.8	2133.6	2133.8	2134.0	2137.8	2140.3	2141.7	2142.5	2143.3	2141.8	2132.6	2139.2	2142.1	2142.8	2142.8	2142.6	2133.5								
08/13/97	2141.6	2133.4	2133.4	2133.9	2137.6	2140.1	2141.5	2142.3	2143.1	2141.6	2132.8	2139.1	2142.0	2142.6	2142.6	2142.4	2133.4								
08/20/97	2141.4	2133.3	2133.1	2133.7	2137.4	2139.9	2141.5	2142.2	2143.1	2141.4	2132.8	2139.0	2141.8	2142.4	2142.5	2142.2	2133.3								
08/27/97	2141.2	2133.1	2132.8	2133.7	2137.2	2139.7	2141.4	2142.0	2142.7	2141.2	2132.8	2139.1	2141.6	2142.2	2142.3	2142.1	2133.2								
09/10/97	2140.9	2133.0	2132.4	2133.7	2137.0	2139.5	2141.3	2141.7	2142.3	2141.0	2132.7	2139.0	2141.4	2141.9	2142.1	2141.9	2133.2	2130.8	2128.4	2129.0				2128.8	2132.3
09/17/97	2140.9	2132.9	2132.3	2133.7	2137.0	2139.2	2140.8	2141.5	2142.2	2141.0	2132.3	2139.3	2141.3	2141.8	2141.7	2142.1	2133.4	2130.7	2127.8	2128.9				2128.8	2132.4
09/24/97	2140.7	2132.9	2132.2	2133.7	2137.1	2139.3	2140.9	2141.4	2142.1	2140.9	2132.3	2139.1	2141.2	2141.6	2141.7	2142.1	2133.5	2131.5	2127.7	2128.8				2128.6	2132.4
10/01/97	2140.6	2132.8	2132.1	2133.7	2137.0	2139.3	2140.8	2141.4	2142.0	2140.7	2131.5	2139.1	2141.1	2141.5	2141.6	2141.9	2133.4	2131.6	2127.6	2128.5				2128.1	2132.4
10/08/97	2140.5	2132.7	2132.1	2133.7	2137.0	2139.4	2140.9	2141.3	2141.8	2140.6	2131.7	2139.1	2141.0	2141.4	2141.4	2142.0	2133.6	2131.5	2127.6	2128.5				2127.8	2132.4
10/15/97	2140.4	2132.7	2132.1	2133.7	2137.2	2139.3	2140.9	2141.2	2141.7	2140.6	2131.5	2139.0	2140.9	2141.3	2141.4	2142.1	2133.5	2131.9	2127.9	2128.5				2127.4	2132.5
10/22/97	2140.3	2132.6	2132.2	2133.7	2137.1	2139.2	2140.8	2141.0	2141.6	2140.5	2131.2	2138.9	2140.9	2141.2	2141.4	2141.9	2133.6	2132.0	2128.3	2128.4				2126.6	2132.5
10/29/97	2140.2	2132.5	2132.3	2133.7	2137.1	2139.2	2140.7	2140.9	2141.6	2140.5	2130.7	2139.6	2140.8	2141.2	2141.3	2141.9	2133.7	2132.1	2128.3	2128.4				2126.1	2132.6
11/05/97	2140.3	2133.0	2133.1	2133.7	2138.1	2140.3	2141.7	2141.4	2141.7	2140.8	2131.8	2139.1	2141.1	2141.6	2142.1	2142.6	2134.5	2133.8	2130.1	2130.0				2126.9	2132.7
11/12/97	2140.5	2133.1	2133.9	2134.5	2138.3	2140.4	2141.7	2141.5	2141.9	2140.8	2131.6	2139.1	2141.3	2141.9	2142.3	2142.8	2134.6	2133.6	2130.4	2130.3				2126.7	2132.7
11/16/97	2140.5	2132.9	2133.9	2134.3	2138.2	2140.3	2141.6	2141.5	2142.0	2140.8	2131.1	2139.3	2141.4	2142.0	2142.2	2142.8	2134.3	2133.6	2130.7	2130.9				2126.3	2132.8
11/25/97	2140.6	2133.3	2134.8	2135.3	2139.0	2140.3	2142.2	2141.5	2142.1	2141.2	2132.0	2139.3	2141.0	2142.2	2142.9	2143.6	2135.6	2133.8	2132.6	2131.4				2126.7	2133.2
12/03/97	2140.9	2133.4	2135.0	2135.5	2139.0	2140.8	2142.2	2141.8	2142.4	2141.2	2131.8	2139.2	2141.8	2142.5	2142.8	2143.4	2135.4	2133.8	2132.8	2132.3				2126.2	2133.4
12/20/97	2141.0	2133.2	2135.8	2136.0	2139.3	2141.3	2142.5	2141.7	2142.5	2141.4	2131.4	2139.4	2142.0	2142.5	2143.2	2143.9	2135.1	2133.9	2133.6	2132.8				2124.8	2133.7
12/26/97	2140.9	2133.1	2135.5	2135.8	2139.0	2141.1	2142.4	2141.9	2142.6	2141.3	2130.9	2139.4	2142.1	2142.7	2143.0	2143.6	2135.0	2133.8	2133.5	2133.2				2124.8	2133.7
01/02/98	2141.0	2133.0	2135.6	2136.0	2139.3	2141.3	2142.6	2141.8	2142.6	2141.5	2131.1	2139.0	2142.1	2142.7	2143.1	2144.1	2134.8	2133.8	2133.7	2133.5				2125.0	2133.7
01/08/98	2141.0	2133.2	2135.8	2136.1	2139.3	2141.4	2142.1	2141.9	2142.7	2141.5	2131.8	2139.5	2142.2	2142.7	2143.2	2144.1	2135.1	2133.9	2133.9	2133.5				2125.1	2133.9
01/16/98	2141.0	2133.0	2135.6	2135.8	2139.0	2141.1	2142.5	2141.8	2142.7	2141.5	2130.9	2139.6	2142.2	2142.8	2143.1	2143.8	2134.9	2134.1	2133.8	2133.5				2125.2	2133.9
01/23/98	2141.1	2133.4	2136.5	2136.6	2139.7	2141.6	2143.0	2141.9	2142.8	2142.0	2131.6	2139.6	2142.4	2143.0	2143.7	2144.6	2135.3	2134.2	2134.0	2133.7				2125.3	2134.0
01/30/98	2141.5	2134.1	2137.7	2138.1	2140.6	2142.8	2144.4	2142.1	2143.4	2142.5	2133.4	2139.7	2143.1	2143.7	2144.3	2145.1	2136.0	2134.4	2134.0	2134.7				2126.6	2134.5
02/06/98	2142.0	2134.2	2137.4	2137.7	2140.4	2142.5	2143.8	2143.0	2143.8	2142.4	2134.7	2139.7	2143.3	2143.9	2144.1	2144.6	2135.7	2134.0	2134.5	2134.7				2126.0	2134.0
02/13/98	2142.0	2134.3	2137.7	2138.2	2140.8	2143.1	2144.6	2142.9	2143.9	2142.6	2133.1	2139.3	2143.4	2143.8	2144.3	2145.1	2135.4	2134.4	2134.6	2134.7				2126.3	2132.7
02/20/98	2142.1	2134.4	2136.9	2137.2	2140.3	2142.6	2143.8	2143.0	2144.0	2142.7	2133.1	2139.8	2143.4	2143.8	2144.2	2144.7	2135.4	2133.8	2134.5	2134.5				2125.9	2133.9
02/27/98	2142.1	2134.5	2136.6	2136.8	2140.2	2142.6	2143.7	2142.7	2144.0	2142.6	2132.5	2139.8	2143.3	2143.8	2144.1	2144.5	2134.8	2133.9	2134.3	2134.1				2125.9	2133.9
03/05/98	2142.1	2134.5	2136.8	2137.0	2140.3	2142.5	2143.7	2143.0	2144.0	2142.7	2132.4	2139.7	2143.4	2143.7	2144.1	2144.6	2134.9	2134.0	2134.5	2134.2				2125.5	2133.9
03/13/98	2142.0	2134.3	2137.0	2137.2	2140.4	2142.9	2144.0	2142.9	2144.0	2142.7	2134.5	2139.8	2143.3	2143.7	2144.2	2144.7	2135.1	2133.9	2134.3	2134.1	2142.2	2125.7	2130.4	2125.2	2134.0
03/19/98	2142.0	2134.4	2136.4	2136.7	2140.0	2142.6	2143.5	2142.9	2144.0	2142.6	2133.0	2139.7	2143.2	2143.7	2144.1	2144.4	2135.0	2133.9	2134.5	2134.2	2142.1	2126.6	2130.6	2127.7	2134.1
03/27/98	2142.1	2135.5	2137.6	2137.7	2140.9	2143.1	2143.9	2142.9	2144.1	2142.9	2133.2	2139.8	2143.4	2143.7	2144.4	2145.0	2135.2	2134.3	2134.6	2134.4	2142.2	2132.6	2134.4	2133.4	2134.2
04/03/98	2142.1	2135.0	2136.4	2136.7	2140.1	2142.2	2143.5	2143.2	2144.1	2142.6	2134.1	2139.7	2143.2	2143.7	2144.1	2144.3	2135.3	2134.1	2135.1	2134.6	2142.2	2129.5	2131.5	2129.1	2134.1
04/10/98	2142.1	2135.1	2136.6	2136.9	2140.1	2142.4	2143.7	2143.2	2144.1	2142.6	2134.3	2139.8	2143.2	2143.7	2144.1	2144.4	2135.2	2134.0	2135.2	2134.8	2142.3	2129.9	2131.8	2129.6	2133.7
04/17/98	2142.0	2134.9	2136.2	2136.6	2139.9	2142.1	2143.3	2143.1	2144.0	2142.5	2133.6	2139.7	2143.0	2143.6	2143.9	2144.1	2135.1	2134.2	2135.0	2134.4	2142.1	2128.6	2130.9	2128.2	2133.2
04/24/98	2141.9	2134.9	2136.0	2136.3	2139.7	2141.8	2143.0	2143.0	2143.8	2142.4	2133.7	2139.7	2142.9	2143.5	2143.8	2143.9	2135.0	2134.1	2134.8	2134.2	2142.0	2131.0	2132.7	2131.7	2133.1
05/01/98	2141.8	2134.9	2135.7	2136.1	2139.4	2141.4	2142.6	2142.7	2143.7	2142.3	2134.0	2139.6	2142.8	2143.4	2143.7	2143.5	2134.9	2134.1	2134.8	2134.1	2141.9	2130.8	2132.2	2130.7	2133.2
05/08/98	2141.6	2134.9	2135.3	2135.6	2139.2	2141.2	2142.4	2142.6	2143.5	2142.1	2134.3	2139.6	2142.6	2143.3	2143.5	2143.2	2134.7	2134.1	2134.5	2133.8	2141.7	2131.0	2132.3	2130.9	2133.1
05/15/98	2141.5	2134.5	2134.9	2135.1	2138.9	2141.2	2142.3	2142.5	2143.3	2142.0	2133.6	2139.6	2142.5	2143.1	2143.2	2143.0	2134.5	2134.1	2134.1	2133.4	2141.6	2129.5	2131.2	2129.4	2133.1

All measurements in feet above mean sea level (from Wakefield, 2001).

DATE	PZ01	PZ02	PZ03	PZ04	PZ05	PZ06	PZ07	PZ08	PZ09	PZ10	PZ11	PZ12	PZ13	PZ14	PZ15	PZ16	PZ17	PZ18	PZ19	PZ20	PZ21	PZ22	PZ23	Coeur d'Alene River	WT03
05/22/98	2141.4	2134.4	2135.3	2135.6	2139.3	2141.1	2142.8	2142.4	2143.2	2142.0	2133.5	2139.8	2142.4	2143.0	2143.2	2143.4	2134.5	2134.3	2134.1	2133.4	2141.5	2129.2	2131.0	2129.2	2133.2
05/29/98	2141.5	2135.1	2136.3	2136.5	2139.9	2141.1	2143.4	2142.4	2143.3	2142.3	2134.5	2139.5	2142.7	2143.1	2143.7	2144.2	2134.5	2134.1	2134.9	2133.9	2141.6	2132.0	2133.5	2132.5	2133.5
06/05/98	2141.4	2134.6	2135.5	2135.7	2139.3	2141.4	2142.7	2142.7	2143.3	2142.0	2133.6	2139.4	2142.6	2143.2	2143.5	2143.5	2134.6	2133.9	2134.7	2134.0	2141.5	2129.9	2131.6	2129.8	2133.5
06/12/98	2141.4	2134.3	2135.2	2135.4	2139.0	2141.2	2142.4	2142.5	2143.2	2141.8	2133.3	2139.4	2142.4	2143.1	2143.2	2143.2	2134.5	2133.9	2134.2	2133.9	2141.5	2129.2	2131.0	2129.3	2133.6
06/19/98	2141.3	2134.1	2134.9	2135.1	2138.8	2141.2	2142.3	2142.3	2143.1	2141.7	2133.3	2139.3	2142.3	2142.9	2143.0	2143.0	2134.3	2133.9	2134.1	2133.6	2141.4	2129.1	2130.9	2129.1	2133.5
06/26/98	2141.2	2133.9	2134.7	2134.9	2138.6	2141.0	2142.1	2142.1	2142.9	2141.6	2133.0	2139.3	2142.2	2142.8	2142.8	2142.8	2134.2	2133.8	2133.5	2133.3	2141.3	2129.0	2130.8	2129.1	2133.3
07/02/98	2141.1	2133.8	2134.5	2134.7	2138.4	2140.7	2142.0	2142.0	2142.8	2141.4	2132.7	2139.2	2142.1	2142.7	2142.7	2142.6	2134.1	2133.7	2133.1	2132.8	2141.2	2128.8	2130.6	2129.0	2133.3
07/10/98	2141.0	2133.5	2134.2	2134.3	2138.1	2140.5	2141.8	2141.9	2142.6	2141.3	2132.2	2139.2	2142.0	2142.5	2142.5	2142.4	2133.9	2133.6	2132.2	2132.3	2141.1	2128.8	2130.5	2129.0	2133.2
07/23/98	2140.8	2133.2	2133.7	2134.0	2137.7					2141.0	2131.9	2138.9	2141.7		2142.1		2133.3	2133.2	2130.2	2131.8	2140.9	2128.7	2130.4	2129.0	2132.9
08/06/98	2140.6	2133.1	2133.0		2137.4					2140.9	2131.9	2138.9	2141.5		2141.8		2133.3	2132.6	2130.2	2131.5	2140.7	2128.7	2130.3	2129.0	2132.2
08/19/98	2140.4	2132.8	2132.3		2137.1					2140.6	2131.6	2138.8	2141.3		2141.5		2133.2	2131.9	2130.1	2131.2	2140.5	2128.5	2130.3	2128.8	2132.1
09/03/98	2140.2	2132.7	2131.6		2136.9					2140.3	2131.4	2138.7	2141.0		2141.2		2132.9	2131.2	2129.9	2130.8	2140.3	2128.5	2130.2	2128.9	2131.9
09/15/98	2140.0	2132.6	2131.0		2136.7					2140.2	2131.3	2138.8	2140.8		2141.1		2132.9	2130.7	2129.8	2130.4	2140.1	2128.3	2130.3	2128.6	2131.8
09/29/98	2139.8	2132.4	2130.6		2136.6					2140.0	2131.0	2138.8	2140.6		2140.8		2133.0	2130.4	2129.6	2130.0	2139.9	2127.8	2130.1	2128.0	2131.7
10/13/98	2139.7	2132.3	2130.3		2136.5					2139.8	2130.7	2138.8	2140.4		2140.7		2133.1	2130.4	2129.4	2129.6	2139.8	2127.0	2129.9	2127.1	2131.7
10/27/98	2139.5	2132.1	2130.2		2136.4					2139.7	2129.8	2138.8	2140.3		2140.5		2133.1		2129.2	2129.2	2139.6	2126.1	2129.8	2126.2	2131.7
11/07/98		2132.0									2129.4						2133.0					2125.6	2129.7	2125.6	
11/23/98		2132.2									2130.0						2134.1					2126.3	2129.6	2126.3	2132.1
12/07/98		2133.7									2130.5						2134.6					2127.2	2130.1	2126.9	2132.6
12/21/98		2133.4									2131.0						2134.9					2126.8	2130.0	2125.5	2133.3
12/31/98		2134.1									2132.1						2135.7					2129.6	2131.8	2129.9	2134.1

All measurements in feet above mean sea level (from Wakefield, 2001).

APPENDIX B

SUMMARY OF GRAIN SIZE ANALYSIS OF CATALDO MISSION FLATS SEDIMENT SAMPLES

Piezometer	Depth Interval (ft.)	Effective Grain Size d_{10} (in.)	Uniformity Coefficient d_{60}/d_{10}	Hydraulic Conductivity (ft./day)	Classification
PZ01	1.5-2.0	0.0018	4.4	3.0	silty/fine sand
	2.0-2.5	0.0031	2.1	8.8	silty/fine sand
	2.5-3.0	0.0035	2.2	11.2	silty/fine sand
	3.5-4.0	0.0003	2.0	8.2	silty/fine sand
	4.5-5.0	0.0029	2.0	7.7	silty/fine sand
	5.5-6.0	0.0027	2.2	6.7	silty/fine sand
	6.0-6.5	0.0031	2.3	8.8	silty/fine sand
	6.5-7.0	0.0028	2.3	7.2	silty/fine sand
	7.0-7.5	0.0018	2.6	3.0	silty/fine sand
	7.5-8.0	0.0008	5.0	0.6	silty/fine sand
	8.0-8.5	0.0029	2.3	7.7	silty/fine sand
PZ02	0.5-1.0	0.0033	2.2	10.0	silty/fine sand
	1.0-1.7	0.0032	2.1	9.4	silty/fine sand
	1.7-2.5	0.0033	2.0	10.0	silty/fine sand
	2.5-3.0	0.0033	2.1	10.0	silty/fine sand
PZ08	1.2-1.7	0.0031	2.3	8.8	silty/fine sand
	2.3-2.8	0.0026	2.5	6.2	silty/fine sand
	2.8-3.2	0.0031	2.3	8.8	silty/fine sand
	3.5-4.0	0.0027	2.2	6.7	silty/fine sand
	4.5-5.1	0.0031	2.2	8.8	silty/fine sand
	5.1-5.4	0.0031	2.2	8.8	silty/fine sand
	5.4-5.5	0.0033	2.4	10.0	silty/fine sand
	5.5-5.8	0.0032	2.3	9.4	silty/fine sand
PZ10	1.2-1.7	0.0027	3.2	6.7	silty/fine sand
	1.7-1.9	0.0027	3.3	6.7	silty/fine sand
	1.9-2.5	0.0028	3.8	7.2	silty/fine sand
	2.5-3.0	0.0031	2.6	8.8	silty/fine sand
	3.0-3.4	0.0019	3.6	3.3	silty/fine sand
	3.4-3.8	0.0015	3.1	2.1	silty/fine sand
PZ11	1.2-1.6	0.0015	4.1	2.1	silty/fine sand
	1.6-2.2	0.0018	4.7	3.0	silty/fine sand
	2.2-2.4	0.0016	5.1	2.3	silty/fine sand
	2.4-2.9	0.0016	5.1	2.3	silty/fine sand
	2.9-3.5	0.0009	6.4	0.7	silty/fine sand
	3.5-4.3	0.0007	6.4	0.5	silty/fine sand
	4.3-4.9	0.0024	3.7	5.3	silty/fine sand
	4.9-5.2	0.0019	3.5	3.3	silty/fine sand
PZ12	0.7-1.1	0.0013	4.0	1.6	silty/fine sand
	1.1-1.7	0.0017	4.0	2.6	silty/fine sand
	1.7-2.3	0.0021	3.2	4.0	silty/fine sand
	2.3-2.8	0.0028	2.8	7.2	silty/fine sand
	2.8-2.9	0.0025	2.9	5.7	silty/fine sand

Piezometer	Depth Interval (ft.)	Effective Grain Size d_{10} (in.)	Uniformity Coefficient d_{60}/d_{10}	Hydraulic Conductivity (ft./day)	Classification
PZ13	1.1-1.6	0.0030	2.3	8.2	silty/fine sand
	2.0-2.5	0.0038	2.3	13.2	silty/fine sand
	2.5-2.9	0.0032	2.2	9.4	silty/fine sand
	2.9-3.5	0.0027	2.7	6.7	silty/fine sand
	3.5-4.2	0.0030	2.6	8.2	silty/fine sand
PZ14	2.3-2.8	0.0044	2.2	17.7	fine sand
	3.8-4.3	0.0042	2.6	16.1	fine sand
	4.9-5.4	0.0054	2.1	26.7	fine sand
	5.4-6.0	0.0050	2.3	22.9	fine sand
	6.0-6.4	0.0008	6.5	0.6	silty/fine sand
	6.4-7.0	0.0012	8.0	1.3	silty/fine sand
	7.0-7.5	0.0019	4.1	3.3	silty/fine sand
	7.5-7.8	0.0032	2.3	9.4	silty/fine sand
PZ15	1.2-1.7	0.0022	2.8	4.4	silty/fine sand
	1.7-2.3	0.0015	3.3	2.1	silty/fine sand
	2.3-3.0	0.0007	11.0	0.5	silty/fine sand
	3.0-3.8	0.0025	3.1	5.7	silty/fine sand
PZ16	1.3-1.9	0.0032	2.3	9.4	silty/fine sand
	1.9-2.3	0.0037	2.3	12.5	silty/fine sand
	2.3-3.0	0.0037	2.3	12.5	silty/fine sand
	3.0-3.5	0.0031	2.3	8.8	silty/fine sand
PZ17	5.2-5.9	0.0013	5.2	1.6	silty/fine sand
	5.9-6.7	0.0013	3.8	1.6	silty/fine sand
	7.2-8.0	0.0007	4.6	0.5	silt/silty sand
	8.6-9.3	0.0008	4.8	0.6	silt/silty sand
	9.8-10.4	0.0004	5.8	0.2	silt
	10.4-10.7	0.0011	6.6	1.1	silty/fine sand
	10.7-11.2	0.0005	5.6	0.2	silt
PZ18	2.5-2.8	0.0026	3.7	6.2	silty/fine sand
	3.3-3.9	0.0010	7.5	0.9	silt/fine sand
	4.4-5.2	0.0037	3.1	12.5	silty/fine sand
	5.2-5.9	0.0010	9.0	0.9	silt/fine sand
	5.9-6.2	0.0006	5.2	0.3	silt
	6.2-6.5	0.0004	7.0	0.2	silt
	6.5-7.2	0.0003	6.7	0.1	silt
PZ19	5.0-5.4	0.0005	5.4	0.2	silt
	5.4-5.9	0.0003	6.3	0.1	silt
	5.9-6.5	0.0002	8.5	0.0	silt
	6.5-6.9	0.0002	6.5	0.0	silt
	6.9-7.2	0.0003	6.3	0.1	silt
	7.2-7.6	0.0002	7.5	0.0	silt
	7.6-8.3	0.0002	8.0	0.0	silt

Piezometer	Depth Interval (ft.)	Effective Grain Size d_{10} (in.)	Uniformity Coefficient d_{60}/d_{10}	Hydraulic Conductivity (ft./day)	Classification
PZ20	5.3-6.0	0.0005	6.0	0.2	silt
	6.0-6.6	0.0007	4.3	0.4	silt/silty sand
	6.6-7.2	0.0005	8.4	0.2	silt
	7.2-7.6	0.0003	6.7	0.1	silt
	7.6-8.2	0.0003	6.0	0.1	silt
	8.2-8.8	0.0002	7.5	0.0	silt
	8.8-9.1	0.0003	9.0	0.1	silt
PZ21	6.8-7.3	0.0042	2.4	16.1	fine sand
	7.3-7.9	0.0037	2.7	12.5	silty/fine sand
	7.9-8.2	0.0040	2.5	14.6	silty/fine sand
PZ22	Approx. 10.0	0.0006	6.3	0.3	silt
	Approx. 12.5	0.0005	7.4	0.2	silt
	Approx. 14.5	0.0009	5.3	0.7	silt/silty sand
PZ23	3.1-3.8	0.0012	3.5	1.3	silty/fine sand
	3.8-5.0	0.0007	4.1	0.4	silt/silty sand
	Approx. 6.2	0.0006	6.3	0.3	silt
	Approx. 9.0	0.0005	5.4	0.2	silt

APPENDIX C

PRECIPITATION DATA JUNE 1997 – DECEMBER 1998

	Date	Precipitation (in.)
July 1997	7/1/97	0.6
	7/5/97	0.1
	7/8/97	0.1
	7/9/97	0.7
	7/19/97	0.3
	7/20/97	0.1
	7/29/97	0.1
	7/31/97	0.1
August 1997	8/2/97	0.1
	8/24/97	0.4
September 1997	9/3/97	0.3
	9/5/97	0.1
	9/11/97	0.2
	9/14/97	0.2
	9/15/97	0.2
	9/16/97	0.4
	9/17/97	0.3
	9/18/97	0.1
	9/26/97	0.2
October 1997	10/2/97	0.1
	10/3/97	0.1
	10/4/97	0.2
	10/5/97	0.3
	10/9/97	0.4
	10/11/97	0.1
	10/13/97	0.1
	10/23/97	0.1
	10/26/97	0.1
	10/27/97	0.2
	10/28/97	0.2
	10/29/97	0.7
	10/30/97	1.0
	10/31/97	0.1
November 1997	11/7/97	0.7
	11/17/97	0.4
	11/19/97	0.2
December 1997	12/16/97	0.2
	12/17/97	0.1
	12/20/97	0.2
	12/23/97	0.1
	12/26/97	0.1
	12/28/97	0.3
	12/29/97	0.1
January 1998	1/1/98	0.1
	1/3/98	0.1
	1/4/98	0.2
	1/6/98	0.1
	1/7/98	0.2

	Date	Precipitation (in.)
Jan. 1998 (continued)	1/8/98	0.2
	1/11/98	0.1
	1/13/98	0.5
	1/14/98	0.3
	1/15/98	0.1
	1/17/98	0.5
	1/19/98	0.4
	1/20/98	0.2
	1/22/98	0.2
	1/23/98	0.2
	1/24/98	0.2
	1/25/98	0.3
	1/27/98	0.8
	1/28/98	0.1
February 1998	2/5/98	0.1
	2/8/98	0.1
	2/11/98	0.2
	2/12/98	0.1
	2/13/98	0.3
	2/15/98	0.1
	2/21/98	0.3
	2/22/98	0.1
	2/26/98	0.1
	2/27/98	0.1
March 1998	3/2/98	0.2
	3/3/98	0.3
	3/22/98[1]	0.37
	3/23/98[1]	0.6
	3/24/98[1]	0.33
April 1998	4/10/98	0.1
	4/11/98	0.3
	4/22/98	0.1
	4/23/98	0.2
	4/24/98	0.1
May 1998	5/14/98	0.1
	5/15/98	0.1
	5/17/98	0.5
	5/18/98	0.1
	5/20/98	0.3
	5/21/98	0.3
	5/22/98	0.6
	5/25/98	0.3
	5/26/98	0.8
	5/27/98	0.2
	5/29/98	0.2
June 1998	6/6/98	0.3
	6/7/98	0.1
	6/10/98	0.1

	Date	Precipitation (in.)
June 1998 (continued)	6/15/98	0.3
	6/16/98	0.2
	6/19/98	0.3
	6/24/98	0.1
	6/27/98	0.1
July 1998	7/3/98	0.6
	7/8/98	0.1
	7/9/98	0.4
	7/10/98	0.1
	7/11/98	0.3
	7/25/98	0.1
	7/30/98	0.1
August 1998	8/23/98	0.1
	8/24/98	0.1
September 1998		0.0
October 1998	10/1/98[1]	0.46
	10/2/98[1]	0.01
	10/3/98[1]	0.05
	10/4/98[1]	0.11
	10/10/98	0.1
	10/13/98	0.1
	10/14/98	0.1
	10/15/98	0.1
	10/28/98	0.2
November 1998	11/4/98	0.1
	11/5/98	2.3
	11/6/98	1.5
	11/12/98[1]	0.36
	11/13/98[1]	1.2
	11/14/98[1]	0.23
	11/15/98[1]	0.08
	11/17/98[1]	0.05
	11/18/98[1]	0.26
	11/19/98[1]	0.05
	11/20/98[1]	0.9
	11/21/98[1]	0.58
	11/22/98[1]	0.1
	11/23/98[1]	0.21
	11/24/98[1]	0.25
	11/25/98[1]	0.33
	11/26/98[1]	0.17
	11/27/98[1]	0.33
	11/28/98[1]	0.4
	11/29/98[1]	0.1
	11/30/98[1]	1.26

	Date	Precipitation (in.)
December 1998	12/1/98[1]	1.2
	12/2/98[1]	0.38
	12/4/98[1]	0.1
	12/5/98[1]	0.03
	12/6/98[1]	0.14
	12/7/98[1]	0.09
	12/8/98[1]	0.15
	12/10/98	0.10
	12/11/98	0.30
	12/12/98	0.10
	12/13/98	0.10
	12/17/98	0.10
	12/24/98	0.2
	12/25/98	0.9
	12/26/98	0.3
	12/27/98	1.0
	12/28/98	0.1
	12/29/98	0.8
	12/31/98	0.10
	Total	44.32

[1] Enaville data believed missing for March 22, 23, 24, and October 1, 1998. Enaville data missing for October 2 - 6, 1998, November 10 - 30, 1998, and December 1 - 8, 1998. Precipitation data for those dates from climatological data from Kellogg, Idaho.

APPENDIX D

WATER QUALITY DATA TABLES JUNE 1997 – MARCH 1998

Dissolved Cadmium Concentration (mg/L)

Groundwater Sites

Date	PZ01	PZ02	PZ03	PZ04	PZ05	PZ06	PZ07	PZ08	PZ09	PZ10	PZ11	PZ12
June 15, 1997	0.39	0.06										
July 13, 1997			0.0075									
August 12, 1997	0.33	0.15							0.15	0.072		
September 15, 1997	0.43	0.17	0.0066				0.009	0.039	0.13	0.061	0.011	0.01
February 23-24, 1998	0.46	0.15	0.01	0.052	0.0038	0.004	0.016	0.018	0.086	0.022	0.014	
March 6, 1998												0.014

Dissolved Cadmium Concentration (mg/L)

Groundwater Sites

Date	PZ13	PZ14	PZ15	PZ16	PZ17	PZ18	PZ19	PZ20	PZ21	PZ22	PZ23
June 15, 1997											
July 13, 1997											
August 12, 1997	0.012	0.051	0.0091		0.04						
September 15, 1997	0.01	0.09	0.0027		0.022						
February 23-24, 1998	0.006	0.018	0.0063	0.012	0.03		0.0061	0.0069			
March 6, 1998						0.0082			0.15	0.026	0.033

Dissolved Cadmium Concentration (mg/L)

River, Creek, and Seep Sites

Date	RV01	RV02	RV03	RV04	CC01	CK01	WT02	WT07
June 15, 1997	0.0053	0.0049					0.02	
July 13, 1997	0.007	0.0055	0.0046		0.003	0.003		0.012
August 12, 1997								0.012
September 15, 1997	0.0087	0.012	0.0044	0.008		0.0075		0.011
February 23-24, 1998	0.0088	0.0085	0.0081	0.01	0.0068		0.018	0.01
March 6, 1998								

Dissolved Cadmium Concentration (mg/L)

Wetland Sites

Date	WT01	WT03	WT04	WT05	WT05B	WT06	WT08	WT09
June 15, 1997	0.0054	0.006	0.0034					
July 13, 1997	0.0045				0.0042	0.0048	0.0056	
August 12, 1997				0.0038				
September 15, 1997				0.0023	0.0066	0.0038		
February 23-24, 1998	0.023	0.0069	0.0054	0.0062	0.01	0.01	0.008	0.011
March 6, 1998								

Appendix D1. Dissolved cadmium concentrations in surface and groundwater sites at Cataldo Mission Flats for sampling dates June 15, 1997, July 13, 1997, August 12, 1997, September 15, 1997, February 23-24, 1998 and March 6, 1998.

Dissolved Lead Concentration (mg/L)	Groundwater Sites												
	Date	**PZ01**	**PZ02**	**PZ03**	**PZ04**	**PZ05**	**PZ06**	**PZ07**	**PZ08**	**PZ09**	**PZ10**	**PZ11**	**PZ12**
	June 15, 1997	0.18											
	July 13, 1997			0.053									
	August 12, 1997	0.009	0.012				0.006			0.17	0.19		
	September 15, 1997	0.034	0.047	0.072		0.004		0.03	0.066	0.21	0.13	0.39	0.009
	February 23-24, 1998	0.007		0.026	0.14	0.007		0.018	0.034	0.17	0.06	0.018	
	March 6, 1998												0.140

Dissolved Lead Concentration (mg/L)	Groundwater Sites											
	Date	**PZ13**	**PZ14**	**PZ15**	**PZ16**	**PZ17**	**PZ18**	**PZ19**	**PZ20**	**PZ21**	**PZ22**	**PZ23**
	June 15, 1997											
	July 13, 1997											
	August 12, 1997		0.019	0.002		0.002						
	September 15, 1997	0.05	0.34	0.012		0.004						
	February 23-24, 1998	0.01	0.13	0.078	0.096							
	March 6, 1998						0.006			0.180	0.032	0.025

Dissolved Lead Concentration (mg/L)	River, Creek, and Seep Sites								
	Date	**RV01**	**RV02**	**RV03**	**RV04**	**CC01**	**CK01**	**WT02**	**WT07**
	June 15, 1997	0.018	0.005						
	July 13, 1997	0.0051	0.0081	0.0025		0.025			
	August 12, 1997	0.0023							
	September 15, 1997		0.0039	0.0085			0.0046		
	February 23-24, 1998					0.0072			
	March 6, 1998								

Dissolved Lead Concentration (mg/L)	Wetland Sites								
	Date	**WT01**	**WT03**	**WT04**	**WT05**	**WT05B**	**WT06**	**WT08**	**WT09**
	June 15, 1997	0.0015		0.014					
	July 13, 1997					0.002		0.005	
	August 12, 1997								
	September 15, 1997		0.002	0.003	0.0051			0.0091	
	February 23-24, 1998					0.02	0.02		0.02
	March 6, 1998								

Appendix D2. Dissolved lead concentrations in surface and groundwater sites at Cataldo Mission Flats for sampling dates June 15, 1997, July 13, 1997, August 12, 1997, September 15, 1997, February 23-24, 1998 and March 6, 1998.

Dissolved Zinc Concentration (mg/L)

Groundwater Sites

Date	PZ01	PZ02	PZ03	PZ04	PZ05	PZ06	PZ07	PZ08	PZ09	PZ10	PZ11	PZ12
June 15, 1997	140	14										
July 13, 1997			2.3									
August 12, 1997	150	69				0.07			79	82		
September 15, 1997	130	72	2.8		0.0037	0.03	9.6	9.8	69	72	68	19
February 23-24, 1998	140	95	2.2	5.9	0.02	0.13	46	13	57	76	83	
March 6, 1998												33

Dissolved Zinc Concentration (mg/L)

Groundwater Sites

Date	PZ13	PZ14	PZ15	PZ16	PZ17	PZ18	PZ19	PZ20	PZ21	PZ22	PZ23
June 15, 1997											
July 13, 1997											
August 12, 1997	14	22	3.8		43						
September 15, 1997	15	22	3.7		42						
February 23-24, 1998	13	24	5.3	63	48		0.15	0.18			
March 6, 1998						0.23			42	13	40

Dissolved Zinc Concentration (mg/L)

River, Creek, and Seep Sites

Date	RV01	RV02	RV03	RV04	CC01	CK01	WT02	WT07
June 15, 1997	0.43	0.25					50	
July 13, 1997	1.6	0.39	0.33		0.045	0.004		15
August 12, 1997	0.45							10
September 15, 1997	0.59	7.3	0.31	0.62	0.51			9.7
February 23-24, 1998	0.53	0.72	0.26	0.31	0.066		49	22
March 6, 1998								

Dissolved Zinc Concentration (mg/L)

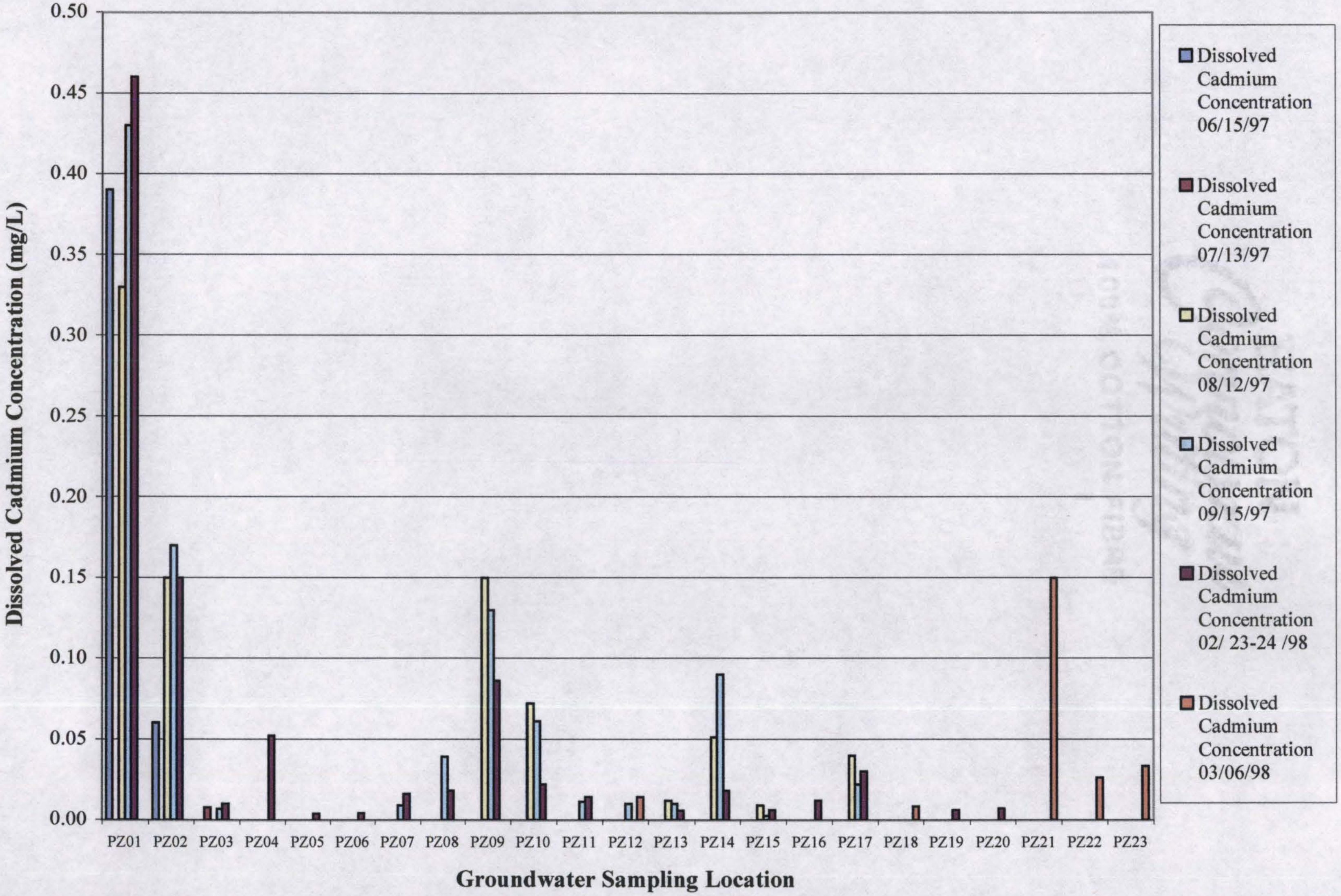
Wetland Sites

Date	WT01	WT03	WT04	WT05	WT05B	WT06	WT08	WT09
June 15, 1997	0.066	0.028	0.075					
July 13, 1997	0.008				0.033	0.087	0.056	
August 12, 1997				0.26				0.028
September 15, 1997		0.31	0.042	0.01	0.32	0.51	0.005	
February 23-24, 1998	5.3	0.060	0.065	0.052	1.1	1.2	0.72	1.0
March 6, 1998								

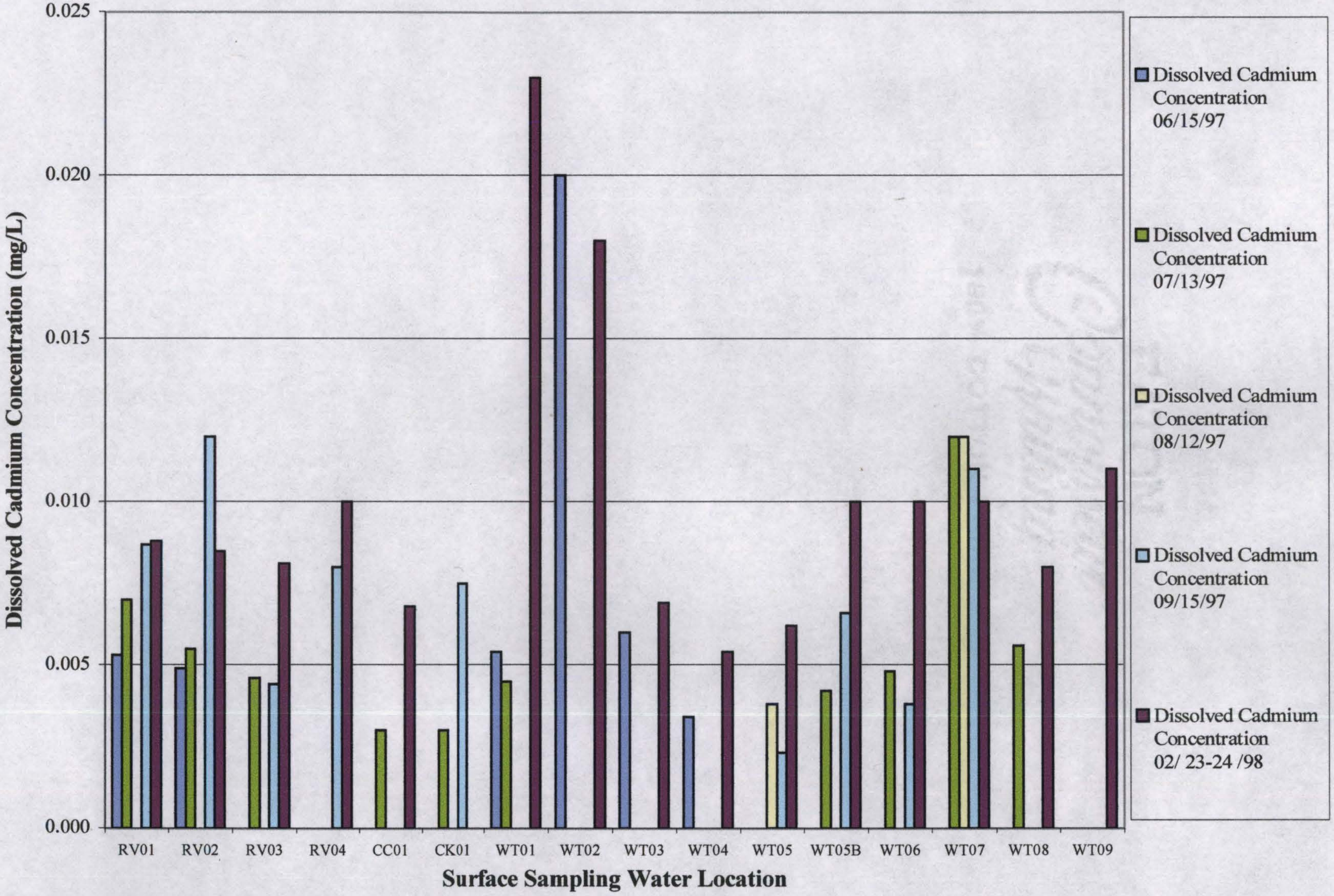
Appendix D3. Dissolved zinc concentrations in surface and groundwater sites at Cataldo Mission Flats for sampling dates June 15, 1997, July 13, 1997, August 12, 1997, September 15, 1997, February 23-24, 1998 and March 6, 1998.

APPENDIX E

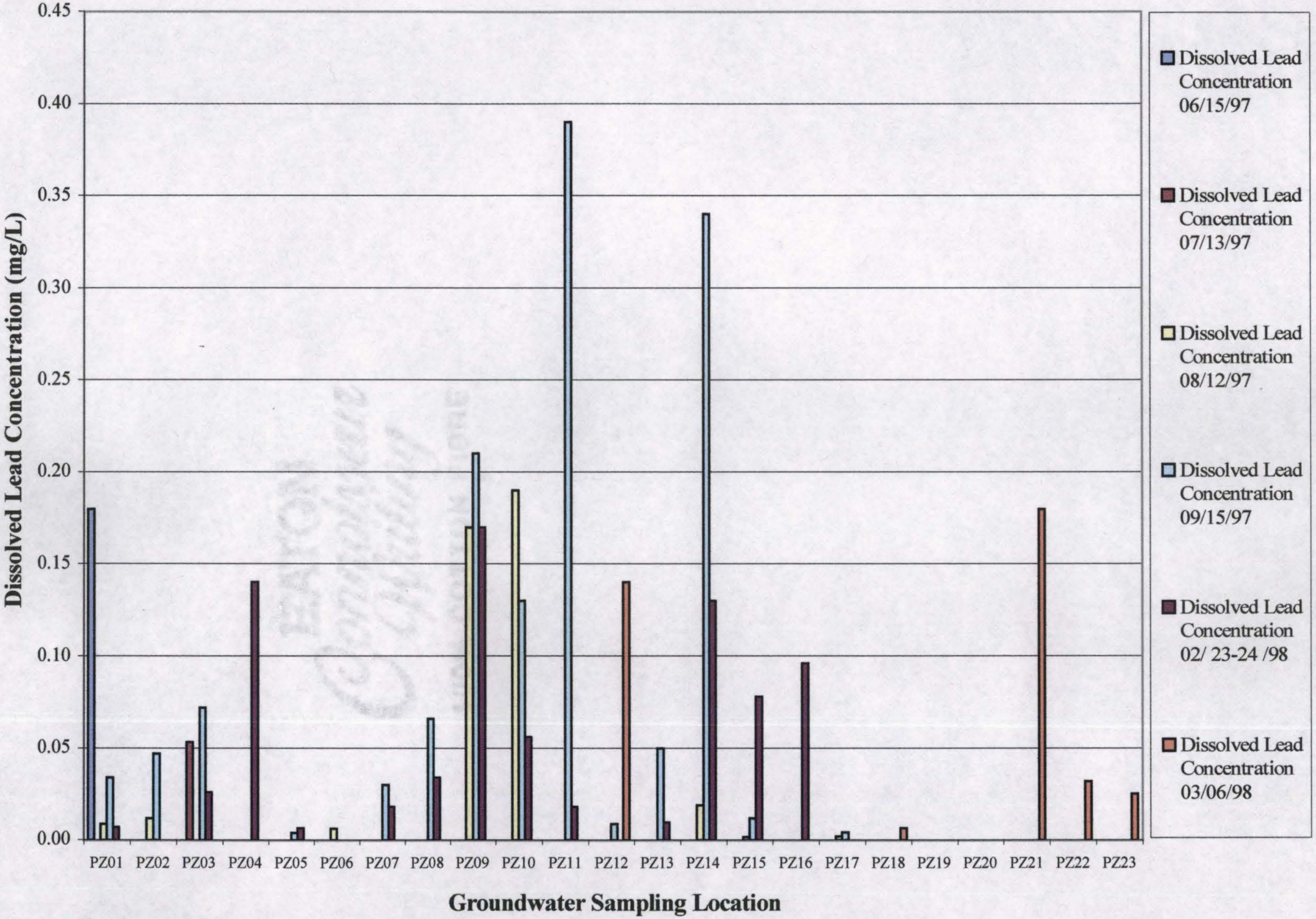
WATER QUALITY DATA GRAPHS JUNE 1997 – MARCH 1998



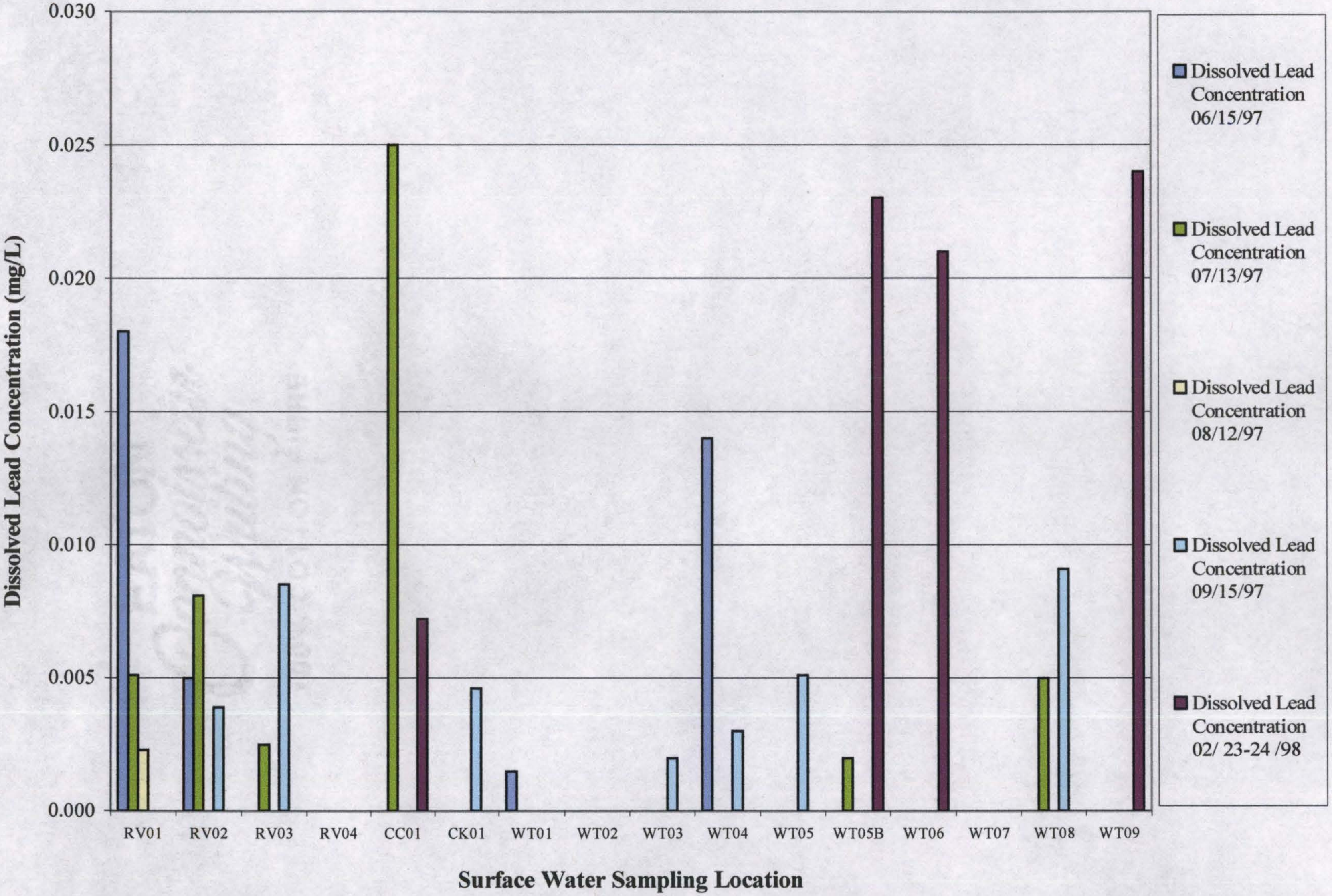
Appendix E1. Dissolved cadmium concentrations in groundwater sites for sampling dates June 15, 1997, July 13, 1997, August 12, 1997, September 15, 1997, and February 23-24, 1998.



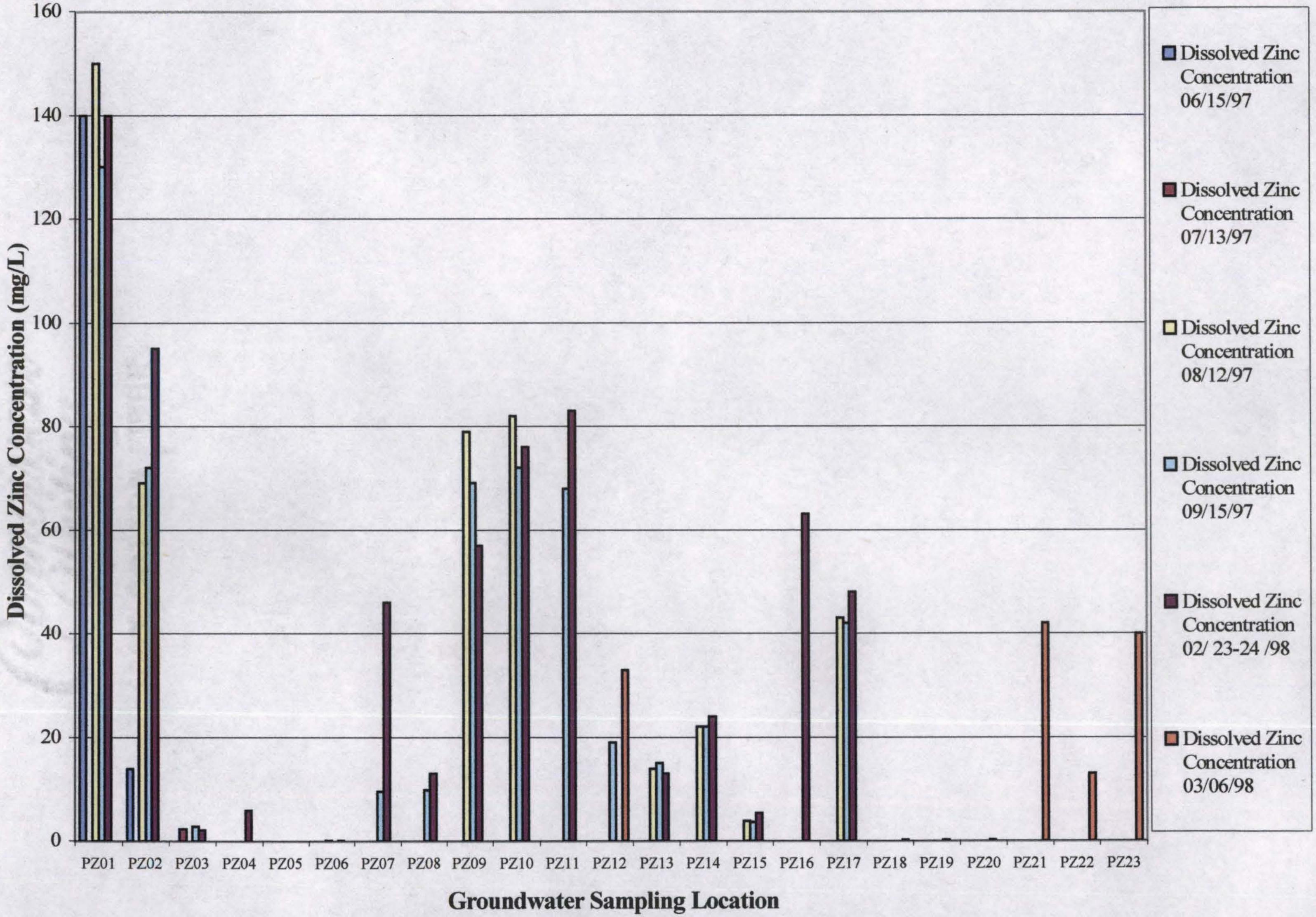
Appendix E2. Dissolved cadmium concentrations in surface water sites for sampling dates June 15, 1997, July 13, 1997, August 12, 1997, September 15, 1997, and February 23-24, 1998.



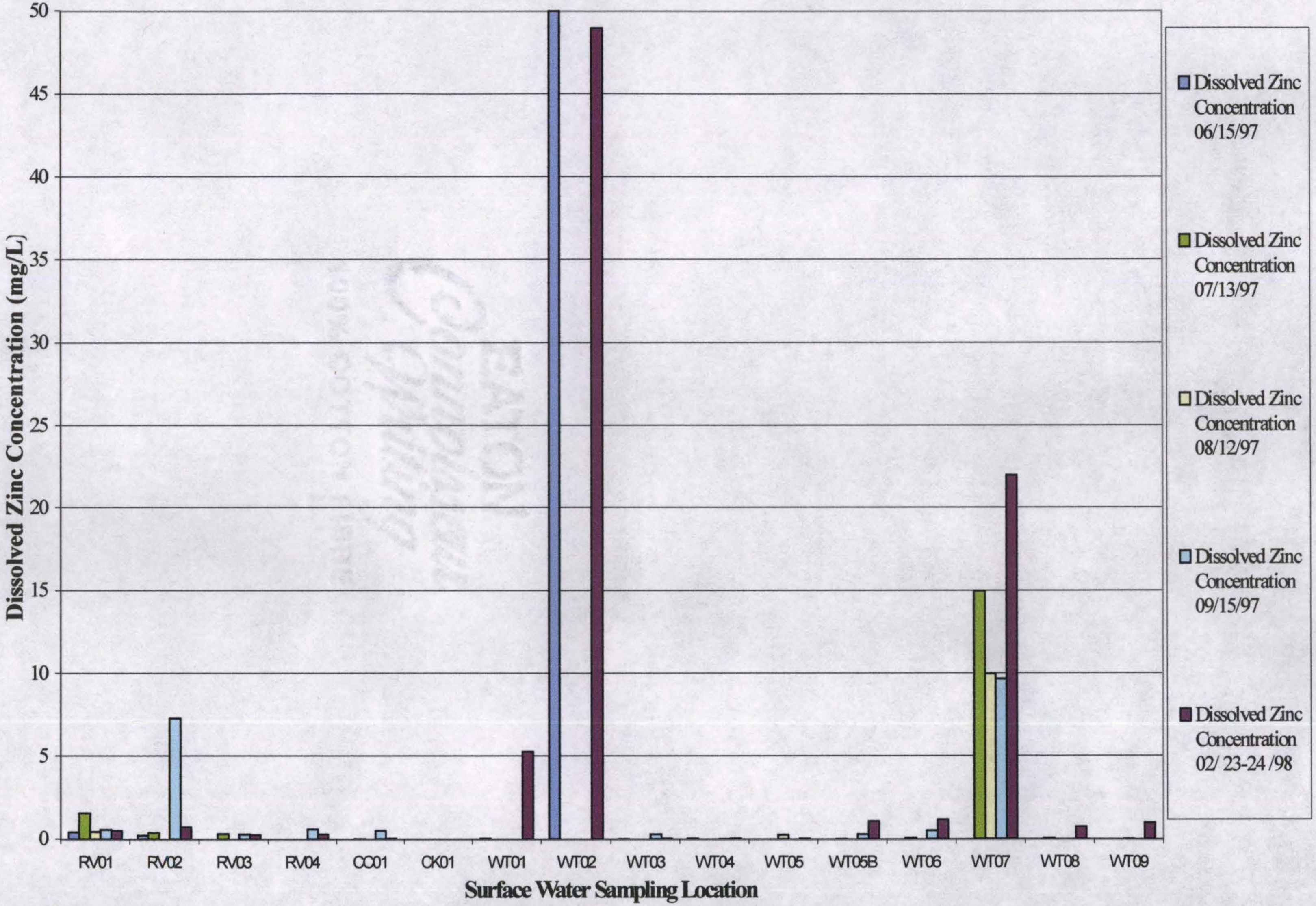
Appendix E3. Dissolved lead concentrations in groundwater sites for sampling dates June 15, 1997, July 13, 1997, August 12, 1997, September 15, 1997, and February 23-24, 1998.



Appendix E4. Dissolved lead concentrations in surface water sites for sampling dates June 15, 1997, July 13, 1997, August 12, 1997, September 15, 1997, and February 23-24, 1998.



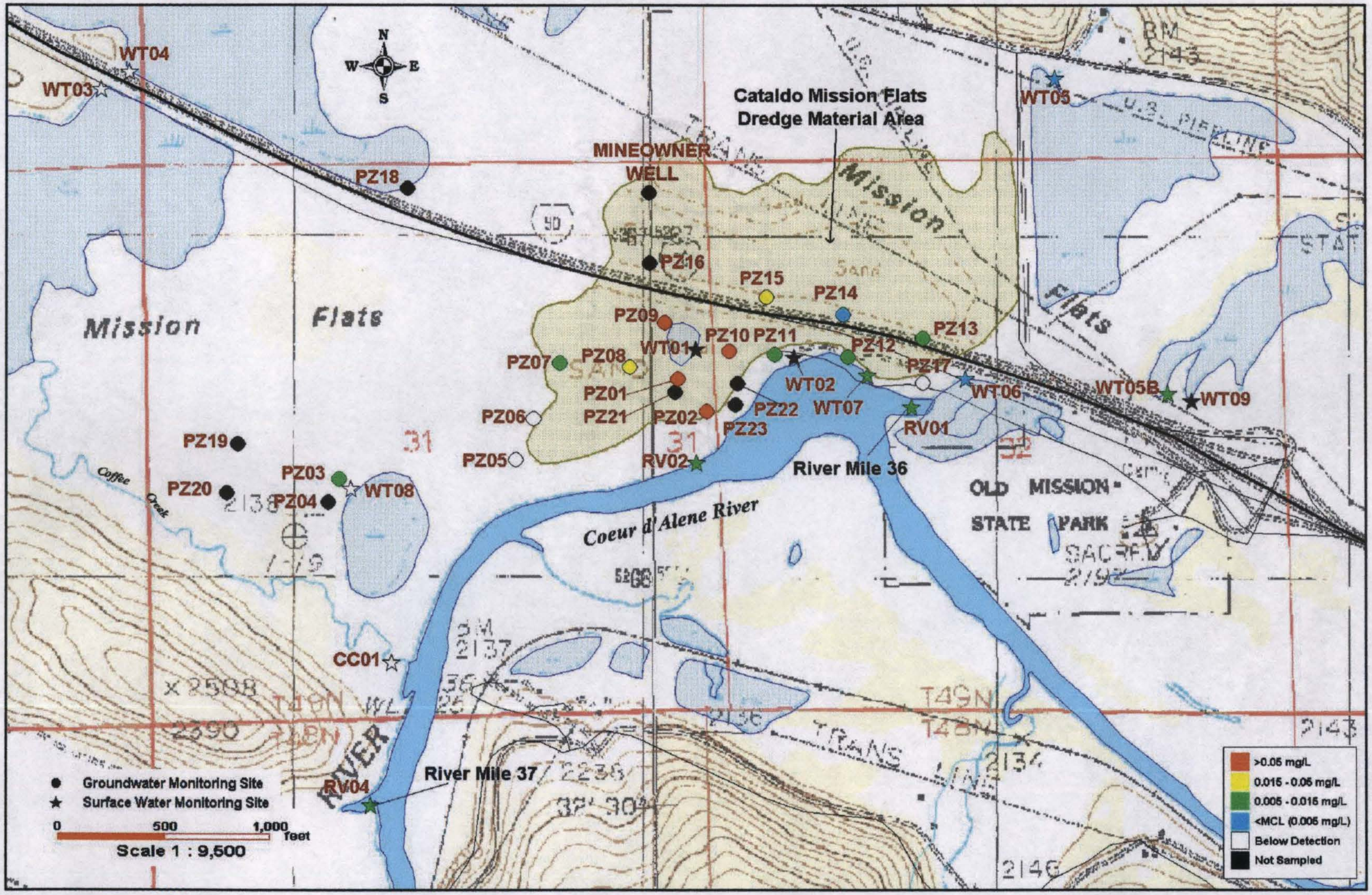
Appendix E5. Dissolved zinc concentrations in groundwater sites for sampling dates June 15, 1997, July 13, 1997, August 12, 1997, September 15, 1997, and February 23-24, 1998.



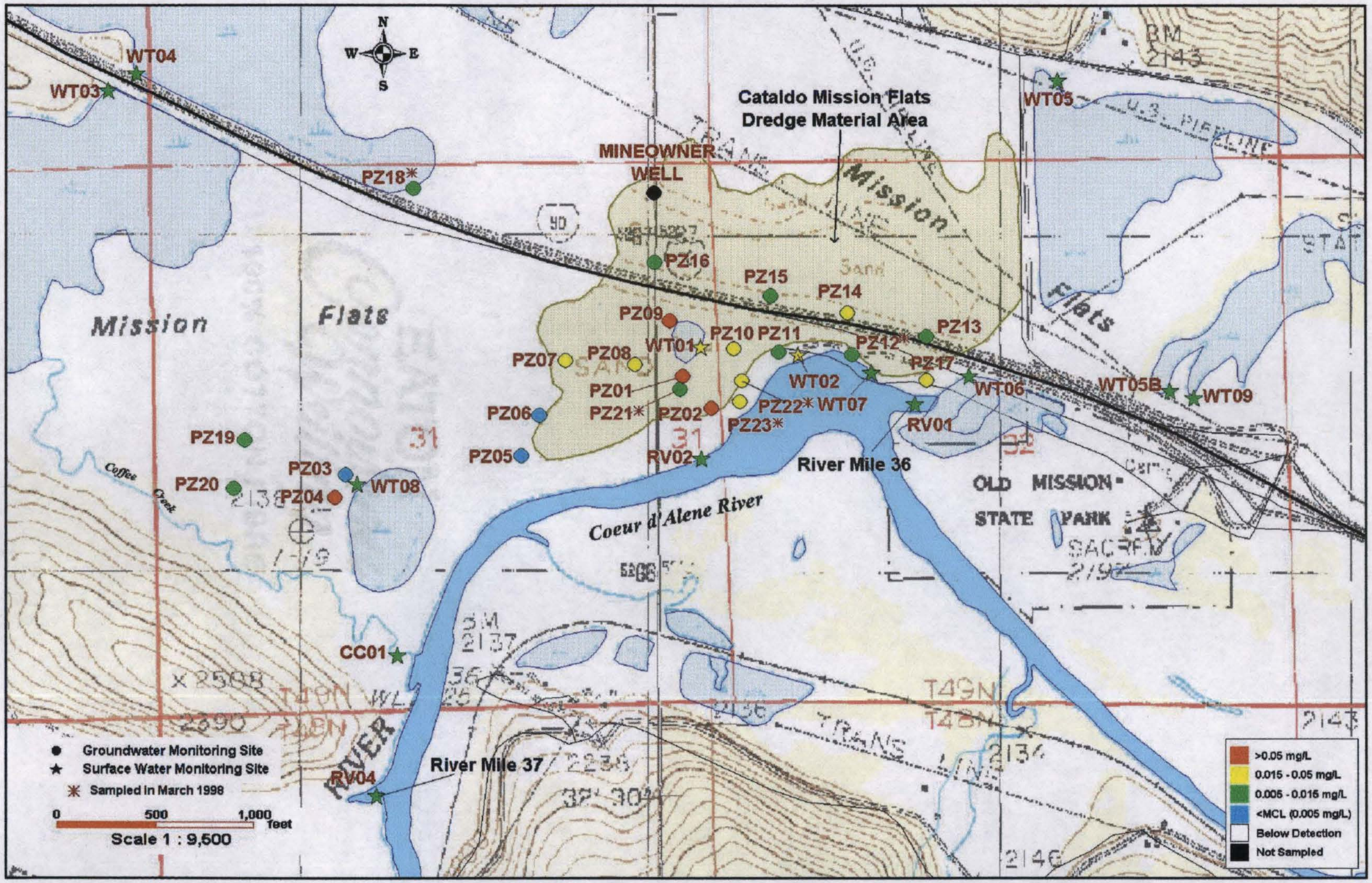
Appendix E6. Dissolved zinc concentrations in surface water sites for sampling dates June 15, 1997, July 13, 1997, August 12, 1997, September 15, 1997, and February 23-24, 1998.

APPENDIX F

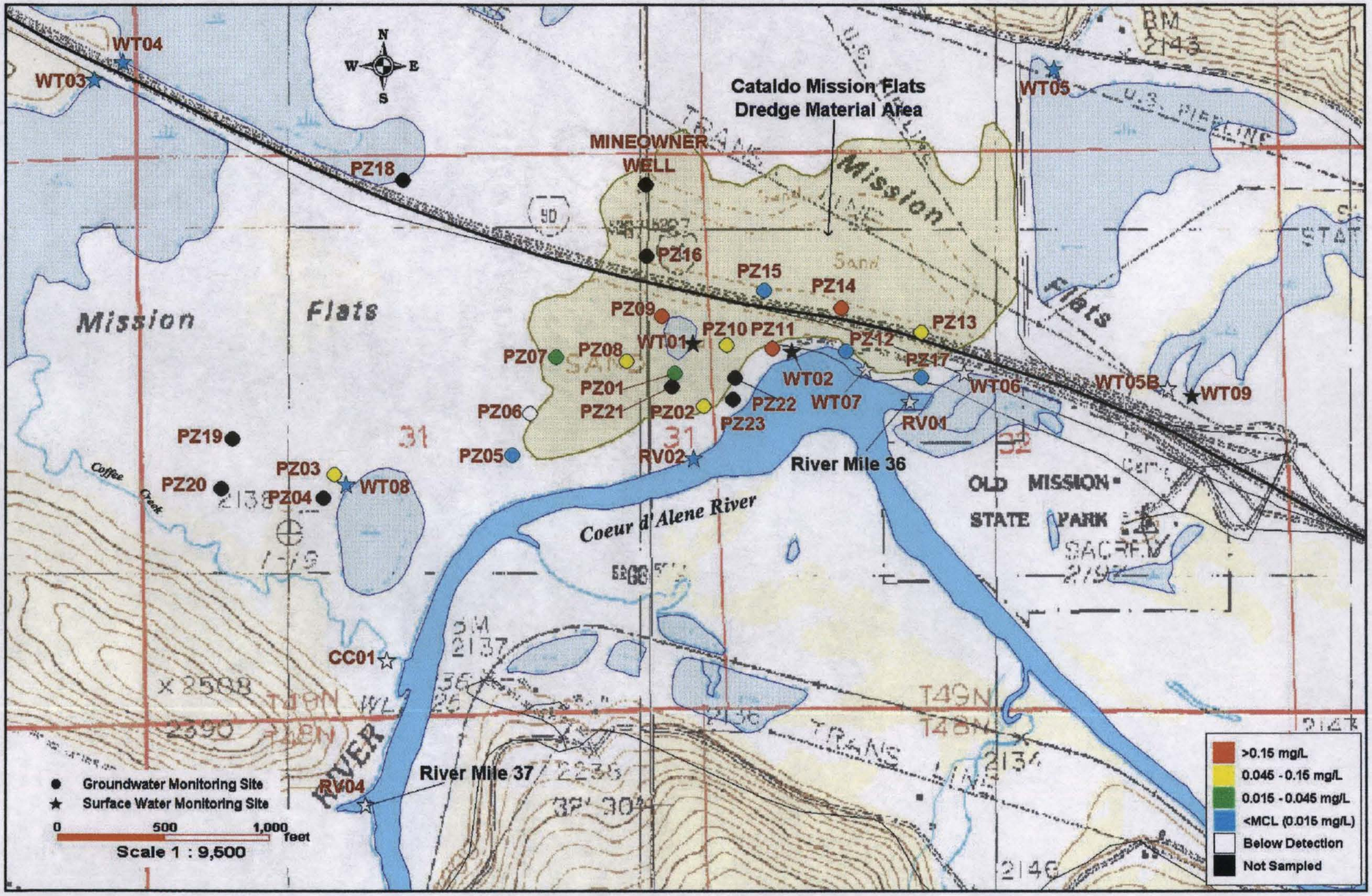
WATER QUALITY DATA PLAN VIEW MAPS JUNE 1997 – MARCH 1998



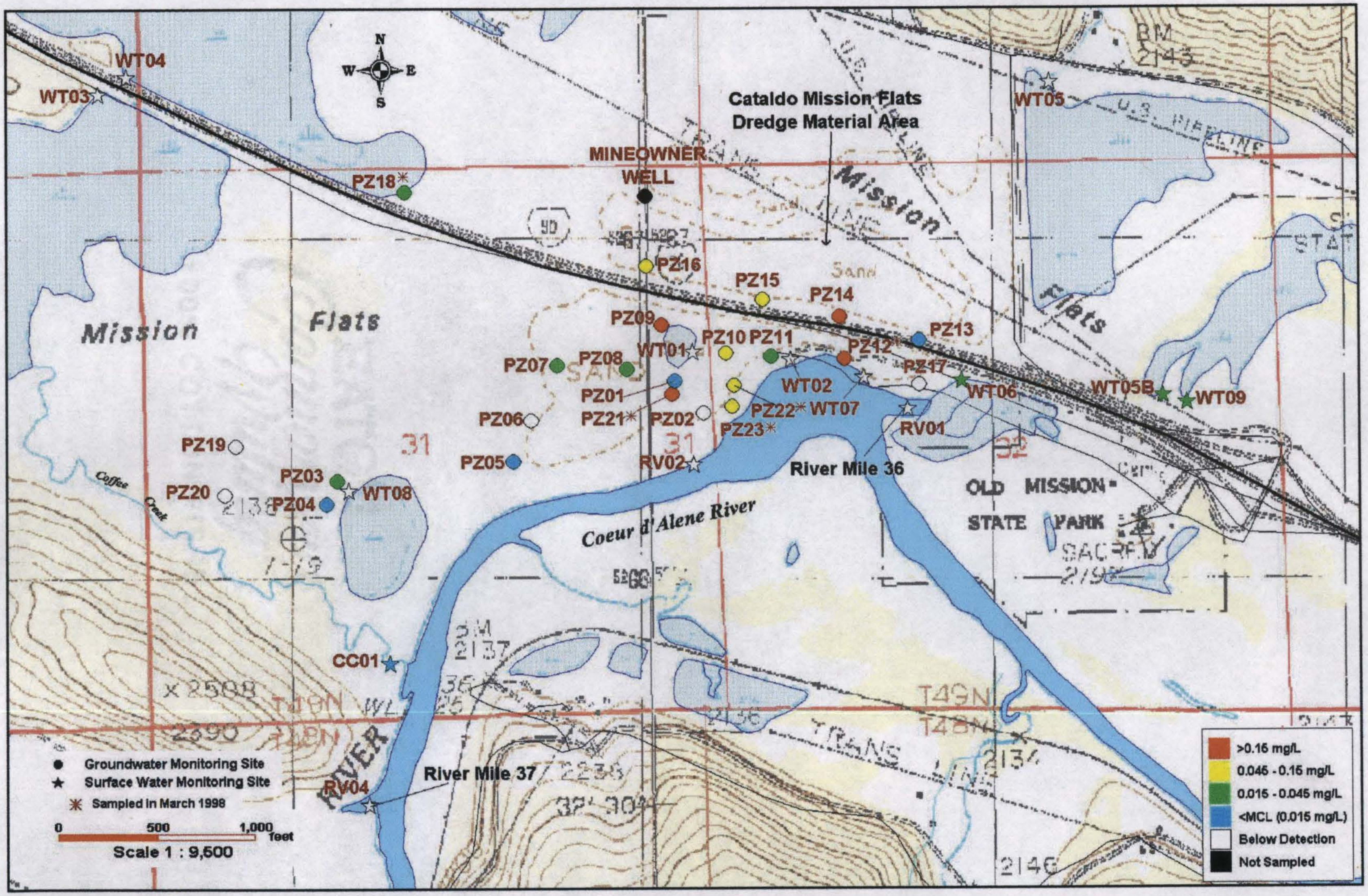
Appendix F1. Dissolved cadmium concentrations in groundwater and surface water measurement locations at Cataldo Mission Flats on September 15, 1997.



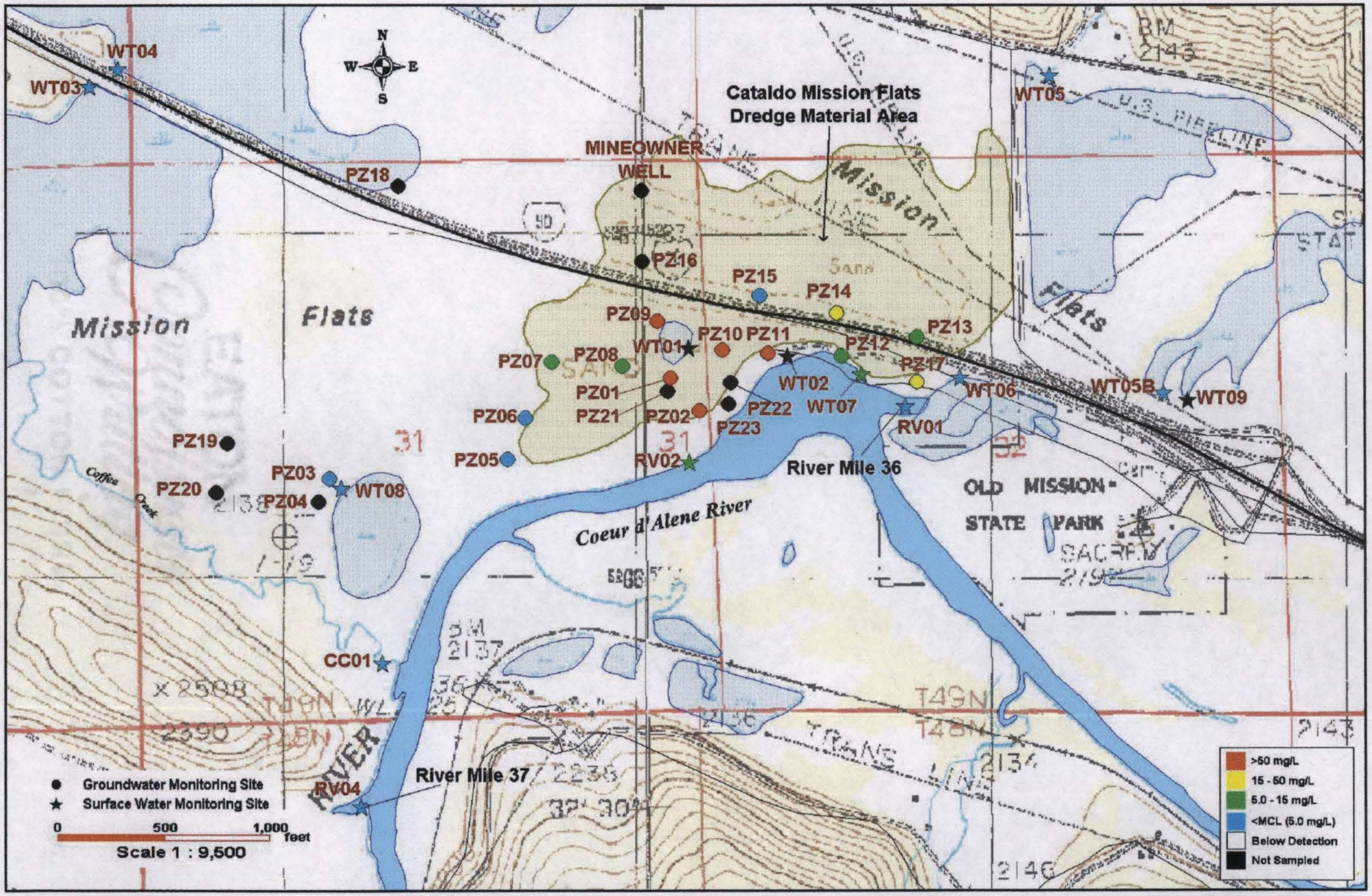
Appendix F2. Dissolved cadmium concentrations in groundwater and surface water measurement locations at Cataldo Mission Flats on February 23-24, 1998 and March 6, 1998.



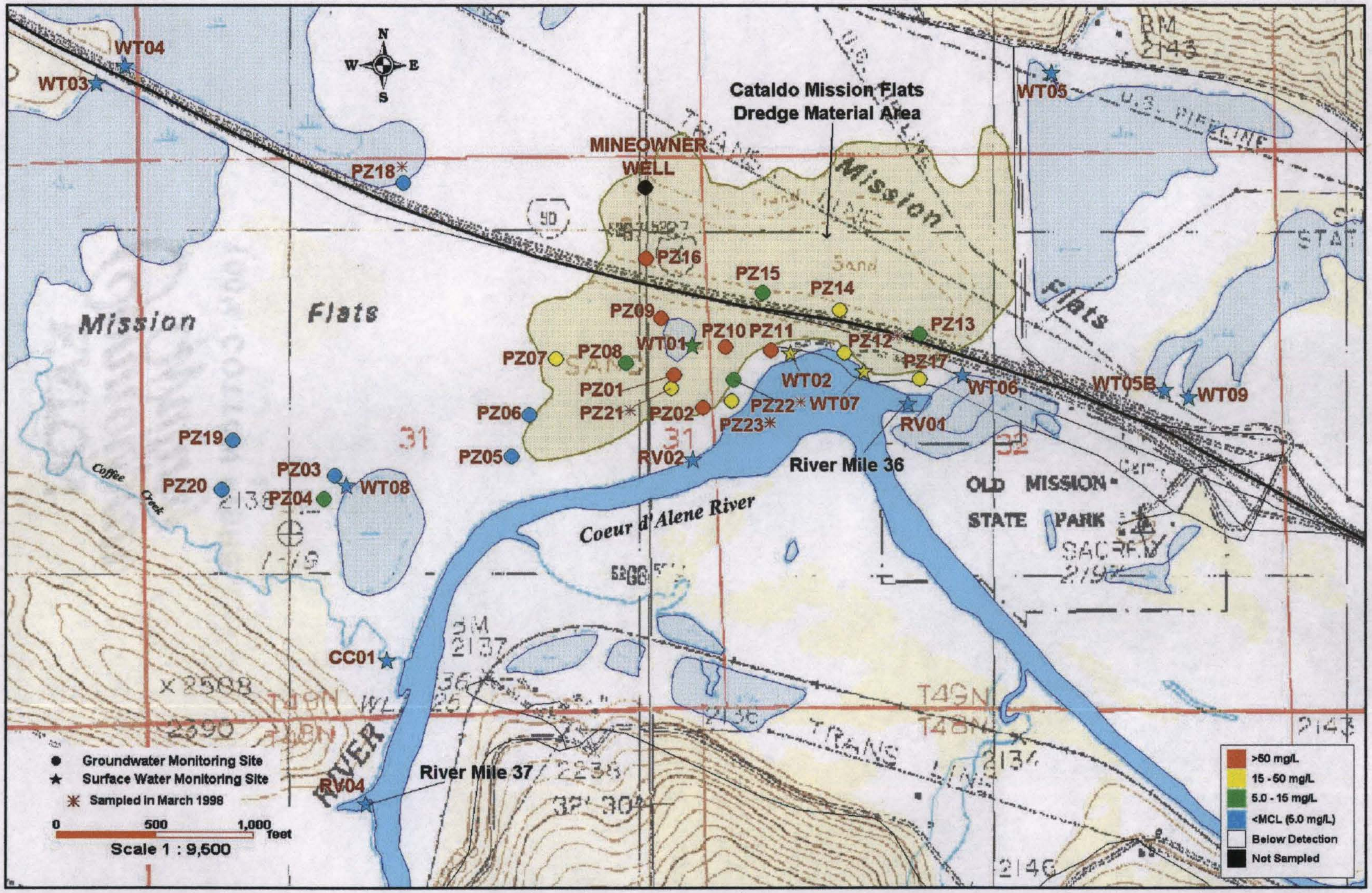
Appendix F3. Dissolved lead concentrations in groundwater and surface water measurement locations at Cataldo Mission Flats on September 15, 1997.



Appendix F4. Dissolved lead concentrations in groundwater and surface water measurement locations at Cataldo Mission Flats on February 23-24, 1998 and March 6, 1998.



Appendix F5. Dissolved zinc concentrations in groundwater and surface water measurement locations at Cataldo Mission Flats on September 15, 1997.



Appendix F6. Dissolved zinc concentrations in groundwater and surface water measurement locations at Cataldo Mission Flats on February 23-24, 1998 and March 6, 1998.