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Long Term Wetland Treatment of Mine Drainage at LTV Steel Mining Company's Dunka Mine

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Acknowledgments

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Executive Summary

A study was conducted at LTV's Dunka Mine in northeastern Minnesota to examine the long term metal removal in two wetland treatment systems that had operated for seven years. One system was an overland flow wetland that had been constructed to treat neutral drainage with an average nickel concentration of around 5 mg/L. The other was a pretreatment system which was installed to treat a drainage with an average pH of 5.4, and which contained 14.7 mg/L of nickel and 0.69 mg/L of copper.

W1D overland flow wetland

The wetland system was constructed in 1992, and the stockpile that contributed the major load to the wetland was capped with a linear low density polyethylene liner in 1995. Over 90% of the metal input to the wetland occurred before the stockpile was capped. After capping, both flow and nickel concentrations decreased. Flow decreased by 55%, while average nickel concentrations decreased by 82%, from 3.98 mg/L to 0.74 mg/L.

The overall nickel removal in the system prior to capping the stockpile averaged 89%. After capping, the input load to the wetland decreased by over 90% and the average percent removal decreased to 61%. Despite lower input concentrations after capping, nickel removal continued throughout the entire study period.

In order to examine treatment lifetime, a portion of the wetland (W1D study cell), which had accounted for 26% of the total nickel removal, was selected for detailed study. Mass balance calculations conducted for the study cell indicated that essentially all the nickel removed from the water could be accounted for by the estimated nickel mass within the substrate. There was no evidence of nickel being removed from the wetland.

Assuming that the post capping load to the wetland remains unchanged, and that new metal removal sites are formed from decaying vegetation in the wetland, there appears to be a balance between the input metal load and the yearly generation of removal sites. If this situation continues, the wetland may be self-sustaining, and treatment may continue indefinitely.

Seep 1 pretreatment system

The pretreatment system is comprised of a pool with two limestone berms, a peat-mixture substrate, and a vertical down-flow section through which the water flows prior to discharge. The system was constructed in 1992, and has generally been successful in increasing pH from an average of 5.40 to 6.95. Copper concentrations have decreased by about 70% and nickel concentrations have decreased by 55%.

The pH increase and much of the copper removal are related to dissolution of the limestone within the pretreatment system. Although it was not possible to calculate a limestone dissolution rate and an expected lifetime, there is no data to suggest that the rate of dissolution has decreased. Nickel removal within the pretreatment system averaged only 15-20%, and occurred primarily in the vertical down-flow section of the system. The major reduction in nickel load appears to be related to capping of the stockpile, and not to removal within the pretreatment system. In 1999, removal in the vertical down-flow section was only 8%, and additional data should be collected to determine if the system has reached saturation.

Introduction

Wetlands have been used to treat a variety of water quality problems, including agricultural, municipal and industrial discharges (Hammer, 1989, Moshiri, 1993). Wetlands have also been successful in treating coal and metal mine drainage and can be an attractive alternative to more conventional treatment methods (Hedin et al., 1994, Eger et al., 1996, Sobolewski, 1997). Wetlands can be less costly to build, use processes which naturally occur to remove metals from the water (e.g. adsorption, filtration), and offer a system that ideally should operate with little to no maintenance for extended periods of time. Since mine drainage problems can persist for hundreds of years, the longevity of any system is a critical issue. The lifetime of a wetland treatment system is a function of the type of removal processes occurring in the wetland. Figure 1 depicts the types of removal processes (and their typical locations) that can occur within a wetland treatment system.

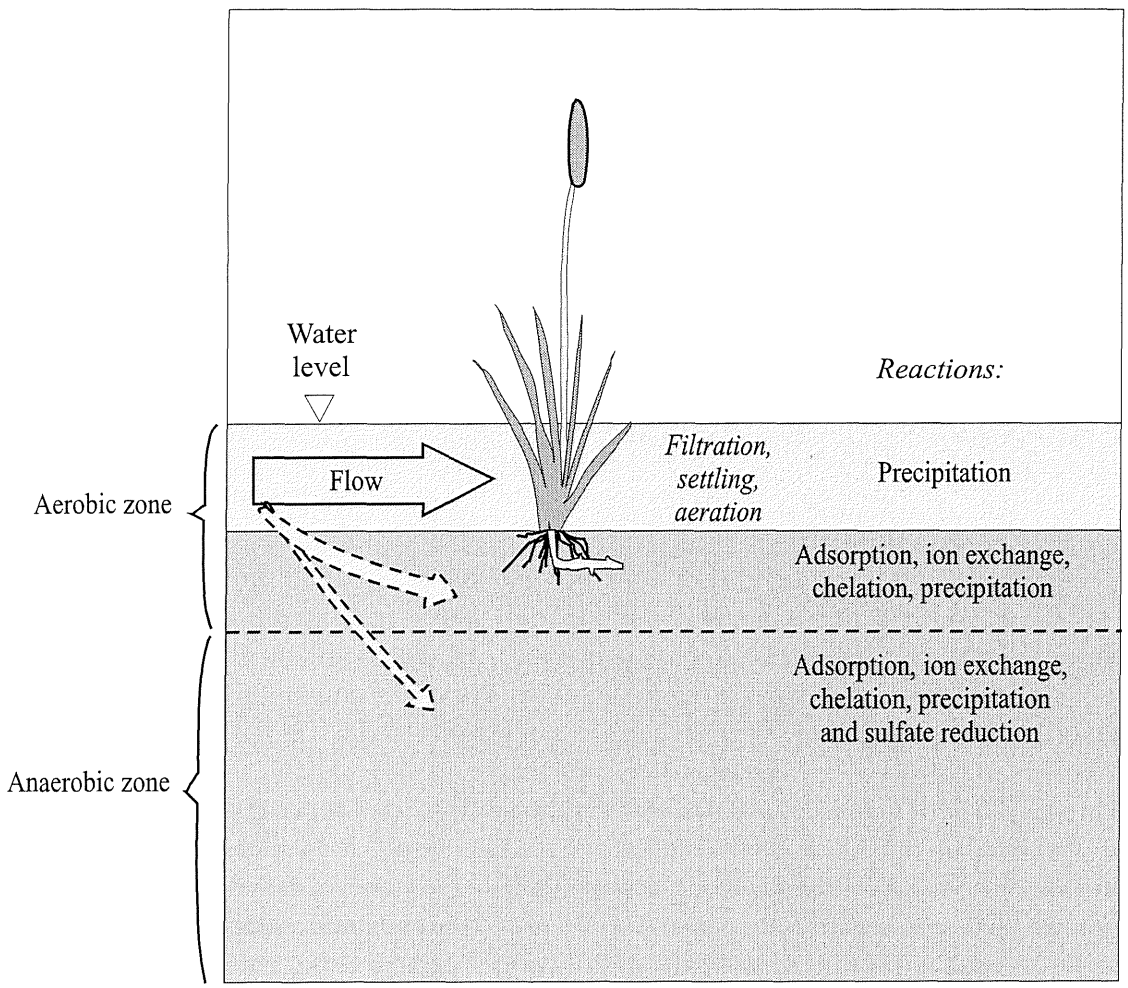


Figure 1. Metal removal processes that occur in overland flow wetlands (schematic).

Physical removal

Some of the contaminants that enter wetlands are associated with solid particles. These can be removed by sedimentation as water spreads out over the wetland and the velocity of the water decreases. As a result, particles begin to settle out and accumulate in the wetland. In addition to physical removal by settling, dense vegetation acts as a filter to remove additional material. Particulate removal can continue for an extended period of time, or until the wetland fills with sediment.

Chemical removal

Chemical processes occur in both the upper, oxygenated , aerobic zone of the wetland and in the deeper, oxygen-poor, anaerobic zone. Some removal reactions including adsorption, ion exchange, and chelation can occur in both zones. Certain processes such as the oxidation of ferrous iron to ferric iron can only occur in the aerobic zone, whereas reactions like sulfate reduction require an anaerobic condition.

Aerobic processes

When there is water on the surface of the wetland, aerobic conditions exist throughout the water column, but conditions quickly become anaerobic below the substrate surface. If the water level is below the substrate surface, the area of the substrate above the water level is usually aerobic. In addition, when vegetation is present, an aerobic zone exists around the roots of each plant as the plant transports oxygen to its roots (Grosse, 1989, Michaud and Richardson, 1989). This occurs even when the roots of the plant are totally submerged.

Most of the wetlands constructed to treat mine drainage have been used in the coal mining industry. These wetlands have typically been constructed so that flow occurs across the surface of an organic substrate which were planted with cattails, and treatment occurs in the aerobic zone (Wieder, 1989, Hedin, 1989). Iron removal primarily occurrs through the oxidation of ferrous iron to ferric iron, and the subsequent removal of iron as a ferric oxyhydroxide precipitate. In addition to iron removal, pH is reduced. This reaction will continue until the wetland fills with iron precipitate. A wetland in Pennsylvania not only operated successfully for over eight years, but treatment efficiency increased over time (Stark et al., 1994). Recently several researchers have been investigating the potential to recover the iron precipitate from wetlands for use as a coloring pigment (Hedin, 1998).

For neutral metal mine drainage, wetland systems similar to those used for coal drainage can effectively remove low levels of metals (Eger and Melchert, 1992, Eger et al., 1996, Hambley, 1996). In these systems, removal reactions primarily occur within the substrate and occur in both the aerobic and anaerobic zones. Most removal occurs in the upper 20 cm of the substrate, since the transport of metals to the deeper layers usually is limited by the rate of diffusion (Eger and Lapakko, 1988, Eger et al., 1994). Ion exchange reactions often involve the exchange of a hydrogen ion for the metal ion, therefore causing pH to decrease. As pH decreases, removal efficiency also decreases. In laboratory studies, metal removal decreased by over 50% as pH decreased from 7.4 to 4.0 (Lapakko and Eger, 1988).

The lifetime of adsorption, chelation, ion exchange reactions is a function of the amount of removal sites present in the substrate. As a result, each substrate has a finite ability to remove metals through these mechanisms. New sites can be generated in a wetland as vegetation decays, but this is a slow process; peat in northern wetlands accumulates at a rate of about 1mm/year (Craft and Richardson, 1993). Although it is theoretically possible to design a system where the input of new sites would equal the input of metals, the ratio of wetland area to flow must be about ten times larger than the ratio to provide short term treatment (Eger et al.,1994).

Anaerobic processes

In most wetlands anaerobic conditions develop in the saturated zone, below the soil/water interface. Although exchange reactions can still occur, the primary reaction which can provide long-term metal removal is sulfate reduction. Sulfate reduction reactions cannot only remove metals but can also increase pH, and therefore can treat acid mine drainage effectively. The reactions involved can be represented as follows:

$$SO_4 + 2 \text{ lactate} \rightarrow 2 \text{ acetate} + H_2S + 2HCO_3$$

$$H_2S + M^{+2} \rightarrow MS + 2H^{+}$$

Bacteria break down complex organic materials into small chain organic compounds (e.g. lactate). These compounds, along with sulfate, can then be used as an energy source by the sulfate reducing bacteria. Sulfate reducing bacteria are ubiquitous and tolerate a wide range of environmental conditions. Their optimal pH range has been reported to be from 5 to 9 (Postgate, 1984), but they can control their microenvironment even when the bulk solution pH is below 5. Successful sulfate reduction has been reported for a drainage with a pH as low as 2.6 (Bolis et al.,1991; Gusek, 1998).

Although anaerobic zones exist in natural wetlands, the peat material itself breaks down very slowly, so the rate of sulfate reduction is low. By constructing a wetland with a more reactive organic substrate, short-term reaction rates can be increased significantly. Spent mushroom compost has been commonly used in constructed wetlands in the eastern United State (Wieder, 1989). Experiments in Colorado and Arkansas have used other local waste products such as steer manure, rice hulls, and chicken litter as the substrate (Howard et al., 1989, Gross et al., 1991).

Sulfate reduction reactions can be modeled as a series of chemical reactions where the rate of reaction is related to the concentration of sulfate and the concentration of small chain organics. Since sulfate is generally present in high concentrations in most mine drainage, the limiting reactant is the amount of small chain organics. Lifetime estimates based on the total amount of organic material in constructed wetlands have been at least 20 to 30 years (Wildeman et al., 1993). Although these wetlands can continue to treat for extended periods of time, treatment efficiency will decrease as the more easily degraded organic material is consumed (Eger and Wagner, 1995, 2001). In several studies efficiency has been improved when a supplemental organic carbon source was added to the system (Stark et al., 1995).

Objectives

The objectives of this study were to:

- Examine metal removal in existing wetland systems at LTV's Dunka Mine in northern Minnesota
- Determine the potential of these systems to provide long-term treatment

Site description

The Dunka Mine was a large open pit taconite operation which operated from 1962 to 1995 (Figure 2). At this location the Duluth Complex, a metalliferous gabbroic intrusion, overlaid the taconite ore and was removed and stockpiled along the east side of the open pit. The Duluth Complex material contains copper, nickel, and iron sulfides, and the stockpiles contain over 50 million tons of waste rock and cover about 300 acres (120 hectares). Seeps appear at the base of the stockpiles, and generally flow continuously from early April to late November. Average flows from the various seeps have ranged from 8 to 220 gal/min (0.5 L/sec to 14 L/sec), but flows exceeding1600 gal/min (100 L/sec) have been observed after periods of heavy precipitation.

Nickel is the major trace metal in the drainage, and annual median concentrations prior to closure were on the order of 3-30 mg/L. Copper, cobalt, and zinc are also present but are generally less than 5% of the nickel values. Median pH ranges from 5.0 to 7.5, but most of the stockpile drainage has pH greater than 6.5.

Wetlands were located near every stockpile and appeared to offer potential treatment areas for each seep (Eger and Lapakko, 1989). These wetlands are typical of the many small lowland areas in northern Minnesota, and would generally be associated with any mining operation in the area.

In the mid-1980s, LTV began an extensive program to evaluate various options for mitigating the problems at this mine. The company's preferred option was a combination of passive alternatives which would reduce flow emanating from their stockpiles, and which would use wetland treatment to remove metals from the resulting drainage. In 1988, four overland flow test cells were built to investigate methods to optimize metal removal and to provide design data for the ultimate implementation of wetland treatment at this facility (Eger and Lapakko, 1989; Eger et al.,1991, 1993, 1994). Based on the results of this study, two full-scale wetland treatment systems were built in March of 1992. In addition, two pretreatment systems were installed in the summer of 1992.

By the time the Dunka mine was closed in 1995, the company had already begun to implement a closure plan. The amount of water flow through the stockpiles was reduced by routing surface and groundwater away from the piles. Infiltration into the waste rock was reduced by covering the top portion of the stockpile. Any residual drainage was to be treated in constructed wetlands (Eger et al., 2000). This study focuses on two sites constructed in 1992, where large amounts of metals had been removed; the W1D wetland treatment system, and the Seep 1 pretreatment system (Figure 2).

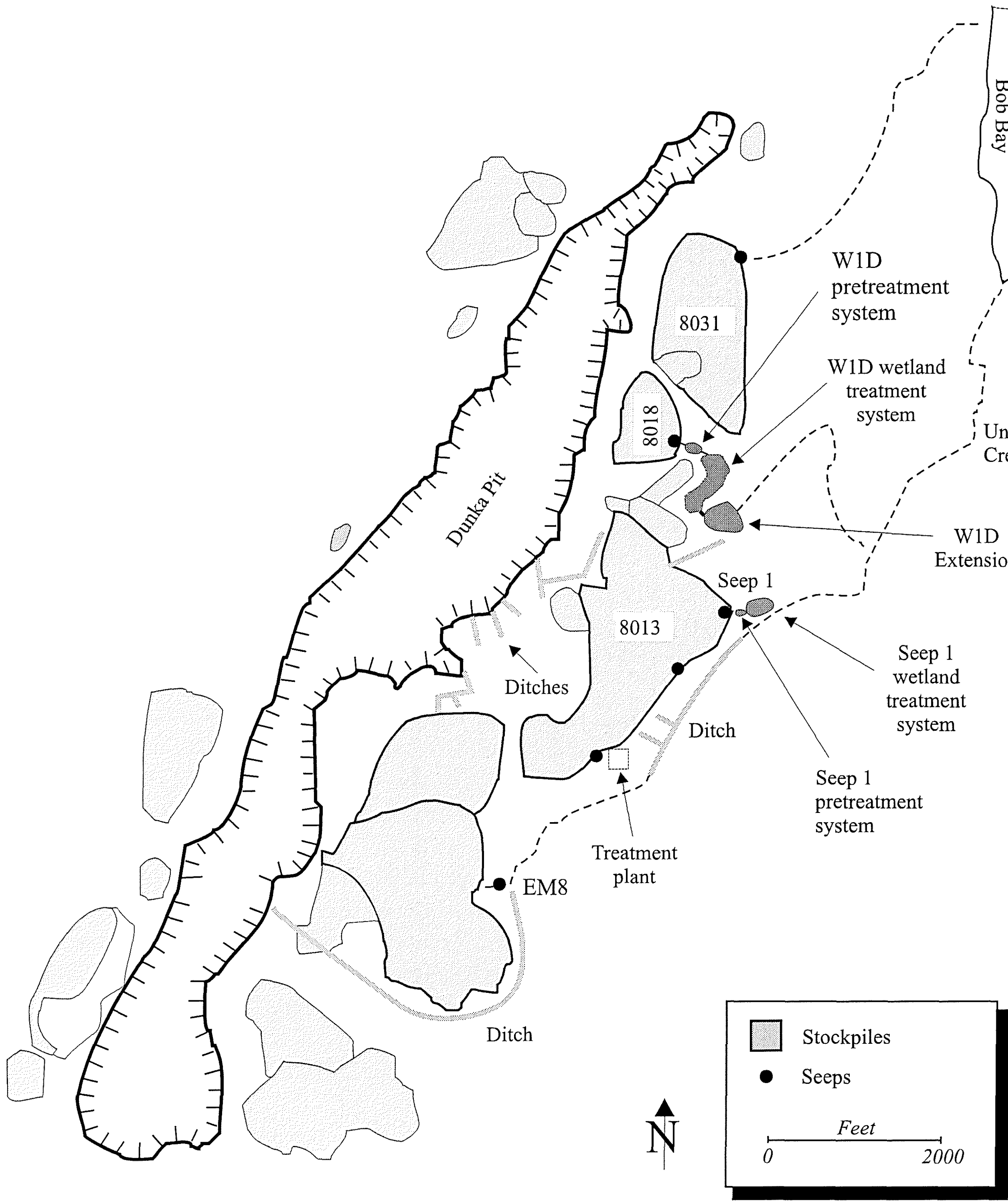


Figure 2. Location of the Seep 1 and W1D wetland treatment systems at LTV Steel Mining Co.'s Dunka Mine, Babbitt, MN.

Overland flow wetland, W1D

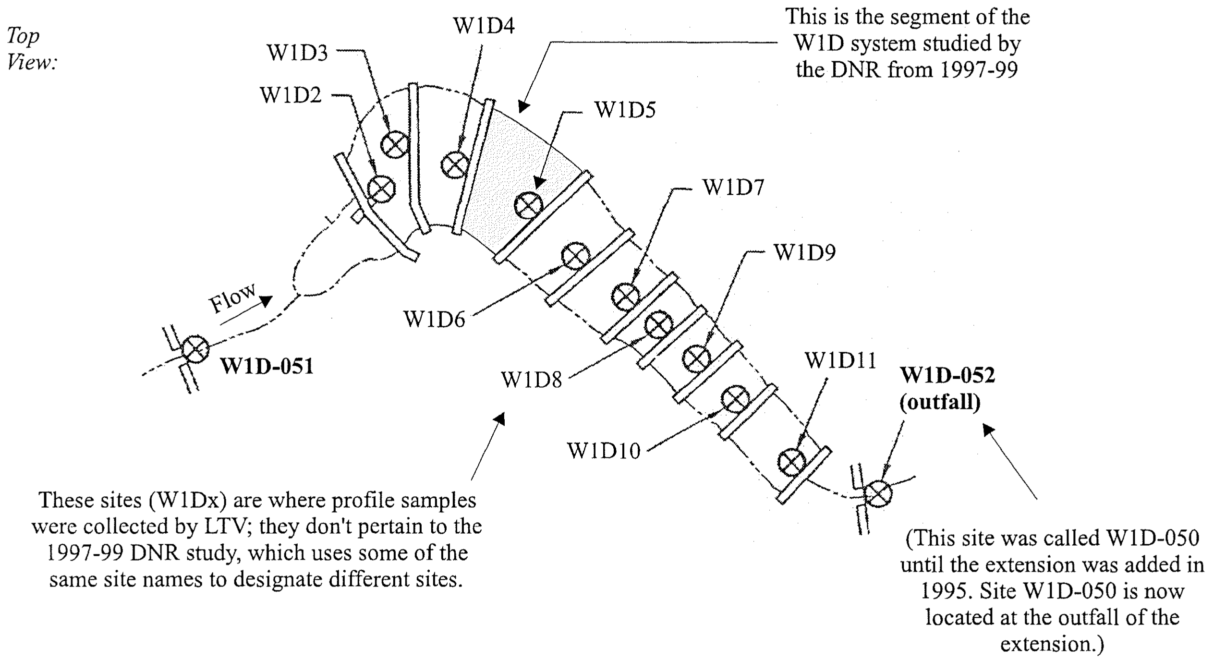
This system was built in an existing wetland. Construction began in March of 1992. The wetland systems were designed by STS Consultants, Ltd., and built by LTV Steel Mining Company (Frostman, 1992). In the summer of 1992 a pretreatment system was constructed at the base of the 8018 stockpile (Figure 2, Appendix 14).

The area was originally a combination of emergent (wet meadow) and scrub-shrub type wetlands, and the majority of the woody vegetation, which consisted primarily of alder (*alnus sp.*), was removed from the site. The basic design for the system included the construction of a series of soil berms, which were built to control water levels and to maximize contact between the drainage and the substrate (Figure 3). Soil berms were built with glacial till (sandy silt) available from a surface overburden stockpile on the property. After the berms were constructed, a one-foot (30 cm) layer of a mixture of local peat and peat screenings was applied to the entire area except the top of the berm. The screenings were a waste material generated during the processing of horticultural peat and consisted mostly of wood fragments and long peat fibers (Appendix 4). This material was selected to increase the permeability of the peat to at least 10^{-3} cm/sec and to provide available organic carbon. In the spring of 1992, the berms were hand-seeded with Japanese Millet, while the open water areas were seeded with cattails. To obtain the cattail seeds, cattail heads were placed in a container of water with a small amount of liquid soap and several large metal bolts. The mixture was agitated until the heads broke and the seeds were dispersed. The slurry was then broadcast by hand over the wetland.

The majority of the flow to this system originates from the base of the 8018 stockpile, although additional seepage from the 8031 stockpile also drains to this area (Figure 4). V-notch weirs were installed to provide continuous measurement of the input and output flows. From 1986 to 1994, May to October flows ranged from 20-40 gal/min (75-150 L/min), with peak flows exceeding 200 gal/min (750 L/min). Flows decreased after the 8018 stockpile was capped with a 30 mil LLDPE (linear low density polyethylene) membrane in 1995. May to October flows from 1996-1999 have ranged from 8-22 gal/min (30-83 L/min). Water quality samples of the inflow and outflow were collected twice per month during the period of flow (generally late March - December). From 1992 through 1994, samples were also collected from within the system about once per month (Figure 3). From 1992-94, the input to the wetland had an average pH of 7.07 and contained 3.98 mg/L nickel, 0.068 mg/L copper, 0.052 mg/L zinc and 0.036 mg/L cobalt (Table 1). Nickel concentrations decreased by over 50% in 1995 to 1.78 mg/L, and the average input concentration for 1996 to 1999 was 0.74 mg/L (Table 1).

The original W1D treatment system, constructed in the spring of 1992, covered 1.7 acres (7000 m^2) and contained a series of 9 berms. From 1992 through 1994, changes were made to the system to disperse flow, minimize channeling and improve contact between the drainage and the substrate (Appendix 3). In 1995, the system was expanded by 2.5 acres (10,000 m^2). The extension included an alternating series of overflow and underflow berms (Eger et al.,1996). Prior to construction of these berms, the original organic soils were removed; the berms were then built on the mineral soil base and compacted to minimize any future settling. This report focues on the original W1D system, and excludes the W1D extension.

Figure 3. Top view of the original W1D wetland treatment system, and cross-section (as designed and as built) of typical berms in this system.



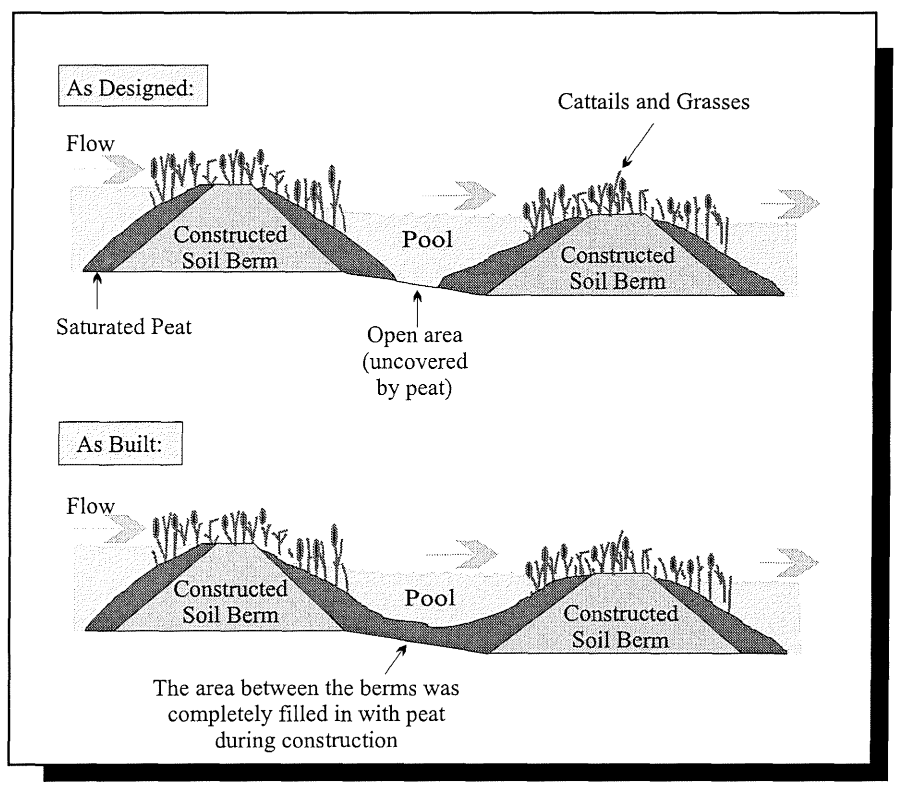


Table 1. Mean water quality data, W1D treatment system, 1992-1999.

Year	pH		SO_4		Cu		Ni		Co		Zn		Ca		Mg	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
1992	7.08	7.03	2480	1840	0.093	0.012	4.28	0.315	0.016	0.016	0.054	0.013	300	190	380	230
1993	7.11	7.14	1660	1290	0.051	0.009	3.14	0.354	0.043	0.004	0.041	0.009	220	190	220	220
1994	7.02	7.36	2120	1510	0.059	0.007	4.53	0.426	0.049	0.004	0.061	0.008	310	210	310	260
Average 1992-94	7.07	7.18	2087	1547	0.068	0.009	3.98	0.365	0.036	0.008	0.052	0.013	277	197	303	237
1995	7.05	7.30	1400	1100	0.105	0.003	1.78	0.392	0.049	0.005	0.022	0.007	240	180	240	200
1996	7.18	7.33	1600	1320	0.043	0.009	1.17	0.337	0.009	0.002	0.030	0.003	260	200	260	200
1997	7.17	7.32	1000	790	0.030	0.001	0.69	0.178	0.012	0.001	0.017	0.007	200	150	200	140
1998	7.74	7.29	970	820	0.031	0.002	0.49	0.121	0.010	0.001	0.023	0.006	200	150	200	150
1999	7.11	7.29	1140	770	0.015	0.001	0.61	0.140	0.006	0.001	0.015	0.007	210	140	210	140
Average 1996-99	7.30	7.48	1180	925	0.030	0.003	0.74	0.194	0.009	0.001	0.021	0.006	220	160	220	170

Notes: pH values are in standard units, all other concentration values are mg/L, and all parameters are total (i.e. unfiltered) values. The site called "in" is W1D-051, the historical sampling point for this drainage, and the site called "out" is the outflow from the original W1D system, which was originally called W1D-050, but which was renamed W1D-052 in 1995 after the W1D extension was put on-line. (Site W1D-050 is now at the outfall of the extension area.) Stockpile 8018 was capped in 1995, therefore 1995 isn't included in the 'post-closure' period (1996-1999).

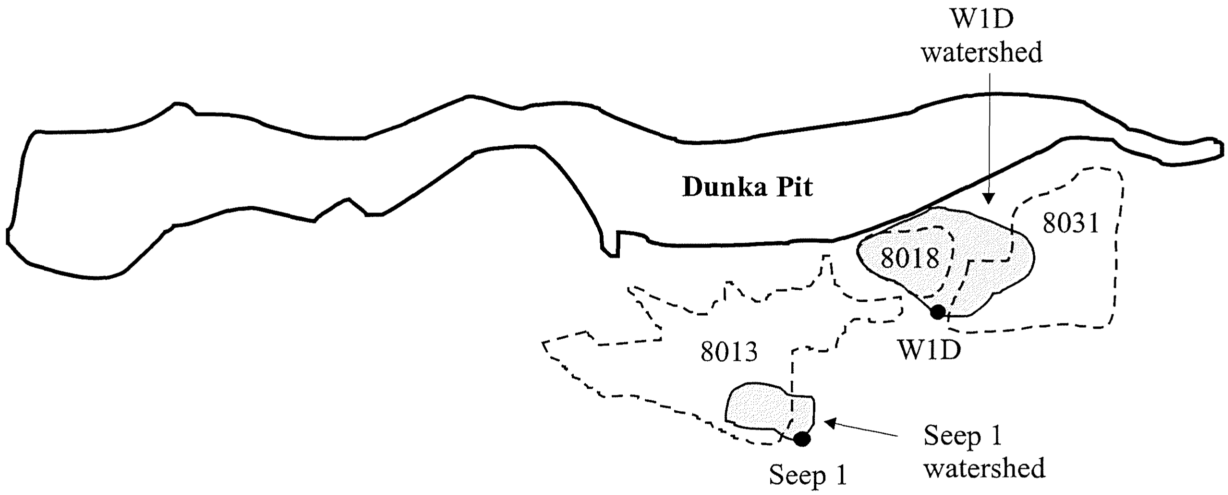


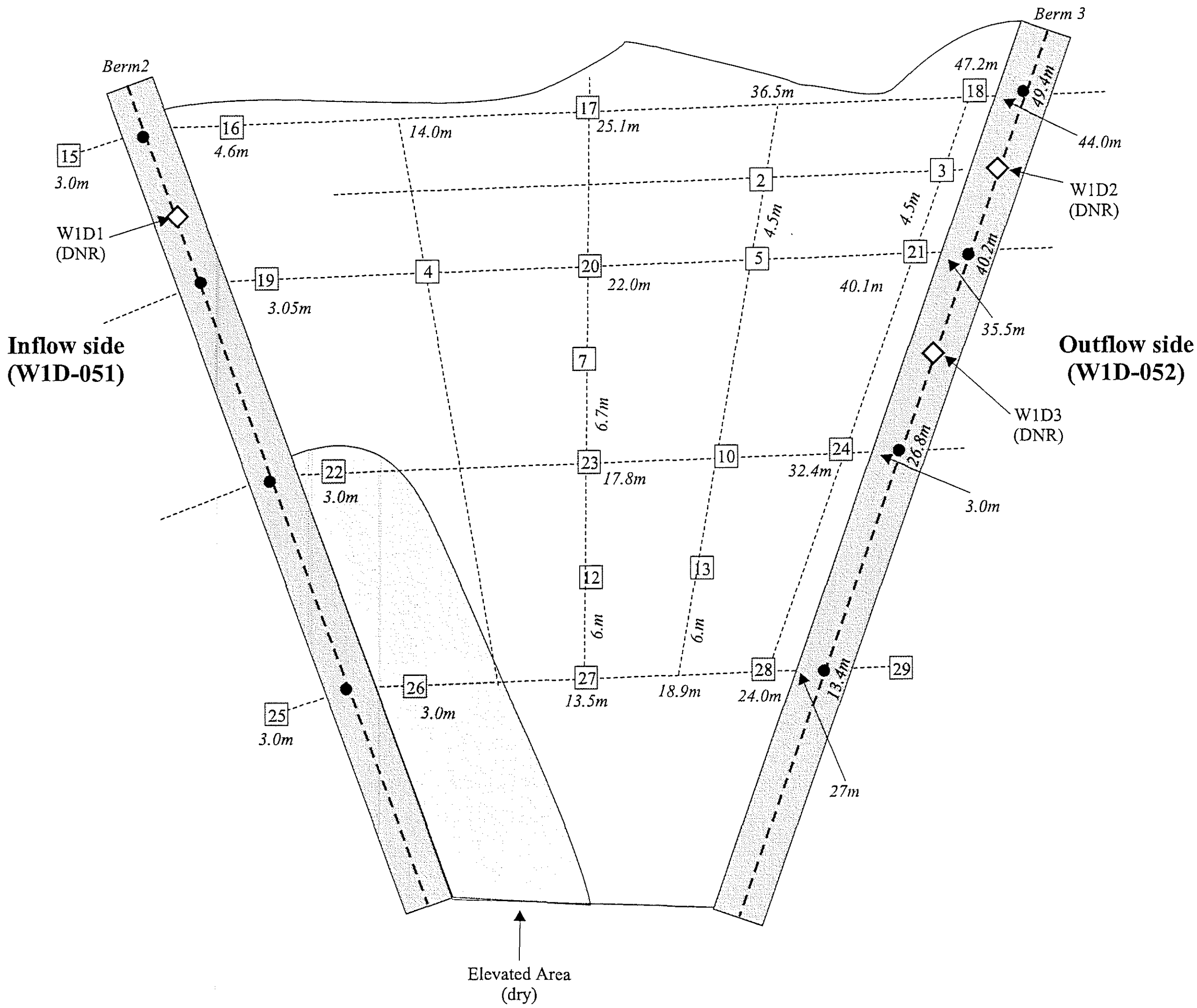
Figure 4. Watersheds and stockpile contributions to the W1D and Seep 1 seeps.

Study cell, W1D

Based on the 1992 to 1994 data collected from within the wetland, an individual cell within the original W1D system was selected for additional study (Figures 3, 5). This cell (the study cell) was chosen because it had the largest drop in nickel concentration. Based on the 1992 to1994 profile data, nickel concentrations decreased by an average of 26% as water moved through the cell (Figure 6). Since the watershed contribution to the cell was small, and since there was no evidence to support a substantial input of groundwater to the cell, there should not be a significant difference between input and output flow. As a result, mass removal was directly related to the change in concentration.

Since over 99% of the metal removal in these types of systems occurs in the substrate (Eger et al.,1994), the goal in this type of constructed wetland is to disperse flow uniformly across the wetland. Although this was the goal, it was difficult to achieve. Essentially all the flow enters the study cell at one point and leaves at two sites (Figure 5). Water depth ranged from near 0 at the berm to about 8 inches (20 cm) in the center of the cell.

The total cell area is about 16,000 ft^2 (1500 m^2), but about 2000 ft^2 (185 m^2) in the northeast corner is higher than the rest of the cell and is dry for most of the year. Vegetation in the treatment system consists primarily of cattails (*Typha sp.*), which occupy most of the study cell except for an area of open water in the center.



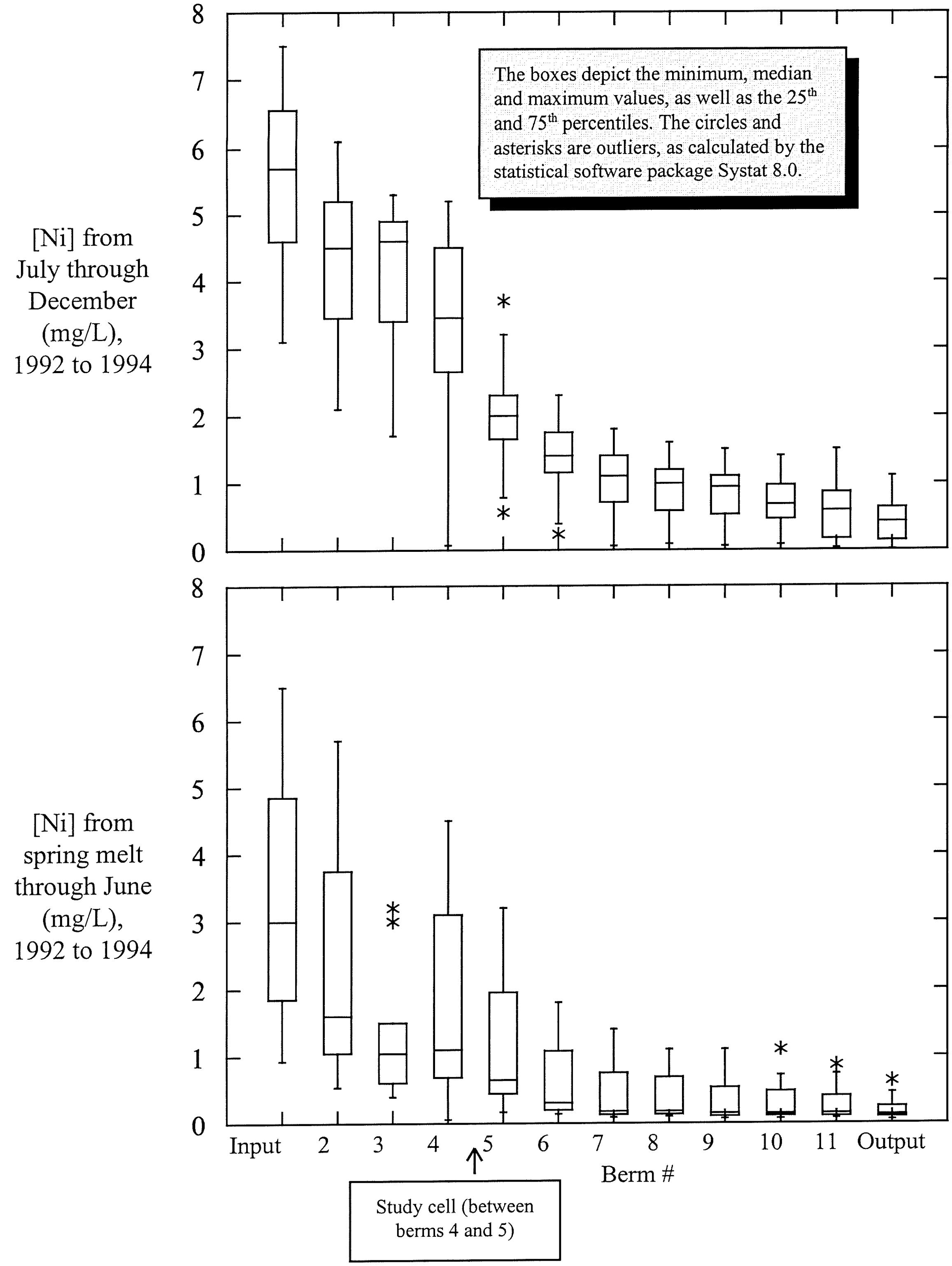
Notes:

1) The sites called W1D1, W1D2 and W1D3 are DNR site names related to the input and output of the study cell. They should not be confused with the LTV profile sites of the same name (see Figure 3 for the LTV profile site locations).

2) The grey squares indicate sites where peat cores were collected in 1996, and the white squares indicate 1997 peat sites. In both cases, the number inside the box indicates the site location number.

3) The distance values depicted on the horizontal dotted lines are the distances from the upstream berm, as measured along the particular transect. The values on the vertical dotted lines are the distance from the site to the appropriate horizontal transect.

Figure 5. Locations of monitoring sites (peat, water quality) in the W1D study cell.



Two plots are depicted, because input nickel concentrations typically increased in July. The bottom plot includes all data in the spring through June, while the top plot includes all data from July through December.

Figure 6. Nickel concentrations within the W1D wetland treatment system, 1992-1994.

Seep 1 pretreatment system

In 1992, LTV built a passive treatment system at Seep 1 which combined peat and limestone in an attempt to increase pH and remove metals. The Seep 1 monitoring site originally collected diffuse seepage that originated at the toe of waste rock stockpile 8013. This stockpile was constructed from 1967-1991 and contains material with an estimated composition of 0.06% copper (as CuO), 0.02 % nickel (as NiO) and 0.24% sulfur (Appendix 3). The Seep 1 watershed was estimated from the original contours in the area to be 10.6 acres (4.3 hectares), with 76% of the wateshed covered by stockpile (Figure 4, Appendix 3). Bedrock in the area is within 6.6 feet (2 meters) of the surface and, as a result, groundwater in the area ranges from 0 to about 3.3 feet (one meter) below surface. Average annual flow is on the order of 5-10 gal/min (19-38 L/min), with maximum daily peak flows on the order of 50 gal/min (200 L/min). Flow typically begins in April and continues until November, when the seep freezes. Peak flows are typically observed after heavy rainfall events that occurr during the summer; instantaneous peak flows of around 100 gal/min (400 L/min) have been recorded.

Monitoring of the drainage began in 1976. The pH was neutral (7.0-7.5), nickel concentrations were 1-2 mg/L and copper was less than 0.1 mg/L. The pH began to decline slowly, and by 1984 had stabilized in the range of 5.0-5.5. Concurrent with the pH decrease was an increase in metal concentrations; nickel concentrations increased by about an order of magnitude to 10-20 mg/L, while copper increased to 0.5-1.5 mg/L (Figure 7.) Water quality did not change substantially from 1985-1991.

Laboratory and small-scale field studies had shown that limestone was successful in increasing the pH of the drainage and reducing copper concentrations by 50-80% (Lapakko and Antonson, 1990a, 1990b). Removal of other trace metals was much lower, ranging from 10% for nickel to around 25% for cobalt. In other experiments peat had removed over 80% of both copper and nickel from drainage at this mine (Eger and Lapakko, 1988). LTV combined the limestone and the peat in a treatment system in an attempt to increase pH and remove metals. The system was built between the toe of the stockpile and the weir monitoring station. The original design was developed by STS Consultants, and modified based on suggestions made by LTV and Minnesota regulatory agencies.

Unfortunately, the size of the treatment system was constrained by the topography of the site. As a result, the overall dimensions were determined by available space, rather than a specific design size. The area was cleared of vegetation and a 10,000 ft^2 (930 m^2) pond, roughly 3 feet (0.9 m) deep, was excavated. Limestone, 3½ inch to 4 inch (7.5 to 10 cm) in diameter was placed around the perimeter of the pond, and two limestone berms were built within the pond. Each berm was about 3 feet (0.9 m) high and the berms ranged in length from about 130 to 200 feet (40 to 60 meters). Once the berms were in place, a 1-2 foot (0.3-0.6 meter) layer of a 1:2 mixture of peat and peat screenings (a waste product from the production of horticultural peat) was placed between the berms. At the outlet end of the pond a limestone under-drain was constructed and covered with a one foot (0.3 m) layer of the peat and screenings mixture. An overflow pipe was installed to handle excess flow. The design of the system is shown schematically in Figure 8.

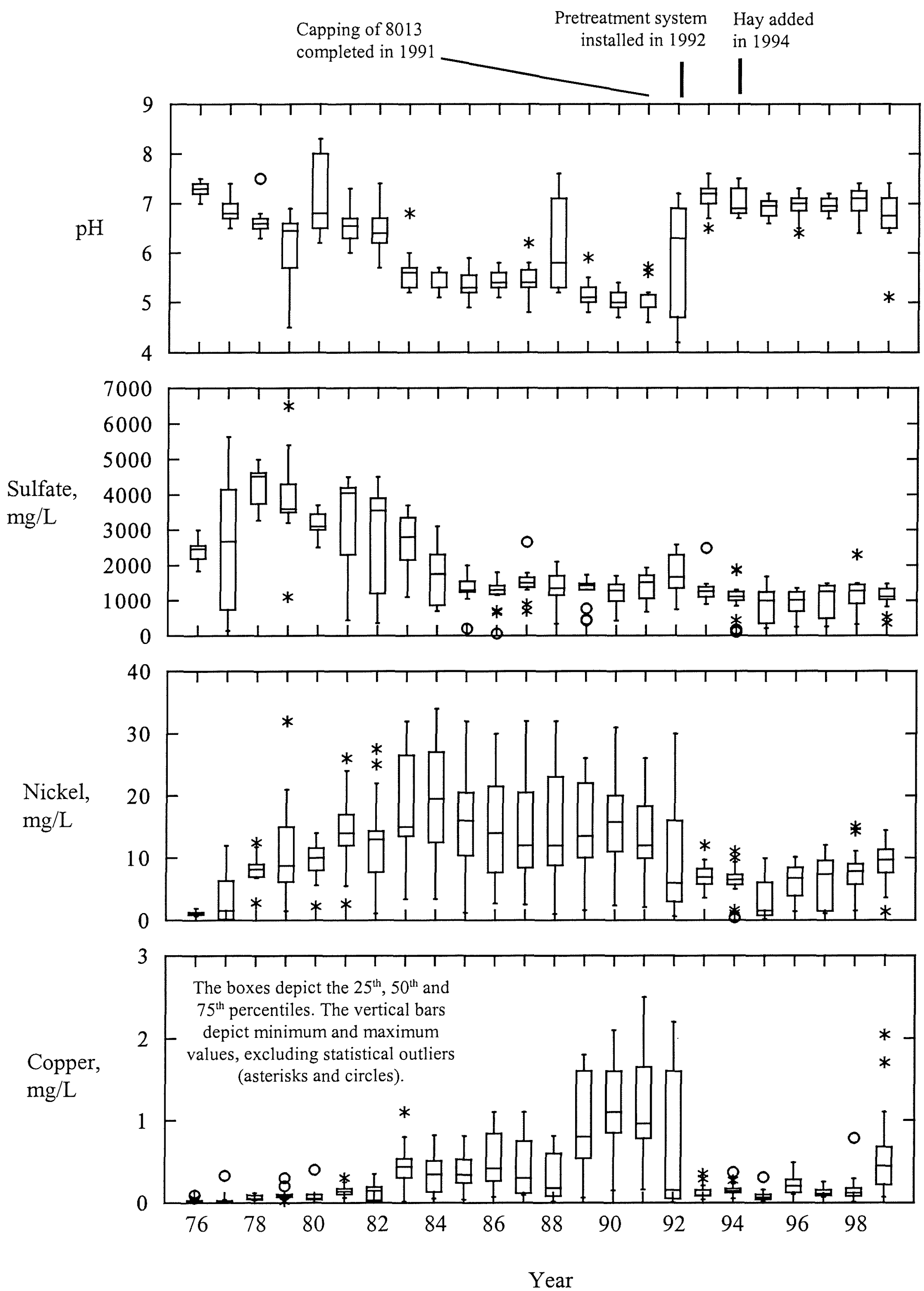


Figure 7. Box plots of pH, sulfate, nickel and copper concentrations vs. time at Seep 1 (site 043), LTV data, 1976-1999.

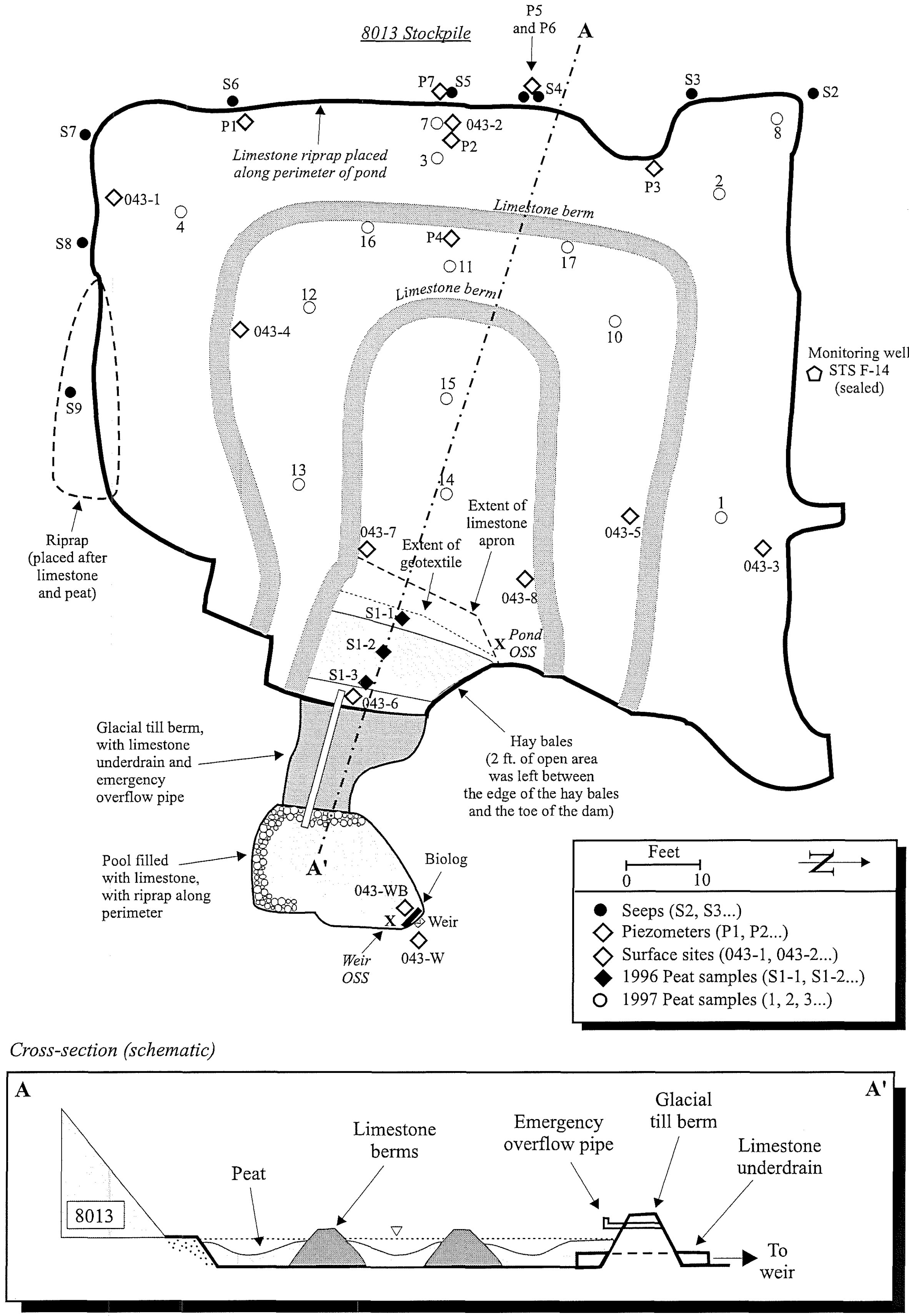


Figure 8. Seep 1 pretreatment system, with locations of monitoring sites.

In 1994, hay was added to the system in an attempt to stimulate sulfate reduction by providing a readily available food source for the sulfate reducing bacteria. In June, three bales weighing about 130 lbs (60 kg) were broken and dispersed in the vertical down-flow section of the system. In August, about 40 intact bales were placed side by side on top of the down-flow section.

Methods

W1D

Water samples of the inflow and outflow of the wetland treatment system are collected twice a month by LTV personnel. From 1992 to 1994, LTV also collected samples at each berm in the wetland (Figure 3). In 1997, input and output samples to the study cell were collected twice per month. In 1998, the plan was to monitor the study cell when nickel concentrations were elevated. Nickel concentrations at site W1D were estimated with a field colorimetric kit. If the nickel concentration exceeded 1 mg/L, then samples would be collected in the study cell. Nickel concentrations stayed low throughout the spring and early summer of 1997 (Appendix 1), so no samples were collected from the study cell. In order to provide some field data in 1998, sample collection in the study cell resumed in August. Monthly samples were collected in 1999. Samples were analyzed for pH, specific conductance, copper, nickel, calcium, magnesium, and sulfate. Water samples were brought back to the DNR laboratory, refrigerated, and analyzed the following day; pH and specific conductance were analyzed directly in the sample bottle. A portion of the remaining sample was poured directly into a 60 mL polyethylene bottle for total metals and the remainder was filtered through a 0.45 micron filter for sulfate. Metal samples were acidified with 0.2 mL of Baker Instra-Analyzed nitric acid per 50 mL of sample.

An Orion SA 720 pH meter equipped with a Ross combination pH electrode (model 8165) was used for pH analysis, and a Myron L model (model EP) conductivity meter was used to determine specific conductance. Sulfate was analyzed at the Minnesota Department of Agriculture (MDA) laboratory. Prior to October 11, 1998, sulfate was analyzed with the Ion Chromatographic Method (Wastewater Method 4500-SO_4 B) with a Dionex DX300 IC. Subsequently, these parameters were measured with a Lachat QuickChem 8000 using the same methods. Metals samples were analyzed at MDA using a Varian 400 SPECTRAA atomic absorption spectrophotometer in the flame mode or a Zeeman GFAA graphite furnace. This was replaced by ICP/MS (Hewlett Packard HP4500 Series, model #G1820A) on August 22, 1999.

Continuous measurements of inflow and outflow water levels were made with a Steven's Model F recorder, and the flow was calculated from the standard equation for a 60 degree V-notch weir. Due to potential problems with the recording equipment under freezing conditions, continuous flow estimates were generally only available from May through October (Appendix 5).

Peat samples were collected in April of 1996 and 1997 (Figure 5). If the surface of the peat was frozen, samples were collected with a specially designed core tube sampler (Appendix 4). A cylindrical cutting head (3 3/4 inches ID) was fabricated and mounted on the shaft of a power soil auger. With this sampler, samples could be collected while the substrate was frozen, which made identifying and separating layers much easier than with a standard coring device. Deeper samples were collected with a standard Macauley peat sampler (Appendix 4).

Samples were generally divided into 10 cm sections: 0-10, 10-20, and 20-30 cm. Samples were dried at 105^{0}C for 24 hours. The samples were then processed in a blender, sieved to -80 mesh, and the -80 mesh material was totally digested. A mixture of 5 ml of water, 10 ml of concentrated nitric acid and 2 ml of concentrated hydrochloric acid was added to each sample. The samples were sequentially microwaved for 10 minutes each at 40, 80, 120 and 160 psi. The digested samples were analyzed for trace metals by the MDA laboratory. Additional information on sample preparation and anlysis is presented in Appendix 4.

Seep 1

In general, water quality samples of the outflow were collected twice per month by LTV and analyzed for pH, specific conductance copper, nickel and sulfate. During the summer of 1993 and 1994, a series of water quality profile samples were collected by LTV from within the pretreatment pond. In 1993, DNR collected samples of the discrete input seeps at the toe of the stockpile (Figure 8).

In 1997, when the intensive study of the pretreatment system began, the sampling points within the pond and at the small input seeps were re-established (Figure 8). Additional samples were collected from within the pond to examine flow paths (Appendix 1). In 1998 and 1999, the sampling program focused on the performance of the vertical down-flow section of the bed (sites 043-6 and 043-WB; Figure 8). Site 043-WB was located about 10 feet (3 meters) upstream of the weir and immediately upstream of a "biolog" LTV had installed in 1996. The biolog contained an organic substrate designed to remove metals from solution. According to LTV, the log plugged and did not remove significant quantities of metals, but became too heavy to remove (Aagnes, personal communication, 2000).

In 1998, nine piezometers were installed to examine vertical groundwater gradients and to collect data on groundwater quality. The piezometers were constructed of ½ inch (1.27 cm) schedule 80 PVC pipe. A metal bolt was inserted in the bottom of the pipe to prevent soil from plugging the pipe while the piezometers were installed. When the piezometers had been hand driven to the desired length, a metal rod was inserted into the pipe, the metal bolt was pushed out and the pipe was opened (Appendix 8). Limited water level and water quality data were obtained in the fall of 1998 (Appendix 1).

Substrate samples from the vertical down-flow section were collected in April 1996 using either the core tube sampler or the Macauley sampler. A Macauley sampler was used to collect samples from the bottom of the pond in the pretreatment system in April 1997. Samples taken with the Macauley sampler were collected within an 8 inch (0.2 meter) circle and combined to form a composite of two or three cores. The core tube samples were analyzed individually. The samples were dried, crushed with a mortar and pestle, sieved to -80 mesh, digested and sent to MDA for analyses.

Results, W1D overland flow wetland

Flow

Input flow was measured at the v-notch weir located about 200 feet (60 meters) from the toe of the 8018 stockpile and about 200 feet upstream of the beginning of the wetland (site W1D-051; Figure 3). Additional watershed area contributed flow to the wetland treatment system, but the majority of the nickel load originated at site W1D (Figure 4). Since continuous flow measurements were only available for May through October, the average daily flow calculated over this period has been used to compare the change in flow over time.

Average input flows ranged from 29-36 gal/min (110-136 L/min) for 1992 to 1994. Flows decreased in 1995 and remained low after the top of the 8018 stockpile was capped. Average flows for 1996 to 1999 ranged from 8 to 22 gal/min (30-83 L/min). Flow in 1999 was the highest of the post-closure flows. Over the July 4th weekend about 7 inches (17.5 cm) of rain fell at the site. A peak flow on the order of 900 gal/min (3400 L/min) was recorded, and the estimated daily flow was 360 gal/min (1360 L/min). Annual precipitation for 1999 was 35.17 in. (89.3 cm), substantially above the long-term average precipitation of 28.49 inches (72.4 cm; Table 2).

Output flows were generally greater than input flow except during hot dry periods when evapotranspiration losses were large. During the summer of 1998 the output flow was 5 to 6 gal/min (19-23 liter/min) less than the input. In July when the input flow decreased to 4-5 gal/min there was no flow at the outlet (Appendix 5). Flow into and out of the study cell was not measured directly. Since there was little contributing watershed between the beginning and end of the wetland, output flow from the entire system (site W1D-052; Figure 3) was used to represent flow through the cell.

Water quality

There was little variation in pH in the wetland (Figure 9). Both input and output pH ranged from 6.8 to 7.6. There was little difference in pH between the input and output of the study cell; the average value for both sites was around 7.2 (Table 3).

From 1992 to 1994, the input nickel concentration to the wetland treatment system typically was on the order of 1 mg/L in the spring, then increased to approximately 6 mg/L in early summer. Concentrations then remained relatively constant until the seep froze in late fall (Figure 9). The average input nickel concentration to the study cell during this period was 2.9 mg/L. As water flowed through the cell, nickel concentrations decreased by about 26%, to about 1.8 mg/L.

Table 2. Flow and precipitation data W1D treatment system, 1992-1999.

Year	Inflow - Average Daily Flow (gal/min)		Outflow - Average Daily Flow (gal/min)		Precipitation (in)	
	May-Oct	Annual Estimate	May-Oct	Annual Estimate	May-Oct	Annual
1992	33	27	44	35	17.3	26.9
1993	29	24	39	31	17.4	29.7
1994	36	31	46	38	19.2	28.7
Average 1992-1994	33	27	43	35	18.0	28.4
1995[1]	27	24	51	43	18.5	25.6
1996	22	28	23	29	18.2	34.2
1997	8	9	8	13	15.5	22.9
1998	8	8	5	4	19.2	31.1
1999	22	21	30	24	28.8	35.2
Average 1996-1999	15	16	16	18	20.4	30.9

[1] The stockpile was capped in 1995.

$$\text{Average Daily Flow (gal/min)} = \frac{\text{total volume (L)}}{\text{\# days x 1440 min/day x 3.785 L/gal}}$$

Notes: The number of days used for the annual estimate was 245: April 1 through November 30. Annual average precipitation for Babbitt, from 1961-1990, was 28.49 inches. Annual May-October precipitation for Babbitt (1961-1990) was 21.16 inches (data from Minnesota Climatology Working Group; www.climate.umn.edu).

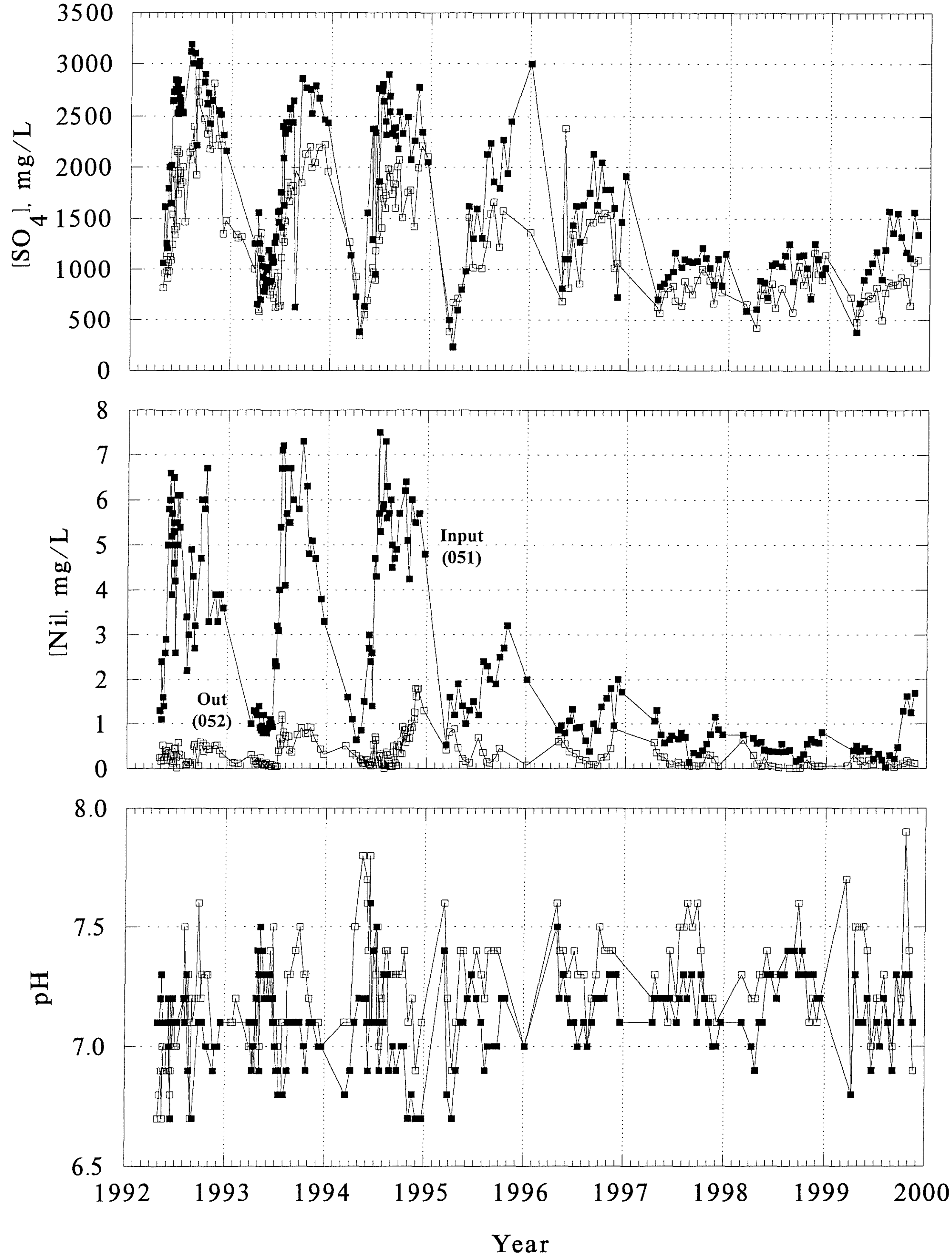


Figure 9. pH, nickel and sulfate concentrations (input and output) vs. time for the original W1D wetland treatment system.

Table 3. Mean water quality data, W1D study cell, 1997-99.

Year	n	pH		Ni		Cu		Co		Zn		Ca		Mg		SO_4	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
1997	13	7.02	7.19	0.346	0.240	0.013	0.011	0.003	0.001	0.033	0.030	180	170	160	160	860	810
1998	3	7.47	7.49	0.216	0.277	0.021	0.017	0.042	0.036	0.028	0.035	220	220	230	220	1040	910
1999	7	7.25	7.28	0.374	0.297	0.013	0.010	0.008	0.006	0.054	0.031	210	200	200	200	640	650
Ave. 1997-99	---	7.16	7.24	0.324	0.259	0.015	0.012	0.017	0.010	0.035	0.032	200	180	190	180	880	810

Notes: Nickel concentration in the W1D study cell decreased by 20–30%, a value consistent with the value measured in 1992-1994. The 1998 data is anomalous, and is likely due to the limited number of samples collected and the very low flow conditions that existed in 1998.

In 1995, input nickel concentrations decreased substantially. Input concentrations were low in the spring but only increased to 2-3 mg/L in the summer. Maximum concentrations gradually decreased to less than 1 mg/L by 1999. As a result of the decrease in nickel concentration, the nickel concentration entering the study cell also decreased. Input concentrations to the cell dropped to 0.32 mg/L in 1997 to 1999. Concentrations in the outflow were lower than the inflow and averaged 0.26 mg/L for 1997 to 1999 (Table 3, Figure 10).

Substrate samples

The initial trace metal content of the mixture of peat and peat screenings that was added to the wetland was very low; all concentrations were less than 10 mg/kg (Appendix 4). By 1996, the peat substrate had accumulated measurable amounts of copper, nickel, cobalt and zinc. Nickel concentrations were the highest and varied with depth and location within the cell. The maximum metal concentrations were generally in the top 10 cm of the core, and nickel concentrations varied from 68 mg/kg to 14,600 mg/kg (Figures 11, 12, 13). The average nickel concentration for the 0-10 cm segment in the cell was 4959 mg/kg, and decreased to 2110 mg/kg for the 20-30 cm segment. Copper, cobalt, and zinc generally followed the same pattern as nickel but concentrations were about an order of magnitude lower. The maximum copper, cobalt, and zinc concentrations were 350 to 420 mg/kg (Appendix 4).

Mass removal

Overall mass into and out of the wetland was calculated by multiplying the average concentration for the month by the average daily flow for that month (Appendix 7). Daily flow data were generally available from May through October, but for April, November and December, there were only a few individual flow readings. Flow data was collected by LTV as part of their NPDES permit (Appendix 5). Since both flow and precipitation in November and December tended to be low, the average of the limited individual measurements was assumed to be a reasonable estimate of flow. An average value may not provide a reaonable estimate of spring melt flow, since the volume and timing of flow depends on the amount of moisture in the snow pack, temperature and rainfall. However, metal concentrations during April were about one-half the summer values, so the total mass input during April even with higher flows would tend to be lower than summer months (Appendix 7). From 1992 through 1995, the May to October input mass accounted for 86% of the annual load. Although this percentage increased from 1996 to 1999, the total input load decreased dramatically during this time (Table A7.3).

The total mass removed by the wetland was the difference between the input and the output masses. Overall mass removal in the wetland ranged from 171 kg in 1994 to 3 kg in 1997, and corresponded to a percent removal that ranged from 38 to 91 percent (Table 4). Lower mass removal occurred in 1995 to 1999 due to the much lower nickel input to the wetland.

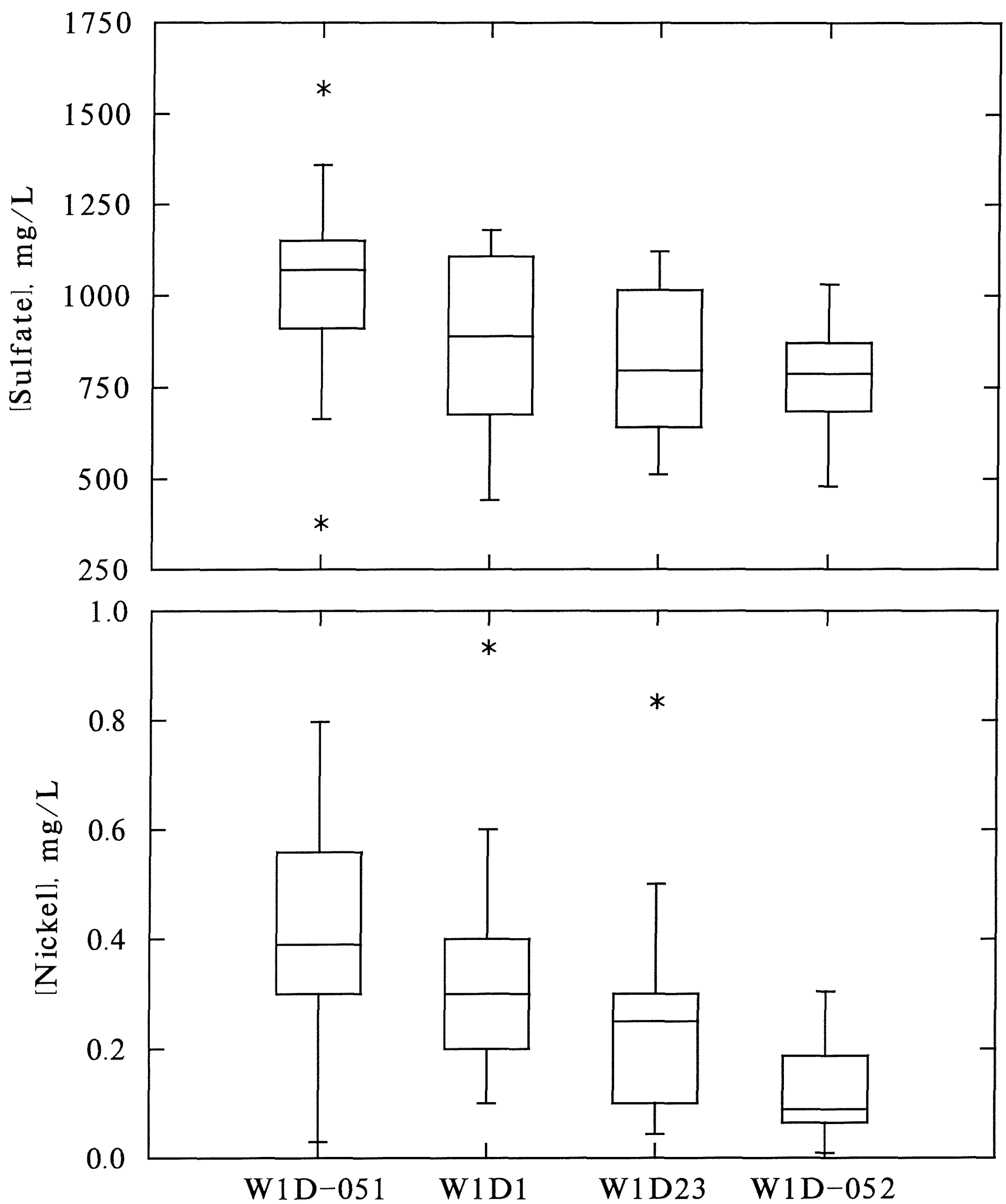
Table 4. Nickel mass removal, W1D wetland and study cell, 1992-1999.

	Entire wetland					Study cell		
	Mass into wetland (kg)	Mass out of wetland (kg)	Annual mass removal (kg)	Mass removal (%)	Cum. mass removal (kg)	Annual mass removal (kg)	Cum. mass removal (kg)	Calculation method
1992	158	16	142	90	142	37	37	1
1993	162	21	141	87	283	37	74	1
1994	190	19	171	91	454	44	118	1
1995	76	26	50	66	504	13	131	1
1996	36	15	21	58	525	5	136	1
1997	8	5	3	38	528	1	137	2
1998	5	1	4	80	532	1	138	2
1999	16	5	11	69	543	3	141	2

Calculation methods

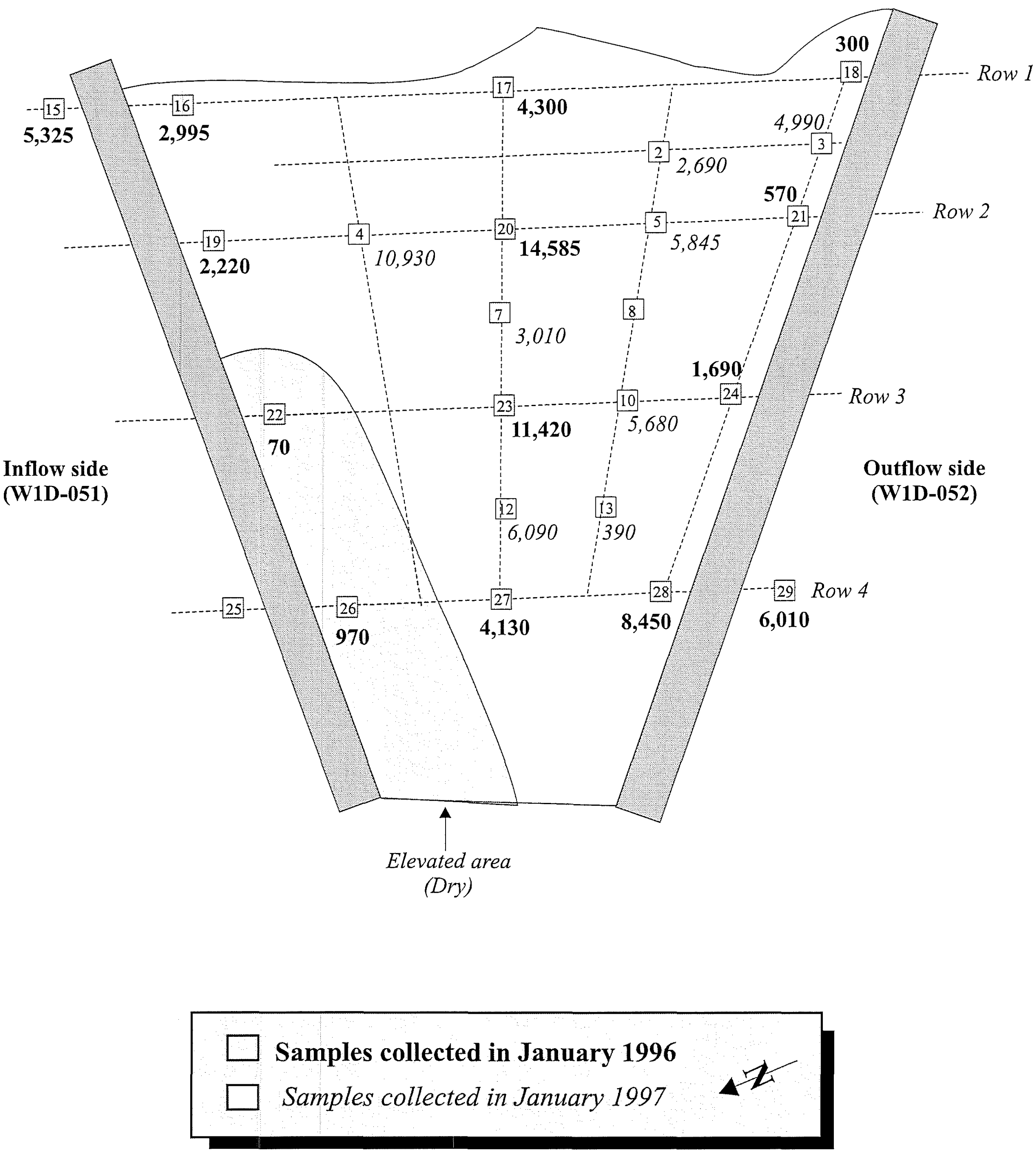
1) From 1992-94, "profile" samples were collected from surface water sites within the W1D wetland. The overall concentration decrease (i.e. from the input to the output) was determined for each day of these studies, and then the concentration decrease observed in the study cell was compared to the total value. It was determined that 26% of the overall removal occurred in this one cell, and the annual removal in the study cell (from 1992-96) was assumed to be 26% of the overall mass removal for each of those five years.

2) From 1997-99, DNR collected water quality samples at the input and output of the study cell. Flow was not measured since the input and output channels (sites W1D1, W1D2 and W1D3) were too shallow to use standard measuring equipment. In addition, diffuse flow probably occurred at other sites along the input and output berms. The water quality data could be combined with flow data from the outfall of the wetland (W1D-052) to arrive at mass estimates for the cell. (The outflow is considered to be a more accurate indicator of flow in the system than is the input, since significant water enters the system downstream of the input weir.) However, since the average decrease in nickel concentration in 1997 and 1999 (26%) was the same as in 1992-1994, calculation method 1 was used for all years.



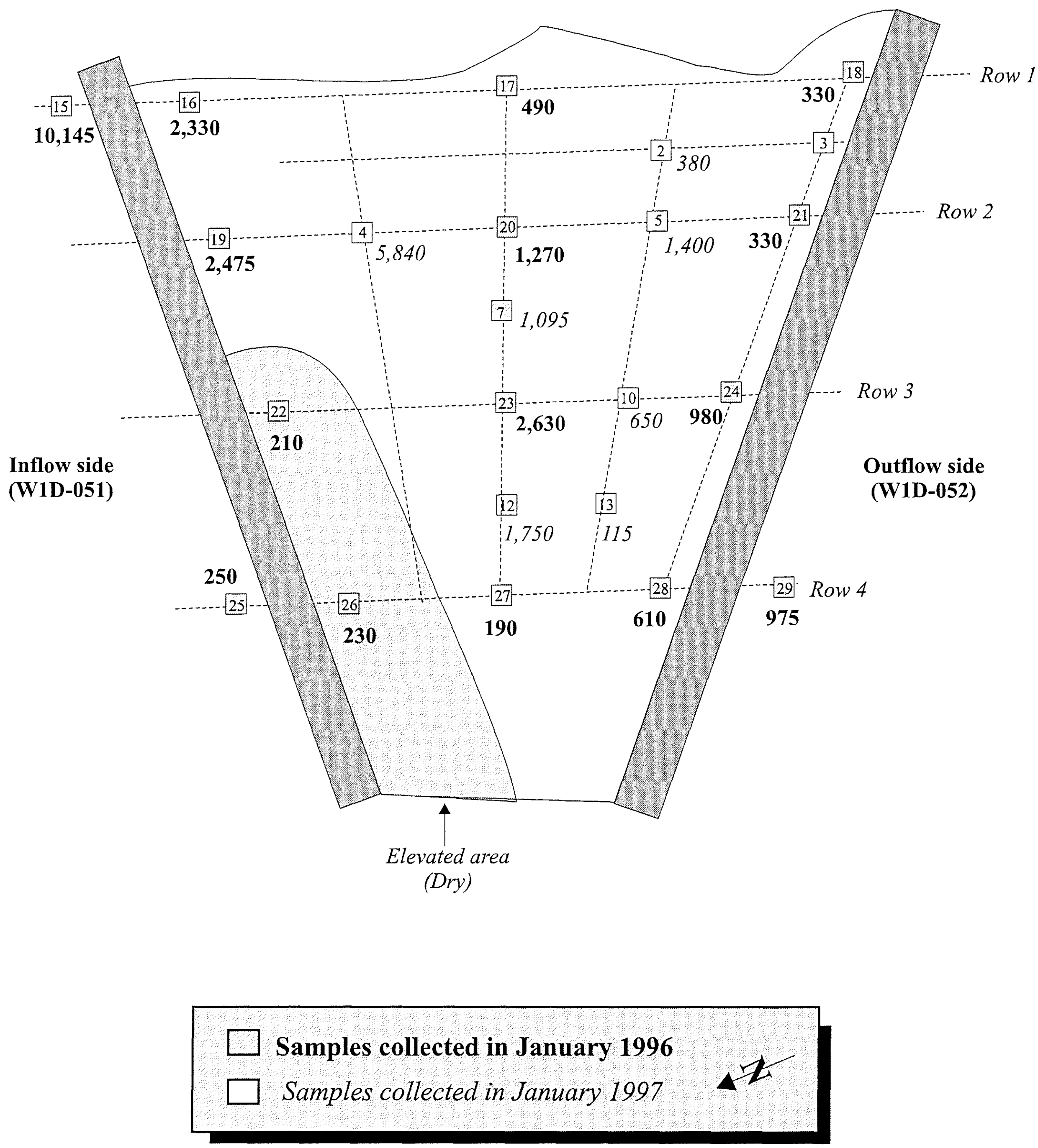
The site called W1D-051 is the input to the entire wetland, W1D1 is the input to the study cell that DNR studied from 1997-99, W1D23 is the average of two outflows from the study cell, and W1D-052 is the outfall from the original system (the extension added in 1995 is not included). The data sets for 051 and 052 have been truncated to correspond to the same time period used for W1D1 and W1D23. The boxes depict the minimum, median and maximum values, as well as the 25th and 75th percentiles; circles and asterisks indicate statistical outliers as calculated by the statistical software package Systat 8.0.

Figure 10. Box plots of nickel and sulfate concentrations in the W1D study cell, 1997-1999.



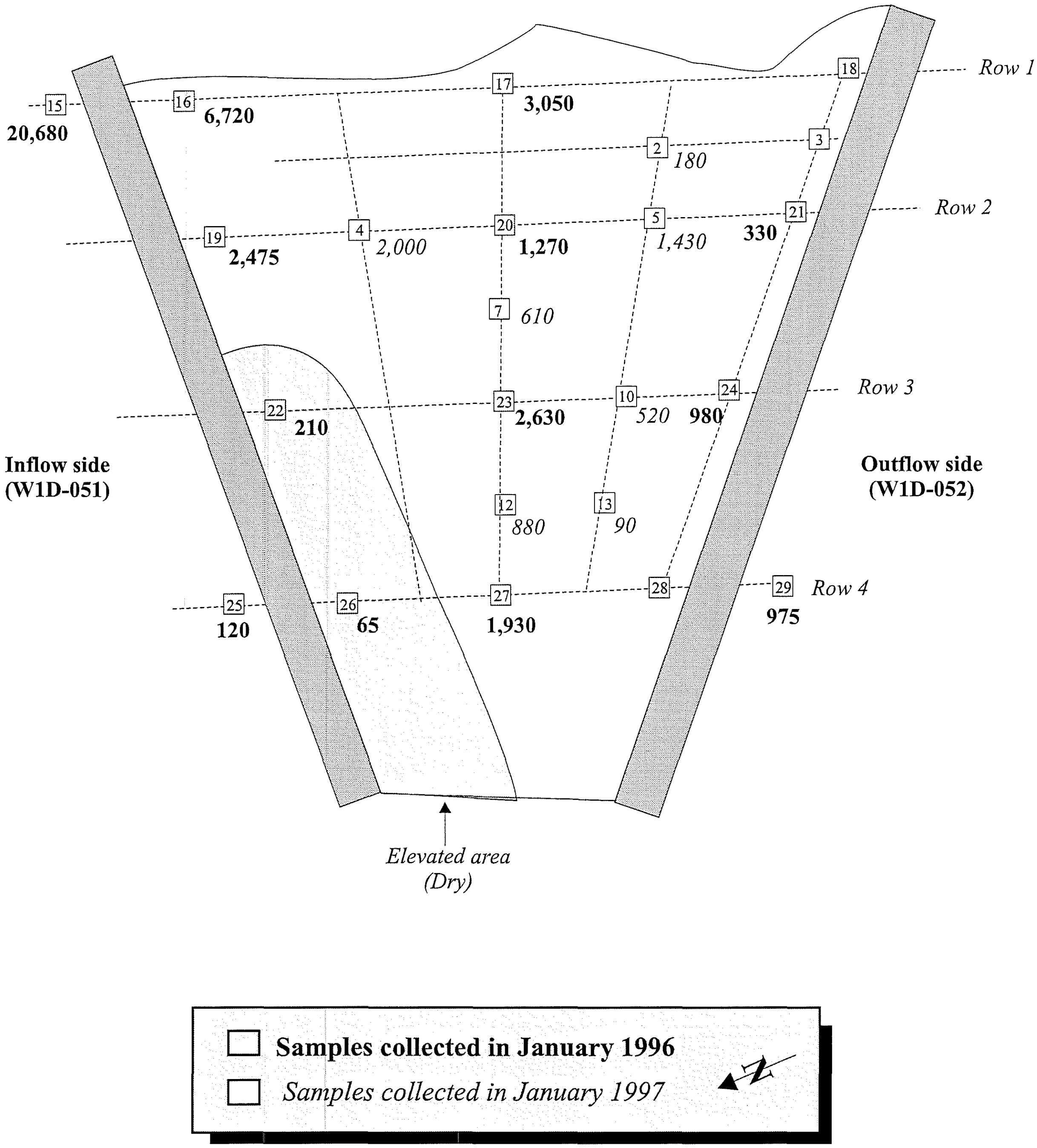
Notes: The number inside each square is the site location ID number.
Concentrations are mg/kg of dry peat.

Figure 11. Nickel concentrations in the 0-10 cm layer of peat in the W1D study cell of the W1D wetland treatment system.



Note: The number inside each square is the site location ID number. Concentrations are mg/kg of dry peat.

Figure 12. Nickel concentrations in the 10-20 cm layer of peat in the W1D study cell of the W1D wetland treatment system.



Note: The number inside each square is the site location ID number. Concentrations are mg/kg of dry peat.

Figure 13. Nickel concentrations in the 20-30 cm layer of peat in the W1D study cell of the W1D wetland treatment system.

W1D study cell

Mass removal in the study cell was calculated using both water quality and peat data. The mass removal in the study cell for 1992 to 1994 was estimated by using the change in concentration over the cell. Since the average change in nickel concentrations over the cell was 26%, it was assumed that 26% of the total annual mass removal occurred within the cell. Percent removal over the study cell in 1997 and 1999 also averaged 26% (Table 3). As a result, a constant percent removal of 26% was assumed for all years (Table 4). The overall nickel removal in the cell from 1992-1999 was 141 kg, with 84% of the removal occurring between 1992 and 1994. Between 1992 and 1996, when the peat samples were collected, 136 kg was removed.

Two methods were used to calculate the mass removal in the study cell from the metal concentrations in the peat. The first method used a computer model which contoured the nickel values in the peat and assigned concentrations to specific areas within the cell The second method made an overall estimate by multiplying the average nickel concentration by the mass of peat. Since the peat samples were collected in April of 1996 and 1997, the value calculated from the peat would represent the total mass removed through 1996. The total nickel mass in the substrate ranged from 112 kg for the computer model to 126 kg for the average calculation method (Table 5). Details of each calculation are provided in Appendix 7.

Results, Seep 1 pretreatment system

Flow

The entire top portion of the 8013 stockpile was capped in 1991 with a composite soil covering, which consisted of 12 inches (30 cm) of minus 3 inch (17.5 cm) buffer layer, 18 inches (45 cm) of minus ½ inch silty soil which was compacted to produce a laboratory permeability of at least 1×10^{-6} cm/sec, and 12 inches (30 cm) of soil cover (Gale, 1992). The area was fertilized, seeded and mulched in 1992, and within three years percent cover exceeded 90%.

Average May to October flow at the weir ranged from 3.5 to 10.6 gal/min (9.1 to 40.1 L/min) prior to stockpile capping and pretreatment system construction and from 2.4 to 7.9 gal/min (9-30 L/min) for the post-closure period (1992 to 1999; Table 6) Although small surface seeps were observed at the toe of the stockpile, the majority of the input enters as groundwater.

Data collected from the piezometers installed in the pretreatment system showed that water generally moves upward into the outer pool of the pretreatment and then laterally through the system (Appendix 8). At the end of the system, water flows vertically down through the substrate and limestone drain. The construction of the pretreatment system did not appear to affect the amount of groundwater that reports to the Seep 1 weir (Appendix 8).

Table 5. Mass removal estimates for the W1D study cell.

Calculation method	Peat layer	Nickel mass (kg)
(A) Combining input/output flow and nickel concentration data.	---	135.7
(B) Peat mass x mean nickel concentration of each layer	0 - 10 cm	65.0
	10 - 20 cm	33.7
	20 - 30 cm	27.7
	Total:	126.4
(C) Peat mass x concentration, as determined by computer model (Tech Base)	0 - 10 cm	71.5
	10 - 20 cm	27.1
	20 - 30 cm	13.9
	Total:	112.5
(D) Average (This includes methods B and C for the individual layers, and methods A, B and C for the total values)	0 - 10 cm	68.2
	10 - 20 cm	30.4
	20 - 30 cm	20.8
	Total:	124.9

Calculation methods

(A) Based on the results of profiles studies carried out within the W1D wetland from 1992 through 1994, it was determined that 25.8% of the overall removal within the system occurred in this single cell. The overall removal value for 1992-1996 (526 kg) was multiplied by 0.258 to yield 135.7 kg of nickel removed in the study segment.

(B) The average nickel concentration of each peat layer (0-10, 10-20 and 20-30 cm) was multiplied by the mass of dry peat assumed to be present in each 10-cm layer (13100 kg). This was based on an area of 1310 m^2 (14,098 ft^2), which was the value used in the Tech Base model (method 3), and on the assumption that the wet peat was 90% water. All available 1996 and 1997 peat data was used to calculate the means (4959 mg/kg in 0-10 cm layer, 2571 mg/kg in 10-20 cm layer, and 2112 mg/klg in 20-30 cm layer). These estimates exclude the dry peninsula area (i.e. removal is assumed to be zero in the peninsula). A few miscellaneous peat samples had unusual peat lengths (i.e. 0 - 8 cm instead of the usual 0-10 cm length), and these were grouped together with the standard core segments prior to calculating the means for each layer.

(C) A software program named Tech Base was used to calculate concentration contours within the W1D study segment, and then to calculate nickel mass in each layers based on these contours. These estimates also exclude the peninsula area (Appendix 7).

(D) Overall results from all three methods were used to calculate the average value of 124.9.

Table 6. Flow and precipitation, Seep 1, 1986-1999.

Year	May - October	
	Precipitation (in.)	Average Daily Flow (gal/min)
1986	20	6.6
1987	21.3	5.9
1988	24.5	9.9
1989	22.1	20.7
1990	16.6	3.5
1991	22.8	10.6
Average 1986-1991	21.2	7.3[a]
1992[b]	17.3	3.1
1993	17.4	6.3
1994	19.2	3.6
1995	18.5	5.8
1996	18.2	5.8
1997	15.5	3.6
1998	19.2	2.4
1999	28.8	7.9
Average 1993-1999	19.5	5.1

[a] 1989 flow data was omitted from the average because the reported volume of water at the weir exceeded the total volume of water that fell on the watershed.

[b] Excluded due to construction of treatment system.

Water quality

Prior to installation of the pretreatment system, the average pH at the weir (Seep 1 site) was 5.35, copper was 0.74 mg/L and nickel was 14.8 mg/L. In September 1992, immediately after the system was constructed, pH increased to 7.2, copper decreased to 0.02 mg/L and nickel decreased to 0.64 mg/L (Appendix 1). Until 1999 the pH of the outflow had remained above 6.5, and copper concentrations had averaged 0.1 mg/L, which corresponded to a removal efficiency of 85%. Nickel concentrations increased from the minimum value observed immediately after construction, but still averaged about 40% lower than pre-1992 levels. After the pretreatment system was constructed, sulfate concentrations averaged about 20% lower, from 1320 to 1060 mg/L (Table 7).

In 1999, about seven inches of rain fell on the July 4th weekend. Output flow was recorded as 265 gal/min (1000 L/min) and the pretreatment system overflowed. Rainfall was above average for most of the summer (Appendix 11) and water levels in the pretreatment pond were high (Appendix 8). The pH at the weir decreased substantially in 1999, and reached a minimum of 4.76 in July. The pH did not increase to above 6 until August (Figure 14). Metal concentrations also increased; nickel reached a maximum of around 15 mg/L, and copper was 1.3 mg/L. Nickel values had reached this level in both 1997 and 1998, but copper was about three times greater than the 1997-1998 values. The median nickel and copper concentrations in 1999 were the highest values observed since the pretreatment system was constructed in 1992 (Figure 7).

Before the pretreatment system was constructed, it was not possible to collect water samples from the base of the stockpile. The flow was diffuse and no channelization was observed until the water collected at the Seep 1 monitoring location. After the system was installed, small seeps at the base of the pile could be seen and sampled (Figure 8). Water quality and flows were sampled for these sites during the summer of 1993, once in 1996, and then periodically from 1997-99 (Appendix 1). In general, pH was lower and metal levels were higher than had been observed historically at the Seep 1 monitoring point. The pH ranged from 4.2 to 5.1, while copper ranged from about 1-6 mg/L and nickel from 10-55 mg/L. Flows were generally estimated qualitatively but some flow measurements were made with a portable flume device. In 1993, flows measured during late summer ranged from 0.002 to 0.02 L/sec, and accounted for only about 10-20% of the flow measured at the weir. Flows had been higher during the early summer but no quantitative measurements were made.

In 1993-1994, the pH in the outer pool samples was substantially higher than the summer average for the Seep 1 monitoring location prior to construction of the pretreatment system. The pH continued to increase as water moved across the pond (Figure 15). Copper concentrations generally decreased throughout the pond, with a 40% reduction as the water moved through the vertical down-flow section (Figure 16). Nickel and sulfate concentrations were also lower than the summer averages prior to construction, but remained relatively constant throughout the pond (Figures 17, 18). A 10% reduction in nickel concentrations was observed as water passed through the vertical down-flow section.

Table 7. Seep 1 water quality summary, 1992-99.

Year	pH	SO4	Cu	Ni	Co	Zn	Ca	Mg
Ave. 1986-1991	5.40	1320	0.69	14.7	1.08	1.41	163	215
1992	5.93	1770	0.686	9.77	0.54	1.10	190	180
1993	7.15	1300	0.135	7.05	0.26	0.69	210	170
1994	7.02	1060	0.153	6.23	0.27	0.62	190	160
1995	6.92	870	0.085	3.48	0.10	0.43	170	150
1996	6.94	930	0.237	6.32	0.182	0.773	190	130
1997	6.96	1010	0.130	6.36	0.123	0.764	190	140
1998	7.03	1180	0.164	7.46	0.136	0.891	230	160
1999	6.64	1100	0.603	9.00	0.319	1.362	210	140
Ave. 1993-1999	6.95	1060	0.215	6.56	0.198	0.790	200	150

Notes: The values showns are means of all available data for each year. pH values are standard units, all other values are mg/L. The metals values shown are totals. These data were collected by LTV and are for site 043, which is the historical measurement point for this seep, and which is now the effluent from the pretreatment pond. The pretreatment system was constructed during 1992, so the data from that year are not included in the overall average.

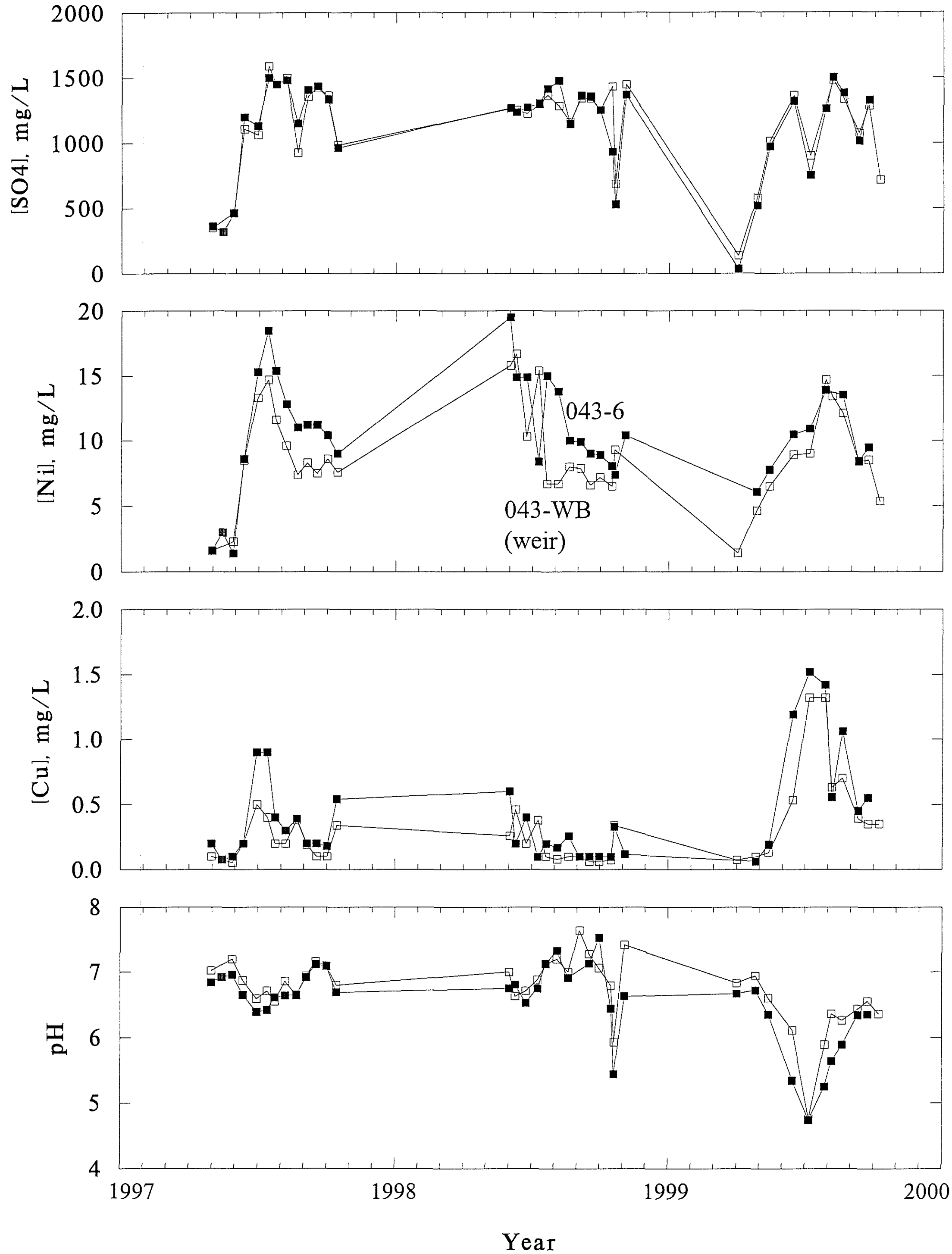
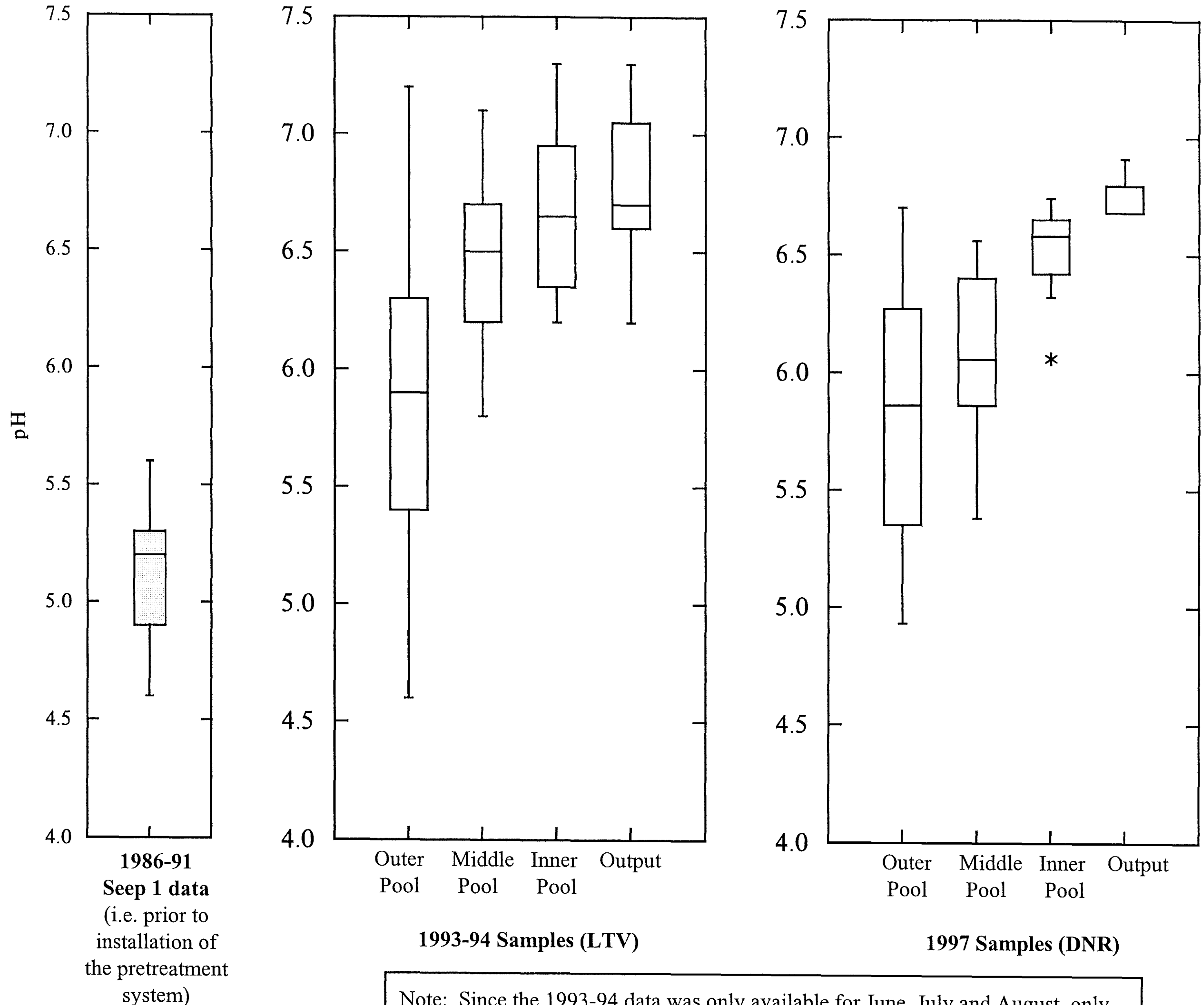


Figure 14. pH, copper, nickel and sulfate concentrations before and after the vertical down-flow section at the Seep 1 pretreatment system.



Note: Since the 1993-94 data was only available for June, July and August, only data from these months were used for the historical and 1997 data.

Figure 15. pH in the surface water and output of the Seep 1 pretreatment system; historical data (1986-1991), and data after construction of the pretreatment system (1993-1994 and 1997 data).

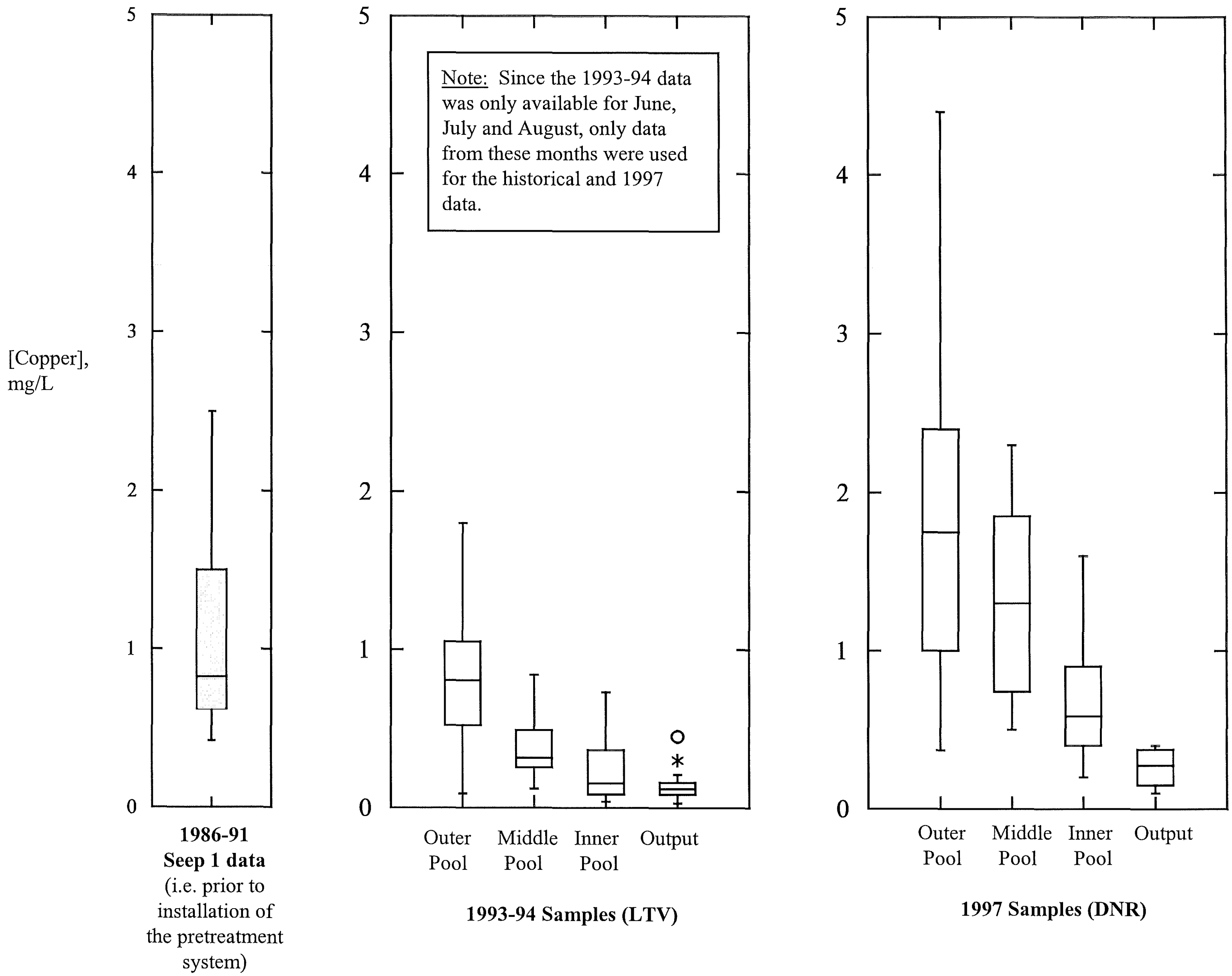


Figure 16. Copper concentrations in the surface water and output of the Seep 1 pretreatment system; historical data (1986-1991), and data after construction of the pretreatment system (1993-1994 and 1997 data).

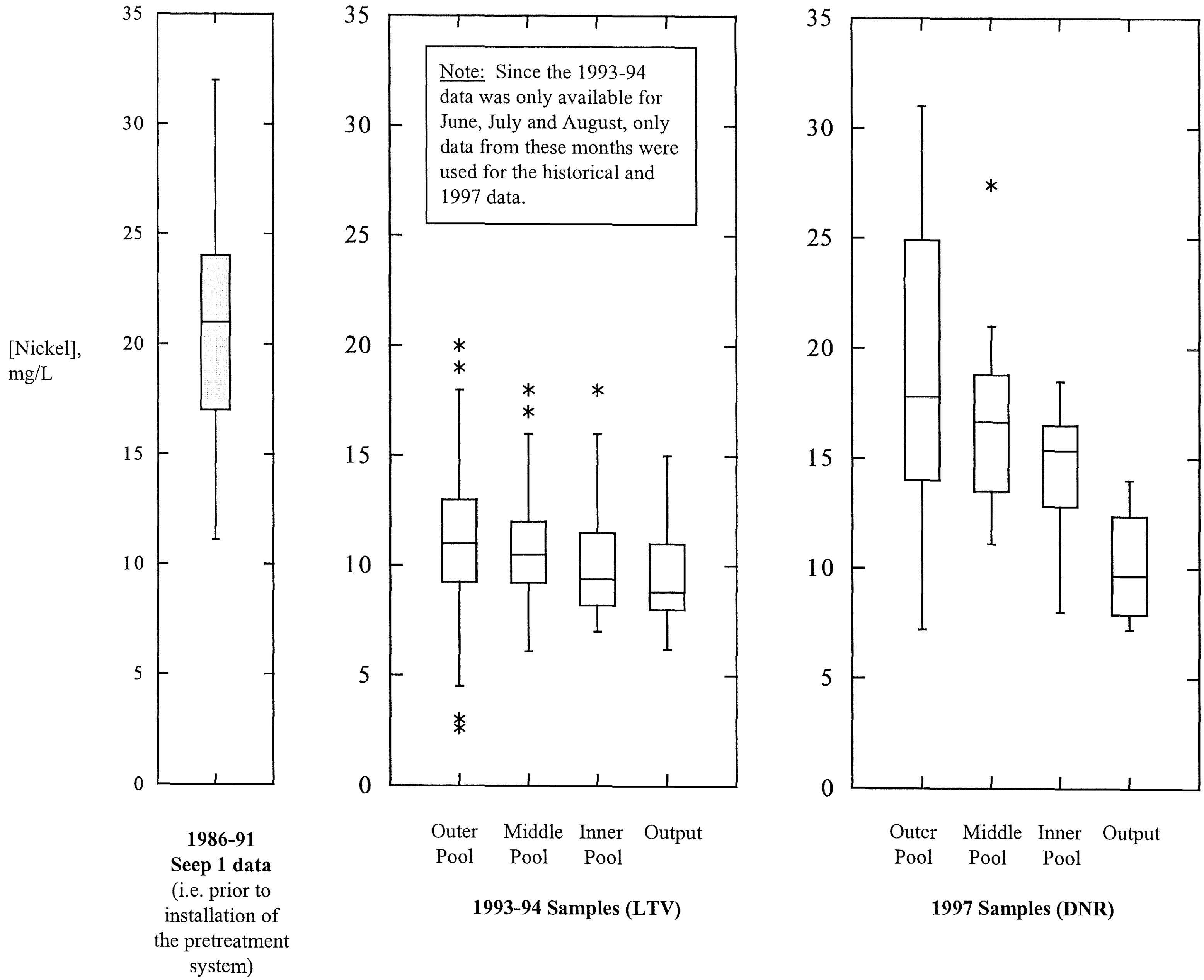


Figure 17. Nickel concentrations in the surface water and output of the Seep 1 pretreatment system; historical data (1986-1991), and data after construction of the pretreatment system (1993-1994 and 1997 data).

In 1997, pH followed the same general trend as in 1993-94, and increased as water flowed across the pond (Figure 15). While copper concentrations followed the same general trend, concentrations were not only higher than in 1993-94, but the outer pool concentrations were substantially greater than the historical data (Figure 16). Nickel concentrations were also greater than those measured in 1993-94, but were less than the historical values at the site prior to pretreatment system construction (Figure 17). For both copper and nickel, the change in concentration in the vertical down-flow section was greater than in 1993-94. Nickel decreased by 21% (from 13.6 mg/L to 10.8 mg/L) and copper decreased by 42% (from 0.52 mg/L to 0.3 mg/L). Sulfate concentrations did not change substantially within the system (Figure 18).

Samples collected from the outer pool in 1997 revealed that the water was not well mixed. Cold water from the small seeps entered the outer pool and tended to flow across the bottom of the pool to the first berm. Water would move over or through the first berm and would generally be mixed in the middle pool (Appendix 9). As a result of this stratification and the relatively constant nickel concentration in the system, sampling in 1998 and 1999 focused on the long-term removal capacity of the vertical down-flow section of the system.

In 1998, nickel concentrations decreased by about 17% in the vertical down-flow section, and a paired t-test confirmed that there was a statistically significant decrease in concentration over this section in 1997 and 1998 (Appendix 1). In 1999, the average change in nickel concentration decreased to only 8% in this section (Figure 14, Table 8).

In 1999, copper concentrations were the highest since the pretreatment system was built, but still generally decreased in the vertical down-flow section, although there was only about a 10% difference between the concentrations immediately following the July storm.

Substrate samples

Three samples were collected from the vertical down-flow section of the treatment system and 15 samples were collected and analyzed throughout the pond area to examine the metal concentrations in the substrate (Figure 8). Samples of both the peat mixture and the hay were collected. Metal concentrations in all substrate samples were two to three orders of magnitude higher than the original peat mixture and several of the samples contained more than 1% nickel (Figures 19, 20, 21). Concentrations were high throughout the substrate, but the highest concentrations were observed in the vertical down-flow section. The maximum concentrations were 14,180 mg/kg nickel, 8392 mg/kg copper, 1347 mg/kg cobalt and 3299 mg/kg zinc (Figures 19, 20, 21 and Appendix 4).

In the samples from the pond area, metal concentrations were about an order of magnitude higher in the top 10 cm of the cores than in the 20-30 cm layer.

A sample of a whitish precipitate was collected from the surface of the substrate and analyzed by Midland Research Center, Nashwauk, MN. A total digestion was performed and x-ray diffraction was used in an attempt to identify any crystalline solids. The precipitate occurs throughout the

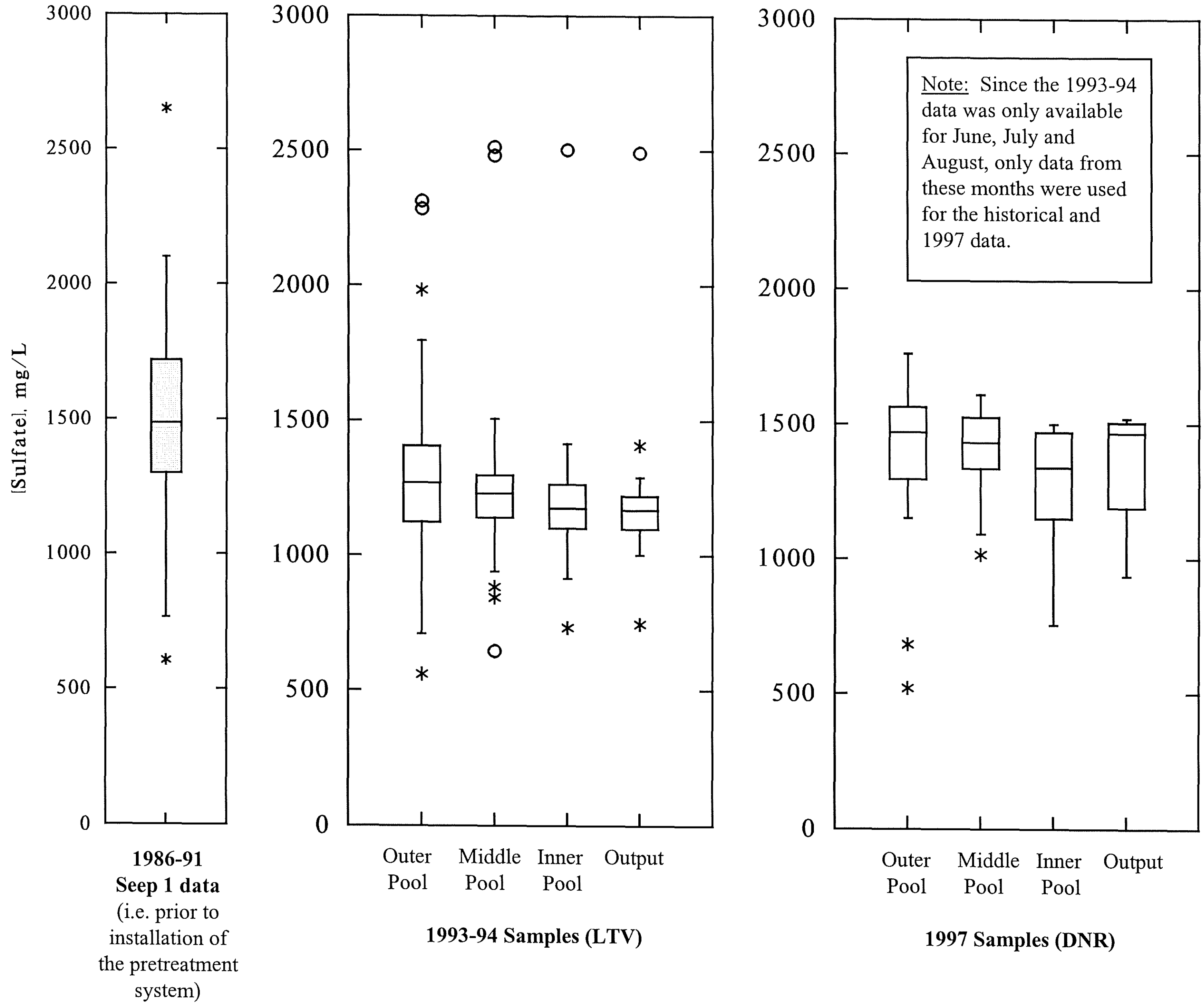


Figure 18. Sulfate concentrations in the surface water and output of the Seep 1 pretreatment system; historical data (1986-1991), and data after construction of the pretreatment system (1993-1994 and 1997 data).

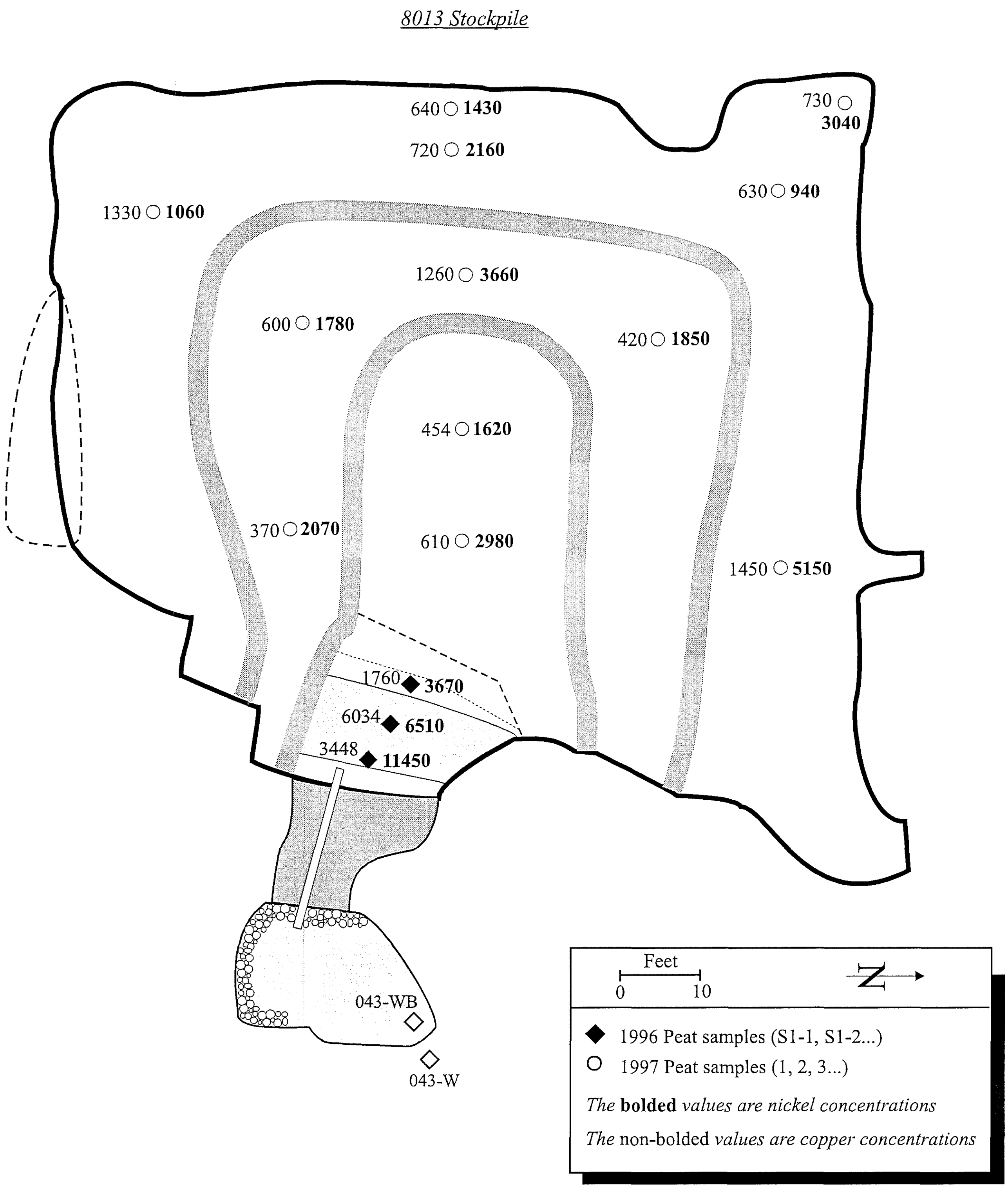


Figure 19. Seep 1 pretreatment system; nickel and copper concentrations (mg/kg) in the 0-10 cm substrate layer.

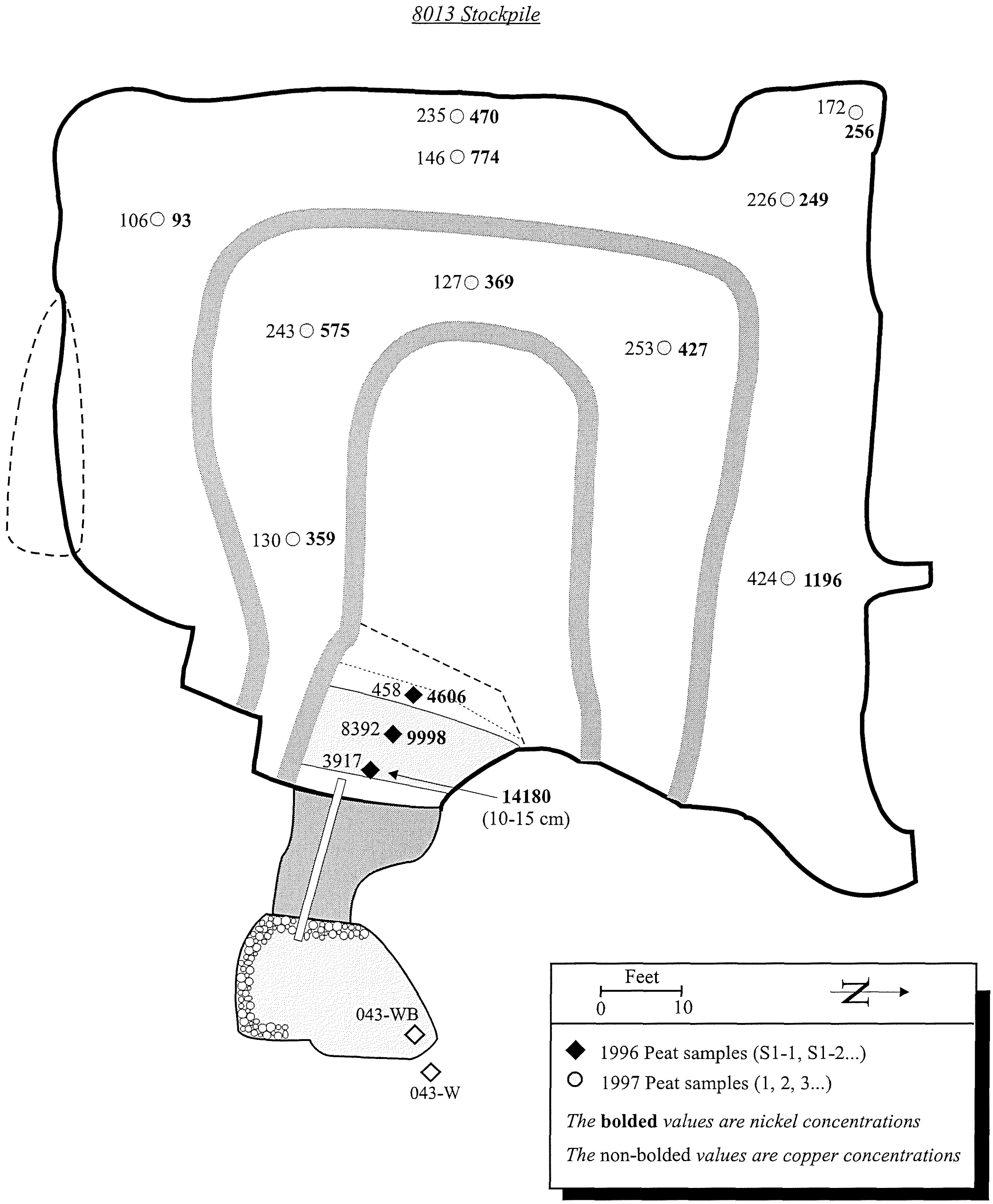


Figure 20. Seep 1 pretreatment system; nickel and copper concentrations (mg/kg) in the 10-20 cm substrate layer.

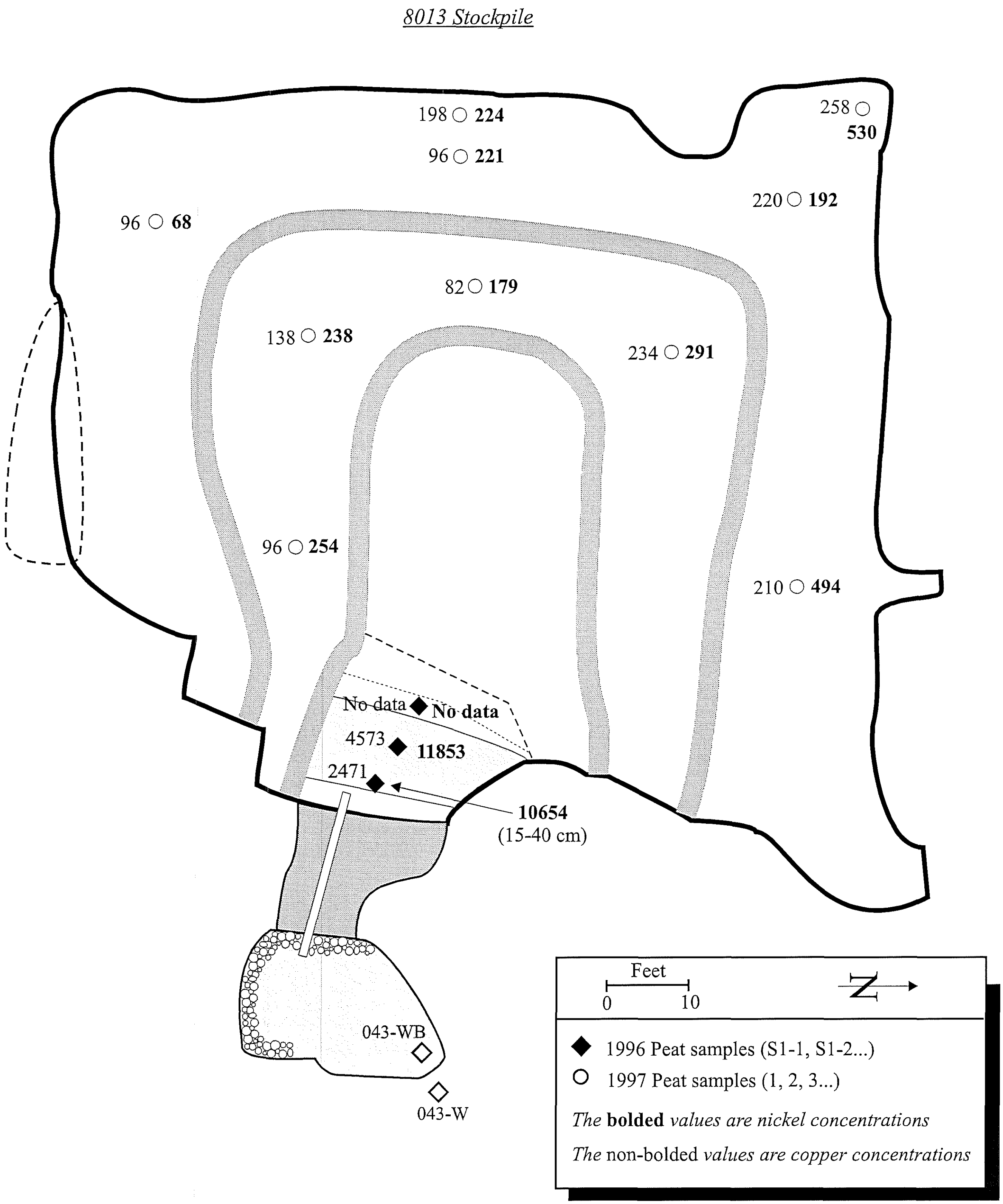


Figure 21. Seep 1 pretreatment system; nickel and copper concentrations (mg/kg) in the 20-30 cm substrate layer.

Table 8. Change in concentration over the Seep 1 vertical down-flow section.

Year	pH		Cu		Ni		SO_4		Ca		Mg	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
1993	6.7	6.8	0.20	0.12	10.5	9.6	1265	1250	no data	no data	no data	no data
1994	6.6	6.7	0.48	0.27	8.3	7.4	990	1010	no data	no data	no data	no data
1997	6.6	6.7	0.52	0.30	13.6	10.8	1320	1270	243	226	173	161
1998	6.9	6.9	0.28	0.23	13.8	11.4	1300	1260	272	274	202	201
1999	5.4	5.9	1.06	0.80	12.2	11.2	1240	1270	253	263	202	203

Notes: pH values are in standard units and all other values are mg/L. The values shown are based on June-August data only.

In: Site 043-6 (water above the vertical section)
Out: 1993-94: Seep 1 weir
1997-99: Site 043-WB (This site was after the vertical down-flow section but upstream of the weir and a biolog, which contained organic materials. This product was installed by LTV in 1996 and tested for its ability to remove metals from the discharge (see Figure 2).

pretreatment pond but the heaviest accumulation appears to be in the outer pool. The sample was amorphous and was dominated by aluminosilicates and clays, and contained some iron sulfate hydrates (Appendix 10). The major trace metal in the precipitate was copper (5400 mg/kg). Nickel content was 1280 mg/kg.

Mass removal

Annual mass release from the site has decreased substantially since the system was installed. Copper mass decreased from 5.4 kg to 1.9 kg, a 65% reduction, while nickel release decreased from about 124 to 45 kg, a 67% reduction (Table 9). (Copper mass release was unusually high in 1999 (Appendix 7). If 1999 data is excluded, the average release was 0.9 kg, an 85% reduction in copper load.) Since there is no single input into the system and most of the water enters as groundwater into the pond area, it is not possible to conduct a standard mass balance (input-output) for this system (Appendix 8). Since metal concentrations in the substrate decreased with depth, there was no evidence for metal removal from upwelling groundwater as it entered the pretreatment area. The majority of the metal removal appeared to occur within the pretreatment system. As a result, mass removal within the pretreatment system was calculated by comparing the estimated concentration in the outer pool with the concentration measured at the weir (Appendix 7). Using these

Table 9. Seep 1 mass release, 1986-1999.

	Before the pre-treatment system was put on line		After the pre-treatment system was put on line	
	Average conc. (mg/L)	Mass release (kg)	Average conc. (mg/L)	Mass release (kg)
pH	5.4	NAp	6.95	NAp
Cu	0.69	5.4	0.22	1.9
Ni	14.7	124	6.6	45
SO4	1,320	10,800	1,060	6,600
Mean annual flow, May-Oct ($L \times 10^6$)	7.3		5.1	

Nap = not applicable

Note: a) The "before" time period includes all water quality data from 1986-1991, and all flow data from 1986-1991 with the exception of data from 1989. The 1989 flow data was excluded because the volume of water measured at the weir exceeded the volume of water that fell on the watershed.

b) The "after" time period includes all data from 1993-1999. Copper release was anomalously high (7.9 kg) due to the July 4th rainstorm - if 1999 is excluded, the average "after" mass release is 0.9 kg instead of 1.9 kg.

assumptions, 9.4 kg of copper and 77.2 kg of nickel were removed from 1993 through the end of 1996 (Table 10). The total mass contained within the peat substrate was calculated by:

$$\text{mass of metal (kg)} = \text{area of pool (m}^2\text{) x depth of sample (cm) x density (gm/cm}^3\text{)}$$
$$\text{x average metal concentration mg/kg}$$
$$\text{x } 10^4 \text{ cm}^2/\text{m}^2 \text{ x } 10^{-6} \text{ kg/mg x } 10^{-3} \text{ kg/gm}$$

Using this method, 11.1 kg of copper and 30.2 kg of nickel were calculated for the top 30 cm of the peat (Table 10). The highest metal concentrations, and about 36% of the total mass, were in the vertical down-flow section.

Table 10. Copper and nickel mass in substrate of the Seep 1 pretreatment system, 1992-1996.

Portion of system	Area (m^2)	Volume in each 10 cm layer of peat (m^3)	Mass of dry [A] peat in each 10 cm layer (kg)	Mean [B] [Ni], mg/kg	Nickel mass (kg)	Mean [Cu], mg/kg	Copper mass (kg)
Outer ring	337.6	33.76	3376				
0-10 cm				2,297	7.75	917	3.10
10-20 cm				506	1.71	185	0.62
20-30 cm				288	0.97	180	0.61
Total				---	10.43	---	4.33
Middle ring	195.6	19.56	1956				
0-10 cm				2,340	4.58	662	1.29
10-20 cm				432	0.85	188	0.37
20-30 cm				240	0.47	138	0.27
Total				---	5.90	---	1.93
Inside ring	99.6	9.96	996				
0-10 cm				2,300	2.29	532	0.53
10-20 cm				432	0.43	188	0.19
20-30 cm				240	0.24	138	0.14
Total				---	2.96	--	0.86
Vertical flow	38.3	3.83	383				
0-10 cm				7,210	2.76	3,747	1.44
10-20 cm				9,594	3.67	4,255	1.63
20-30 cm				11,254	4.31	2,348	0.90
Total				---	10.74	---	3.97
Berms	103.7	---	---	---	---	---	---
Total in substrate	774.5	67.08	6708	---	30.03	---	11.09
Mass removal calculated from water quality	---	---	---	---	77.20	---	9.40

A: Assumes 0.1 g of dry peat per cc of wet peat
B: No copper or nickel data was available for the 10-20 and 20-30 cm layers for the inner ring, so the corresponding values from the middle ring were used for these calculations.
Note: The peat samples used to calculate the mean nickel values were collected 4/14/97 - 4/24/97, except for the vertical flow section, which were collected 4/4/96.

Discussion, W1D

The overall objective of the W1D study was to determine the lifetime of the wetland treatment system. LTV designed the original W1D system based on average input values for 1990-1991. Average daily flow was 20 gal/min and the average nickel concentration was 5.4 mg/L (Eger et al., 1996). Based on a wetland area of 7000 m^2, an effective removal depth of 20 cm, a peat bulk density of 0.1 gm/cm^3, a maximum removal capacity of 10,000 mg nickel/kg dry peat, and flow from April through November (245 days), the design lifetime was:

$$\text{Lifetime (years)} = \frac{\text{total removal capacity of the wetland (kg nickel)}}{\text{annual load (kg nickel/year)}}$$

$$= \frac{\text{volume of reactive peat x bulk density x removal capacity}}{\text{average daily flow x average nickel concentration x number of days of flow}}$$

$$= \frac{7000\ m^2 \text{ x } (100\ cm/m)^2 \text{ x } 20\ cm \text{ x } 0.1\ gm/cm^3 \text{ x } 10{,}000\ mg\ nickel \text{ x } 10^{-3}\ kg/mg \text{ x } 10^{-6}\ kg/mg}{20\ gal/min \text{ x } 3.785\ L/gal \text{ x } 1440\ min/day \text{ x } 5.4\ mg\ nickel/L \text{ x } 1/10^6 mg/kg \text{ x } 245\ days}$$

$$= \frac{1400\ kg}{144\ Kg} \approx 10 \text{ years}$$

In 1995 the entire top of the stockpile was covered with a 30 mil linear low density polyethylene liner (LLDPE). While this cover prevented water from contacting most of the reactive material in the stockpile, mineralized rock was still exposed on the uncovered side slopes. Flow at the W1D weir dropped 55%, from an average May to October flow of 33 gal/min (125 L/min) during 1992-1994, to 15 gal/min (57 L/min) for the post-closure period (1996-1999).

By preventing precipitation from infiltrating the stockpile and contacting the reactive material, the transport of reactive products was significantly reduced. Nickel concentrations decreased from an average of 3.98 mg/L in 1992-1994 to 0.74 mg/L for 1996-1999. Since both flow and nickel concentrations decreased, the overall load to the wetland decreased by about 90% (Table 5). By reducing the load, the estimated lifetime was increased substantially, from the initial design lifetime of 10 years to an average of 150 years in 1996-1999 (Table 11).

The ultimate goal of a passive treatment system is to provide permanent treatment. The major mode of metal removal in this system is assumed to be the same as observed in the initial test cell study (Eger et al., 1994). Over 90% of the nickel removal in the test cells occurred within the substrate, through a series of reactions (adsorption, ion exchange, chelation) associated with the organic fraction of the peat. With this type of removal mechanism, the wetland will have a finite life unless new removal sites can be generated at a rate greater than or equal to the incoming metal load (Eger et al., 1994).

New sites are generated as vegetation dies and new organic substrate accumulates. The average rate of peat accumulation in northern wetlands is about 1 mm/year (Craft and Richardson, 1993). If the

Table 11. Effect of stockpile capping on load to the W1D wetland and wetland lifetime.

Year	Annual nickel load (kg)	Percent of pre-capping load	Lifetime of wetland [1] (years)
Initial design lifetime	144	---	10
1992-1994	170	---	8
1995	76	45	18
1996	36	21	39
1997	8	5	175
1998	5	3	280 (self sustaining [2])
1999	16	9	88

[1] Lifetime is calculated by dividing the initial removal capacity of the wetland (1400 kg) by the annual load.

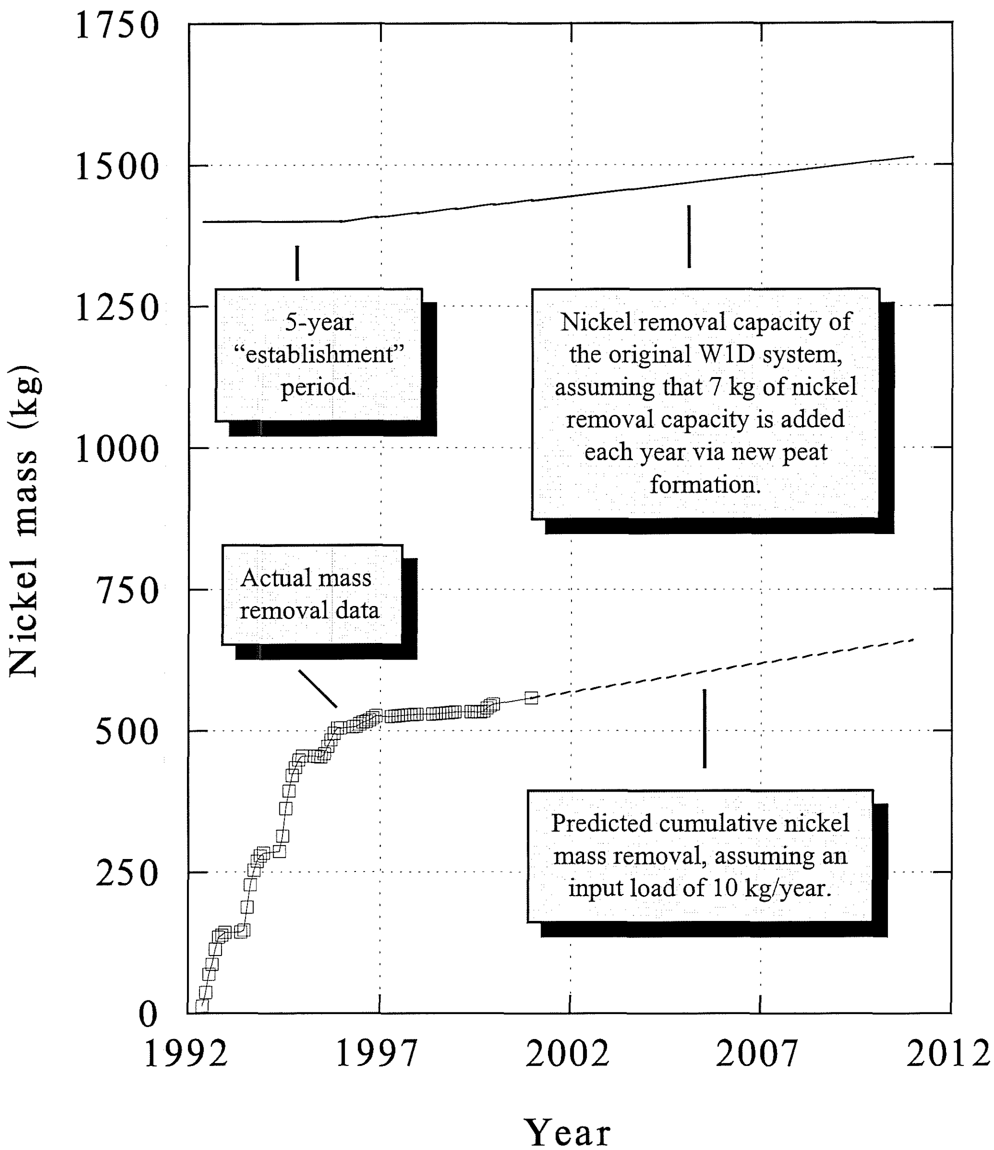
[2] Annual nickel load to the wetland is less than the estimated annual gain in nickel removal capacity (7 kg); the wetland is self-sustaining.

removal capacity of the newly accumulated material is assumed to be 10,000 mg nickel/kg, the wetland would add 7 kg of nickel removal capacity each year:

$$\text{Annual gain in nickel removal capacity} = \text{rate of peat accumulation} \times \text{nickel removal capacity} \times \text{wetland area}$$

$$= \frac{1\ \text{mm/year} \times 0.1\ \text{cm/mm} \times 10{,}000\ \text{mg Ni/kg} \times 7000\ \text{m}^2 \times (100\ \text{cm/m})^2 \times 0.1\ \text{gm/cm}^3 \times 10^{-3}\ \text{kg/gm}}{10^6\ \text{mg/kg}}$$

In 1998 the annual nickel input load was less than the gain in nickel removal capacity. If the annual input load is less than or equal to the annual increase in removal capacity, the wetland should be self-sustaining. In 1999 the input load was greater than the sustainable load, but the increased load was the result of above normal precipitation, particularly in July when 9.49 inches (24.1 cm) of rain fell. Using the average of the 1997-1999 input load (10 kg) as representative of the post-closure period, and assuming an annual increase of 7 kg nickel removal capacity, the projected lifetime for the wetland is about 290 years (Figure 22, Appendix 12).



This model assumes that:

1. The original W1D wetland system had a nickel removal capacity of 1400 kg.
2. Organic matter accumulates at an annual rate of 1 mm/year.
3. Newly formed organic matter has the same removal capacity as the original substrate and can remove 7 kg nickel per year.
4. It took 5 years for the vegetation to become fully established and to start contributing to substrate formation.
5. The input nickel load will stay at 10 kg/year, which was the average input from 1997-1999.

At these metal loading and organic matter deposition rates, the model predicts that the peat would become saturated in about 290 years. This simple model does not account for uneven flow distribution, which would decrease the amount of peat contact and therefore reduce system lifetime. (Additional details on the assumptions used in these calculations are provided in Appendix 12.)

Figure 22. Nickel mass removal in the W1D system, and projected nickel removal capacity.Fora

wetland to be sustainable, not only must there be new metal removal capacity generated, but the metal must be retained within the wetland. Mass balances calculated on wetland test cells demonstrated that over 99% of the removed metals were associated with the substrate and less than 1% of the total removal occurring in the vegetation (Eger et al.,1994). These results were consistent with earlier studies on metal removal in a white cedar wetland (Eger and Lapakko, 1988) and with data reported by others (Skousen et al., 1992, Wildeman et al.,1993). Nickel contained within the substrate of the study cell accounted for essentially all of the total nickel removal that was calculated from the change in water quality data. Sequential extraction tests, conducted on a series of substrate samples collected from test cells constructed at the Dunka Mine, demonstrated that only 1-2% of the nickel was water soluble and could be readily removed from the substrate (Eger et al., 1994).

Additional evidence for the permanent nature of the removal is that nickel removal in the wetland has continued despite a decrease in input concentration of almost an order of magnitude. If the nickel was weakly bound to the substrate, nickel would be released from the substrate as nickel concentrations in the water decreased, and no removal would occur. Although continuous flow data is only collected from May through October, water quality samples are collected whenever there is water flowing into or out of the wetland. Over the seven years of operation, output concentrations have rarely exceeded input values, and there has always been a net nickel removal in the wetland (Figure 9).

Discussion, Seep 1

Until 1999, the pretreatment system routinely increased pH and reduced copper and nickel concentrations. The pH at the outflow of the pretreatment system generally met discharge limits. Copper concentrations were reduced by about 70%, but still routinely exceeded the NPDES discharge limit of 0.022 mg/L. Average nickel concentrations were about 55% below historic levels, but they were also substantially greater than the discharge limit of 0.484 mg/L (Table 8). Based on the topography of the site, the construction of the pond did not alter the overall amount or direction of groundwater flow, so any reduction in concentrations at the weir monitoring site must be due to reactions that occur in the treatment system, or a reduction in the total load from the stockpile.

Typically, to analyze the performance of a treatment system, the amount of mass removal is calculated by subtracting the output mass from the input mass. Since this system does not contain a single input point and the majority of the water enters as groundwater, a standard analysis (input mass minus output mass) cannot be done. Therefore, changes in flow and concentration must be analyzed separately.

Average May to October flow, after the stockpile had been capped and the pretreatment system built, was about 30% less than the historic (1986-1991) values. Some of this reduction in flow was probably due to lower precipitation. When flow was corrected for the lower precipitation, the overall reduction in flow due to capping was estimated to be 25% (Appendix 8). The projected flow reduction, based on the total watershed area at Seep 1, the capped stockpile area, and a 40% reduction in flow for the covered portion of the stockpile, was 24% (Appendix 8). Assuming a 25% reduction in flow after capping, the annual copper load would be 4 kg and the annual nickel load would be 93 kg.

Based on these input loads and the measured output loads at the Seep 1 site after the pretreatment system was constructed, annual average removal would be about 3 kg for copper and about 50 kg for nickel. For 1993 through 1996, the total metal removal would be 12 kg of copper and 200 kg of nickel. This amount of copper was within 10% of the mass calculated to be contained within the substrate, but the nickel mass was almost seven times higher than the substrate value (Appendix 7). When the outer pool concentrations were used to represent the input, the copper removal was 9.4 kg, while the nickel mass removal decreased to 77.2 kg, a value much closer to the mass contained within the substrate (30.0 kg).

Since the nickel concentrations in the outer pool were significantly less than the historical concentrations, and provided a better correlation with the mass contained in the substrate, it appears that capping of the stockpile has not only reduced flow but may have also reduced nickel concentrations in the input seepage. Limited measurements of the contribution of the individual surface seeps to the overall load indicated that the majority of the nickel input was via groundwater, while copper enters primarily as surface flow (Table 12; Appendix 7). Any change in the input nickel concentration could not be quantified due to the lack of both wells and historical data.

Table 12. Comparison of the load from surface seeps, with the load at Seep 1 weir, August, September, 1993.

Date	(Sum of seeps / Seep 1) x 100%				Seep 1 Flow	
	Flow	Cu	Ni	Mg	L/sec	gal/min
8/17/93	23	242	53	32	0.30	4.8
8/30/93	17	206	35	21	0.37 (e)	5.8
9/16/93	13	127	25	16	0.27	4.3
Average	18	192	38	23	0.31	4.9

Notes: The instantaneous load from each surface seep was calculated by multiplying the flow (measured with a small portable flume) by the concentration. The load from all seeps with measurable flows were added to estimate the total load (Appendix 7). Samples were collected at some seeps but there was not sufficient flow to measure. The contributing seeps included S-2, S-3, S-4, S-8 and S-9 (Figure 8).

The sum of the load from the seeps was divided by the instantaneous load measured at Seep 1. When the ratio exceeds 100%, more mass entered the system through the seeps than left the system at the weir.

(e) = estimated flow, see Table A7.6

Copper entered the pretreatment system primarily through the small acidic seeps. Copper concentrations decreased as water moved through the pool, contacted the limestone berms, and increased in pH. This removal was consistent with that observed in both laboratory and field experiments conducted with water from the site. A field pilot system, using 6-mm limestone chips, was constructed at this site in 1989 (Lapakko and Antonson, 1990a). With an average residence time of about 1 hour, the average pH increased from around 5.0 to 6.8. Even with residence times as short as 15 minutes, pH always increased to 6.2 or higher. Copper removal averaged about 50%, while nickel was reduced by 10%. In laboratory limestone columns, with residence times on the order of 5 hours, pH increased to 7.5, and 80% of the copper and 10% of the nickel were removed (Lapakko and Antonson, 1990b).

The limestone used in the existing treatment system ranged in size from 7½-10 cm, and the reactive surface area was an order of magnitude less per unit mass than the limestone used in the pilot and laboratory experiments. (The larger limestone was used to avoid plugging problems that had been observed in the pilot study.) Therefore, the residence time in the treatment system would have to be increased by at least a factor of 10 to achieve results similar to the pilot study. Based on the size of the treatment system (930 m^2) and an assumed average water depth of 0.3 m, the overall residence time was calculated to have ranged from around 120 hours for the average flow to 12 hours for the typical daily maximum flow, generally meeting the criteria for an increased residence time. With the exception of 1999, the pH of the outflow was similar to that observed in the pilot system and tended to decrease as flow increased (Appendix 1).

During storms over the July 4th weekend in 1999, daily flow increased to about 265 gal/min (1000 L/min), with a peak flow of around 790 gal/min (2990 L/min). This flow rate exceeded the capacity of the vertical down-flow section. As a result, the water level rose about 1.3 feet (0.4 m) and flowed through the emergency overflow. On July 7th, the pH at the site above the vertical down-flow section (site 043-6) was only 4.74, and there was essentially no change as the water moved through this section. Flow at the weir dropped to about 35 gal/min (139 L/min) within two days of the rain, but the pH did not increase until August. The estimated residence time ranged from five hours during peak flow to 35 hours two days later. Even though flow had decreased within two days, water levels in the pond remained high. The water level was only 0.3 feet (9 cm) below the overlow level, and was about one foot (30 cm) above the limestone berms (Appendix 8). Despite increased residence time, the high water level prevented contact between the drainage and the limestone berms.

As water moved through the pretreatment system and contacted the substrate, removal reactions similar to those at the W1D wetland would be expected to occur. As the water moves through the vertical down-flow section, other reactions such as sulfate reduction may become important. The addition of the hay to the system in 1994 appears to have provided a short-term stimulus to the sulfate reduction process. Hay has been used in other studies to provide a readily available source of food for sulfate reducing bacteria (Wildeman et al., 1993). After the hay was added, sulfate and nickel concentrations decreased, but returned to the original values in less than a year.

In earlier laboratory experiments, peat columns were used to treat drainage from another stockpile at the Dunka Mine (site EM-8, Figure 2). Nickel concentrations in the outflow of the column followed a classical adsorption type breakthrough curve, except that the final concentration was about 10-20% lower than the input, and remained at that level for the duration of the experiment (Lapakko et al., 1986). This change in nickel concentration was similar to that observed in the vertical down-flow section. It is possible that sulfate reduction reactions occurring within the substrate account for this sustained removal. Nickel concentrations calculated for the peat in the columns were on the order of 20,000 mg/kg, similar to the values measured within the vertical down-flow section (Lapakko et al., 1986).

Although summer nickel removal in the vertical section averaged 18% for 1997 and 1998, removal decreased to 8% in 1999. The decrease in nickel removal could be due to slower reaction rates, a loss in treatment capacity or the result of higher than average flows. Additional data should be collected to determine if the system has reached saturation.

Conclusions

W1D

Since 1995, when the mine was closed and the stockpiles capped, nickel loads into the W1D wetland have dropped by almost an order of magnitude. Nickel has been removed every year and there has been no evidence of nickel release from the wetland. The nickel load into the wetland is now about the same as the estimated annual production of new removal sites. If conditions remain unchanged, treatment could continue indefinitely.

Seep 1

Since 1992, the pretreatment system has been effective in increasing pH and removing copper. The system appeared to provide treatment for a range of flows, but could not handle the flows following the seven inches of rain over the July 4th weekend in 1999. After this rain event, the pH of the outflow decreased and metal concentrations increased. Since much of the copper removal is related to the increase in pH, the system should continue to remove copper until the limestone dissolution rate can no longer neutralize the pH of the input drainage. Since a detailed mass balance could not be conducted on the pretreatment system, the rate of limestone dissolution and an expected lifetime could not be calculated. However, there is no data to suggest that the system's ability to neutralize the drainage has decreased.

Most of the nickel removal occurred in the vertical down-flow section, but concentrations decreased by only 10-20%. Nickel concentrations in the substrate of the vertical down-flow section were on the order of 10,000 mg/kg, a value that has been used to estimate total removal capacity. In 1999, nickel removal in the vertical down-flow section decreased to only 8%. The lower rate of removal could be due to the higher flow in 1999 or a decreased treatment efficiency. Additional data should be collected to determine if the system has reached saturation.

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Appendix 1

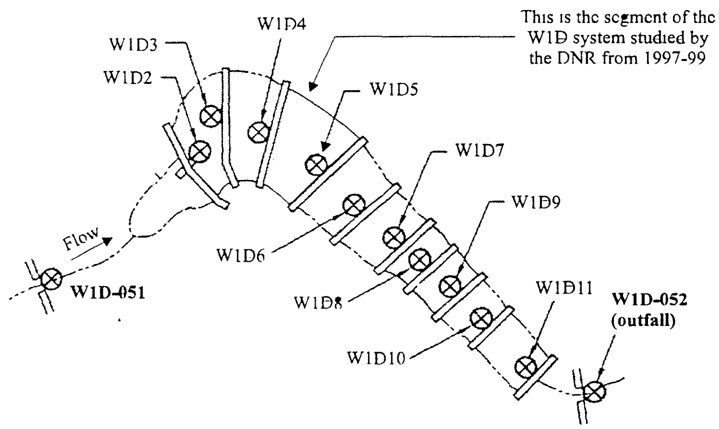
Water quality data

Tables

Figures

Table A1.1. W1D water quality data, collected by LTV from 1992-1999.

This file includes all W1D data (orginal system) collected by LTV. DNR also conducted a separate study of a particular segment of the treatment system; the data from that study is presented in Table A1.2.



Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg

Input (W1D-051)

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-051	4 29 92	7.1	0.080	1.300	0.004	0.010	0.100	.	1064.0	130.0	130.0
W1D-051	5 4 92	.	0.120	1.100	0.024	0.050	.	.	.	235.0	280.0
W1D-051	5 6 92	7.1	0.130	2.400	0.008	0.030	0.200	3.2	1613.0	270.0	310.0
W1D-051	5 11 92	7.2	0.130	1.600	0.012	0.030	.	.	1257.0	200.0	205.0
W1D-051	5 13 92	7.3	0.090	1.400	0.008	0.020	.	.	1209.0	150.0	165.0
W1D-051	5 18 92	7.1	0.120	2.600	0.008	0.030	.	.	1794.0	198.0	253.0
W1D-051	5 21 92	7.1	0.140	2.900	0.001	0.040	0.050	2.8	2002.0	240.0	270.0
W1D-051	5 26 92	7.1	0.110	5.000	0.032	0.060	.	.	1648.0	320.0	410.0
W1D-051	5 28 92	7.1	0.110	5.800	0.017	0.040	.	.	2019.0	300.0	445.0
W1D-051	6 1 92	7.1	0.100	6.000	0.019	0.040	.	.	2644.0	280.0	450.0
W1D-051	6 3 92	7.1	0.110	6.600	0.018	0.050	.	.	2728.0	370.0	490.0
W1D-051	6 8 92	7.2	0.110	5.200	0.008	0.050	.	.	2753.0	345.0	450.0
W1D-051	6 10 92	7.0	0.140	3.900	0.013	0.050	.	.	2844.0	.	.
W1D-051	6 10 92	7.1	0.140	5.700	0.014	0.050	0.200	2.8	2728.0	400.0	435.0
W1D-051	6 15 92	6.7	0.100	5.300	0.019	0.060	.	.	2820.0	300.0	560.0
W1D-051	6 15 92	7.2	0.100	6.500	0.015	0.040	.	.	2728.0	.	.
W1D-051	6 17 92	.	0.110	5.500	0.006	0.040	.	.	2532.0	.	.
W1D-051	6 17 92	7.2	0.110	4.600	0.022	0.060	0.050	5.6	2836.0	300.0	400.0
W1D-051	6 22 92	7.1	0.080	4.200	0.011	0.050	.	.	2523.0	300.0	420.0
W1D-051	6 22 92	.	0.090	5.000	0.012	0.080	.	.	2567.0	.	.
W1D-051	6 24 92	7.2	0.070	2.600	0.007	0.040	.	.	2669.0	290.0	370.0
W1D-051	6 29 92	.	0.110	5.500	0.011	0.050	.	.	2610.0	310.0	370.0
W1D-051	6 29 92	.	0.110	6.100	0.011	0.100	.	.	2644.0	.	.
W1D-051	6 30 92	7.1	0.110	5.000	0.008	0.060	.	.	2753.0	300.0	450.0
W1D-051	7 6 92	.	0.080	6.100	0.015	0.110	.	.	2541.0	.	.
W1D-051	7 9 92	7.1	0.100	5.400	0.016	0.050	0.050	0.8	2532.0	310.0	410.0
W1D-051	8 3 92	7.2	0.100	3.400	0.012	0.040	.	.	3118.0	.	.
W1D-051	8 6 92	7.1	0.090	2.200	0.011	0.030	0.050	2.0	3188.0	410.0	460.0
W1D-051	8 12 92	7.3	0.090	3.000	0.016	0.040	0.100	.	2999.0	340.0	430.0
W1D-051	8 19 92	6.9	0.070	4.900	0.011	0.040	0.050	3.2	3102.0	340.0	420.0
W1D-051	8 26 92	.	0.070	4.300	0.012	0.090	.	.	2212.0	.	.
W1D-051	9 2 92	6.7	0.045	2.700	0.019	0.060	0.100	0.8	2974.0	220.0	260.0

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-051	9 4 92	.	0.060	3.200	0.008	0.060	.	.	3023.0	.	.
W1D-051	9 23 92	.	0.060	4.700	0.060	0.060	.	.	2819.0	.	.
W1D-051	9 25 92	7.1	0.060	6.000	0.050	0.060	0.100	1.2	2895.0	310.0	470.0
W1D-051	10 5 92	.	0.060	6.000	0.034	0.100	.	.	2614.0	.	.
W1D-051	10 7 92	7.1	0.070	5.800	0.028	0.060	0.050	2.8	2715.0	350.0	430.0
W1D-051	10 15 92	.	0.050	6.700	0.011	0.100	.	.	2426.0	.	.
W1D-051	10 23 92	7.0	0.070	3.300	0.026	0.050	0.050	3.6	2648.0	310.0	440.0
W1D-051	11 17 92	6.9	0.070	3.900	0.027	0.060	0.050	.	2555.0	360.0	430.0
W1D-051	11 24 92	7.0	0.080	3.300	0.019	0.070	0.050	.	2517.0	310.0	390.0
W1D-051	12 4 92	7.0	0.080	3.900	0.003	0.060	0.050	.	2316.0	390.0	430.0
W1D-051	12 14 92	7.1	0.080	3.600	0.003	0.060	0.050	.	2157.0	300.0	380.0
W1D-051	3 29 93	7.1	0.060	1.000	0.070	0.005	0.100	4.4	1252.0	70.0	90.0
W1D-051	4 8 93	6.9	0.060	1.300	0.070	0.020	0.100	.	654.0	110.0	110.0
W1D-051	4 12 93	7.0	0.070	1.300	0.070	0.020	0.050	.	1555.0	130.0	120.0
W1D-051	4 15 93	7.0	0.057	1.270	0.052	0.020	0.500	.	1253.0	140.0	130.0
W1D-051	4 19 93	7.1	0.060	1.200	0.014	0.010	0.050	.	697.0	140.0	140.0
W1D-051	4 22 93	8.3	0.060	1.200	0.002	0.010	0.050	.	1102.0	150.0	160.0
W1D-051	4 26 93	7.2	0.040	1.400	0.007	0.005	0.050	.	1030.0	160.0	160.0
W1D-051	4 29 93	7.4	0.040	0.920	0.006	0.005	0.050	.	919.0	120.0	130.0
W1D-051	5 3 93	7.3	0.040	0.860	0.004	0.050	0.050	.	779.0	90.0	90.0
W1D-051	5 6 93	6.9	0.050	0.960	0.003	0.050	0.050	.	821.0	110.0	120.0
W1D-051	5 10 93	7.5	0.060	0.800	0.003	0.050	0.050	.	892.0	130.0	130.0
W1D-051	5 13 93	7.4	0.060	1.200	0.002	0.050	0.050	.	992.0	130.0	130.0
W1D-051	5 17 93	7.4	0.040	0.860	0.001	0.010	0.050	.	1020.0	.	.
W1D-051	5 19 93	7.3	0.050	0.840	0.004	0.050	0.050	.	1188.0	180.0	170.0
W1D-051	5 24 93	7.2	0.060	0.790	0.004	0.050	0.100	.	872.0	170.0	140.0
W1D-051	5 27 93	7.2	0.040	0.900	.	0.050	0.050	.	883.0	240.0	150.0
W1D-051	6 2 93	7.2	0.040	0.940	0.001	0.050	0.050	.	1122.0	170.0	170.0
W1D-051	6 3 93	7.3	0.040	1.000	0.001	0.010	0.050	.	1068.0	180.0	170.0
W1D-051	6 7 93	.	0.050	1.100	0.001	0.060	.	.	1073.0	190.0	180.0
W1D-051	6 10 93	.	0.050	1.000	.	.	.	.	1261.0	170.0	170.0
W1D-051	6 14 93	7.3	0.050	0.930	0.005	0.060	.	.	1319.0	.	.
W1D-051	6 23 93	7.1	0.070	2.400	0.013	0.020	0.400	.	1564.0	300.0	350.0
W1D-051	6 24 93	7.2	0.036	2.300	.	.	.	.	1461.0	.	.
W1D-051	6 28 93	7.1	0.040	2.300	.	.	.	.	1573.0	.	.
W1D-051	7 1 93	7.0	0.050	3.200	.	.	.	.	1754.0	.	.
W1D-051	7 6 93	6.9	0.040	3.100	.	.	.	.	1408.0	.	.
W1D-051	7 8 93	.	0.007	4.000	.	.	.	.	2398.0	.	.
W1D-051	7 12 93	.	0.030	5.400	.	.	.	.	2087.0	.	.
W1D-051	7 14 93	6.9	0.050	6.700	0.450	0.030	0.100	.	1626.0	410.0	450.0
W1D-051	7 15 93	6.8	0.040	7.100	.	.	.	.	2330.0	.	.
W1D-051	7 19 93	6.8	0.030	7.200	.	.	.	.	2439.0	.	.
W1D-051	7 26 93	6.8	0.030	6.700	.	.	.	.	2439.0	.	.
W1D-051	7 28 93	6.8	0.030	4.100	0.410	0.030	0.100	.	2370.0	360.0	430.0
W1D-051	8 2 93	6.8	0.026	5.700	.	.	.	.	2575.0	.	.
W1D-051	8 13 93	6.9	0.050	5.500	0.024	0.050	0.100	.	2438.0	370.0	450.0
W1D-051	8 16 93	7.1	0.030	6.700	.	.	.	.	2642.0	.	.
W1D-051	8 25 93	7.1	0.050	6.000	0.010	0.060	0.100	.	622.0	390.0	460.0
W1D-051	9 15 93	7.1	0.070	5.800	0.029	0.070	0.100	.	2852.0	360.0	430.0
W1D-051	9 29 93	7.1	0.080	7.300	0.029	0.090	0.100	.	2766.0	340.0	430.0
W1D-051	10 15 93	7.0	0.080	6.300	0.014	0.070	0.100	.	2749.0	370.0	460.0
W1D-051	10 22 93	6.9	0.070	4.800	0.009	0.060	0.100	.	2525.0	310.0	420.0
W1D-051	11 3 93	7.1	0.070	5.100	0.009	0.060	0.005	.	2783.0	330.0	410.0
W1D-051	11 17 93	7.1	0.080	4.700	0.011	0.060	0.100	.	2671.0	340.0	470.0
W1D-051	12 8 93	7.0	0.090	3.800	0.019	0.060	0.100	.	2468.0	.	.
W1D-051	12 20 93	7.0	0.090	3.300	0.035	0.060	0.100	.	2435.0	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-051	3 17 94	6.8	0.100	1.600	0.160	0.050	0.810	.	1136.0	.	.
W1D-051	4 4 94	6.9	0.050	1.100	0.070	0.030	0.600	.	726.0	.	.
W1D-051	4 18 94	7.1	0.050	0.640	0.050	0.010	0.100	.	379.0	.	.
W1D-051	5 6 94	7.2	0.050	0.850	0.009	0.010	0.050	.	631.0	130.0	120.0
W1D-051	5 16 94	7.2	0.060	1.500	0.008	0.010	0.100	.	1555.0	220.0	260.0
W1D-051	6 2 94	7.2	0.050	2.700	0.007	0.020	0.050	.	2376.0	290.0	350.0
W1D-051	6 3 94	7.1	0.050	3.000	.	.	.	.	1292.0	.	.
W1D-051	6 8 94	6.9	0.050	2.400	.	.	.	.	2381.0	.	.
W1D-051	6 13 94	7.1	0.050	2.600	0.004	0.020	0.050	.	2341.0	310.0	380.0
W1D-051	6 15 94	7.6	0.050	1.400	.	.	.	.	950.0	.	.
W1D-051	6 22 94	7.1	0.030	4.700	.	.	.	.	2761.0	.	.
W1D-051	6 27 94	7.4	0.040	4.300	.	.	.	.	1861.0	.	.
W1D-051	7 6 94	.	0.050	7.500	.	.	.	.	2737.0	.	.
W1D-051	7 7 94	7.5	0.060	5.700	0.080	0.060	0.100	.	2803.0	360.0	440.0
W1D-051	7 11 94	7.1	0.040	5.300	.	.	.	.	2643.0	.	.
W1D-051	7 20 94	6.9	0.050	5.800	0.050	0.060	0.100	.	2450.0	300.0	410.0
W1D-051	7 21 94	.	0.050	5.900	.	.	.	.	2319.0	.	.
W1D-051	7 29 94	.	0.070	7.300	.	.	.	.	2895.0	.	.
W1D-051	8 3 94	7.1	0.070	6.300	0.030	0.070	0.100	.	2689.0	350.0	440.0
W1D-051	8 4 94	7.3	0.040	5.600	.	.	.	.	2545.0	.	.
W1D-051	8 11 94	6.1	0.040	5.700	.	.	.	.	2331.0	.	.
W1D-051	8 18 94	7.3	0.040	6.000	.	.	.	.	2379.0	.	.
W1D-051	8 24 94	6.9	0.050	5.000	0.001	0.060	0.100	.	2390.0	340.0	430.0
W1D-051	8 25 94	6.9	0.060	4.500	.	.	.	.	2308.0	.	.
W1D-051	9 2 94	.	0.050	4.700	.	.	.	.	2178.0	.	.
W1D-051	9 8 94	7.0	0.070	4.900	0.021	0.070	0.050	.	2544.0	340.0	420.0
W1D-051	9 20 94	6.9	0.050	5.700	0.080	0.070	0.050	.	2331.0	330.0	410.0
W1D-051	10 10 94	7.0	0.090	6.200	0.040	0.100	0.050	.	2493.0	345.0	430.0
W1D-051	10 12 94	.	.	6.400	.	.	.	.	.	.	.
W1D-051	10 12 94	.	.	6.400	.	.	.	.	.	.	.
W1D-051	10 19 94	7.0	0.080	5.100	0.090	0.070	0.050	.	2072.0	320.0	380.0
W1D-051	10 27 94	.	.	4.240	.	.	.	.	.	.	.
W1D-051	11 3 94	6.7	0.080	6.000	0.090	0.090	0.050	.	2257.0	340.0	410.0
W1D-051	11 17 94	6.8	0.090	5.500	0.060	0.080	0.050	.	2773.0	330.0	420.0
W1D-051	12 1 94	6.7	0.090	5.700	0.060	0.200	0.100	.	2344.0	350.0	410.0
W1D-051	12 22 94	6.7	0.090	4.800	0.021	0.070	0.100	.	2048.0	350.0	410.0
W1D-051	3 14 95	7.4	0.030	0.530	0.038	0.020	0.100	.	499.0	90.0	80.0
W1D-051	3 27 95	6.8	0.100	1.600	0.080	0.040	0.500	.	234.0	190.0	220.0
W1D-051	3 27 95	6.8	0.100	1.600	0.080	0.040	0.400	.	230.0	200.0	220.0
W1D-051	4 13 95	6.7	0.600	1.200	0.070	0.020	0.500	.	596.0	140.0	150.0
W1D-051	4 27 95	6.9	0.080	1.900	0.210	0.020	0.100	.	798.0	150.0	160.0
W1D-051	5 12 95	7.1	0.080	1.400	0.050	0.010	0.050	.	978.0	170.0	180.0
W1D-051	5 23 95	7.1	0.050	1.000	0.050	0.010	0.100	.	1617.0	180.0	200.0
W1D-051	6 7 95	7.2	0.150	1.300	0.019	0.010	0.050	.	1303.0	310.0	230.0
W1D-051	6 21 95	7.3	0.110	1.500	0.035	0.010	0.100	.	1594.0	250.0	300.0
W1D-051	7 10 95	7.2	0.060	1.200	0.017	0.010	0.050	.	1306.0	210.0	230.0
W1D-051	7 27 95	7.1	0.040	2.400	0.040	0.020	0.100	.	2126.0	300.0	380.0
W1D-051	8 10 95	6.9	0.040	2.300	0.024	0.030	0.100	.	2236.0	356.0	409.0
W1D-051	8 21 95	7.0	0.070	2.000	0.017	0.010	0.100	.	1857.0	270.0	317.0
W1D-051	9 11 95	7.0	0.070	1.900	0.026	0.020	0.100	.	1796.0	284.0	313.0
W1D-051	9 25 95	7.0	0.040	2.500	0.037	0.030	0.100	.	2266.0	321.0	350.0
W1D-051	10 10 95	7.2	0.050	2.700	0.023	0.030	0.050	.	1937.0	290.0	310.0
W1D-051	10 23 95	7.2	0.110	3.200	0.020	0.040	0.100	.	2449.0	310.0	170.0
W1D-051	1 4 96	7.0	0.080	2.000	0.040	0.030	0.100	.	3001.0	350.0	320.0
W1D-051	4 29 96	7.5	0.046	0.853	0.019	0.029	0.060	.	809.0	.	.
W1D-051	5 9 96	7.2	0.031	0.955	0.007	0.005	0.070	.	1100.0	135.0	258.0

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-051	5 22 96	7.3	0.034	0.790	0.007	0.023	0.089	.	1100.0	165.0	161.0
W1D-051	6 7 96	7.2	0.053	1.060	0.005	0.031	0.060	.	1430.0	243.0	246.0
W1D-051	6 19 96	7.1	0.053	1.330	0.005	0.031	0.070	.	1620.0	292.0	277.0
W1D-051	7 2 96	7.1	0.033	0.908	0.009	0.021	0.100	.	1270.0	216.0	222.0
W1D-051	7 15 96	7.0	0.038	0.927	0.005	0.027	0.070	.	1630.0	222.0	231.0
W1D-051	8 6 96	7.1	0.013	0.624	0.002	0.018	0.290	.	1750.0	248.0	269.0
W1D-051	8 20 96	7.0	0.010	0.385	0.003	0.011	0.040	.	2130.0	326.0	308.0
W1D-051	9 4 96	7.1	0.037	0.999	0.001	0.027	0.080	.	1630.0	308.0	314.0
W1D-051	9 19 96	7.2	0.025	0.844	0.006	0.025	0.110	.	2045.0	322.0	301.0
W1D-051	10 2 96	7.2	0.026	1.380	0.009	0.035	0.070	.	1780.0	308.0	285.0
W1D-051	10 21 96	7.2	0.066	1.575	0.004	0.048	0.100	.	1780.0	291.0	278.0
W1D-051	11 6 96	7.3	0.054	1.795	0.012	0.049	0.080	.	1600.0	278.0	265.0
W1D-051	11 18 96	7.3	0.043	0.958	0.010	0.022	0.040	.	722.0	115.0	110.0
W1D-051	12 2 96	7.3	0.059	2.000	0.010	0.055	0.040	.	1460.0	277.0	255.0
W1D-051	12 16 96	7.1	0.069	1.720	0.008	0.056	0.040	.	1910.0	293.0	276.0
W1D-051	4 14 97	7.1	0.043	1.060	0.045	0.028	0.040	.	700.0	113.0	105.0
W1D-051	4 22 97	7.2	0.015	1.300	0.019	0.028	0.080	.	828.0	109.0	104.0
W1D-051	5 7 97	7.2	0.033	0.754	0.005	0.022	0.070	.	860.0	154.0	141.0
W1D-051	5 21 97	7.2	0.031	0.571	0.001	0.012	0.040	.	924.0	158.0	147.0
W1D-051	6 9 97	7.2	0.043	0.643	0.005	0.015	0.060	.	975.0	191.0	174.0
W1D-051	6 16 97	7.2	0.033	0.726	0.004	0.005	0.050	.	1160.0	206.0	183.0
W1D-051	7 10 97	7.1	0.025	0.658	0.002	0.022	0.070	.	1020.0	210.0	179.0
W1D-051	7 21 97	7.2	0.048	0.797	0.013	0.020	0.070	.	1100.0	232.0	189.0
W1D-051	8 4 97	7.3	0.041	0.700	0.009	0.021	0.030	.	1080.0	223.0	191.0
W1D-051	8 18 97	7.2	0.007	0.144	0.013	0.005	0.070	.	1070.0	224.0	202.0
W1D-051	9 4 97	7.3	0.016	0.354	0.012	0.005	0.110	.	1080.0	237.0	215.0
W1D-051	9 23 97	7.1	0.017	0.305	0.009	0.012	0.080	.	1210.0	246.0	218.0
W1D-051	10 6 97	7.3	0.027	0.401	0.005	0.020	0.050	.	1110.0	244.0	223.0
W1D-051	10 21 97	7.2	0.018	0.550	0.016	0.013	0.015	.	1010.0	202.0	194.0
W1D-051	11 3 97	7.1	0.023	0.755	0.017	0.014	0.070	.	846.0	194.0	165.0
W1D-051	11 20 97	7.0	0.047	1.150	0.020	0.023	0.050	.	1100.0	226.0	201.0
W1D-051	12 3 97	7.0	0.041	0.865	0.015	0.024	0.050	.	837.0	209.0	186.0
W1D-051	12 18 97	7.1	0.037	0.750	0.007	0.019	0.050	.	1150.0	221.0	194.0
W1D-051	3 3 98	7.1	0.018	0.748	0.011	0.014	-0.030	.	586.0	105.0	105.0
W1D-051	4 9 98	7.0	0.017	0.675	0.005	0.017	-0.030	.	605.0	113.0	99.8
W1D-051	4 22 98	6.9	0.037	0.566	0.002	-0.010	0.040	.	887.0	140.0	129.0
W1D-051	5 7 98	7.1	0.053	0.589	0.002	0.014	0.030	.	869.0	172.0	164.0
W1D-051	5 18 98	7.1	0.035	0.417	0.003	-0.010	.	.	719.0	146.0	129.0
W1D-051	6 3 98	7.3	0.026	0.393	0.002	0.016	0.090	.	1040.0	203.0	183.0
W1D-051	6 16 98	7.3	0.024	0.378	0.006	0.022	-0.030	.	1060.0	202.0	182.0
W1D-051	7 9 98	7.2	0.025	0.373	0.008	0.015	0.060	.	1030.0	230.0	206.0
W1D-051	7 21 98	7.3	0.049	0.551	0.007	0.018	0.060	.	1135.0	238.0	213.0
W1D-051	8 4 98	7.3	0.047	0.381	0.024	0.015	0.030	.	1250.0	263.0	237.0
W1D-051	8 18 98	7.4	0.031	0.414	-0.001	0.020	-0.030	.	881.0	200.0	176.0
W1D-051	9 10 98	7.4	0.014	0.170	0.013	0.012	0.070	.	1130.0	243.0	222.0
W1D-051	9 25 98	7.3	0.015	0.209	0.009	0.014	0.040	.	1140.0	247.0	225.0
W1D-051	10 8 98	7.4	0.014	0.318	0.015	0.020	0.140	.	1010.0	232.0	208.0
W1D-051	10 21 98	7.3	0.024	0.546	0.013	0.167	0.040	.	708.0	151.0	125.0
W1D-051	11 4 98	7.3	0.026	0.653	0.015	0.018	-0.030	.	1250.0	209.0	194.0
W1D-051	11 17 98	7.3	0.031	0.590	0.011	0.017	0.050	.	1100.0	228.0	206.0
W1D-051	12 2 98	7.2	0.035	0.565	0.004	0.027	-0.030	.	948.0	207.0	184.0
W1D-051	12 14 98	7.2	0.069	0.799	0.032	0.031	0.050	.	1010.0	201.0	186.0
W1D-051	4 8 99	6.8	0.034	0.400	0.010	0.020	0.040	.	378.0	74.4	61.7
W1D-051	4 19 99	7.3	0.023	0.505	0.006	0.031	0.060	.	663.0	124.0	114.0
W1D-051	5 3 99	7.1	0.032	0.388	0.002	0.015	0.040	.	895.0	177.0	161.0
W1D-051	5 19 99	7.1	0.024	0.450	0.005	0.022	0.050	.	977.0	196.0	174.0

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-051	6 3 99	7.2	0.022	0.390	0.007	0.016	0.090	.	1060.0	206.0	194.0
W1D-051	6 19 99	6.9	0.009	0.215	0.012	0.014	-0.030	.	1170.0	222.0	212.0
W1D-051	7 8 99	7.1	0.008	0.322	0.004	0.017	0.410	.	897.0	152.0	138.0
W1D-051	7 20 99	7.0	0.004	0.187	0.002	0.015	0.100	.	1190.0	210.0	197.0
W1D-051	8 17 99	7.1	0.008	0.295	0.002	-0.010	0.050	.	1360.0	262.0	242.0
W1D-051	8 23 99	7.2	0.001	0.030	0.002	-0.010	0.090	.	1570.0	256.0	244.0
W1D-051	9 3 99	6.9	0.003	0.220	0.001	0.010	.	.	1550.0	284.0	264.0
W1D-051	9 16 99	7.3	0.005	0.473	0.002	-0.010	.	.	1320.0	239.0	224.0
W1D-051	10 5 99	7.1	0.011	1.290	0.013	0.030	.	.	1170.0	237.0	211.0
W1D-051	10 19 99	7.3	0.017	1.620	0.012	0.026	.	.	1110.0	243.0	230.0
W1D-051	11 2 99	7.3	0.023	1.250	0.009	0.026	.	.	1560.0	259.0	259.0
W1D-051	11 17 99	7.1	0.015	1.690	0.011	0.030	.	.	1340.0	282.0	258.0

Outfall (W1D-052: outfall from original treatment system)

W1D-052	4 29 92	6.7	0.011	0.250	0.017	0.005	.	.	817.0	95.0	90.0
W1D-052	5 4 92	.	0.010	0.170	0.016	0.010	.	.	.	105.0	110.0
W1D-052	5 6 92	6.8	0.022	0.260	0.018	0.010	1.600	20.4	961.0	.	.
W1D-052	5 11 92	6.9	0.032	0.530	0.040	0.020	.	.	1095.0	170.0	160.0
W1D-052	5 13 92	6.9	0.018	0.190	0.025	0.005	.	.	985.0	120.0	106.0
W1D-052	5 15 92	6.7	0.017	0.250	0.040	0.005	.	.	911.0	71.0	90.0
W1D-052	5 18 92	7.0	0.019	0.420	0.040	0.020	.	.	1067.0	113.0	111.0
W1D-052	5 21 92	6.9	0.020	0.330	0.008	0.005	4.200	19.6	981.0	120.0	95.0
W1D-052	5 26 92	6.9	0.016	0.400	0.050	0.005	.	.	1123.0	156.0	160.0
W1D-052	5 28 92	6.9	0.012	0.200	0.060	0.005	.	.	1091.0	130.0	145.0
W1D-052	6 1 92	7.0	0.011	0.360	0.030	0.005	.	.	1244.0	150.0	210.0
W1D-052	6 3 92	7.0	0.020	0.500	0.040	0.005	.	.	1539.0	220.0	260.0
W1D-052	6 8 92	7.0	0.012	0.270	0.030	0.005	.	.	1389.0	225.0	245.0
W1D-052	6 10 92	7.2	0.015	0.180	0.040	0.010	.	.	1932.0	.	.
W1D-052	6 10 92	6.9	0.003	0.290	0.003	0.005	5.100	16.4	1339.0	225.0	230.0
W1D-052	6 15 92	6.8	0.019	0.130	0.027	0.005	.	.	1882.0	.	.
W1D-052	6 15 92	6.9	0.009	0.160	0.026	0.005	.	.	1418.0	210.0	310.0
W1D-052	6 17 92	6.4	0.000	0.220	0.005	0.010	.	.	2172.0	.	.
W1D-052	6 17 92	7.1	0.019	0.320	0.015	0.005	0.900	30.8	2153.0	240.0	310.0
W1D-052	6 22 92	7.0	0.014	0.450	0.017	0.005	.	.	1739.0	210.0	280.0
W1D-052	6 22 92	7.0	0.006	0.460	0.012	0.060	.	.	1961.0	.	.
W1D-052	6 24 92	7.1	0.017	0.450	0.013	0.005	.	.	2134.0	220.0	280.0
W1D-052	6 29 92	7.1	0.002	0.280	0.013	0.050	.	.	1872.0	.	.
W1D-052	6 29 92	7.1	0.005	0.250	0.011	0.005	.	.	1831.0	210.0	240.0
W1D-052	6 30 92	7.0	0.004	0.020	0.014	0.005	.	.	1941.0	200.0	270.0
W1D-052	7 6 92	7.0	0.005	0.580	0.008	0.060	.	.	1852.0	.	.
W1D-052	7 9 92	7.0	0.010	0.330	0.009	0.005	0.700	10.4	2000.0	200.0	260.0
W1D-052	7 17 92	.	0.011	0.300	0.014	0.005	2.200	.	1464.0	200.0	250.0
W1D-052	7 31 92	.	0.014	0.080	0.010	0.005	0.200	.	.	190.0	230.0
W1D-052	8 3 92	7.2	0.013	0.090	0.010	0.005	.	.	2144.0	.	.
W1D-052	8 6 92	7.5	0.019	0.080	0.009	0.005	0.100	9.6	2068.0	200.0	280.0
W1D-052	8 11 92	.	0.026	0.150	0.009	0.005	0.100	.	2181.0	230.0	290.0
W1D-052	8 12 92	7.2	0.011	0.140	0.013	0.005	0.100	.	2200.0	220.0	290.0
W1D-052	8 17 92	7.1	0.008	0.100	0.009	0.005	0.300	.	2400.0	200.0	260.0
W1D-052	8 19 92	7.3	0.006	0.100	0.009	0.005	0.200	.	2228.0	220.0	270.0
W1D-052	8 26 92	6.7	0.017	0.140	0.009	0.060	.	.	1922.0	.	.
W1D-052	8 28 92	6.4	0.008	0.100	0.001	0.010	.	.	2733.0	.	.
W1D-052	9 1 92	7.2	0.006	0.500	0.004	0.005	.	.	2811.0	.	.
W1D-052	9 2 92	7.2	0.004	0.530	0.006	0.040	1.000	.	.	170.0	210.0

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-052	9 4 92	7.1	0.008	0.550	0.005	0.040	.	.	2627.0	.	.
W1D-052	9 17 92	7.2	0.014	0.062	0.003	0.005	.	.	.	.	.
W1D-052	9 23 92	.	0.003	0.490	0.003	0.020	.	.	2474.0	.	.
W1D-052	9 25 92	7.6	0.010	0.590	0.004	0.005	0.900	10.4	2460.0	230.0	320.0
W1D-052	10 5 92	7.2	0.004	0.560	0.003	0.040	.	.	2323.0	.	.
W1D-052	10 7 92	7.3	0.007	0.380	0.004	0.005	0.200	5.2	2382.0	210.0	270.0
W1D-052	10 15 92	.	0.002	0.510	0.011	0.040	.	.	2175.0	.	.
W1D-052	10 23 92	7.3	0.013	0.430	0.011	0.005	0.050	6.4	2211.0	240.0	350.0
W1D-052	10 28 92	7.3	0.002	0.440	0.007	0.005	.	.	2809.0	.	.
W1D-052	11 17 92	7.0	0.022	0.520	0.016	0.005	0.200	2.0	2280.0	280.0	320.0
W1D-052	11 24 92	7.0	0.022	0.530	0.019	0.010	0.200	2.0	2212.0	250.0	300.0
W1D-052	12 4 92	7.0	0.010	0.410	0.007	0.010	0.050	0.8	1348.0	300.0	320.0
W1D-052	12 14 92	7.1	0.005	0.330	0.010	0.005	0.200	4.4	1481.0	240.0	300.0
W1D-052	1 21 93	7.1	0.009	0.140	0.002	0.020	0.300	3.6	1341.0	240.0	260.0
W1D-052	1 27 93	7.1	0.008	0.120	0.003	0.005	0.300	2.4	1307.0	210.0	260.0
W1D-052	2 9 93	7.2	0.004	0.120	0.005	0.005	0.200	6.4	1320.0	240.0	270.0
W1D-052	3 29 93	7.0	0.015	0.310	0.010	0.005	0.400	6.8	1001.0	80.0	110.0
W1D-052	4 8 93	7.0	0.024	0.170	0.007	0.005	0.200	21.6	1294.0	150.0	170.0
W1D-052	4 12 93	6.9	0.018	0.220	0.008	0.005	0.200	3.6	601.0	130.0	140.0
W1D-052	4 15 93	7.0	0.017	0.160	0.005	0.005	0.300	7.6	583.0	150.0	150.0
W1D-052	4 19 93	6.9	0.012	0.100	0.004	0.005	0.200	10.0	1287.0	160.0	170.0
W1D-052	4 22 93	7.2	0.009	0.110	0.008	0.005	0.300	0.4	1358.0	170.0	180.0
W1D-052	4 26 93	7.0	0.015	0.140	0.003	0.005	0.500	8.8	1047.0	80.0	70.0
W1D-052	4 29 93	7.2	0.012	0.170	0.002	0.005	0.050	4.0	988.0	120.0	140.0
W1D-052	5 3 93	7.4	0.015	0.240	0.002	0.005	0.500	4.8	817.0	80.0	91.0
W1D-052	5 6 93	7.0	0.012	0.120	0.003	0.005	0.400	1.6	888.0	100.0	110.0
W1D-052	5 10 93	7.3	0.015	0.120	0.004	0.005	0.400	7.2	922.0	130.0	140.0
W1D-052	5 13 93	7.3	0.011	0.090	0.006	0.005	0.600	7.6	977.0	120.0	120.0
W1D-052	5 17 93	7.3	0.016	0.080	0.003	0.005	0.200	6.4	995.0	.	.
W1D-052	5 19 93	7.3	0.017	0.100	0.001	0.005	0.200	10.0	1174.0	180.0	180.0
W1D-052	5 24 93	7.3	0.018	0.130	0.001	0.005	0.300	14.8	746.0	150.0	140.0
W1D-052	5 27 93	7.2	0.006	0.090	0.002	0.005	0.200	5.6	774.0	190.0	130.0
W1D-052	6 2 93	7.2	0.018	0.050	0.003	0.005	0.200	8.4	855.0	140.0	140.0
W1D-052	6 3 93	7.3	0.007	0.050	0.002	0.005	0.100	6.8	839.0	140.0	140.0
W1D-052	6 7 93	.	0.007	0.100	0.002	0.050	.	.	714.0	120.0	130.0
W1D-052	6 10 93	7.2	0.007	0.050	0.001	0.040	.	.	962.0	120.0	130.0
W1D-052	6 14 93	7.4	0.004	0.090	0.002	0.040	.	.	621.0	.	.
W1D-052	6 23 93	7.2	0.005	0.044	0.003	0.005	0.100	9.6	925.0	150.0	150.0
W1D-052	6 24 93	7.5	0.005	0.070	.	.	.	.	628.0	.	.
W1D-052	6 28 93	7.1	0.001	0.050	.	.	.	.	628.0	.	.
W1D-052	7 1 93	7.1	0.006	0.050	.	.	.	.	640.0	.	.
W1D-052	7 6 93	7.1	0.005	0.370	.	.	.	.	1113.0	.	.
W1D-052	7 8 93	.	0.005	0.410	.	.	.	.	1294.0	.	.
W1D-052	7 12 93	7.0	0.003	0.680	.	.	.	.	1368.0	.	.
W1D-052	7 14 93	7.0	0.012	0.520	0.002	0.005	0.300	4.4	1269.0	270.0	290.0
W1D-052	7 15 93	6.8	0.005	0.560	.	.	.	.	1479.0	.	.
W1D-052	7 19 93	6.8	0.008	1.100	.	.	.	.	1464.0	.	.
W1D-052	7 19 93	6.8	0.013	1.200	0.005	0.010	0.200	.	1464.0	230.0	290.0
W1D-052	7 26 93	6.8	0.004	0.810	.	.	.	.	1848.0	.	.
W1D-052	7 28 93	7.1	0.008	0.560	0.002	0.005	0.200	7.6	1734.0	270.0	320.0
W1D-052	8 2 93	7.1	0.004	0.740	.	.	.	.	1665.0	.	.
W1D-052	8 13 93	7.1	0.005	0.720	0.003	0.005	0.200	3.6	1818.0	290.0	350.0
W1D-052	8 16 93	7.3	0.005	0.420	.	.	.	.	1766.0	.	.
W1D-052	8 25 93	7.3	-0.001	0.370	0.003	0.005	0.200	10.8	1964.0	320.0	370.0
W1D-052	9 15 93	7.4	0.001	0.750	0.003	0.005	0.200	5.2	1846.0	260.0	320.0
W1D-052	9 29 93	7.5	0.005	0.910	0.001	0.005	0.100	4.4	2128.0	280.0	360.0

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-052	10 15 93	7.3	0.003	0.770	0.002	0.005	0.100	5.2	2194.0	310.0	390.0
W1D-052	10 22 93	7.3	0.009	0.790	0.009	0.005	0.100	5.6	1992.0	270.0	370.0
W1D-052	11 3 93	7.2	0.004	0.920	0.003	0.005	0.300	10.2	2043.0	290.0	370.0
W1D-052	11 17 93	7.1	0.004	0.680	0.003	0.005	0.500	13.2	2194.0	300.0	420.0
W1D-052	12 8 93	7.1	0.004	0.440	0.007	0.005	1.000	10.8	2221.0	270.0	350.0
W1D-052	12 20 93	7.0	0.004	0.320	0.008	0.005	1.400	15.6	1956.0	230.0	300.0
W1D-052	3 11 94	7.1	0.006	0.510	0.021	0.005	0.780	8.0	1265.0	190.0	220.0
W1D-052	4 4 94	7.1	0.001	0.330	0.006	0.005	0.900	7.2	926.0	150.0	170.0
W1D-052	4 18 94	7.5	0.011	0.280	0.006	0.005	0.200	2.4	338.0	70.0	70.0
W1D-052	5 2 94	.	.	0.209	.	.	.	.	.	.	.
W1D-052	5 5 94	.	.	0.168	.	.	.	.	.	.	.
W1D-052	5 6 94	8.2	0.007	0.190	0.001	0.010	0.100	2.0	548.0	100.0	110.0
W1D-052	5 9 94	.	.	0.119	.	.	.	.	.	.	.
W1D-052	5 12 94	.	.	0.129	.	.	.	.	.	.	.
W1D-052	5 16 94	7.8	0.005	0.168	0.001	0.005	0.100	1.0	693.0	110.0	130.0
W1D-052	5 19 94	.	.	0.128	.	.	.	.	.	.	.
W1D-052	5 23 94	.	.	0.203	.	.	.	.	.	.	.
W1D-052	5 27 94	.	.	0.197	.	.	.	.	.	.	.
W1D-052	5 31 94	.	.	0.139	.	.	.	.	.	.	.
W1D-052	6 2 94	7.7	0.003	0.100	0.002	0.005	0.100	8.4	906.0	150.0	180.0
W1D-052	6 3 94	7.6	0.002	0.100	.	.	.	.	1015.0	.	.
W1D-052	6 6 94	.	.	0.093	.	.	.	.	.	.	.
W1D-052	6 8 94	7.4	0.004	0.100	.	.	.	.	974.0	.	.
W1D-052	6 9 94	.	.	0.064	.	.	.	.	.	.	.
W1D-052	6 13 94	7.8	0.003	0.070	0.001	0.005	0.100	19.6	892.0	160.0	190.0
W1D-052	6 15 94	.	0.005	0.156	.	.	.	.	1182.0	.	.
W1D-052	6 16 94	.	.	0.137	.	.	.	.	.	.	.
W1D-052	6 20 94	.	.	0.534	.	.	.	.	.	.	.
W1D-052	6 22 94	7.1	0.006	0.280	.	.	.	.	1832.0	.	.
W1D-052	6 23 94	.	.	0.317	.	.	.	.	.	.	.
W1D-052	6 27 94	7.4	0.005	0.630	.	.	.	.	1286.0	.	.
W1D-052	6 27 94	.	.	0.697	.	.	.	.	.	.	.
W1D-052	6 30 94	.	.	0.646	.	.	.	.	.	.	.
W1D-052	7 5 94	.	.	0.201	.	.	.	.	.	.	.
W1D-052	7 6 94	7.3	0.016	0.140	.	.	.	.	1404.0	.	.
W1D-052	7 7 94	7.5	0.005	0.107	0.002	0.005	0.200	7.6	1807.0	270.0	320.0
W1D-052	7 11 94	.	.	0.293	.	.	.	.	.	.	.
W1D-052	7 11 94	7.5	0.005	0.280	.	.	.	.	1693.0	.	.
W1D-052	7 14 94	.	.	0.325	.	.	.	.	.	.	.
W1D-052	7 18 94	.	.	0.180	.	.	.	.	.	.	.
W1D-052	7 20 94	7.0	0.004	0.122	0.002	0.005	0.200	6.8	1598.0	230.0	310.0
W1D-052	7 21 94	.	.	0.103	.	.	.	.	.	.	.
W1D-052	7 21 94	7.2	0.006	0.090	.	.	.	.	1725.0	.	.
W1D-052	7 25 94	.	.	0.067	.	.	.	.	.	.	.
W1D-052	7 28 94	.	.	0.087	.	.	.	.	.	.	.
W1D-052	7 29 94	7.2	0.003	0.007	.	.	.	.	1987.0	.	.
W1D-052	8 1 94	.	.	0.050	.	.	.	.	.	.	.
W1D-052	8 3 94	7.3	0.009	0.050	0.002	0.005	0.100	8.0	1906.0	270.0	330.0
W1D-052	8 4 94	.	.	0.066	.	.	.	.	.	.	.
W1D-052	8 4 94	.	0.003	0.050	.	.	.	.	1973.0	.	.
W1D-052	8 8 94	.	.	0.365	.	.	.	.	.	.	.
W1D-052	8 11 94	.	.	0.296	.	.	.	.	.	.	.
W1D-052	8 11 94	7.4	0.003	0.310	.	.	.	.	1737.0	.	.
W1D-052	8 15 94	.	.	0.102	.	.	.	.	.	.	.
W1D-052	8 18 94	7.4	0.002	0.060	.	.	.	.	1840.0	.	.
W1D-052	8 18 94	.	.	0.056	.	.	.	.	.	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-052	8 22 94	.	.	0.052	.	.	.	.	.	.	.
W1D-052	8 24 94	7.3	0.002	.	0.002	0.005	0.100	8.8	1832.0	260.0	340.0
W1D-052	8 25 94	.	.	0.050	.	.	.	.	.	.	.
W1D-052	8 25 94	7.3	0.004	0.040	.	.	.	.	1599.0	.	.
W1D-052	8 29 94	.	.	0.041	.	.	.	.	.	.	.
W1D-052	9 2 94	.	.	0.501	.	.	.	.	.	.	.
W1D-052	9 2 94	7.3	0.002	0.380	.	.	.	.	2003.0	.	.
W1D-052	9 6 94	.	.	0.196	.	.	.	.	.	.	.
W1D-052	9 8 94	7.3	0.002	0.127	0.003	0.010	0.000	1.6	2071.0	280.0	350.0
W1D-052	9 12 94	.	.	0.068	.	.	.	.	.	.	.
W1D-052	9 15 94	.	.	0.535	.	.	.	.	.	.	.
W1D-052	9 20 94	7.3	0.006	0.506	0.002	0.005	0.100	4.4	1508.0	240.0	290.0
W1D-052	9 22 94	.	.	0.478	.	.	.	.	.	.	.
W1D-052	9 26 94	.	.	0.351	.	.	.	.	.	.	.
W1D-052	9 29 94	.	.	0.605	.	.	.	.	.	.	.
W1D-052	10 3 94	.	.	0.329	.	.	.	.	.	.	.
W1D-052	10 6 94	.	.	0.931	.	.	.	.	.	.	.
W1D-052	10 10 94	7.3	0.006	0.770	0.001	0.010	0.100	2.8	1754.0	250.0	310.0
W1D-052	10 12 94	.	.	0.854	.	.	.	.	.	.	.
W1D-052	10 12 94	.	.	0.854	.	.	.	.	.	.	.
W1D-052	10 13 94	.	.	0.858	.	.	.	.	.	.	.
W1D-052	10 17 94	.	.	0.580	.	.	.	.	.	.	.
W1D-052	10 19 94	7.4	0.005	0.660	0.001	0.010	0.100	3.2	1774.0	260.0	330.0
W1D-052	10 20 94	.	.	0.661	.	.	.	.	.	.	.
W1D-052	10 24 94	.	.	0.696	.	.	.	.	.	.	.
W1D-052	10 27 94	.	.	0.897	.	.	.	.	.	.	.
W1D-052	10 27 94	.	.	0.897	.	.	.	.	.	.	.
W1D-052	10 31 94	.	.	0.671	.	.	.	.	.	.	.
W1D-052	11 3 94	7.1	0.023	0.840	0.002	0.005	0.000	4.0	1417.0	230.0	290.0
W1D-052	11 7 94	.	.	1.009	.	.	.	.	.	.	.
W1D-052	11 10 94	.	.	0.917	.	.	.	.	.	.	.
W1D-052	11 17 94	7.2	0.060	1.100	0.001	0.010	0.000	1.6	1992.0	260.0	340.0
W1D-052	11 18 94	.	.	1.260	.	.	.	.	.	.	.
W1D-052	11 21 94	.	.	1.790	.	.	.	.	.	.	.
W1D-052	11 23 94	.	.	1.610	.	.	.	.	.	.	.
W1D-052	11 28 94	.	.	1.780	.	.	.	.	.	.	.
W1D-052	12 1 94	6.9	0.011	1.800	0.004	0.200	0.200	6.0	2208.0	300.0	370.0
W1D-052	12 22 94	7.1	0.008	1.300	0.007	0.020	0.600	9.6	2100.0	310.0	380.0
W1D-052	3 14 95	7.6	0.001	0.420	0.007	0.010	0.100	.	382.0	60.0	60.0
W1D-052	3 27 95	7.2	0.007	0.810	0.001	0.005	0.050	.	671.0	120.0	140.0
W1D-052	4 13 95	6.9	0.002	0.880	0.001	0.010	0.050	.	713.0	120.0	160.0
W1D-052	4 27 95	7.1	0.002	0.460	0.002	0.005	0.100	.	819.0	140.0	180.0
W1D-052	5 12 95	7.4	0.005	0.220	0.002	0.005	0.050	.	989.0	170.0	200.0
W1D-052	5 23 95	7.4	0.003	0.160	0.001	0.100	0.100	4.4	1507.0	140.0	170.0
W1D-052	6 7 95	7.2	0.003	0.130	0.002	0.005	0.050	8.8	1017.0	170.0	200.0
W1D-052	7 10 95	7.4	0.005	0.690	0.006	0.100	0.100	-0.4	1008.0	170.0	180.0
W1D-052	7 27 95	7.3	0.003	0.360	0.004	0.100	0.100	2.8	1243.0	190.0	220.0
W1D-052	8 10 95	7.2	0.003	0.150	0.007	0.100	0.100	5.6	1545.0	285.0	319.0
W1D-052	8 21 95	7.4	0.003	0.120	0.020	0.100	0.100	5.2	1658.0	274.0	319.0
W1D-052	9 11 95	7.4	0.002	0.240	0.002	0.005	0.050	0.4	1218.0	195.0	218.0
W1D-052	9 25 95	7.4	0.002	0.450	0.006	0.005	0.050	0.4	1573.0	252.0	283.0
W1D-052	1 4 96	7.0	-0.001	0.080	0.007	-0.010	1.800	13.6	1361.0	250.0	260.0
W1D-052	4 29 96	7.6	0.010	0.599	-0.001	0.019	0.060	-1.0	679.0	.	.
W1D-052	5 9 96	7.4	0.004	0.644	-0.001	-0.010	0.100	1.6	2380.0	106.0	139.0
W1D-052	5 22 96	7.4	0.003	0.543	0.002	0.015	0.140	1.2	814.0	115.0	116.0
W1D-052	6 7 96	7.3	0.015	0.372	-0.001	0.011	0.060	2.8	1340.0	176.0	161.0

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-052	7 2 96	7.4	0.008	0.336	-0.001	-0.010	0.080	3.2	857.0	140.0	123.0
W1D-052	7 15 96	7.3	0.011	0.207	0.002	-0.010	0.060	1.2	1290.0	193.0	176.0
W1D-052	8 6 96	7.3	-0.001	0.181	-0.001	-0.010	0.290	3.2	1460.0	247.0	234.0
W1D-052	8 20 96	7.0	0.008	0.096	0.007	-0.010	0.050	17.2	1460.0	234.0	235.0
W1D-052	9 4 96	7.2	0.002	0.089	0.002	-0.010	0.100	8.8	1580.0	241.0	229.0
W1D-052	9 19 96	7.3	0.005	0.056	-0.001	-0.010	0.090	6.4	1490.0	272.0	258.0
W1D-052	10 2 96	7.5	0.033	0.245	0.003	0.018	0.090	4.0	1550.0	217.0	251.0
W1D-052	10 21 96	7.4	0.026	0.261	0.002	0.022	0.080	4.4	1530.0	248.0	245.0
W1D-052	11 6 96	7.4	0.009	0.449	-0.001	0.022	0.080	2.0	1010.0	147.0	141.0
W1D-052	11 18 96	7.4	0.009	0.891	0.005	0.025	0.120	2.0	1060.0	170.0	169.0
W1D-052	4 14 97	7.2	0.004	0.580	0.004	0.017	0.090	1.2	625.0	88.0	86.5
W1D-052	4 22 97	7.3	-0.001	0.355	0.001	0.005	0.060	2.0	566.0	66.7	58.0
W1D-052	5 7 97	7.2	0.003	0.266	0.001	0.011	0.070	1.2	750.0	119.0	115.0
W1D-052	5 21 97	7.2	-0.001	0.253	0.001	0.005	0.090	1.2	816.0	112.0	116.0
W1D-052	6 9 97	7.1	0.001	0.102	0.001	0.005	0.080	4.4	832.0	142.0	143.0
W1D-052	6 16 97	7.4	0.002	0.077	0.001	0.016	0.050	4.8	684.0	160.0	152.0
W1D-052	7 10 97	7.2	0.002	0.143	0.001	0.012	0.070	4.8	638.0	145.0	135.0
W1D-052	7 21 97	7.5	-0.001	0.076	0.001	0.005	0.050	2.0	882.0	149.0	148.0
W1D-052	8 4 97	7.5	0.002	0.082	0.001	0.011	0.050	6.4	808.0	143.0	135.0
W1D-052	8 18 97	7.6	0.001	0.051	0.001	0.005	0.015	2.8	752.0	162.0	156.0
W1D-052	9 4 97	7.5	-0.001	0.063	0.001	0.005	0.040	2.8	892.0	175.0	174.0
W1D-052	9 23 97	7.6	-0.001	0.053	0.001	0.005	0.060	2.4	1000.0	170.0	169.0
W1D-052	10 6 97	7.4	0.001	0.067	0.001	0.005	0.060	2.4	978.0	188.0	184.0
W1D-052	10 21 97	7.2	0.001	0.313	0.001	0.005	0.050	4.0	888.0	180.0	174.0
W1D-052	11 3 97	7.2	0.002	0.299	0.001	0.005	0.050	1.2	659.0	139.0	124.0
W1D-052	11 20 97	7.2	0.003	0.196	0.001	0.005	0.015	4.4	904.0	175.0	164.0
W1D-052	12 3 97	7.1	-0.001	0.050	0.001	0.005	0.040	5.6	769.0	181.0	181.0
W1D-052	3 3 98	7.3	0.012	0.640	0.006	0.030	0.110	2.5	654.0	104.0	106.0
W1D-052	4 9 98	7.2	0.003	0.299	-0.001	0.013	-0.030	1.6	421.0	90.1	84.7
W1D-052	4 22 98	7.2	0.002	0.104	-0.001	-0.010	-0.030	6.0	748.0	116.0	115.0
W1D-052	5 7 98	7.3	-0.001	0.048	-0.001	-0.010	-0.030	10.0	804.0	144.0	150.0
W1D-052	5 18 98	7.3	0.005	0.267	-0.001	-0.010	0.040	3.0	699.0	119.0	117.0
W1D-052	6 3 98	7.4	-0.001	0.069	-0.001	0.013	0.060	4.0	856.0	149.0	142.0
W1D-052	6 16 98	7.3	0.002	0.046	-0.001	0.012	-0.030	4.0	618.0	109.0	108.0
W1D-052	7 9 98	7.3	-0.001	0.024	-0.001	-0.010	0.040	6.0	808.0	151.0	149.0
W1D-052	7 21 98	.	.	.	.	.	.	.	.	.	.
W1D-052	8 18 98	7.4	0.005	0.009	-0.001	0.026	-0.030	5.0	574.0	111.0	107.0
W1D-052	9 10 98	7.4	-0.001	0.017	-0.001	-0.010	0.030	2.4	1030.0	192.0	195.0
W1D-052	9 25 98	7.6	-0.001	0.017	-0.001	0.011	-0.030	1.2	845.0	182.0	188.0
W1D-052	10 8 98	7.4	0.002	0.079	0.002	0.015	0.080	4.5	952.0	191.0	198.0
W1D-052	10 21 98	7.3	0.003	0.206	0.001	0.015	0.130	1.6	730.0	131.0	126.0
W1D-052	11 4 98	7.1	-0.001	0.085	0.002	-0.010	0.050	4.0	1160.0	175.0	179.0
W1D-052	11 17 98	7.2	-0.001	0.047	0.001	-0.010	0.060	4.0	951.0	179.0	182.0
W1D-052	12 2 98	7.1	0.002	0.057	0.002	0.019	-0.030	5.2	893.0	165.0	167.0
W1D-052	12 14 98	7.2	-0.001	0.043	0.002	0.013	0.050	9.0	1140.0	199.0	209.0
W1D-052	3 17 99	7.7	0.002	0.063	0.002	0.021	0.330	4.0	721.0	97.8	99.2
W1D-052	4 8 99	6.8	0.015	0.304	0.003	0.023	0.090	2.5	479.0	65.3	57.0
W1D-052	4 19 99	7.5	0.003	0.229	-0.001	0.024	0.080	-1.0	573.0	76.9	70.4
W1D-052	5 3 99	7.5	-0.001	0.166	-0.001	-0.010	0.090	1.0	684.0	124.0	116.0
W1D-052	5 19 99	7.5	0.001	0.064	-0.001	0.020	0.040	3.0	737.0	130.0	131.0
W1D-052	6 3 99	7.4	-0.001	0.184	0.002	0.015	0.070	1.2	714.0	132.0	134.0
W1D-052	6 19 99	7.0	-0.001	0.095	-0.001	0.011	0.080	4.0	817.0	142.0	144.0
W1D-052	7 9 99	7.2	0.004	0.229	-0.001	0.019	0.020	.	494.0	103.0	86.8
W1D-052	7 20 99	7.2	0.001	0.187	-0.001	0.016	0.020	4.0	765.0	140.0	133.0
W1D-052	8 2 99	7.3	-0.001	0.075	0.001	-0.010	0.040	4.0	870.0	146.0	144.0
W1D-052	8 17 99	7.1	-0.001	0.110	-0.001	-0.010	0.040	3.5	845.0	187.0	178.0

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-052	9 3 99	7.0	-0.001	0.037	-0.001	0.011	.	.	854.0	170.0	162.0
W1D-052	9 16 99	7.3	-0.001	0.085	-0.001	-0.010	.	.	921.0	157.0	151.0
W1D-052	10 5 99	7.2	-0.001	0.117	-0.001	0.014	.	.	879.0	160.0	148.0
W1D-052	10 19 99	7.9	-0.001	0.172	-0.001	-0.010	.	.	640.0	173.0	164.0
W1D-052	11 2 99	7.4	-0.001	0.140	-0.001	-0.010	.	.	1070.0	187.0	188.0
W1D-052	11 17 99	6.9	-0.001	0.115	0.001	0.013	.	.	1090.0	206.0	201.0

Profile sites (sites within the system; see figure at top for site ID's)

W1D-1	6 10 92	7.5	0.025	0.170	0.000	0.005	.	.	1306.0	.	.
W1D-1	6 15 92	7.4	0.007	0.120	0.000	0.005	.	.	1377.0	.	.
W1D-1	6 17 92	.	0.001	0.160	0.000	0.005	.	.	1633.0	.	.
W1D-1	6 22 92	.	0.006	0.210	0.000	0.040	.	.	1411.0	.	.
W1D-1	6 29 92	.	0.004	0.320	0.000	0.050	.	.	1342.0	.	.
W1D-1	7 6 92	.	0.012	0.420	0.000	0.040	.	.	1171.0	.	.
W1D-1	8 26 92	.	0.005	0.380	0.006	0.060	.	.	1422.0	.	.
W1D-1	9 4 92	.	0.004	0.330	0.000	0.050	.	.	1365.0	.	.
W1D-1	9 23 92	.	0.020	4.000	0.029	0.060	.	.	2800.0	.	.
W1D-1	10 5 92	.	0.019	5.000	0.016	0.080	.	.	2610.0	.	.
W1D-1	10 15 92	.	0.005	0.470	0.000	0.040	.	.	1638.0	.	.
W1D-1	6 7 93	.	0.005	0.140	0.001	0.040	.	.	412.0	70.0	64.0
W1D-1	6 10 93	.	0.006	0.110	0.001	0.040	.	.	125.0	73.0	60.0
W1D-1	6 14 93	.	0.004	0.140	.	.	.	.	529.0	.	.
W1D-1	6 24 93	.	0.005	0.190	.	.	.	.	616.0	.	.
W1D-1	6 28 93	.	0.006	1.300	.	.	.	.	496.0	.	.
W1D-1	7 1 93	.	0.007	0.140	.	.	.	.	894.0	.	.
W1D-1	7 6 93	.	0.004	0.250	.	.	.	.	772.0	.	.
W1D-1	7 8 93	.	0.006	0.770	.	.	.	.	875.0	.	.
W1D-1	7 12 93	6.8	0.006	0.300	.	.	.	.	340.0	.	.
W1D-1	7 15 93	.	0.010	1.800	.	.	.	.	760.0	.	.
W1D-1	7 19 93	.	0.008	0.570	.	.	.	.	468.0	.	.
W1D-1	7 26 93	.	0.006	0.300	.	.	.	.	626.0	.	.
W1D-1	8 2 93	.	0.005	0.360	.	.	.	.	558.0	.	.
W1D-1	8 16 93	.	0.005	0.260	.	.	.	.	1178.0	.	.
W1D-1	6 3 94	.	0.005	0.200	.	.	.	.	451.0	.	.
W1D-1	6 8 94	.	0.030	0.400	.	.	.	.	763.0	.	.
W1D-1	6 15 94	.	0.007	0.200	.	.	.	.	398.0	.	.
W1D-1	6 22 94	.	0.008	0.470	.	.	.	.	505.0	.	.
W1D-1	6 27 94	.	0.008	0.580	.	.	.	.	451.0	.	.
W1D-1	7 6 94	.	0.013	0.670	.	.	.	.	523.0	.	.
W1D-1	7 11 94	.	0.008	0.680	.	.	.	.	548.0	.	.
W1D-1	7 21 94	.	0.014	0.490	.	.	.	.	514.0	.	.
W1D-1	7 29 94	.	0.018	4.200	.	.	.	.	2182.0	.	.
W1D-1	8 4 94	.	0.008	0.470	.	.	.	.	3136.0	.	.
W1D-1	8 11 94	.	0.008	0.370	.	.	.	.	407.0	.	.
W1D-1	8 18 94	.	0.012	0.320	.	.	.	.	1645.0	.	.
W1D-1	8 25 94	.	0.009	1.800	.	.	.	.	1206.0	.	.
W1D-1	9 2 94	.	0.009	0.300	.	.	.	.	571.0	.	.
W1D-1	10 12 94	.	.	0.270	.	.	.	.	.	.	.
W1D-1	10 12 94	.	.	0.270	.	.	.	.	.	.	.
W1D-1	10 27 94	.	.	0.256	.	.	.	.	.	.	.
W1D-10	6 10 92	7.3	0.009	0.270	0.014	0.005	.	.	2096.0	.	.
W1D-10	6 15 92	6.8	0.015	0.140	0.010	0.005	.	.	2125.0	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-10	6 17 92	.	0.001	0.500	0.002	0.010	.	.	2228.0	.	.
W1D-10	6 22 92	.	0.003	0.720	0.008	0.060	.	.	1981.0	.	.
W1D-10	6 29 92	.	0.002	0.480	0.005	0.050	.	.	2058.0	.	.
W1D-10	7 6 92	.	0.005	0.880	0.005	0.060	.	.	2039.0	.	.
W1D-10	8 26 92	.	0.019	0.330	0.002	0.070	.	.	2012.0	.	.
W1D-10	9 4 92	.	0.036	0.790	0.002	0.050	.	.	2737.0	.	.
W1D-10	9 23 92	.	0.010	0.690	0.000	0.020	.	.	2550.0	.	.
W1D-10	10 5 92	.	0.003	0.940	0.000	0.040	.	.	2400.0	.	.
W1D-10	10 15 92	.	0.000	1.000	0.000	0.040	.	.	2255.0	.	.
W1D-10	6 7 93	.	0.005	0.110	0.001	0.050	.	.	714.0	120.0	140.0
W1D-10	6 10 93	.	0.007	0.120	0.001	0.030	.	.	947.0	130.0	140.0
W1D-10	6 14 93	.	0.006	0.080	.	.	.	.	990.0	.	.
W1D-10	6 24 93	.	0.006	0.070	.	.	.	.	1054.0	.	.
W1D-10	6 28 93	.	0.003	0.070	.	.	.	.	1191.0	.	.
W1D-10	7 1 93	.	0.004	0.080	.	.	.	.	1153.0	.	.
W1D-10	7 6 93	.	0.006	0.490	.	.	.	.	1181.0	.	.
W1D-10	7 8 93	.	0.012	0.600	.	.	.	.	1346.0	.	.
W1D-10	7 12 93	.	0.003	0.660	.	.	.	.	1379.0	.	.
W1D-10	7 15 93	.	0.004	0.630	.	.	.	.	1474.0	.	.
W1D-10	7 19 93	.	0.006	1.400	.	.	.	.	1536.0	.	.
W1D-10	7 26 93	.	0.006	1.100	.	.	.	.	1848.0	.	.
W1D-10	8 2 93	.	0.002	0.880	.	.	.	.	1708.0	.	.
W1D-10	8 16 93	.	0.005	0.640	.	.	.	.	1880.0	.	.
W1D-10	6 3 94	.	0.003	0.140	.	.	.	.	1089.0	.	.
W1D-10	6 8 94	.	0.009	.	.	.	.	.	1110.0	.	.
W1D-10	6 15 94	.	0.005	0.150	.	.	.	.	1284.0	.	.
W1D-10	6 22 94	.	0.007	0.460	.	.	.	.	1869.0	.	.
W1D-10	6 27 94	.	0.010	1.100	.	.	.	.	1310.0	.	.
W1D-10	7 6 94	.	0.005	0.920	.	.	.	.	1647.0	.	.
W1D-10	7 11 94	.	0.008	0.990	.	.	.	.	1712.0	.	.
W1D-10	7 21 94	.	0.005	0.430	.	.	.	.	1840.0	.	.
W1D-10	7 29 94	.	0.003	0.270	.	.	.	.	2128.0	.	.
W1D-10	8 4 94	.	0.004	0.210	.	.	.	.	1991.0	.	.
W1D-10	8 11 94	.	0.005	0.680	.	.	.	.	1748.0	.	.
W1D-10	8 18 94	.	0.003	0.290	.	.	.	.	1991.0	.	.
W1D-10	8 25 94	.	0.002	0.130	.	.	.	.	1863.0	.	.
W1D-10	9 2 94	.	0.005	0.530	.	.	.	.	1979.0	.	.
W1D-10	10 12 94	.	.	1.200	.	.	.	.	.	.	.
W1D-10	10 12 94	.	.	1.200	.	.	.	.	.	.	.
W1D-10	10 27 94	.	.	1.160	.	.	.	.	.	.	.
W1D-11	6 10 92	7.3	0.010	0.210	0.016	0.005	.	.	2049.0	.	.
W1D-11	6 15 92	6.8	0.009	0.160	0.012	0.005	.	.	2068.0	.	.
W1D-11	6 17 92	.	0.000	0.430	0.002	0.010	.	.	2172.0	.	.
W1D-11	6 22 92	.	0.003	0.740	0.008	0.060	.	.	2000.0	.	.
W1D-11	6 29 92	.	0.002	0.380	0.008	0.050	.	.	1990.0	.	.
W1D-11	7 6 92	.	0.010	0.870	0.006	0.060	.	.	1990.0	.	.
W1D-11	8 26 92	.	0.003	0.220	0.003	0.060	.	.	1892.0	.	.
W1D-11	9 4 92	.	0.008	0.790	0.000	0.050	.	.	3015.0	.	.
W1D-11	9 23 92	.	0.004	0.590	0.000	0.020	.	.	2563.0	.	.
W1D-11	10 5 92	.	0.003	0.800	0.001	0.030	.	.	2378.0	.	.
W1D-11	10 15 92	.	0.000	0.830	0.002	0.040	.	.	2255.0	.	.
W1D-11	6 7 93	.	0.005	0.110	0.001	0.050	.	.	708.0	120.0	130.0
W1D-11	6 10 93	.	0.006	0.120	0.001	0.040	.	.	1037.0	130.0	140.0
W1D-11	6 14 93	.	0.004	0.080	.	.	.	.	1041.0	.	.
W1D-11	6 24 93	.	0.003	0.090	.	.	.	.	1054.0	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-11	6 28 93	.	0.003	0.080	.	.	.	.	1220.0	.	.
W1D-11	7 1 93	.	0.012	0.070	.	.	.	.	1172.0	.	.
W1D-11	7 6 93	.	0.008	0.470	.	.	.	.	1193.0	.	.
W1D-11	7 8 93	.	0.009	0.590	.	.	.	.	1336.0	.	.
W1D-11	7 12 93	.	0.003	0.780	.	.	.	.	1368.0	.	.
W1D-11	7 15 93	.	0.004	0.850	.	.	.	.	1575.0	.	.
W1D-11	7 19 93	.	0.006	1.500	.	.	.	.	1536.0	.	.
W1D-11	7 26 93	.	0.004	1.100	.	.	.	.	1848.0	.	.
W1D-11	8 2 93	.	0.004	0.890	.	.	.	.	1729.0	.	.
W1D-11	8 16 93	.	0.005	0.870	.	.	.	.	1922.0	.	.
W1D-11	6 3 94	.	0.004	0.130	.	.	.	.	1077.0	.	.
W1D-11	6 8 94	.	0.005	0.150	.	.	.	.	1117.0	.	.
W1D-11	6 14 94	.	0.004	0.100	.	.	.	.	1277.0	.	.
W1D-11	6 22 94	.	0.018	0.690	.	.	.	.	1980.0	.	.
W1D-11	6 27 94	.	0.008	0.860	.	.	.	.	1286.0	.	.
W1D-11	7 6 94	.	0.006	0.590	.	.	.	.	1556.0	.	.
W1D-11	7 11 94	.	0.007	0.680	.	.	.	.	1681.0	.	.
W1D-11	7 21 94	.	0.010	0.480	.	.	.	.	1806.0	.	.
W1D-11	7 29 94	.	0.002	0.110	.	.	.	.	2045.0	.	.
W1D-11	8 4 94	.	0.003	0.110	.	.	.	.	2096.0	.	.
W1D-11	8 4 94	.	0.003	0.050	.	.	.	.	2049.0	.	.
W1D-11	8 11 94	.	0.004	0.440	.	.	.	.	851.0	.	.
W1D-11	8 11 94	.	0.005	0.320	.	.	.	.	1656.0	.	.
W1D-11	8 18 94	.	0.002	0.080	.	.	.	.	2038.0	.	.
W1D-11	8 18 94	.	0.002	0.040	.	.	.	.	1898.0	.	.
W1D-11	8 25 94	.	0.001	0.040	.	.	.	.	1829.0	.	.
W1D-11	8 25 94	.	0.001	0.030	.	.	.	.	1875.0	.	.
W1D-11	9 2 94	.	0.003	0.530	.	.	.	.	2003.0	.	.
W1D-11	9 2 94	.	0.002	0.360	.	.	.	.	1956.0	.	.
W1D-11	10 12 94	.	.	0.930	.	.	.	.	.	.	.
W1D-11	10 12 94	.	.	0.930	.	.	.	.	.	.	.
W1D-11	10 27 94	.	.	1.040	.	.	.	.	.	.	.
W1D-12	10 15 92	.	0.003	0.370	0.011	0.040	.	.	2077.0	.	.
W1D-12	6 7 93	.	0.007	0.080	0.007	0.050	.	.	763.0	120.0	130.0
W1D-12	6 10 93	.	0.006	0.090	0.001	0.030	.	.	1018.0	130.0	140.0
W1D-12	6 14 93	.	0.004	0.090	.	.	.	.	995.0	.	.
W1D-12	6 24 93	.	0.005	0.050	.	.	.	.	978.0	.	.
W1D-12	6 28 93	.	0.080	0.047	.	.	.	.	1104.0	.	.
W1D-12	7 1 93	.	0.004	0.050	.	.	.	.	1071.0	.	.
W1D-12	7 6 93	.	0.004	0.240	.	.	.	.	1084.0	.	.
W1D-12	7 8 93	.	0.002	0.210	.	.	.	.	1172.0	.	.
W1D-12	7 12 93	.	0.003	0.530	.	.	.	.	1236.0	.	.
W1D-12	7 15 93	.	0.005	0.220	.	.	.	.	1225.0	.	.
W1D-12	7 19 93	.	0.005	0.690	.	.	.	.	1291.0	.	.
W1D-12	7 26 93	.	0.005	0.430	.	.	.	.	1556.0	.	.
W1D-12	8 2 93	.	0.002	0.380	.	.	.	.	1393.0	.	.
W1D-12	8 16 93	.	0.003	0.290	.	.	.	.	1429.0	.	.
W1D-12	6 3 94	.	0.003	0.120	.	.	.	.	959.0	.	.
W1D-12	6 8 94	.	0.004	0.080	.	.	.	.	948.0	.	.
W1D-12	6 15 94	.	0.005	0.090	.	.	.	.	1028.0	.	.
W1D-12	6 22 94	.	0.014	0.230	.	.	.	.	1521.0	.	.
W1D-12	6 27 94	.	0.007	0.600	.	.	.	.	1209.0	.	.
W1D-12	7 6 94	.	0.003	0.130	.	.	.	.	1332.0	.	.
W1D-12	7 11 94	.	0.004	0.030	.	.	.	.	363.0	.	.
W1D-12	7 21 94	.	0.011	0.080	.	.	.	.	1398.0	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-12	7 29 94	.	0.001	0.050	.	.	.	.	1357.0	.	.
W1D-12	8 4 94	.	0.006	0.080	.	.	.	.	1807.0	.	.
W1D-12	8 11 94	.	0.006	0.170	.	.	.	.	1622.0	.	.
W1D-12	8 18 94	.	0.006	0.040	.	.	.	.	1267.0	.	.
W1D-12	8 25 94	.	0.002	0.040	.	.	.	.	1362.0	.	.
W1D-12	9 2 94	.	0.002	0.150	.	.	.	.	1702.0	.	.
W1D-12	10 12 94	.	.	0.810	.	.	.	.	.	.	.
W1D-12	10 12 94	.	.	0.110	.	.	.	.	.	.	.
W1D-12	10 13 94	.	.	0.850	.	.	.	.	.	.	.
W1D-12	10 13 94	.	.	0.120	.	.	.	.	.	.	.
W1D-12	10 27 94	.	.	0.297	.	.	.	.	.	.	.
W1D-2	6 10 92	6.5	0.060	3.300	0.004	0.040	.	.	2355.0	.	.
W1D-2	6 15 92	7.1	0.050	5.700	0.006	0.040	.	.	2669.0	.	.
W1D-2	6 17 92	.	0.050	4.000	0.001	0.030	.	.	2237.0	.	.
W1D-2	6 22 92	.	0.037	4.000	0.005	0.070	.	.	2409.0	.	.
W1D-2	6 29 92	.	0.037	4.800	0.004	0.080	.	.	2346.0	.	.
W1D-2	7 6 92	.	0.026	4.700	0.005	0.090	.	.	2283.0	.	.
W1D-2	8 26 92	.	0.037	2.900	0.005	0.080	.	.	2049.0	.	.
W1D-2	9 4 92	.	0.032	2.500	0.006	0.060	.	.	2828.0	.	.
W1D-2	9 23 92	.	0.018	3.400	0.023	0.060	.	.	2766.0	.	.
W1D-2	10 5 92	.	0.011	4.100	0.020	0.080	.	.	2567.0	.	.
W1D-2	10 15 92	.	0.030	5.700	0.017	0.090	.	.	2461.0	.	.
W1D-2	6 7 93	.	0.020	0.670	0.002	0.050	.	.	796.0	120.0	130.0
W1D-2	6 10 93	.	0.030	0.540	0.001	0.040	.	.	1037.0	130.0	130.0
W1D-2	6 14 93	.	0.019	0.560	.	.	.	.	947.0	.	.
W1D-2	6 24 93	.	0.025	1.400	.	.	.	.	1282.0	.	.
W1D-2	6 28 93	.	0.017	1.300	.	.	.	.	1405.0	.	.
W1D-2	7 1 93	.	0.018	2.100	.	.	.	.	1617.0	.	.
W1D-2	7 6 93	.	0.012	2.500	.	.	.	.	1316.0	.	.
W1D-2	7 8 93	.	0.010	3.000	.	.	.	.	1654.0	.	.
W1D-2	7 12 93	.	0.019	3.600	.	.	.	.	1688.0	.	.
W1D-2	7 15 93	.	0.016	5.100	.	.	.	.	2269.0	.	.
W1D-2	7 19 93	.	0.025	5.300	.	.	.	.	2061.0	.	.
W1D-2	7 26 93	.	0.026	5.400	.	.	.	.	2104.0	.	.
W1D-2	8 2 93	.	0.018	4.500	.	.	.	.	2267.0	.	.
W1D-2	8 16 93	.	0.021	5.200	.	.	.	.	1398.0	.	.
W1D-2	6 3 94	.	0.027	1.600	.	.	.	.	1525.0	.	.
W1D-2	6 8 94	.	0.030	1.200	.	.	.	.	1781.0	.	.
W1D-2	6 15 94	.	0.024	0.900	.	.	.	.	1022.0	.	.
W1D-2	6 22 94	.	0.016	3.500	.	.	.	.	2382.0	.	.
W1D-2	6 27 94	.	0.026	3.500	.	.	.	.	1669.0	.	.
W1D-2	7 6 94	.	0.025	6.100	.	.	.	.	2084.0	.	.
W1D-2	7 11 94	.	0.030	4.400	.	.	.	.	2075.0	.	.
W1D-2	7 21 94	.	0.028	5.400	.	.	.	.	2061.0	.	.
W1D-2	7 29 94	.	0.028	6.100	.	.	.	.	2870.0	.	.
W1D-2	8 4 94	.	0.030	5.200	.	.	.	.	2402.0	.	.
W1D-2	8 11 94	.	0.030	4.600	.	.	.	.	2026.0	.	.
W1D-2	8 18 94	.	0.029	3.700	.	.	.	.	2155.0	.	.
W1D-2	8 25 94	.	0.030	4.000	.	.	.	.	2284.0	.	.
W1D-2	9 2 94	.	0.050	3.500	.	.	.	.	1794.0	.	.
W1D-2	10 12 94	.	.	5.200	.	.	.	.	.	.	.
W1D-2	10 12 94	.	.	5.200	.	.	.	.	.	.	.
W1D-2	10 27 94	.	.	2.740	.	.	.	.	.	.	.
W1D-3	6 7 93	.	0.018	0.610	0.003	0.060	.	.	801.0	120.0	130.0

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-3	6 10 93	.	0.030	0.510	.	0.040	.	.	1009.0	130.0	130.0
W1D-3	6 14 93	.	0.014	0.660	.	.	.	.	1064.0	.	.
W1D-3	6 24 93	.	0.033	1.500	.	.	.	.	1161.0	.	.
W1D-3	6 28 93	.	0.018	1.200	.	.	.	.	1372.0	.	.
W1D-3	7 1 93	.	0.022	1.700	.	.	.	.	1467.0	.	.
W1D-3	7 6 93	.	0.016	2.500	.	.	.	.	1450.0	.	.
W1D-3	7 8 93	.	0.012	3.000	.	.	.	.	1603.0	.	.
W1D-3	7 12 93	.	0.015	3.400	.	.	.	.	1774.0	.	.
W1D-3	7 15 93	.	0.014	4.600	.	.	.	.	2116.0	.	.
W1D-3	7 19 93	.	0.021	4.900	.	.	.	.	1997.0	.	.
W1D-3	7 26 93	.	0.025	5.300	.	.	.	.	2168.0	.	.
W1D-3	8 2 93	.	0.016	4.300	.	.	.	.	2224.0	.	.
W1D-3	8 16 93	.	0.024	4.900	.	.	.	.	2364.0	.	.
W1D-3	6 3 94	.	0.026	1.300	.	.	.	.	1415.0	.	.
W1D-3	6 8 94	.	0.017	0.400	.	.	.	.	1628.0	.	.
W1D-3	6 15 94	.	0.022	0.890	.	.	.	.	1304.0	.	.
W1D-3	6 22 94	.	0.017	3.000	.	.	.	.	2221.0	.	.
W1D-3	6 27 94	.	0.021	3.200	.	.	.	.	1694.0	.	.
W1D-3	7 6 94	.	0.017	5.000	.	.	.	.	1933.0	.	.
W1D-3	7 11 94	.	0.025	4.600	.	.	.	.	2315.0	.	.
W1D-3	7 21 94	.	0.023	4.900	.	.	.	.	2003.0	.	.
W1D-3	7 29 94	.	0.027	5.300	.	.	.	.	2557.0	.	.
W1D-3	8 4 94	.	0.027	4.600	.	.	.	.	2249.0	.	.
W1D-3	8 11 94	.	0.026	4.000	.	.	.	.	1921.0	.	.
W1D-3	8 18 94	.	0.030	3.600	.	.	.	.	2308.0	.	.
W1D-3	8 25 94	.	0.023	3.600	.	.	.	.	2096.0	.	.
W1D-3	9 2 94	.	0.040	3.200	.	.	.	.	1829.0	.	.
W1D-3	10 12 94	.	.	4.600	.	.	.	.	.	.	.
W1D-3	10 12 94	.	.	4.600	.	.	.	.	.	.	.
W1D-3	10 27 94	.	.	2.620	.	.	.	.	.	.	.
W1D-4	6 10 92	7.3	0.040	2.500	0.004	0.030	.	.	2264.0	.	.
W1D-4	6 15 92	6.8	0.050	4.500	0.034	0.050	.	.	2686.0	.	.
W1D-4	6 17 92	.	0.040	3.800	0.002	0.040	.	.	2444.0	.	.
W1D-4	6 22 92	.	0.018	3.200	0.007	0.050	.	.	2246.0	.	.
W1D-4	6 29 92	.	0.014	3.800	0.011	0.050	.	.	2162.0	.	.
W1D-4	7 6 92	.	0.016	3.900	0.010	0.090	.	.	2319.0	.	.
W1D-4	8 26 92	.	0.035	2.900	0.001	0.080	.	.	2078.0	.	.
W1D-4	9 4 92	.	0.024	1.900	0.004	0.050	.	.	2627.0	.	.
W1D-4	9 23 92	.	0.007	2.300	0.014	0.040	.	.	2672.0	.	.
W1D-4	10 5 92	.	0.008	3.600	0.014	0.050	.	.	2555.0	.	.
W1D-4	10 15 92	.	0.012	4.400	0.012	0.070	.	.	2395.0	.	.
W1D-4	6 7 93	.	0.014	0.580	0.002	0.050	.	.	741.0	120.0	120.0
W1D-4	6 10 93	.	-0.001	0.390	0.001	0.040	.	.	1050.0	130.0	130.0
W1D-4	6 14 93	.	0.017	0.510	.	.	.	.	976.0	.	.
W1D-4	6 24 93	.	0.017	1.100	.	.	.	.	1294.0	.	.
W1D-4	6 28 93	.	0.014	1.000	.	.	.	.	1333.0	.	.
W1D-4	7 1 93	.	0.030	1.700	.	.	.	.	1462.0	.	.
W1D-4	7 6 93	.	0.015	2.900	.	.	.	.	1223.0	.	.
W1D-4	7 8 93	.	0.017	2.900	.	.	.	.	1555.0	.	.
W1D-4	7 12 93	.	0.014	3.300	.	.	.	.	1808.0	.	.
W1D-4	7 15 93	.	0.013	4.500	.	.	.	.	2057.0	.	.
W1D-4	7 19 93	.	0.016	4.500	.	.	.	.	1912.0	.	.
W1D-4	7 26 93	.	0.027	5.200	.	.	.	.	2136.0	.	.
W1D-4	8 2 93	.	0.016	4.300	.	.	.	.	2007.0	.	.
W1D-4	8 16 93	.	0.022	4.800	.	.	.	.	2289.0	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-4	6 3 94	.	0.015	1.000	.	.	.	.	1408.0	.	.
W1D-4	6 8 94	.	0.002	0.060	.	.	.	.	1222.0	.	.
W1D-4	6 15 94	.	0.016	0.800	.	.	.	.	1008.0	.	.
W1D-4	6 22 94	.	0.015	3.000	.	.	.	.	2375.0	.	.
W1D-4	6 27 94	.	0.018	2.900	.	.	.	.	1531.0	.	.
W1D-4	7 6 94	.	0.016	4.700	.	.	.	.	1944.0	.	.
W1D-4	7 11 94	.	0.020	4.200	.	.	.	.	2087.0	.	.
W1D-4	7 21 94	.	0.020	4.500	.	.	.	.	2061.0	.	.
W1D-4	7 29 94	.	0.013	4.500	.	.	.	.	2569.0	.	.
W1D-4	8 4 94	.	0.013	3.300	.	.	.	.	2225.0	.	.
W1D-4	8 11 94	.	0.015	2.900	.	.	.	.	1577.0	.	.
W1D-4	8 18 94	.	0.023	2.600	.	.	.	.	2237.0	.	.
W1D-4	8 25 94	.	0.011	2.100	.	.	.	.	2143.0	.	.
W1D-4	9 2 94	.	0.022	2.700	.	.	.	.	1852.0	.	.
W1D-4	10 12 94	.	.	0.090	.	.	.	.	.	.	.
W1D-4	10 12 94	.	.	.	.	.	.	.	.	.	.
W1D-4	10 13 94	.	.	4.600	.	.	.	.	.	.	.
W1D-4	10 13 94	.	.	4.300	.	.	.	.	.	.	.
W1D-4	10 27 94	.	.	0.072	.	.	.	.	.	.	.
W1D-5	6 10 92	7.3	0.029	1.800	0.009	0.020	.	.	2592.0	.	.
W1D-5	6 15 92	6.5	0.025	2.000	0.015	0.030	.	.	2770.0	.	.
W1D-5	6 17 92	.	0.003	3.200	0.003	0.030	.	.	2471.0	.	.
W1D-5	6 22 92	.	0.009	2.100	0.011	0.070	.	.	2153.0	.	.
W1D-5	6 29 92	.	0.006	2.500	0.013	0.070	.	.	2153.0	.	.
W1D-5	7 6 92	.	0.008	2.400	0.013	0.070	.	.	2218.0	.	.
W1D-5	8 26 92	.	0.016	2.300	0.010	0.090	.	.	2128.0	.	.
W1D-5	9 4 92	.	0.051	1.600	0.007	0.060	.	.	2635.0	.	.
W1D-5	9 23 92	.	0.006	1.700	0.009	0.040	.	.	2672.0	.	.
W1D-5	10 5 92	.	0.004	2.000	0.004	0.050	.	.	2461.0	.	.
W1D-5	10 15 92	.	0.003	3.200	0.006	0.050	.	.	2231.0	.	.
W1D-5	6 7 93	.	0.001	0.480	0.002	0.060	.	.	752.0	120.0	130.0
W1D-5	6 10 93	.	-0.001	0.230	0.001	0.060	.	.	1064.0	130.0	140.0
W1D-5	6 14 93	.	0.003	0.290	.	.	.	.	1078.0	.	.
W1D-5	6 24 93	.	0.011	0.620	.	.	.	.	1243.0	.	.
W1D-5	6 28 93	.	0.006	0.410	.	.	.	.	1284.0	.	.
W1D-5	7 1 93	.	0.007	0.560	.	.	.	.	1376.0	.	.
W1D-5	7 6 93	.	0.008	1.800	.	.	.	.	1341.0	.	.
W1D-5	7 8 93	.	0.009	1.800	.	.	.	.	1505.0	.	.
W1D-5	7 12 93	.	0.006	2.200	.	.	.	.	1357.0	.	.
W1D-5	7 15 93	.	0.009	2.600	.	.	.	.	1883.0	.	.
W1D-5	7 19 93	.	0.007	2.700	.	.	.	.	1775.0	.	.
W1D-5	7 26 93	.	0.011	3.700	.	.	.	.	1650.0	.	.
W1D-5	8 2 93	.	0.008	2.600	.	.	.	.	1985.0	.	.
W1D-5	8 16 93	.	0.007	2.300	.	.	.	.	2237.0	.	.
W1D-5	6 3 94	.	0.007	0.650	.	.	.	.	1292.0	.	.
W1D-5	6 8 94	.	0.003	0.170	.	.	.	.	1403.0	.	.
W1D-5	6 15 94	.	0.010	0.500	.	.	.	.	1121.0	.	.
W1D-5	6 22 94	.	0.069	1.900	.	.	.	.	2290.0	.	.
W1D-5	6 27 94	.	0.010	1.800	.	.	.	.	1556.0	.	.
W1D-5	7 6 94	.	0.008	1.800	.	.	.	.	1760.0	.	.
W1D-5	7 11 94	.	0.011	2.300	.	.	.	.	1885.0	.	.
W1D-5	7 21 94	.	0.007	1.600	.	.	.	.	1875.0	.	.
W1D-5	7 29 94	.	0.007	2.300	.	.	.	.	2967.0	.	.
W1D-5	8 4 94	.	0.008	0.780	.	.	.	.	2073.0	.	.
W1D-5	8 11 94	.	0.012	2.000	.	.	.	.	1565.0	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-5	8 18 94	.	0.011	2.000	.	.	.	.	1968.0	.	.
W1D-5	8 25 94	.	0.010	1.600	.	.	.	.	2084.0	.	.
W1D-5	9 2 94	.	0.011	1.500	.	.	.	.	1968.0	.	.
W1D-5	10 12 94	.	.	1.800	.	.	.	.	.	.	.
W1D-5	10 12 94	.	.	1.800	.	.	.	.	.	.	.
W1D-5	10 27 94	.	.	1.540	.	.	.	.	.	.	.
W1D-6	6 10 92	6.3	0.006	0.280	0.007	0.005	.	.	2200.0	.	.
W1D-6	6 15 92	6.4	0.005	0.140	0.007	0.005	.	.	2601.0	.	.
W1D-6	6 17 92	.	0.001	1.700	0.002	0.020	.	.	2283.0	.	.
W1D-6	6 22 92	.	0.005	1.400	0.008	0.060	.	.	2000.0	.	.
W1D-6	6 29 92	.	0.002	0.960	0.007	0.060	.	.	2144.0	.	.
W1D-6	7 6 92	.	0.005	1.600	0.009	0.060	.	.	2190.0	.	.
W1D-6	8 26 92	.	0.035	1.300	0.005	0.060	.	.	2142.0	.	.
W1D-6	9 4 92	.	0.011	1.300	0.004	0.050	.	.	2669.0	.	.
W1D-6	9 23 92	.	0.009	1.300	0.005	0.040	.	.	2655.0	.	.
W1D-6	10 5 92	.	0.004	1.600	0.004	0.040	.	.	2473.0	.	.
W1D-6	10 15 92	.	0.002	7.300	0.003	0.050	.	.	2350.0	.	.
W1D-6	6 7 93	.	0.007	0.360	0.002	0.060	.	.	779.0	120.0	140.0
W1D-6	6 10 93	.	0.008	0.210	0.001	0.040	.	.	1041.0	130.0	140.0
W1D-6	6 14 93	.	0.005	0.170	.	.	.	.	1082.0	.	.
W1D-6	6 24 93	.	0.007	0.260	.	.	.	.	1148.0	.	.
W1D-6	6 28 93	.	0.004	0.190	.	.	.	.	1210.0	.	.
W1D-6	7 1 93	.	0.008	0.230	.	.	.	.	1327.0	.	.
W1D-6	7 6 93	.	0.004	1.100	.	.	.	.	1248.0	.	.
W1D-6	7 8 93	.	0.006	1.100	.	.	.	.	1424.0	.	.
W1D-6	7 12 93	.	0.004	1.700	.	.	.	.	1363.0	.	.
W1D-6	7 15 93	.	0.007	1.800	.	.	.	.	1683.0	.	.
W1D-6	7 19 93	.	0.004	1.800	.	.	.	.	1691.0	.	.
W1D-6	7 26 93	.	0.007	2.100	.	.	.	.	1764.0	.	.
W1D-6	8 2 93	.	0.004	1.400	.	.	.	.	1910.0	.	.
W1D-6	8 16 93	.	0.007	1.300	.	.	.	.	2058.0	.	.
W1D-6	6 3 94	.	0.004	0.310	.	.	.	.	1184.0	.	.
W1D-6	6 8 94	.	0.003	0.140	.	.	.	.	1309.0	.	.
W1D-6	6 15 94	.	0.006	0.360	.	.	.	.	1155.0	.	.
W1D-6	6 22 94	.	0.025	1.200	.	.	.	.	2092.0	.	.
W1D-6	6 27 94	.	0.010	1.800	.	.	.	.	1346.0	.	.
W1D-6	7 6 94	.	0.011	1.500	.	.	.	.	1783.0	.	.
W1D-6	7 11 94	.	0.008	2.000	.	.	.	.	1902.0	.	.
W1D-6	7 21 94	.	0.007	1.600	.	.	.	.	1794.0	.	.
W1D-6	7 29 94	.	0.004	1.000	.	.	.	.	2318.0	.	.
W1D-6	8 4 94	.	0.005	0.900	.	.	.	.	1968.0	.	.
W1D-6	8 11 94	.	0.007	1.200	.	.	.	.	1760.0	.	.
W1D-6	8 18 94	.	0.005	0.520	.	.	.	.	2131.0	.	.
W1D-6	8 25 94	.	0.004	0.390	.	.	.	.	2084.0	.	.
W1D-6	9 2 94	.	0.009	1.400	.	.	.	.	1991.0	.	.
W1D-6	10 12 94	.	.	2.000	.	.	.	.	.	.	.
W1D-6	10 12 94	.	.	2.000	.	.	.	.	.	.	.
W1D-6	10 27 94	.	.	1.570	.	.	.	.	.	.	.
W1D-7	6 10 92	6.6	0.009	0.260	0.011	0.005	.	.	2355.0	.	.
W1D-7	6 15 92	6.6	0.007	0.140	0.008	0.005	.	.	2328.0	.	.
W1D-7	6 17 92	.	0.002	0.720	0.003	0.020	.	.	2255.0	.	.
W1D-7	6 22 92	.	0.005	1.200	0.007	0.060	.	.	2209.0	.	.
W1D-7	6 29 92	.	0.003	0.790	0.006	0.070	.	.	2144.0	.	.
W1D-7	7 6 92	.	0.006	1.300	0.007	0.060	.	.	2172.0	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-7	8 26 92	.	0.005	0.800	0.003	0.060	.	.	1960.0	.	.
W1D-7	9 4 92	.	0.003	0.650	0.002	0.050	.	.	2669.0	.	.
W1D-7	9 23 92	.	0.003	0.850	0.000	0.030	.	.	2572.0	.	.
W1D-7	10 5 92	.	0.004	1.100	0.001	0.030	.	.	2431.0	.	.
W1D-7	10 15 92	.	0.000	1.800	0.002	0.040	.	.	2299.0	.	.
W1D-7	6 7 93	7.2	0.002	0.180	0.002	0.070	.	.	790.0	130.0	140.0
W1D-7	6 10 93	.	0.004	0.110	0.001	0.040	.	.	1037.0	130.0	140.0
W1D-7	6 14 93	7.2	0.003	0.090	.	.	.	.	1004.0	.	.
W1D-7	6 24 93	7.2	0.005	0.180	.	.	.	.	1148.0	.	.
W1D-7	6 28 93	6.9	0.001	0.100	.	.	.	.	1176.0	.	.
W1D-7	7 1 93	6.8	-0.001	0.060	.	.	.	.	1172.0	.	.
W1D-7	7 6 93	7.0	0.006	0.510	.	.	.	.	1228.0	.	.
W1D-7	7 8 93	.	0.005	0.770	.	.	.	.	1389.0	.	.
W1D-7	7 12 93	6.9	0.004	1.600	.	.	.	.	1329.0	.	.
W1D-7	7 15 93	6.8	0.006	1.200	.	.	.	.	1626.0	.	.
W1D-7	7 19 93	6.8	0.004	1.400	.	.	.	.	1691.0	.	.
W1D-7	7 26 93	6.8	0.008	1.600	.	.	.	.	1629.0	.	.
W1D-7	8 2 93	7.1	0.006	1.100	.	.	.	.	1771.0	.	.
W1D-7	8 16 93	7.0	0.003	0.830	.	.	.	.	1880.0	.	.
W1D-7	6 3 94	7.4	0.003	0.170	.	.	.	.	1171.0	.	.
W1D-7	6 8 94	7.5	0.007	0.120	.	.	.	.	1229.0	.	.
W1D-7	6 15 94	7.4	0.008	0.290	.	.	.	.	1121.0	.	.
W1D-7	6 22 94	7.2	0.007	0.930	.	.	.	.	2115.0	.	.
W1D-7	6 27 94	7.4	0.007	1.400	.	.	.	.	1383.0	.	.
W1D-7	7 6 94	7.3	0.006	1.300	.	.	.	.	1789.0	.	.
W1D-7	7 11 94	7.5	0.007	1.400	.	.	.	.	1902.0	.	.
W1D-7	7 21 94	7.1	0.006	1.100	.	.	.	.	1806.0	.	.
W1D-7	7 29 94	7.3	0.006	0.500	.	.	.	.	2272.0	.	.
W1D-7	8 4 94	7.3	0.006	0.470	.	.	.	.	2061.0	.	.
W1D-7	8 11 94	7.2	0.006	1.100	.	.	.	.	1737.0	.	.
W1D-7	8 18 94	.	0.009	0.330	.	.	.	.	2003.0	.	.
W1D-7	8 25 94	7.2	0.002	0.230	.	.	.	.	1910.0	.	.
W1D-7	9 2 94	.	0.007	1.400	.	.	.	.	1921.0	.	.
W1D-7	10 12 94	.	.	1.600	.	.	.	.	.	.	.
W1D-7	10 12 94	.	.	1.600	.	.	.	.	.	.	.
W1D-7	10 27 94	.	.	1.180	.	.	.	.	.	.	.
W1D-8	6 10 92	6.8	0.014	0.290	0.012	0.005	.	.	2283.0	.	.
W1D-8	6 15 92	6.7	0.012	0.140	0.009	0.005	.	.	2382.0	.	.
W1D-8	6 17 92	.	0.001	0.710	0.003	0.010	.	.	2246.0	.	.
W1D-8	6 22 92	.	0.006	0.770	0.008	0.070	.	.	2077.0	.	.
W1D-8	6 29 92	.	0.003	0.670	0.006	0.050	.	.	2200.0	.	.
W1D-8	7 6 92	.	0.006	1.100	0.006	0.070	.	.	1971.0	.	.
W1D-8	8 26 92	.	0.007	0.470	0.002	0.090	.	.	1953.0	.	.
W1D-8	9 4 92	.	0.008	0.840	0.002	0.040	.	.	2661.0	.	.
W1D-8	9 23 92	.	0.003	0.760	0.001	0.030	.	.	2528.0	.	.
W1D-8	10 5 92	.	0.003	1.000	0.001	0.040	.	.	2426.0	.	.
W1D-8	10 15 92	.	0.001	1.400	0.001	0.050	.	.	2231.0	.	.
W1D-8	6 7 93	.	0.004	0.140	0.001	0.090	.	.	730.0	120.0	140.0
W1D-8	6 10 93	.	0.005	0.130	0.001	0.040	.	.	976.0	130.0	140.0
W1D-8	6 14 93	.	0.002	0.100	.	.	.	.	1046.0	.	.
W1D-8	6 24 93	.	0.002	0.110	.	.	.	.	1072.0	.	.
W1D-8	6 28 93	.	0.002	0.100	.	.	.	.	1204.0	.	.
W1D-8	7 1 93	.	0.003	0.090	.	.	.	.	1187.0	.	.
W1D-8	7 6 93	.	0.006	0.510	.	.	.	.	1202.0	.	.
W1D-8	7 8 93	.	0.004	0.650	.	.	.	.	1363.0	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-8	7 12 93	.	0.004	1.400	.	.	.	.	1285.0	.	.
W1D-8	7 15 93	.	0.005	1.100	.	.	.	.	1581.0	.	.
W1D-8	7 19 93	.	0.005	1.400	.	.	.	.	1608.0	.	.
W1D-8	7 26 93	.	0.004	1.200	.	.	.	.	1743.0	.	.
W1D-8	8 2 93	.	0.002	1.200	.	.	.	.	1238.0	.	.
W1D-8	8 16 93	.	0.004	0.790	.	.	.	.	1922.0	.	.
W1D-8	6 3 94	.	0.002	0.180	.	.	.	.	1114.0	.	.
W1D-8	6 8 94	.	0.002	0.180	.	.	.	.	1249.0	.	.
W1D-8	6 15 94	.	0.006	0.210	.	.	.	.	1277.0	.	.
W1D-8	6 22 94	.	0.007	0.870	.	.	.	.	2123.0	.	.
W1D-8	6 27 94	.	0.006	1.100	.	.	.	.	1359.0	.	.
W1D-8	7 6 94	.	0.006	0.990	.	.	.	.	1672.0	.	.
W1D-8	7 11 94	.	0.007	1.100	.	.	.	.	1794.0	.	.
W1D-8	7 21 94	.	0.005	0.930	.	.	.	.	1821.0	.	.
W1D-8	7 29 94	.	0.003	0.480	.	.	.	.	2093.0	.	.
W1D-8	8 4 94	.	0.024	0.320	.	.	.	.	2038.0	.	.
W1D-8	8 11 94	.	0.009	0.930	.	.	.	.	1725.0	.	.
W1D-8	8 18 94	.	0.003	0.330	.	.	.	.	2084.0	.	.
W1D-8	8 25 94	.	0.002	0.230	.	.	.	.	1794.0	.	.
W1D-8	9 2 94	.	0.006	1.100	.	.	.	.	1863.0	.	.
W1D-8	10 12 94	.	.	1.600	.	.	.	.	.	.	.
W1D-8	10 12 94	.	.	1.600	.	.	.	.	.	.	.
W1D-8	10 27 94	.	.	1.180	.	.	.	.	.	.	.
W1D-9	6 10 92	7.1	0.020	0.260	0.015	0.010	.	.	2274.0	.	.
W1D-9	6 15 92	6.7	0.005	0.130	0.009	0.005	.	.	2237.0	.	.
W1D-9	6 17 92	.	0.001	0.560	0.003	0.010	.	.	2427.0	.	.
W1D-9	6 22 92	.	0.004	0.800	0.008	0.060	.	.	2134.0	.	.
W1D-9	6 29 92	.	0.003	0.510	0.005	0.060	.	.	1990.0	.	.
W1D-9	7 6 92	.	0.010	1.100	0.005	0.060	.	.	2020.0	.	.
W1D-9	8 26 92	.	0.020	0.360	0.001	0.060	.	.	1983.0	.	.
W1D-9	9 4 92	.	0.018	0.530	0.008	0.060	.	.	2575.0	.	.
W1D-9	9 23 92	.	0.006	0.750	0.001	0.020	.	.	2563.0	.	.
W1D-9	10 5 92	.	0.004	1.000	0.001	0.040	.	.	2413.0	.	.
W1D-9	10 15 92	.	0.001	1.100	0.000	0.040	.	.	2255.0	.	.
W1D-9	6 7 93	.	0.005	0.120	0.001	0.050	.	.	736.0	120.0	130.0
W1D-9	6 10 93	.	0.006	0.110	0.001	0.040	.	.	1032.0	130.0	140.0
W1D-9	6 14 93	.	0.003	0.090	.	.	.	.	1037.0	.	.
W1D-9	6 24 93	.	0.008	0.070	.	.	.	.	1029.0	.	.
W1D-9	6 28 93	.	0.003	0.100	.	.	.	.	1199.0	.	.
W1D-9	7 1 93	.	0.005	0.060	.	.	.	.	1156.0	.	.
W1D-9	7 6 93	.	0.008	0.520	.	.	.	.	1181.0	.	.
W1D-9	7 8 93	.	0.006	0.630	.	.	.	.	1327.0	.	.
W1D-9	7 12 93	.	0.004	1.400	.	.	.	.	1368.0	.	.
W1D-9	7 15 93	.	0.004	1.000	.	.	.	.	1541.0	.	.
W1D-9	7 19 93	.	0.006	1.500	.	.	.	.	1567.0	.	.
W1D-9	7 26 93	.	0.006	1.100	.	.	.	.	1733.0	.	.
W1D-9	8 2 93	.	0.007	0.940	.	.	.	.	1718.0	.	.
W1D-9	8 16 93	.	0.004	0.750	.	.	.	.	2005.0	.	.
W1D-9	6 3 94	.	0.002	0.150	.	.	.	.	1177.0	.	.
W1D-9	6 8 94	.	0.005	0.100	.	.	.	.	1262.0	.	.
W1D-9	6 15 94	.	0.007	0.180	.	.	.	.	1250.0	.	.
W1D-9	6 22 94	.	0.008	0.690	.	.	.	.	2025.0	.	.
W1D-9	6 27 94	.	0.006	1.100	.	.	.	.	1286.0	.	.
W1D-9	7 6 94	.	0.007	1.100	.	.	.	.	1709.0	.	.
W1D-9	7 11 94	.	0.015	1.100	.	.	.	.	1756.0	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
W1D-9	7 19 94	.	0.008	0.370	.	.	.	.	2140.0	.	.
W1D-9	7 21 94	.	0.009	0.980	.	.	.	.	1840.0	.	.
W1D-9	8 4 94	.	0.004	0.370	.	.	.	.	2143.0	.	.
W1D-9	8 11 94	.	0.006	0.900	.	.	.	.	1691.0	.	.
W1D-9	8 18 94	.	0.003	0.350	.	.	.	.	2003.0	.	.
W1D-9	8 25 94	.	0.002	0.200	.	.	.	.	1852.0	.	.
W1D-9	9 2 94	.	0.005	0.910	.	.	.	.	1898.0	.	.
W1D-9	10 12 94	.	.	1.400	.	.	.	.	.	.	.
W1D-9	10 12 94	.	.	1.400	.	.	.	.	.	.	.
W1D-9	10 27 94	.	.	1.080	.	.	.	.	.	.	.

The following sites are all upstream of the input (W1D-051)

Upstream1	6 7 93	7.1	0.280	0.620	0.008	0.060	.	.	1695.0	240.0	160.0
Upstream1	6 10 93	.	0.450	0.550	.	0.070	.	.	1096.0	270.0	290.0
Upstream1	6 14 93	6.6	0.280	0.620	0.007	0.070	.	.	1545.0	.	.
Upstream1	6 24 93	.	0.260	0.600	.	.	.	.	1484.0	.	.
Upstream1	6 28 93	6.7	0.250	0.410	.	.	.	.	1305.0	.	.
Upstream1	7 1 93	.	0.250	0.590	.	.	.	.	1413.0	.	.
Upstream1	7 6 93	.	0.030	0.400	.	.	.	.	1207.0	.	.
Upstream1	7 8 93	.	0.090	0.450	.	.	.	.	1327.0	.	.
Upstream1	7 12 93	6.5	0.060	0.360	.	.	.	.	1247.0	.	.
Upstream1	7 15 93	6.6	0.070	0.350	.	.	.	.	1351.0	.	.
Upstream1	7 19 93	6.7	0.110	0.430	.	.	.	.	2374.0	.	.
Upstream1	7 26 93	6.6	0.100	0.350	.	.	.	.	1095.0	.	.
Upstream1	8 2 93	6.7	0.050	0.320	.	.	.	.	827.0	.	.
Upstream1	8 16 93	8.0	0.040	0.100	.	.	.	.	599.0	.	.
Upstream1	6 3 94	6.7	0.190	0.460	.	.	.	.	1945.0	.	.
Upstream1	6 8 94	6.8	0.160	0.400	.	.	.	.	2265.0	.	.
Upstream1	6 15 94	6.7	0.080	0.270	.	.	.	.	2168.0	.	.
Upstream1	6 22 94	6.5	0.040	0.240	.	.	.	.	2010.0	.	.
Upstream1	6 27 94	7.1	0.030	0.300	.	.	.	.	1900.0	.	.
Upstream1	7 6 94	7.4	0.070	0.390	.	.	.	.	2049.0	.	.
Upstream1	7 11 94	7.0	0.050	0.310	.	.	.	.	1968.0	.	.
Upstream1	7 21 94	7.0	0.060	0.290	.	.	.	.	2003.0	.	.
Upstream1	7 29 94	7.2	0.050	0.290	.	.	.	.	2509.0	.	.
Upstream1	8 4 94	7.4	0.060	0.430	.	.	.	.	2319.0	.	.
Upstream1	8 11 94	6.7	0.070	0.390	.	.	.	.	1910.0	.	.
Upstream1	8 18 94	7.3	0.130	0.300	.	.	.	.	1956.0	.	.
Upstream1	8 25 94	6.6	0.140	0.310	.	.	.	.	1452.0	.	.
Upstream1	9 2 94	6.7	0.120	0.310	.	.	.	.	1542.0	.	.
Upstream2	8 26 92	.	0.080	3.900	0.140	0.110	.	.	1486.0	.	.
Upstream2	9 4 92	7.3	0.023	0.970	0.024	0.040	.	.	1388.0	.	.
Upstream2	9 23 92	.	0.310	3.900	0.150	0.130	.	.	2554.0	.	.
Upstream2	10 5 92	.	0.460	5.800	0.220	0.170	.	.	2332.0	.	.
Upstream2	10 15 92	.	0.540	9.100	0.390	0.250	.	.	2138.0	.	.
Upstream2	6 7 93	.	0.070	0.790	0.004	0.050	.	.	752.0	130.0	280.0
Upstream2	6 10 93	.	0.160	0.920	.	.	.	.	1223.0	160.0	140.0
Upstream2	6 14 93	.	0.060	0.920	0.004	0.050	.	.	1078.0	.	.
Upstream2	6 24 93	.	0.040	1.600	.	.	.	.	1256.0	.	.
Upstream2	6 28 93	.	0.120	2.000	.	.	.	.	1445.0	.	.
Upstream2	7 1 93	.	0.110	3.600	.	.	.	.	1588.0	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
Upstream2	7 6 93	.	0.040	3.300	.	.	.	.	1355.0	.	.
Upstream2	7 8 93	.	0.030	3.400	.	.	.	.	1615.0	.	.
Upstream2	7 12 93	.	0.070	5.100	.	.	.	.	2028.0	.	.
Upstream2	7 15 93	.	0.070	3.300	.	.	.	.	2133.0	.	.
Upstream2	7 19 93	.	0.050	2.600	.	.	.	.	1484.0	.	.
Upstream2	7 26 93	.	0.120	5.400	.	.	.	.	2395.0	.	.
Upstream2	8 2 93	.	0.130	4.300	.	.	.	.	2278.0	.	.
Upstream2	8 16 93	.	0.210	4.800	.	.	.	.	2385.0	.	.
Upstream2	6 3 94	.	0.140	3.100	.	.	.	.	1924.0	.	.
Upstream2	6 8 94	.	0.110	2.200	.	.	.	.	2035.0	.	.
Upstream2	6 15 94	.	0.030	1.200	.	.	.	.	1465.0	.	.
Upstream2	6 22 94	.	0.050	5.800	.	.	.	.	2350.0	.	.
Upstream2	6 27 94	.	0.040	4.700	.	.	.	.	1913.0	.	.
Upstream2	7 6 94	.	0.090	6.600	.	.	.	.	2545.0	.	.
Upstream2	7 11 94	.	0.040	3.600	.	.	.	.	2195.0	.	.
Upstream2	7 21 94	.	0.050	3.600	.	.	.	.	2119.0	.	.
Upstream2	7 29 94	.	0.050	3.500	.	.	.	.	2401.0	.	.
Upstream2	8 4 94	.	0.190	4.100	.	.	.	.	2073.0	.	.
Upstream2	8 4 94	.	0.190	4.000	.	.	.	.	2225.0	.	.
Upstream2	8 11 94	.	0.030	2.300	.	.	.	.	1497.0	.	.
Upstream2	8 18 94	.	0.050	1.500	.	.	.	.	1829.0	.	.
Upstream2	8 25 94	.	0.030	1.700	.	.	.	.	1852.0	.	.
Upstream2	9 2 94	.	0.013	3.100	.	.	.	.	1599.0	.	.
Upstream3	6 10 92	6.4	0.310	4.300	0.070	0.060	.	.	2678.0	.	.
Upstream3	6 15 92	7.2	0.240	6.700	0.050	0.040	.	.	2770.0	.	.
Upstream3	6 17 92	6.6	0.260	5.900	0.070	0.050	.	.	2541.0	.	.
Upstream3	6 22 92	7.1	0.210	5.400	0.050	0.090	.	.	2541.0	.	.
Upstream3	6 29 92	7.0	0.110	6.400	0.050	0.110	.	.	2274.0	.	.
Upstream3	7 6 92	6.9	0.160	6.900	0.070	0.120	.	.	2480.0	.	.
Upstream3	8 26 92	.	0.032	4.400	0.050	0.090	.	.	2233.0	.	.
Upstream3	9 4 92	6.7	0.029	2.700	0.032	0.060	.	.	2983.0	.	.
Upstream3	9 23 92	.	0.033	3.200	0.100	0.070	.	.	2676.0	.	.
Upstream3	10 5 92	7.0	0.032	4.600	0.100	0.080	.	.	2603.0	.	.
Upstream3	10 15 92	.	0.040	4.400	0.060	0.080	.	.	2323.0	.	.
Upstream3	6 7 93	.	0.040	1.200	0.005	0.060	.	.	1133.0	200.0	190.0
Upstream3	6 10 93	.	0.050	0.850	0.002	0.060	.	.	1968.0	180.0	180.0
Upstream3	6 14 93	.	0.040	1.100	0.006	0.070	.	.	1400.0	.	.
Upstream3	6 24 93	.	0.031	1.500	.	.	.	.	1297.0	.	.
Upstream3	6 28 93	.	0.030	1.600	.	.	.	.	1511.0	.	.
Upstream3	7 1 93	.	0.030	4.700	.	.	.	.	1743.0	.	.
Upstream3	7 6 93	.	0.030	4.500	.	.	.	.	1540.0	.	.
Upstream3	7 8 93	.	0.019	4.100	.	.	.	.	2456.0	.	.
Upstream3	7 12 93	.	0.028	5.500	.	.	.	.	2169.0	.	.
Upstream3	7 15 93	.	0.030	6.800	.	.	.	.	2447.0	.	.
Upstream3	7 19 93	.	0.040	8.300	.	.	.	.	2615.0	.	.
Upstream3	7 26 93	.	0.023	4.900	.	.	.	.	2298.0	.	.
Upstream3	8 2 93	.	0.030	5.900	.	.	.	.	2708.0	.	.
Upstream3	8 16 93	.	0.060	7.100	.	.	.	.	2524.0	.	.
Upstream3	6 3 94	.	0.090	3.800	.	.	.	.	2169.0	.	.
Upstream3	6 8 94	.	0.090	3.100	.	.	.	.	2359.0	.	.
Upstream3	6 15 94	.	0.030	0.880	.	.	.	.	1416.0	.	.
Upstream3	6 22 94	.	0.040	6.000	.	.	.	.	2595.0	.	.
Upstream3	6 27 94	.	0.040	4.000	.	.	.	.	2162.0	.	.
Upstream3	7 6 94	.	0.090	7.400	.	.	.	.	2629.0	.	.
Upstream3	7 11 94	.	0.040	4.600	.	.	.	.	2303.0	.	.

Table A1.1. W1D water quality data, collected by LTV from 1992-1999 (continued).

Site	Date	pH	Cu	Ni	Co	Zn	Fe	TSS	SO_4	Ca	Mg
Upstream3	7 21 94	.	0.015	2.500	.	.	.	.	2003.0	.	.
Upstream3	7 29 94	.	0.026	3.700	.	.	.	.	2354.0	.	.
Upstream3	8 4 94	.	0.080	5.500	.	.	.	.	2390.0	.	.
Upstream3	8 11 94	.	0.030	4.700	.	.	.	.	2284.0	.	.
Upstream3	8 18 94	.	0.030	4.700	.	.	.	.	2450.0	.	.
Upstream3	8 25 94	.	0.140	6.100	.	.	.	.	2308.0	.	.
Upstream3	9 2 94	.	0.100	5.400	.	.	.	.	2237.0	.	.

Note: a minus sign preceding a value indicates the value is less than detection limit. pH values are in standard units, and all other parameters are mg/L.

Table A1.2. Water quality data (1997-99) from the DNR study cell of the W1D treatment system.

Site	Year	#	S.C.	pH	Cu	Ni	Co	Zn	SO_4	Ca	Mg
W1D1 (the site on the influent side of the DNR study cell)											
W1D1	5 1 97	18013	1000	7.030	0.008	0.500	0.002	0.040	441.1	.	.
W1D1	5 15 97	18026	1150	7.090	0.007	0.500	0.001	0.030	550.0	.	.
W1D1	5 29 97	18041	1250	6.950	0.008	0.600	0.003	0.040	658.0	.	.
W1D1	6 12 97	18056	1600	6.890	0.003	0.300	0.008	0.020	840.0	.	.
W1D1	6 30 97	18070	1400	7.040	0.010	0.500	.	.	693.0	169.0	121.0
W1D1	7 14 97	18084	1500	7.100	0.002	0.300	.	.	903.0	168.0	151.0
W1D1	7 24 97	18100	1790	6.670	0.004	0.100	0.002	.	958.0	.	.
W1D1	8 7 97	18131	1800	7.040	0.008	0.300	0.001	.	1062.0	.	.
W1D1	8 22 97	18151	1575	6.750	<0.050	0.400	.	.	874.0	161.0	150.0
W1D1	9 4 97	18167	2000	6.860	<0.050	0.100	.	.	1105.0	206.0	187.0
W1D1	9 17 97	18182	2000	7.230	<0.050	0.300	.	.	1172.0	212.0	193.0
W1D1	10 1 97	18196	1900	7.350	<0.050	0.200	.	.	1075.0	204.0	186.0
W1D1	10 14 97	18210	1450	7.250	<0.050	0.400	.	.	768.0	140.0	126.0
W1D1	8 5 98	18228	2100	7.160	<0.050	0.100	<0.100	0.030	1108.0	230.0	237.0
W1D1	9 4 98	18234	1800	7.760	<0.050	0.100	<0.100	.	1146.0	220.0	228.0
W1D1	9 17 98	18238	2200	7.110	<0.050	0.200	<0.100	0.030	1179.0	223.0	232.0
W1D1	9 30 98	18243	2250	7.840	<0.050	0.300	<0.100	0.020	1124.0	219.0	215.0
W1D1	10 20 98	18254		.	0.004	0.380	0.011	0.033	645.0	.	.
W1D1	4 2 99	18269	900	7.410	0.047	0.933	0.036	0.081	470.0	.	.
W1D1	5 14 99	18279	1400	7.360	<0.002	0.288	<0.002	0.028	816.0	.	.
W1D1	6 15 99	18288	1600	7.220	.	.	.	.	.	.	.
W1D1	7 7 99	18294	1200	7.250	.	.	.	.	.	.	.
W1D1	8 6 99	18307	2275	.	0.007	0.258	0.002	.	.	247.0	249.0
W1D1	9 10 99	18316	1950	7.160	0.006	0.150	<0.002	.	.	214.0	200.0
W1D1	10 6 99	18325	1500	7.080	0.004	0.239	0.002	.	.	162.0	164.0

Table A1.2. Water quality data (1997-99) from the DNR study cell of the W1D treatment system (continued).

Site	Year	#	S.C.	pH	Cu	Ni	Co	Zn	SO4	Ca	Mg
W1D2 (one of the two sample sites on the effluent side of the DNR study cell)											
W1D2	5 1 97	18014	1150	7.140	0.004	0.400	<0.001	0.040	506.1	.	.
W1D2	5 15 97	18027	1150	7.130	0.004	0.500	<0.001	0.040	546.0	.	.
W1D2	5 29 97	18042	1300	7.000	0.003	0.400	<0.001	0.030	655.0	.	.
W1D2	6 12 97	18057	1500	7.220	0.002	0.200	0.004	0.020	770.0	.	.
W1D2	6 30 97	18071	1300	7.080	0.001	0.300	.	.	638.0	134.0	115.0
W1D2	7 14 97	18085	1400	7.390	0.002	0.200	.	.	824.0	152.0	145.0
W1D2	7 24 97	18101	1825	7.380	0.002	<0.100	0.001	.	911.0	.	.
W1D2	8 7 97	18132	1700	7.250	0.003	0.100	<0.001	.	960.0	.	.
W1D2	8 22 97	18152	1500	6.860	<0.050	0.300	.	.	850.0	161.0	144.0
W1D2	9 4 97	18168	1900	7.250	<0.050	0.100	.	.	1036.0	193.0	187.0
W1D2	9 17 97	18183	1950	7.290	<0.050	0.100	.	.	1090.0	197.0	192.0
W1D2	10 1 97	18197	1925	7.200	<0.050	0.100	.	.	1085.0	199.0	186.0
W1D2	10 14 97	18211	1375	7.260	<0.050	0.300	.	.	769.0	139.0	127.0
W1D2	9 4 98	18235	1900	7.770	<0.050	0.300	<0.100	.	1172.0	228.0	231.0
W1D2	9 17 98	18239	2000	7.440	<0.050	0.200	<0.100	0.020	1078.0	212.0	229.0
W1D2	10 20 98	18255		.	<0.001	0.274	0.008	0.023	599.0	.	.
W1D2	4 2 99	18268	1000	7.440	0.035	0.875	0.028	0.064	545.0	.	.
W1D2	5 14 99	18278	1375	7.440	<0.002	0.210	<0.002	0.022	775.0	.	.
W1D2	6 15 99	18287	1500	7.050	.	.	.	.	.	.	.
W1D2	7 7 99	18296	1125	7.250	.	.	.	.	.	.	.
W1D2	8 6 99	18308	2100	7.160	0.004	0.086	<0.002	.	.	244.0	249.0
W1D2	9 10 99	18317	1750	7.230	0.004	0.131	<0.002	.	.	208.0	203.0
W1D2	10 6 99	18326	1550	7.280	0.007	0.276	0.002	0.010	.	161.0	164.0

Table A1.2. Water quality data (1997-99) from the DNR study cell of the W1D treatment system (continued).

Site	Year	#	S.C.	pH	Cu	Ni	Co	Zn	SO4	Ca	Mg
W1D3 (one of the two sample sites on the effluent side of the DNR study cell)											
W1D3	5 1 97	18015	1200	7.070	0.002	0.300	<0.001	0.030	517.5	.	.
W1D3	5 15 97	18028	1150	7.120	0.004	0.500	<0.001	0.030	542.0	.	.
W1D3	5 29 97	18043	1300	7.060	0.003	0.400	<0.001	0.030	650.0	.	.
W1D3	6 12 97	18058	1300	7.130	0.002	0.200	0.002	.	796.0	.	.
W1D3	6 30 97	18072	1300	7.180	<0.001	0.300	.	.	643.0	130.0	116.0
W1D3	7 14 97	18086	1400	7.320	0.001	0.300	.	.	793.0	156.0	148.0
W1D3	7 24 97	18102	1750	7.290	0.002	0.100	0.002	.	890.0	.	.
W1D3	8 7 97	18133	1650	7.310	0.012	0.100	<0.001	.	949.0	.	.
W1D3	8 22 97	18153	1525	6.860	<0.050	0.300	.	.	807.0	156.0	140.0
W1D3	9 4 97	18169	1850	7.200	<0.050	0.100	.	.	994.0	190.0	182.0
W1D3	9 17 97	18184	1925	7.300	<0.050	0.100	.	.	1026.0	191.0	189.0
W1D3	10 1 97	18198	1875	7.260	.	.	.	.	.	.	.
W1D3	10 14 97	18212	1400	7.270	<0.050	0.400	.	.	752.0	138.0	126.0
W1D3	8 5 98	18229	2100	7.130	<0.050	0.300	<0.100	0.020	1068.0	225.0	229.0
W1D3	9 17 98	18240	2000	7.450	<0.050	0.300	<0.100	0.100	967.0	202.0	213.0
W1D3	10 20 98	18256		.	0.001	0.289	0.009	0.024	592.0	.	.
W1D3	4 2 99	18267	900	7.500	0.029	0.793	0.024	0.064	499.0	.	.
W1D3	5 14 99	18277	1450	7.500	<0.002	0.205	<0.002	0.019	781.0	.	.
W1D3	6 15 99	18286	1500	7.120	.	.	.	.	.	.	.
W1D3	7 7 99	18292	1100	7.180	.	.	.	.	.	.	.
W1D3	8 6 99	18309	2200	7.140	0.004	<0.002	<0.002	.	.	238.0	246.0
W1D3	9 10 99	18318	1750	7.250	0.004	0.154	<0.002	.	.	213.0	202.0
W1D3	10 6 99	18327	1500	7.340	0.007	0.240	<0.002	.	.	156.0	158.0

Table A1.2. Water quality data (1997-99) from the DNR study cell of the W1D treatment system (continued).

Site	Year			#	S.C.	pH	Cu	Ni	Co	Zn	SO4	Ca	Mg
W1DH (equivalent to W1D-051; the input to the entire treatment system)													
W1DH	10	20	98	18262		.	.	.	.	.	646.0	.	.
W1DH	4	2	99	18270	950	7.000	0.055	0.771	0.032	0.028	443.0	.	.
W1DH	4	27	99	18273	1500	7.160	0.036	0.547	0.004	0.029	851.0	.	.
W1DH	5	14	99	18276	1750	7.200	.	.	.	.	998.0	.	.
W1DH	6	15	99	18285	1950	6.910	.	.	.	.	.	.	.
W1DH	7	7	99	18291	1175	6.820	.	.	.	.	.	.	.
W1DH	7	28	99	18303	2100	7.080	.	<0.100	<0.100	1.980	1230.0	236.0	238.0
W1DH	8	6	99	18306	2400	7.070	0.003	0.020	<0.002	.	.	264.0	266.0
W1DH	8	20	99	18312	2200	7.080	0.010	0.252	0.004	.	.	265.0	274.0
W1DH	9	10	99	18315	1900	7.050	0.003	0.014	<0.002	.	.	215.0	198.0
W1DH	9	23	99	18321	1750	7.090	0.004	0.235	0.002	0.010	.	262.0	256.0
W1DH	10	6	99	18324	1650	7.000	.	.	.	.	.	.	.

Note: Specific conductance (S.C.) values are in microsiemens, pH values are in standard units, and all other parameters are in mg/L.

Table A1.3. Water quality data from the input (051) and output (052) of the W1D wetland treatment system, obtained during the 1993 study of the Dunka Mine conducted by the DNR.

Site	Date	S.C.	pH	SO4	Cu	Ni	Co	Zn	Ca	Mg	O.S.S.	Flow rate (gpm) Bucket Gage	Flow rate (gpm) Stream Gage
W1D-051	7 16 93	.	.	.	.	.	.	.	.	.	2.00	95.0	.
W1D-051	7 20 93	3850.0	7.20	2440.0	0.060	6.300	0.060	0.040	295.0	410.0	1.90	55.7	.
W1D-051	7 26 93	3400.0	6.69	2640.0	0.080	6.800	0.090	0.050	315.0	425.0	1.90	66.3	.
W1D-051	7 28 93	.	.	.	.	.	.	.	.	.	1.92	74.2	.
W1D-051	7 29 93	.	.	.	.	.	.	.	.	.	1.94	79.4	.
W1D-051	8 2 93	3700.0	6.82	.	0.070	7.180	0.070	0.080	325.0	399.0	1.88	56.6	.
W1D-051	8 3 93	.	.	.	.	.	.	.	.	.	1.90	67.3	.
W1D-051	8 4 93	3400.0	6.93	.	0.070	6.800	0.080	0.080	326.0	407.0	1.87	53.5	.
W1D-051	8 6 93	.	.	.	.	.	.	.	.	.	1.86	53.9	.
W1D-051	8 9 93	3150.0	7.06	.	.	.	.	.	.	.	1.98	96.3	.
W1D-051	8 11 93	.	.	.	0.020	0.930	0.030	0.020	233.0	279.0	1.86	50.4	.
W1D-051	8 13 93	.	.	.	.	.	.	.	.	.	1.85	44.4	.
W1D-051	8 17 93	3900.0	7.06	.	.	.	.	.	.	.	1.84	41.0	.
W1D-051	8 20 93	.	.	.	.	.	.	.	.	.	1.82	36.4	37.00
W1D-051	8 25 93	4200.0	6.90	.	.	.	.	.	.	.	1.83	33.8	28.00
W1D-051	8 27 93	.	.	.	.	.	.	.	.	.	1.81	34.9	.
W1D-051	8 30 93	3890.0	6.95	.	.	.	.	.	.	.	1.88	52.8	45.70
W1D-051	9 16 93	3650.0	6.94	.	.	.	.	.	.	.	1.80	30.1	27.10
W1D-052	7 16 93	.	.	.	.	.	.	.	.	.	4.66	222.0	.
W1D-052	7 20 93	2480.0	7.61	1250.0	0.020	0.930	0.020	0.010	205.0	255.0	4.34	78.4	.
W1D-052	7 26 93	2650.0	7.13	1870.0	0.030	0.800	0.040	0.010	250.0	320.0	4.38	96.4	.
W1D-052	7 28 93	.	.	.	.	.	.	.	.	.	4.46	130.0	.
W1D-052	7 29 93	.	.	.	.	.	.	.	.	.	4.48	152.0	.
W1D-052	8 2 93	2600.0	7.05	.	0.030	1.010	0.020	0.020	229.0	267.0	4.30	55.5	.
W1D-052	8 3 93	.	.	.	.	.	.	.	.	.	4.40	52.3	.
W1D-052	8 4 93	2600.0	7.30	.	0.020	0.980	0.040	0.020	235.0	279.0	4.30	63.1	.
W1D-052	8 6 93	.	.	.	.	.	.	.	.	.	4.30	64.6	.
W1D-052	8 9 93	2450.0	7.48	.	0.070	6.200	0.090	0.070	294.0	359.0	4.48	144.0	.

Table A1.3. Water quality data from the input (051) and output (052) of the W1D wetland treatment system, obtained during the 1993 study of the Dunka Mine conducted by the DNR (continued).

Site	Date	S.C.	pH	SO4	Cu	Ni	Co	Zn	Ca	Mg	O.S.S.	Flow rate (gpm) Bucket Gage	Flow rate (gpm) Stream Gage
W1D-052	8 11 93	.	.	.	.	.	.	.	.	.	4.25	35.2	.
W1D-052	8 13 93	.	.	.	.	.	.	.	.	.	4.24	34.9	.
W1D-052	8 16 93	2900.0	7.49	.	.	.	.	.	.	.	4.24	33.2	.
W1D-052	8 20 93	.	.	.	.	.	.	.	.	.	4.20	27.4	54.00
W1D-052	8 25 93	3450.0	7.32	.	.	.	.	.	.	.	4.18	19.8	18.80
W1D-052	8 27 93	.	.	.	.	.	.	.	.	.	4.20	27.7	.
W1D-052	8 30 93	2910.0	7.46	.	.	.	.	.	.	.	4.38	90.4	110.60
W1D-052	9 16 93	3000.0	7.44	.	.	.	.	.	.	.	4.20	24.5	49.60

Notes: The bucket gage values are the average value (gpm) of four buckets. S.C. values are microsiemens, metals and sulfate are mg/L, and O.S.S. values are in feet.

These samples were collected in 1993 by an automatic water sampler:

Site	Sample	Date	Time (hr)	pH	S.C.
W1D-051	1	9 2 93	1430	7.80	2410
W1D-051	2	9 2 93	1600	7.85	2400
W1D-052	1	9 2 93	1500	8.11	2800
W1D-052	2	9 2 93	1630	8.22	2780
W1D-052	3	9 2 93	1800	8.19	2800
W1D-052	4	9 2 93	1930	8.21	2800
W1D-052	5	9 2 93	2100	8.17	2810
W1D-052	6	9 2 93	2230	8.19	2880
W1D-052	7	9 2 93	2400	8.17	2850
W1D-052	8	9 3 93	130	8.17	2820
W1D-052	9	9 3 93	300	8.15	2820
W1D-052	10	9 3 93	430	8.15	2880
W1D-052	11	9 3 93	600	8.10	2880

Site	Sample	Date	Time (hr)	pH	S.C.
W1D-052	12	9 3 93	730	8.11	2870
W1D-052	13	9 3 93	900	8.11	2880
W1D-052	14	9 3 93	1030	8.11	2850
W1D-052	15	9 3 93	1200	8.12	2880
W1D-052	16	9 3 93	1330	8.14	2860
W1D-052	17	9 3 93	1500	8.14	2840
W1D-052	18	9 3 93	1630	8.16	2850
W1D-052	19	9 3 93	1800	8.13	2880
W1D-052	20	9 3 93	1930	8.22	2840

Notes: Staff gage for 051-#1 was 2.01, 4.66 for 052-#1.

Table A1.4. Water quality data for individual seeps at Seep 1; from samples collected by the DNR in 1993.

Seep	Date	pH	S.C.	Sulfate	Cu	Ni	Co	Zn	Ca	Mg	OSS	Flow (L/sec)
S1	7 15 93	6.93	1550.0	.	0.28	10.60	0.61	1.02	.	.	1.28	0.485
S1	7 16 93	.	.	.	.	.	.	.	.	.	1.40	1.218
S1	7 19 93	.	.	.	.	.	.	.	.	.	1.28	0.662
S1	7 20 93	6.80	1710.0	1090.0	0.35	9.67	0.50	1.00	190.0	151.0	.	.
S1	7 26 93	.	.	.	.	.	.	.	.	.	1.28	0.719
S1	7 27 93	6.80	1900.0	1330.0	0.28	10.70	0.61	1.06	200.0	180.0	.	.
S1	7 28 93	.	.	.	.	.	.	.	.	.	1.36	0.776
S1	8 2 93	.	.	.	.	.	.	.	.	.	1.28	0.479
S1	8 3 93	.	.	.	.	.	.	.	.	.	1.28	0.562
S1	8 4 93	7.09	1700.0	955.0	0.31	10.00	0.56	1.21	188.0	156.0	1.28	0.498
S1	8 5 93	.	.	.	.	.	.	.	.	.	1.26	0.744
S1	8 9 93	7.15	1720.0	1125.0	0.25	9.83	0.53	0.98	183.0	164.0	1.34	Med
S1	8 16 93	7.39	1920.0	1150.0	0.22	10.00	0.57	1.12	228.0	182.0	1.24	0.404
S1	8 17 93	7.25	2100.0	1150.0	0.22	10.00	0.54	1.10	234.0	190.0	1.24	0.300
S1	8 30 93	7.19	2340.0	1430.0	0.13	8.97	0.46	0.78	242.0	204.0	1.25	.
S1	9 16 93	7.23	1800.0	1015.0	0.12	6.43	0.32	0.74	206.0	160.0	1.23	0.267
S1	9 28 93	7.17	1950.0	1095.0	0.09	6.27	0.26	0.58	218.0	168.0	1.23	0.240
S2	7 15 93	4.55	2100.0	.	1.42	15.80	0.97	2.74	.	.	.	Hi
S2	7 20 93	4.68	1900.0	1370.0	1.26	13.00	0.69	2.25	175.0	170.0	.	Hi
S2	7 27 93	4.46	2000.0	1340.0	1.38	15.00	0.90	3.49	219.0	209.0	.	.
S2	8 4 93	4.58	1700.0	1070.0	1.15	11.00	0.71	2.18	181.0	163.0	.	Low
S2	8 10 93	4.67	1800.0	1090.0	1.08	13.00	0.75	3.15	186.0	160.0	.	Low
S2	8 17 93	4.38	2550.0	1660.0	1.46	17.00	1.07	3.80	252.0	252.0	.	0.023
S2	8 30 93	4.64	2680.0	1710.0	1.30	17.00	1.04	3.80	254.0	248.0	.	0.023
S2	9 16 93	4.77	2450.0	1600.0	1.04	16.00	0.84	3.19	264.0	238.0	.	0.009

Table A1.4. Water quality data for individual seeps at Seep 1; from samples collected by the DNR in 1993, continued.

Seep	Date	pH	S.C.	Sulfate	Cu	Ni	Co	Zn	Ca	Mg	OSS	Flow (L/sec)
S3	7 15 93	4.41	2700.0	.	2.36	28.00	1.84	4.89	.	.	.	Med
S3	7 20 93	4.52	2650.0	1840.0	1.96	24.00	1.40	4.13	240.0	255.0	.	Med
S3	7 27 93	4.29	2800.0	2320.0	2.37	29.00	1.89	6.65	265.0	313.0	.	.
S3	8 4 93	4.38	2760.0	1880.0	2.23	24.00	1.75	6.52	268.0	301.0	.	Low
S3	8 10 93	4.34	1820.0	2030.0	2.05	25.00	1.69	6.84	280.0	276.0	.	Low
S3	8 17 93	4.20	3600.0	2420.0	2.51	30.00	2.14	7.94	336.0	370.0	.	0.006
S3	8 30 93	4.38	3460.0	2280.0	1.94	28.00	2.07	7.42	302.0	338.0	.	0.004
S4	7 15 93	4.44	3410.0	.	6.33	55.00	3.74	4.13	.	.	.	Hi
S4	7 20 93	4.55	3550.0	2640.0	5.78	48.00	3.14	3.54	325.0	325.0	.	Hi
S4	7 27 93	4.26	3000.0	2580.0	5.74	45.00	3.23	3.94	344.0	316.0	.	.
S4	8 4 93	4.50	3000.0	1880.0	5.09	40.00	3.08	4.38	332.0	313.0	.	Low
S4	8 10 93	4.46	2920.0	1980.0	4.78	43.00	2.99	4.30	312.0	298.0	.	Low
S4	8 17 93	4.43	3360.0	1960.0	4.68	42.00	3.21	4.61	338.0	338.0	.	0.017
S4	8 30 93	4.57	3320.0	2150.0	2.97	36.00	2.74	4.58	306.0	318.0	.	0.006
S4	9 16 93	4.79	3100.0	2180.0	2.57	30.00	2.03	3.16	352.0	316.0	.	0.002
S5	7 15 93	4.47	1600.0	.	4.43	27.00	1.87	1.59	.	.	.	Low
S5	7 20 93	4.57	1620.0	1035.0	4.02	29.00	1.81	1.49	160.0	115.0	.	Low
S5	7 27 93	4.23	1450.0	1005.0	3.50	24.00	1.65	1.59	148.0	112.0	.	.
S5	8 4 93	4.51	1150.0	600.0	3.31	20.00	1.45	1.33	123.0	84.0	.	0.000
S5	8 10 93	4.51	1210.0	635.0	2.97	22.00	1.99	1.30	114.0	78.0	.	0.000
S5	8 17 93	4.49	1320.0	690.0	2.70	19.00	1.49	1.29	130.0	84.0	.	0.000
S5	8 30 93	4.56	1510.0	880.0	2.46	19.00	1.48	1.36	146.0	104.0	.	0.000
S5	9 16 93	4.69	2500.0	1640.0	3.23	27.00	1.98	2.09	290.0	214.0	.	0.000

Table A1.4. Water quality data for individual seeps at Seep 1; from samples collected by the DNR in 1993, continued.

Seep	Date	pH	S.C.	Sulfate	Cu	Ni	Co	Zn	Ca	Mg	OSS	Flow (L/sec)
S6	7 15 93	4.51	1600.0	.	3.20	19.70	1.49	1.60	.	.	.	Low
S6	7 20 93	4.64	1410.0	890.0	2.97	20.00	1.36	1.33	160.0	90.0	.	Low
S6	7 27 93	4.32	1300.0	850.0	2.54	16.00	1.22	1.45	151.0	88.0	.	.
S6	8 4 93	4.57	1300.0	730.0	2.64	16.00	1.30	1.42	146.0	88.0	.	0.000
S6	8 10 93	4.53	1400.0	735.0	2.49	17.00	1.32	1.44	154.0	86.0	.	0.000
S6	8 17 93	4.49	1490.0	900.0	2.53	17.00	1.40	1.54	164.0	94.0	.	0.000
S6	8 30 93	4.58	1390.0	700.0	2.08	14.00	1.16	1.27	142.0	84.0	.	0.000
S6	9 16 93	4.79	2100.0	1080.0	2.43	17.00	1.30	1.46	194.0	116.0	.	0.000
S7	7 15 93	4.57	2450.0	.	5.21	25.00	2.12	2.61	.	.	.	Med
S7	7 20 93	4.78	2200.0	1360.0	3.94	23.00	1.71	2.01	285.0	165.0	.	Med
S7	7 27 93	4.38	2100.0	1380.0	3.52	19.00	1.62	2.17	282.0	165.0	.	.
S7	8 4 93	4.62	2000.0	1420.0	3.74	20.00	1.72	2.06	279.0	155.0	.	Low
S7	8 10 93	4.84	1880.0	1115.0	1.59	19.00	1.53	2.12	242.0	126.0	.	0.000
S7	8 17 93	4.67	2000.0	1430.0	1.63	19.00	1.62	2.15	238.0	132.0	.	0.000
S7	8 30 93	4.81	2020.0	1130.0	1.29	17.00	1.48	1.95	218.0	132.0	.	Low
S8	7 15 93	4.61	1950.0	.	1.45	11.90	0.70	2.50	.	.	.	Low
S8	7 20 93	4.72	1780.0	1140.0	1.20	9.51	0.55	1.95	175.0	155.0	.	Low
S8	7 27 93	4.38	2150.0	1300.0	1.61	13.00	0.80	2.84	227.0	205.0	.	.
S8	8 4 93	4.63	1900.0	1315.0	1.42	10.00	0.69	2.26	196.0	181.0	.	Med
S8	8 10 93	4.61	1900.0	1180.0	1.30	11.00	0.73	2.23	202.0	162.0	.	Low
S8	8 17 93	4.58	2250.0	1469.0	1.44	12.00	0.84	2.40	234.0	210.0	.	0.014
S8	8 30 93	4.58	2620.0	1550.0	1.50	14.00	0.95	2.70	260.0	230.0	.	0.023
S8	9 16 93	4.74	2000.0	1365.0	1.14	9.90	0.68	2.04	216.0	190.0	.	0.015

Table A1.4. Water quality data for individual seeps at Seep 1; from samples collected by the DNR in 1993, continued.

Seep	Date	pH	S.C.	Sulfate	Cu	Ni	Co	Zn	Ca	Mg	OSS	Flow (L/sec)
S9	7 15 93	4.70	1800.0	.	1.07	9.90	0.58	2.28	.	.	.	Med
S9	7 20 93	5.08	1600.0	1030.0	0.68	6.73	0.38	1.63	145.0	140.0	.	Med
S9	7 27 93	4.62	2000.0	1280.0	1.07	10.00	0.64	2.59	209.0	198.0	.	.
S9	8 4 93	4.76	1750.0	1085.0	0.91	9.14	0.54	2.06	176.0	169.0	.	Low
S9	8 10 93	4.82	1800.0	1040.0	1.78	8.90	0.54	2.00	174.0	150.0	.	0.000
S9	8 17 93	4.65	2150.0	1430.0	1.16	11.00	0.78	2.36	222.0	204.0	.	0.000
S9	8 30 93	4.66	2530.0	1590.0	1.18	12.00	0.84	2.57	252.0	228.0	.	0.008
S9	9 16 93	4.88	2000.0	1300.0	0.88	8.73	0.61	1.87	202.0	186.0	.	0.008
S10	7 15 93	4.57	2350.0	.	2.60	23.00	1.44	3.97	.	.	.	0.000
S10	7 20 93	4.70	2240.0	1440.0	2.14	20.00	1.14	3.00	235.0	195.0	.	0.000
S10	7 27 93	4.40	2210.0	1320.0	2.24	20.00	1.20	3.78	254.0	221.0	.	.
S10	8 4 93	4.66	1900.0	1335.0	1.98	19.00	1.26	2.90	221.0	185.0	.	0.000
S10	8 10 93	4.70	1790.0	1065.0	1.60	14.00	1.16	2.43	198.0	136.0	.	0.000
S10	8 17 93	4.69	2250.0	735.0	1.41	22.00	1.50	2.59	252.0	194.0	.	0.000
S10	8 30 93	4.68	2400.0	1400.0	1.77	20.00	1.40	2.61	256.0	184.0	.	0.000

Notes: All flow measurements were taken under low flow conditions, with the exception of S1, which was bucket gaged. S10 had no visual flow, so water quality samples were taken from standing water. Qualitative flow descriptors may be estimated as follows:

Low = <0.063 L/sec (<1 gpm)
Med = 0.063 to 0.505 L/sec (1 to 8 gpm)
Hi = >0.505 L/sec (>8 gpm)

Specific conductance values are in microsiemens, pH values are in standard units, and all other water quality parameters are in mg/L.

Table A1.5. Water quality data for Seep 1; samples collected by the DNR from 1997-1999.

Site	Date	Sample	S.C.	pH	Cu	Ni	Co	Zn	SO4	Ca	Mg
Pool Samples											
043-1	5 1 97	18000	800.0	6.64	0.100	1.800	0.100	0.280	284.4	.	.
043-1	5 15 97	18016	800.0	6.69	0.200	2.200	0.065	0.540	456.0	.	.
043-1	5 29 97	18029	1000.0	6.62	0.200	4.600	0.200	0.650	601.0	.	.
043-1	6 12 97	18044	2500.0	5.81	2.000	26.400	1.400	2.640	1594.0	.	.
043-1	6 30 97	18059	2100.0	4.93	4.400	26.700	.	.	1598.0	276.0	217.0
043-1	7 14 97	18073	3000.0	5.44	2.400	19.700	.	.	1499.0	287.0	199.0
043-1	7 24 97	18087	2200.0	6.27	1.000	14.900	0.700	1.600	1302.0	.	.
043-1	8 7 97	18116	1800.0	6.30	0.900	14.000	0.600	1.370	1440.0	.	.
043-1	8 22 97	18134	1790.0	5.84	1.600	11.700	.	.	1150.0	230.0	161.0
043-1	9 4 97	18154	1950.0	6.39	0.890	14.300	.	.	1393.0	267.0	181.0
043-1	9 17 97	18170	1700.0	6.37	1.610	13.200	.	.	1116.0	241.0	125.0
043-1	10 1 97	18185	2200.0	5.92	1.100	13.000	.	.	1555.0	274.0	214.0
043-1	10 14 97	18199	1200.0	6.50	0.720	9.400	.	.	795.0	178.0	80.9
043-2	5 1 97	18001	600.0	6.82	0.100	1.800	0.100	0.300	272.9	.	.
043-2	5 15 97	18017	750.0	6.85	0.100	2.100	0.050	0.390	407.0	.	.
043-2	5 29 97	18030	750.0	6.76	0.200	4.100	0.100	0.440	424.0	.	.
043-2	6 12 97	18045	2500.0	5.88	2.100	25.400	1.300	2.680	1524.0	.	.
043-2	6 30 97	18060	2000.0	5.39	1.900	18.200	.	.	1230.0	218.0	170.0
043-2	7 14 97	18074	2700.0	6.14	1.300	17.400	.	.	1295.0	246.0	178.0
043-2	7 24 97	18088	2075.0	6.19	1.300	15.400	0.700	1.900	1384.0	.	.
043-2	8 7 97	18117	1850.0	6.44	0.900	14.000	0.600	1.690	1324.0	.	.
043-2	8 22 97	18135	975.0	6.37	0.900	7.500	.	.	519.0	116.0	65.7
043-2	9 4 97	18155	2100.0	6.54	0.860	14.600	.	.	1392.0	255.0	191.0
043-2	9 17 97	18171	2125.0	6.54	1.200	15.600	.	.	1402.0	277.0	177.0
043-2	10 1 97	18186	2100.0	6.23	1.100	16.200	.	.	1422.0	274.0	189.0
043-2	10 14 97	18200	1350.0	6.73	0.340	6.800	.	.	816.0	159.0	102.0

Table A1.5. Water quality data for the Seep 1 samples collected by DNR from 1997-1999 (continued).

Site	Date	Sample	S.C.	pH	Cu	Ni	Co	Zn	SO_4	Ca	Mg
043-3	5 1 97	18002	500.0	7.04	0.063	0.500	0.017	0.100	143.1	.	.
043-3	5 15 97	18018	500.0	6.98	0.100	1.500	0.056	0.260	207.0	.	.
043-3	5 29 97	18031	400.0	7.17	0.039	0.300	0.007	0.060	133.0	.	.
043-3	6 12 97	18046	2600.0	5.04	3.200	31.000	1.900	3.170	1760.0	.	.
043-3	6 30 97	18061	2200.0	5.35	2.700	24.900	.	.	1531.0	260.0	215.0
043-3	7 14 97	18075	2500.0	5.09	2.900	24.300	.	.	1627.0	300.0	228.0
043-3	7 24 97	18089	2425.0	5.19	2.300	19.900	1.100	2.400	1563.0	.	.
043-3	8 7 97	18118	2050.0	6.05	1.400	16.000	0.800	2.460	1538.0	.	.
043-3	8 22 97	18136	1325.0	6.70	0.370	7.200	.	.	681.0	236.0	94.6
043-3	9 4 97	18156	2350.0	6.30	1.180	17.000	.	.	1604.0	275.0	222.0
043-3	9 17 97	18172	2275.0	6.70	0.500	14.600	.	.	1518.0	283.0	212.0
043-3	10 1 97	18187	2200.0	6.37	0.800	16.000	.	.	1572.0	292.0	213.0
043-3	10 14 97	18201	1500.0	6.62	0.360	7.900	.	.	917.0	178.0	118.0
043-4	5 1 97	18003	.	.	0.100	1.700	0.065	0.270	.	.	.
043-4	5 15 97	18019	750.0	6.94	0.100	2.100	0.042	0.380	370.0	.	.
043-4	5 29 97	18032	1050.0	6.91	0.074	3.200	0.063	0.500	616.0	.	.
043-4	6 12 97	18047	2400.0	5.91	1.500	21.000	1.000	2.580	1531.0	.	.
043-4	6 30 97	18062	2000.0	5.38	2.200	18.600	.	.	1395.0	247.0	204.0
043-4	7 14 97	18076	2600.0	5.86	1.600	17.000	.	.	1609.0	285.0	221.0
043-4	7 24 97	18090	2390.0	6.28	0.700	15.100	0.600	1.700	1390.0	.	.
043-4	8 7 97	18119	2050.0	6.56	0.500	13.300	0.500	1.540	1518.0	.	.
043-4	8 22 97	18137	1775.0	5.98	1.400	11.100	.	.	1092.0	224.0	150.0
043-4	9 4 97	18157	2250.0	6.68	0.500	12.600	.	.	1451.0	270.0	196.0
043-4	9 17 97	18173	2225.0	6.75	0.480	13.100	.	.	1472.0	281.0	197.0
043-4	10 1 97	18188	2000.0	6.60	0.600	12.400	.	.	1367.0	264.0	178.0
043-4	10 14 97	18202	1475.0	5.96	1.130	9.500	.	.	888.0	162.0	110.0
043-5	5 1 97	18004	700.0	6.94	0.100	1.300	0.057	0.260	294.4	.	.
043-5	5 15 97	18020	650.0	6.97	0.077	1.600	0.039	0.270	.	.	.
043-5	5 29 97	18033	950.0	6.80	0.500	5.800	0.200	0.580	512.0	.	.

Table A1.5. Water quality data for the Seep 1 samples collected by DNR from 1997-1999 (continued).

Site	Date	Sample	S.C.	pH	Cu	Ni	Co	Zn	SO_4	Ca	Mg
043-5	6 12 97	18048	2500.0	5.86	2.300	27.400	1.400	2.820	1601.0	.	.
043-5	6 30 97	18063	1900.0	5.56	2.100	19.000	.	.	1279.0	226.0	180.0
043-5	7 14 97	18077	2400.0	6.13	1.200	18.400	.	.	1487.0	275.0	200.0
043-5	7 24 97	18091	2310.0	6.37	1.000	16.300	0.600	1.800	1418.0	.	.
043-5	8 7 97	18120	2100.0	6.51	0.600	13.700	0.500	1.570	1445.0	.	.
043-5	8 22 97	18138	1600.0	6.43	0.780	11.100	.	.	1015.0	209.0	144.0
043-5	9 4 97	18158	2100.0	6.73	0.560	13.500	.	.	1450.0	271.0	203.0
043-5	9 17 97	18174	2200.0	6.83	0.400	13.300	.	.	1463.0	274.0	202.0
043-5	10 1 97	18189	2100.0	6.79	0.400	.	.	.	1432.0	273.0	187.0
043-5	10 14 97	18203	1400.0	6.71	0.400	8.100	.	.	879.0	166.0	111.0
043-6	5 1 97	18005	800.0	6.84	0.200	1.600	0.031	0.200	360.8	.	.
043-6	5 15 97	18021	700.0	6.92	0.076	3.000	0.043	0.290	318.0	.	.
043-6	5 29 97	18034	850.0	6.96	0.100	1.400	0.008	0.120	459.0	.	.
043-6	6 12 97	18049	1900.0	6.65	0.200	8.600	0.052	0.270	1197.0	.	.
043-6	6 30 97	18064	1700.0	6.39	0.900	15.300	.	.	1128.0	210.0	158.0
043-6	7 14 97	18078	2400.0	6.42	0.900	18.500	.	.	1500.0	281.0	205.0
043-6	7 24 97	18092	2375.0	6.61	0.400	15.400	0.400	1.500	1447.0	.	.
043-6	8 7 97	18121	2000.0	6.64	0.300	12.800	0.300	1.460	1482.0	.	.
043-6	8 22 97	18139	1750.0	6.65	0.390	11.000	.	.	1149.0	239.0	157.0
043-6	9 4 97	18159	2100.0	6.92	0.200	11.200	.	.	1405.0	263.0	190.0
043-6	9 17 97	18175	2175.0	7.12	0.200	11.200	.	.	1432.0	273.0	198.0
043-6	10 1 97	18190	2050.0	7.09	0.180	10.400	.	.	1333.0	258.0	178.0
043-6	10 14 97	18204	1500.0	6.69	0.540	9.000	.	.	964.0	177.0	124.0
043-6	6 2 98	18215	2200.0	6.75	0.600	19.500	0.600	1.960	1268.0	255.0	223.0
043-6	6 10 98	18218	2100.0	6.81	0.200	14.900	0.200	1.400	1235.0	258.0	206.0
043-6	6 24 98	18220	1850.0	6.53	0.400	14.900	0.300	1.630	1272.0	231.0	183.0
043-6	7 10 98	18222	2100.0	6.75	0.100	8.400	0.100	0.920	1302.0	279.0	196.0
043-6	7 21 98	18224	2100.0	7.13	0.200	15.000	0.200	1.360	1413.0	292.0	216.0
043-6	8 5 98	18226	2300.0	7.33	0.170	13.800	0.100	1.100	1475.0	326.0	218.0
043-6	8 20 98	18230	1900.0	6.91	0.260	10.000	0.200	1.420	1143.0	269.0	173.0

Table A1.5. Water quality data for the Seep 1 samples collected by DNR from 1997-1999 (continued).

Site	Date	Sample	S.C.	pH	Cu	Ni	Co	Zn	SO_4	Ca	Mg
043-6	9 4 98	18232	2000.0	.	0.100	9.900	.	1.220	1361.0	298.0	194.0
043-6	9 17 98	18236	2100.0	7.13	0.100	9.000	0.100	1.030	1353.0	294.0	193.0
043-6	9 30 98	18241	2000.0	7.53	0.100	8.900	0.100	1.080	1250.0	280.0	180.0
043-6	10 16 98	18244	1600.0	6.44	0.098	8.060	0.116	0.932	932.0	.	.
043-6	10 20 98	18252	1300.0	5.44	0.330	7.400	0.629	.	529.0	.	.
043-6	11 3 98	18263	2150.0	6.63	0.118	10.400	0.285	1.950	1366.0	.	.
043-6	4 2 99	18265	110.0	6.67	.	.	.	.	36.9	.	.
043-6	4 27 99	18271	900.0	6.72	0.062	6.080	0.142	0.609	519.0	.	.
043-6	5 14 99	18274	1400.0	6.35	0.193	7.771	0.160	0.991	971.0	.	.
043-6	6 15 99	18283	2000.0	5.34	1.191	10.470	0.533	1.513	1318.0	.	.
043-6	7 7 99	18289	1275.0	4.74	1.520	10.900	0.647	1.670	752.0	.	.
043-6	7 28 99	18301	1700.0	5.25	1.420	13.900	0.890	1.990	1261.0	231.0	183.0
043-6	8 6 99	18304	2150.0	5.64	0.555	.	.	.	1500.0	276.0	220.0
043-6	8 20 99	18310	1900.0	5.89	1.060	13.500	0.790	2.130	1378.0	253.0	203.0
043-6	9 10 99	18313	1450.0	6.34	0.450	8.400	0.410	1.410	1011.0	199.0	139.0
043-6	9 23 99	18319	2150.0	6.35	0.550	9.420	0.480	1.630	1326.0	278.0	178.0
043-6	10 8 99	18322	.	.	.	.	.	.	.	.	.
043-7	5 1 97	18006	800.0	7.00	0.100	1.500	0.063	0.260	354.9	.	.
043-7	5 15 97	18022	750.0	7.03	0.066	1.700	0.032	0.270	352.0	.	.
043-7	5 29 97	18035	900.0	7.09	0.100	3.400	0.071	0.360	483.0	.	.
043-7	6 12 97	18050	2000.0	6.72	0.400	15.900	0.500	1.600	1228.0	.	.
043-7	6 30 97	18065	1800.0	6.32	1.100	15.800	.	.	1148.0	231.0	166.0
043-7	7 14 97	18079	2400.0	6.53	0.800	17.800	.	.	1469.0	278.0	206.0
043-7	7 24 97	18093	2325.0	6.54	0.500	15.000	0.500	1.600	1388.0	.	.
043-7	8 7 97	18122	2000.0	6.74	0.300	12.900	0.400	1.260	1486.0	.	.
043-7	8 22 97	18140	1690.0	6.61	0.570	11.100	.	.	1136.0	233.0	152.0
043-7	9 4 97	18160	2050.0	6.90	0.300	11.600	.	.	1385.0	270.0	188.0
043-7	9 17 97	18176	2200.0	7.05	0.200	11.500	.	.	1446.0	269.0	193.0
043-7	10 1 97	18191	2000.0	7.01	0.210	10.600	.	.	1327.0	260.0	178.0
043-7	10 14 97	18205	1525.0	6.72	0.550	8.900	.	.	920.0	175.0	119.0

Table A1.5. Water quality data for the Seep 1 samples collected by DNR from 1997-1999 (continued).

Site	Date	Sample	S.C.	pH	Cu	Ni	Co	Zn	SO_4	Ca	Mg
043-8	5 1 97	18007	780.0	7.03	0.100	1.400	0.058	0.240	336.0	.	.
043-8	5 15 97	18023	750.0	7.01	0.066	1.800	0.036	0.280	350.0	.	.
043-8	5 29 97	18036	900.0	6.98	0.300	4.600	0.200	0.450	485.0	.	.
043-8	6 12 97	18051	2100.0	6.69	0.600	16.500	0.500	1.580	1290.0	.	.
043-8	6 30 97	18066	1900.0	6.06	1.600	16.600	.	.	1185.0	209.0	167.0
043-8	7 14 97	18080	2800.0	6.41	1.000	18.400	.	.	1494.0	278.0	201.0
043-8	7 24 97	18094	2225.0	6.55	0.600	15.400	0.500	1.700	1442.0	.	.
043-8	8 7 97	18123	2000.0	6.69	0.400	13.200	0.400	1.330	1470.0	.	.
043-8	8 22 97	18141	1225.0	6.47	0.600	8.000	.	.	754.0	147.0	99.8
043-8	9 4 97	18161	2100.0	6.90	0.300	11.900	.	.	1362.0	265.0	191.0
043-8	9 17 97	18177	2175.0	7.03	0.290	11.900	.	.	1459.0	273.0	197.0
043-8	10 1 97	18192	2100.0	7.01	0.220	10.800	.	.	1345.0	262.0	180.0
043-8	10 14 97	18206	1500.0	6.70	0.450	8.400	.	.	919.0	172.0	119.0
043-W	5 1 97	18008	800.0	7.00	0.100	1.500	0.050	0.200	358.5	.	.
043-W	7 14 97	18081	2700.0	6.68	0.400	14.000	.	.	1442.0	275.0	197.0
043-W	7 24 97	18095	.	.	0.200	10.700	0.300	1.000	1521.0	.	.
043-W	8 7 97	18124	2050.0	6.91	0.100	8.600	0.200	0.680	1490.0	.	.
043-W	8 22 97	18142	1475.0	6.68	0.350	7.200	.	.	936.0	191.0	129.0
043-W	9 4 97	18162	2100.0	6.97	0.160	7.800	.	.	1331.0	266.0	181.0
043-W	9 17 97	18178	2080.0	7.13	0.100	8.200	.	.	1395.0	266.0	186.0
043-W	10 1 97	18193	2100.0	7.10	0.100	8.400	.	.	1357.0	269.0	180.0
043-W	10 14 97	18207	1600.0	6.83	0.330	7.700	.	.	963.0	182.0	127.0
043-W	4 2 99	18266	300.0	6.83	.	.	.	.	138.0	.	.
043-W	4 27 99	18272	.	.	.	.	.	.	576.0	.	.
043-W	5 14 99	18275	.	.	.	.	.	.	1012.0	.	.
043-WB	5 1 97	18009	800.0	7.02	0.100	1.600	0.053	0.230	350.4	.	.
043-WB	5 29 97	18037	850.0	7.20	0.055	2.300	0.027	0.240	462.0	.	.
043-WB	6 12 97	18052	1800.0	6.87	0.200	8.500	0.094	0.570	1106.0	.	.
043-WB	6 30 97	18067	1800.0	6.59	0.500	13.300	.	.	1062.0	213.0	160.0

Table A1.5. Water quality data for the Seep 1 samples collected by DNR from 1997-1999 (continued).

Site	Date	Sample	S.C.	pH	Cu	Ni	Co	Zn	SO_4	Ca	Mg
043-WB	7 14 97	18082	1400.0	6.71	0.400	14.700	.	.	1589.0	277.0	199.0
043-WB	7 24 97	18096	2350.0	6.55	0.200	11.600	0.300	1.100	1449.0	.	.
043-WB	8 7 97	18125	2050.0	6.86	0.200	9.600	0.200	0.860	1497.0	.	.
043-WB	8 22 97	18143	1500.0	6.64	0.380	7.400	.	.	927.0	187.0	125.0
043-WB	9 4 97	18163	2150.0	6.94	0.190	8.300	.	.	1354.0	269.0	184.0
043-WB	9 17 97	18179	2100.0	7.16	0.100	7.500	.	.	1418.0	266.0	187.0
043-WB	10 1 97	18194	2100.0	7.10	0.100	8.600	.	.	1360.0	269.0	180.0
043-WB	10 14 97	18208	1650.0	6.80	0.340	7.600	.	.	985.0	186.0	128.0
043-WB	6 2 98	18216	2250.0	7.00	0.260	15.800	0.300	1.480	1262.0	252.0	212.0
043-WB	6 10 98	18219	2150.0	6.63	0.460	16.700	0.300	1.730	1253.0	255.0	209.0
043-WB	6 24 98	18221	1850.0	6.71	0.200	10.300	0.200	1.240	1224.0	238.0	187.0
043-WB	7 10 98	18223	2050.0	6.88	0.380	15.400	0.300	1.600	1305.0	277.0	198.0
043-WB	7 21 98	18225	2100.0	7.12	0.100	6.700	-0.100	0.640	1364.0	302.0	207.0
043-WB	8 5 98	18227	2300.0	7.20	0.080	6.700	-0.100	0.590	1284.0	321.0	213.0
043-WB	8 20 98	18231	1800.0	7.00	0.100	8.000	0.100	1.000	1157.0	275.0	181.0
043-WB	9 4 98	18233	2000.0	7.64	0.100	7.900	0.100	0.880	1341.0	298.0	194.0
043-WB	9 17 98	18237	2100.0	7.28	0.060	6.600	-0.100	0.660	1342.0	294.0	198.0
043-WB	9 30 98	18242	2000.0	7.06	0.060	7.200	0.100	0.790	1251.0	283.0	181.0
043-WB	10 16 98	18245	1650.0	6.79	0.073	6.510	0.054	0.687	1431.0	.	.
043-WB	10 20 98	18253	1500.0	5.93	0.340	9.300	0.570	0.001	687.0	.	.
043-WB	11 3 98	18264	2150.0	7.42	.	.	.	.	1446.0	.	.
043-WB	4 2 99	18266	300.0	6.83	0.074	1.434	0.097	0.237	138.0	.	.
043-WB	4 27 99	18272	1000.0	6.94	0.100	4.631	0.134	0.455	576.0	.	.
043-WB	5 14 99	18275	1550.0	6.60	0.131	6.509	0.127	0.918	1012.0	.	.
043-WB	6 15 99	18284	2025.0	6.11	0.533	8.912	0.340	1.168	1360.0	.	.
043-WB	7 7 99	18290	1525.0	4.76	1.320	9.000	0.536	1.280	901.0	.	.
043-WB	7 28 99	18302	2000.0	5.89	1.320	14.700	0.880	1.970	.	250.0	199.0
043-WB	8 6 99	18305	2100.0	6.36	0.630	13.400	0.620	1.570	1480.0	282.0	208.0
043-WB	8 20 99	18311	2000.0	6.26	0.700	12.100	0.600	1.720	1333.0	258.0	202.0
043-WB	9 10 99	18314	1600.0	6.43	0.390	8.360	0.380	1.250	1070.0	231.0	153.0
043-WB	9 23 99	18320	1800.0	6.55	0.350	8.510	0.360	1.380	1284.0	284.0	183.0

Table A1.5. Water quality data for the Seep 1 samples collected by DNR from 1997-1999 (continued).

Site	Date	Sample	S.C.	pH	Cu	Ni	Co	Zn	SO_4	Ca	Mg
043-WB	10 8 99	18323	1200.0	6.36	0.350	5.360	0.300	0.970	717.0	151.0	99.3
Piezometer Samples											
P1	10 16 98	18246	.	.	0.003	0.062	0.021	0.044	.	.	.
P2	10 16 98	18247	.	.	0.009	0.160	0.033	0.108	.	.	.
P3	10 16 98	18248	.	.	0.050	9.810	0.099	0.138	.	.	.
P4	10 16 98	18249	.	.	0.005	0.155	0.027	0.031	.	.	.
P5	10 16 98	18250	.	.	0.003	33.300	1.810	0.043	.	.	.
P6	10 16 98	18251	.	.	0.660	31.000	1.610	1.910	.	.	.
Seeps											
S2	5 1 97	18010	700.0	5.43	0.200	3.400	0.200	0.450	315.5	.	.
S2	5 15 97	18024	750.0	5.25	0.300	3.700	0.200	0.550	396.0	.	.
S2	5 29 97	18038	700.0	5.31	0.300	3.000	0.100	0.490	347.0	.	.
S2	6 12 97	18053	3300.0	4.46	3.700	38.400	2.400	4.700	2335.0	.	.
S2	6 30 97	18068	2700.0	4.47	2.300	23.400	.	.	1935.0	294.0	264.0
S2	7 14 97	18083	2000.0	4.43	2.000	20.200	.	.	1969.0	287.0	240.0
S2	7 24 97	18097	2900.0	4.44	2.000	19.900	1.200	4.200	2069.0	.	.
S2	8 7 97	18126	2700.0	4.47	2.100	20.100	1.200	4.940	2215.0	.	.
S2	8 22 97	18144	1950.0	4.70	1.400	13.600	.	.	1411.0	207.0	192.0
S2	9 4 97	18164	2900.0	4.55	2.060	19.400	.	.	2203.0	308.0	288.0
S2	9 17 97	18180	3025.0	4.62	2.160	21.800	.	.	2450.0	334.0	321.0
S2	10 1 97	18195	1875.0	4.55	.	.	.	.	1050.0	202.0	184.0
S2	10 14 97	18209	2100.0	4.68	1.360	12.900	.	.	1434.0	224.0	179.0
S2	6 2 98	18217	2100.0	4.61	1.750	18.300	1.100	2.470	1200.0	219.0	194.0
S2	10 20 98	18257	.	.	0.536	10.000	0.909	2.770	850.0	.	.
S2	5 14 99	18280	3075.0	.	1.818	17.430	1.322	2.819	2337.0	.	.
S2	7 7 99	18295	1900.0	4.58	1.600	.	.	.	.	.	.
S2	7 7 99	18296	2150.0	4.47	1.710	14.100	1.080	2.540	1385.0	276.0	196.0

Table A1.5. Water quality data for the Seep 1 samples collected by DNR from 1997-1999 (continued).

Site	Date	Sample	S.C.	pH	Cu	Ni	Co	Zn	SO_4	Ca	Mg
S3	5 29 97	18039	1000.0	4.76	0.600	5.400	0.400	1.510	583.0	.	.
S3	6 12 97	18054	4000.0	4.38	4.300	54.300	3.700	5.990	2959.0	.	.
S3	6 30 97	18069	3200.0	4.42	2.400	28.700	.	.	2411.0	363.0	330.0
S3	7 24 97	18098	2750.0	4.39	2.200	24.200	1.600	4.100	1965.0	.	.
S3	8 7 97	18127	2700.0	4.42	2.400	24.600	1.700	4.760	2182.0	.	.
S3	8 22 97	18145	2200.0	4.51	1.950	19.500	.	.	1678.0	217.0	229.0
S3	9 5 97	18165	3500.0	4.44	2.670	31.000	.	.	2807.0	334.0	357.0
S3	10 20 98	18258	1750.0	4.61	.	11.600	0.586	2.590	855.0	.	.
S3	7 7 99	18297	2750.0	4.35	2.400	21.000	1.640	3.910	1847.0	311.0	253.0
S4	8 7 97	18128	1850.0	4.52	3.000	21.100	1.500	2.040	1430.0	.	.
S4	8 22 97	18146	1725.0	4.63	2.900	23.900	.	.	1196.0	195.0	150.0
S4	10 20 98	18259	2150.0	4.68	1.520	21.900	.	2.030	1116.0	.	.
S5	8 22 97	18147	2125.0	4.56	5.700	27.000	.	.	1572.0	287.0	164.0
S5	10 20 98	18260	2450.0	4.67	2.880	35.400	1.880	2.460	1214.0	.	.
S5	5 14 99	18282	4500.0	.	9.816	52.340	4.473	3.369	.	.	.
S5	7 7 99	18298	2225.0	4.58	4.320	23.500	2.020	2.140	1426.0	219.0	200.0
S6	8 7 97	18129	1490.0	4.52	3.900	14.600	1.200	1.180	1063.0	.	.
S6	8 22 97	18148	1325.0	4.62	3.480	14.700	.	.	985.0	183.0	76.5
S6	7 7 99	18299	1825.0	4.51	4.590	16.100	1.520	1.660	1135.0	274.0	112.0
S7	7 24 97	18099	2600.0	4.35	7.300	22.700	2.000	2.400	1751.0	.	.
S7	8 7 97	18130	2250.0	4.44	6.300	19.800	1.700	2.220	1889.0	.	.
S7	8 22 97	18149	1650.0	4.57	4.100	15.000	.	.	1201.0	240.0	100.0
S7	9 17 97	18181	2125.0	4.61	4.660	20.000	.	.	1620.0	327.0	132.0
S7	10 20 98	18261	2050.0	6.55	6.000	.	.	.	32.6	.	.
S7	5 12 99	18281	4200.0	.	8.622	34.610	3.228	2.674	3416.0	.	.
S7	7 7 99	18300	2675.0	4.37	6.680	28.400	2.510	2.480	1777.0	380.0	206.0

Table A1.5. Water quality data for the Seep 1 samples collected by DNR from 1997-1999 (continued).

Site	Date	Sample	S.C.	pH	Cu	Ni	Co	Zn	SO_4	Ca	Mg
S8	5 1 97	18011	1200.0	5.02	0.300	2.200	0.100	0.940	634.0	.	.
S8	8 22 97	18150	1900.0	4.70	1.400	10.900	.	.	1496.0	230.0	196.0
S9	5 1 97	18012	1100.0	4.98	0.200	2.200	0.100	0.870	594.8	.	.
S9	5 15 97	18025	1150.0	4.90	0.300	2.400	0.100	0.960	670.0	.	.
S9	5 29 97	18040	1300.0	4.93	0.300	3.300	0.200	1.250	790.0	.	.
S9	6 12 97	18055	2300.0	4.46	1.800	18.100	1.200	3.500	1577.0	.	.
S9	9 4 97	18166	2500.0	4.62	1.390	10.600	.	.	1791.0	264.0	227.0

Note: pH values are in standard units, specific conductance values are in microsiemens, and all other values are mg/L. Site locations are depicted in Figure 8.

Table A1.6. Historical Seep 1 data (1985-1991), and 1993-94 data from the surface sites within the Seep 1 pretreatment system.

Note: The "historic" values (i.e. before construction of the pretreatment system) presented here are from site 043 before construction of the pretreatment system. pH values are in standard units, all other values are mg/L.

Site	Date	Cu	Ni	Co	Zn	Ca	SO4	pH
Historic	6 14 85	0.81	32.0	1.4	1.6	200.0	1850	5.3
Historic	6 24 85	0.57	21.0	2.1	2.4	150.0	1300	5.3
Historic	7 12 85	0.81	27.0	1.4	1.8	200.0	1700	4.9
Historic	7 25 85	0.60	21.0	1.9	2.1	180.0	1600	5.1
Historic	8 16 85	0.48	20.0	1.3	1.6	240.0	1400	5.2
Historic	8 28 85	0.42	19.0	1.4	1.5	230.0	1300	5.2
Historic	6 13 86	1.10	25.0	1.8	2.2	130.0	1400	5.2
Historic	6 24 86	1.00	24.0	1.6	2.1	170.0	1400	5.1
Historic	7 9 86	0.84	21.0	1.5	1.9	180.0	1200	5.3
Historic	7 28 86	0.84	22.0	1.5	2.0	200.0	1600	5.3
Historic	8 11 86	0.62	12.0	1.4	1.3	200.0	1300	5.5
Historic	8 21 86	0.56	18.0	1.4	1.3	210.0	1450	5.6
Historic	6 11 87	0.90	22.0	1.6	1.8	.	1700	5.4
Historic	6 23 87	1.10	31.0	2.2	2.3	.	2650	5.3
Historic	7 15 87	0.72	17.0	1.1	1.3	.	1400	5.3
Historic	7 28 87	0.77	26.0	1.6	1.7	.	1780	5.4
Historic	8 13 87	0.55	19.0	1.4	1.4	.	1750	5.4
Historic	8 24 87	0.44	14.0	1.0	1.1	.	1600	5.5
Historic	6 1 88	0.74	32.0	2.5	2.0	.	2100	5.3
Historic	6 29 88	0.62	23.0	1.5	1.6	.	1700	5.2
Historic	7 13 88	0.81	30.0	2.4	2.1	.	1925	5.3
Historic	7 28 88	0.49	26.0	2.1	1.5	.	1950	5.5
Historic	8 11 88	0.60	25.0	1.9	2.6	.	1800	5.2
Historic	8 25 88	0.60	15.0	1.0	1.9	.	1275	5.3
Historic	6 8 89	1.80	24.0	1.9	2.1	.	1450	5.0
Historic	6 22 89	0.80	12.0	0.7	1.1	.	765	5.0
Historic	7 6 89	1.60	20.0	1.4	2.5	.	1400	5.0
Historic	7 26 89	1.60	24.0	1.6	3.0	.	1675	4.8
Historic	8 8 89	1.20	22.0	1.7	2.1	.	1725	4.9
Historic	8 28 89	1.30	20.0	1.4	1.9	.	1450	5.1
Historic	6 6 90	0.76	11.1	0.8	1.5	.	850	5.0
Historic	6 21 90	1.10	11.3	0.8	1.6	.	1300	4.8
Historic	7 3 90	1.65	17.0	1.5	2.0	.	605	4.9
Historic	7 18 90	1.88	20.0	1.7	2.6	.	1285	4.8
Historic	8 3 90	2.10	31.0	1.8	2.9	.	1700	4.7
Historic	8 31 90	1.40	21.0	1.3	2.0	.	1310	4.9
Historic	6 5 91	2.50	23.0	2.7	3.0	.	1730	4.6
Historic	6 19 91	1.80	21.0	1.6	2.6	.	1206	4.9

Table A1.6. Historical Seep 1 data (1985-1991), and 1993-94 data from the surface sites within the Seep 1 pretreatment system (continued).

Site	Date	Cu	Ni	Co	Zn	Ca	SO4	pH
Historic	7 3 91	0.78	12.0	0.5	0.8	.	902	5.2
Historic	7 3 91	0.78	12.0	0.5	0.8	.	890	5.2
Historic	7 18 91	1.70	19.6	1.1	2.6	.	1711	4.9
Historic	8 8 91	1.60	17.0	0.9	2.1	.	1710	4.9
Historic	8 8 91	1.60	13.0	0.9	2.1	.	1732	4.9
Historic	8 29 91	1.40	12.0	0.7	1.9	.	1522	4.6
Inf-1	6 7 93	0.54	7.8	.	.	.	1111	6.8
Inf-1	6 11 93	1.00	11.0	.	.	.	1655	.
Inf-1	6 15 93	0.94	12.0	.	.	.	1420	.
Inf-1	6 25 93	0.82	11.0	.	.	.	1161	5.0
Inf-1	6 29 93	1.30	11.0	.	.	.	1358	5.0
Inf-1	7 2 93	1.50	13.0	.	.	.	1421	.
Inf-1	7 7 93	1.10	11.0	.	.	.	1248	.
Inf-1	7 9 93	0.82	7.9	.	.	.	1095	4.6
Inf-1	7 13 93	0.09	2.6	.	.	.	1220	.
Inf-1	7 16 93	0.86	10.0	.	.	.	1329	.
Inf-1	7 20 93	0.50	10.0	.	.	.	1143	5.9
Inf-1	7 29 93	0.39	5.8	.	.	.	971	6.3
Inf-1	8 3 93	0.54	7.6	.	.	.	1337	5.7
Inf-1	8 6 93	0.09	4.5	.	.	.	1429	6.0
Inf-1	8 10 93	0.69	8.6	.	.	.	1230	4.8
Inf-1	8 17 93	0.67	10.0	.	.	.	1530	5.7
Inf-1	8 20 93	0.88	9.9	.	.	.	1391	5.3
Inf-1	6 30 94	0.97	6.1	.	.	.	1031	5.4
Inf-1	7 15 94	1.40	9.4	.	.	.	1392	5.3
Inf-1	7 28 94	0.73	.	.	.	.	1496	5.8
Out	6 7 93	0.03	6.2	.	.	.	1002	7.2
Out	6 11 93	0.05	6.6	.	.	.	1290	7.2
Out	6 15 93	0.06	11.0	.	.	.	1191	7.0
Out	6 25 93	0.11	11.0	.	.	.	1131	6.5
Out	6 29 93	0.09	8.8	.	.	.	1191	6.9
Out	7 2 93	0.09	11.0	.	.	.	1243	.
Out	7 7 93	0.13	10.0	.	.	.	1100	.
Out	7 9 93	0.14	8.9	.	.	.	1052	.
Out	7 13 93	0.20	14.0	.	.	.	1127	.
Out	7 16 93	0.16	11.0	.	.	.	1203	.
Out	7 20 93	0.16	15.0	.	.	.	1165	6.5
Out	7 29 93	0.21	9.0	.	.	.	1095	6.2
Out	8 3 93	0.13	8.0	.	.	.	1172	6.7
Out	8 6 93	0.13	7.6	.	.	.	1139	6.7
Out	8 10 93	0.10	8.3	.	.	.	2492	6.7

Table A1.6. Historical Seep 1 data (1985-1991), and 1993-94 data from the surface sites within the Seep 1 pretreatment system (continued).

Site	Date	Cu	Ni	Co	Zn	Ca	SO4	pH
Out	8 17 93	0.09	8.4	.	.	.	1203	7.3
Out	8 20 93	0.08	8.1	.	.	.	1408	7.1
Out	6 30 94	0.45	6.8	.	.	.	745	6.7
Out	7 15 94	0.30	8.0	.	.	.	1060	6.4
Out	7 28 94	0.05	.	.	.	.	1237	6.9
SP-1	6 7 93	0.55	9.1	.	.	.	1247	.
SP-1	6 11 93	0.77	9.9	.	.	.	1568	5.5
SP-1	6 15 93	0.32	10.0	.	.	.	1058	6.2
SP-1	6 25 93	0.78	11.0	.	.	.	1169	5.5
SP-1	6 29 93	0.82	11.0	.	.	.	1376	6.5
SP-1	7 2 93	0.45	9.5	.	.	.	1288	.
SP-1	7 7 93	0.98	11.0	.	.	.	1251	.
SP-1	7 9 93	1.40	9.8	.	.	.	1247	4.6
SP-1	7 13 93	1.10	11.0	.	.	.	1324	.
SP-1	7 16 93	1.60	12.0	.	.	.	1390	.
SP-1	7 20 93	1.20	18.0	.	.	.	1374	5.5
SP-1	7 29 93	1.30	12.0	.	.	.	1135	4.8
SP-1	8 3 93	0.50	8.6	.	.	.	1085	6.6
SP-1	8 6 93	1.00	11.0	.	.	.	1796	6.1
SP-1	8 10 93	1.20	15.0	.	.	.	1342	4.8
SP-1	8 17 93	0.72	9.6	.	.	.	1483	6.1
SP-1	8 20 93	0.25	8.5	.	.	.	1316	6.6
SP-1	6 30 94	1.00	6.2	.	.	.	939	5.3
SP-1	7 15 94	1.40	9.9	.	.	.	1225	5.3
SP-1	7 28 94	0.66	.	.	.	.	1435	6.2
SP-2	6 7 93	0.14	6.0	.	.	.	790	7.2
SP-2	6 11 93	0.45	9.5	.	.	.	1265	6.6
SP-2	6 15 93	0.41	11.0	.	.	.	1154	6.4
SP-2	6 25 93	0.41	11.0	.	.	.	999	5.9
SP-2	6 29 93	0.29	7.3	.	.	.	969	6.8
SP-2	7 2 93	0.39	10.0	.	.	.	1005	.
SP-2	7 7 93	0.96	10.0	.	.	.	1225	.
SP-2	7 9 93	1.50	16.0	.	.	.	1280	4.8
SP-2	7 13 93	0.65	14.0	.	.	.	998	.
SP-2	7 16 93	0.71	13.0	.	.	.	1390	.
SP-2	7 20 93	0.36	11.0	.	.	.	717	6.2
SP-2	7 29 93	1.40	15.0	.	.	.	1691	5.0
SP-2	8 3 93	0.14	3.0	.	.	.	558	6.8
SP-2	8 6 93	0.45	10.0	.	.	.	1310	6.2
SP-2	8 10 93	0.57	13.0	.	.	.	2311	5.9
SP-2	8 17 93	0.18	7.5	.	.	.	897	6.9
SP-2	8 20 93	0.16	8.3	.	.	.	2282	6.8

Table A1.6. Historical Seep 1 data (1985-1991), and 1993-94 data from the surface sites within the Seep 1 pretreatment system (continued).

Site	Date	Cu	Ni	Co	Zn	Ca	SO4	pH
SP-2	6 30 94	0.70	7.4	.	.	.	708	6.7
SP-2	7 15 94	0.82	9.1	.	.	.	995	5.6
SP-2	7 28 94	0.64	.	.	.	.	1153	6.3
SP-3	6 7 93	0.54	13.0	.	.	.	1333	7.1
SP-3	6 11 93	0.91	13.0	.	.	.	1579	6.5
SP-3	6 15 93	0.43	11.0	.	.	.	1227	6.1
SP-3	6 25 93	0.84	15.0	.	.	.	1183	5.6
SP-3	6 29 93	0.59	11.0	.	.	.	1260	6.6
SP-3	7 2 93	0.67	13.0	.	.	.	1184	.
SP-3	7 7 93	0.83	13.0	.	.	.	1274	.
SP-3	7 9 93	1.30	20.0	.	.	.	1592	5.3
SP-3	7 13 93	1.00	18.0	.	.	.	1307	.
SP-3	7 16 93	1.40	19.0	.	.	.	1734	.
SP-3	7 20 93	1.00	19.0	.	.	.	1280	5.9
SP-3	7 29 93	1.50	17.0	.	.	.	1090	5.0
SP-3	8 3 93	1.10	15.0	.	.	.	1443	6.2
SP-3	8 6 93	0.82	14.0	.	.	.	1658	5.9
SP-3	8 10 93	1.10	17.0	.	.	.	1388	5.5
SP-3	8 17 93	1.20	12.0	.	.	.	1982	6.1
SP-3	8 20 93	0.79	16.0	.	.	.	1742	6.2
SP-3	6 30 94	1.80	15.0	.	.	.	970	6.2
SP-3	7 15 94	0.87	10.0	.	.	.	1066	5.9
SP-3	7 28 94	0.73	.	.	.	.	1254	6.2
SP-4	6 7 93	0.13	9.3	.	.	.	1122	.
SP-4	6 11 93	0.12	9.2	.	.	.	1448	.
SP-4	6 15 93	0.14	11.0	.	.	.	1272	.
SP-4	6 25 93	0.33	13.0	.	.	.	1177	6.1
SP-4	6 29 93	0.23	11.0	.	.	.	1279	6.7
SP-4	7 2 93	0.32	12.0	.	.	.	1294	.
SP-4	7 7 93	0.46	12.0	.	.	.	1187	.
SP-4	7 9 93	0.54	15.0	.	.	.	1230	6.0
SP-4	7 13 93	0.57	16.0	.	.	.	1274	.
SP-4	7 16 93	0.42	13.0	.	.	.	1396	.
SP-4	7 20 93	0.49	17.0	.	.	.	1291	6.2
SP-4	7 29 93	0.52	10.0	.	.	.	1041	5.8
SP-4	8 3 93	0.35	9.8	.	.	.	1199	7.0
SP-4	8 6 93	0.28	10.0	.	.	.	1294	6.4
SP-4	8 10 93	0.30	9.7	.	.	.	2481	6.3
SP-4	8 17 93	0.19	9.0	.	.	.	1379	7.0
SP-4	8 20 93	0.17	7.7	.	.	.	1333	6.8
SP-4	6 30 94	0.49	6.1	.	.	.	644	6.7
SP-4	7 15 94	0.66	8.1	.	.	.	882	6.1
SP-4	7 28 94	0.25	.	.	.	.	1177	6.7

Table A1.6. Historical Seep 1 data (1985-1991), and 1993-94 data from the surface sites within the Seep 1 pretreatment system (continued).

Site	Date	Cu	Ni	Co	Zn	Ca	SO4	pH
SP-5	6 7 93	0.13	8.7	.	.	.	1122	.
SP-5	6 11 93	0.16	9.4	.	.	.	1298	.
SP-5	6 15 93	0.27	12.0	.	.	.	1304	.
SP-5	6 25 93	0.26	12.0	.	.	.	1119	6.3
SP-5	6 29 93	0.26	11.0	.	.	.	1270	6.7
SP-5	7 2 93	0.22	11.0	.	.	.	1193	.
SP-5	7 7 93	0.41	11.0	.	.	.	1159	.
SP-5	7 9 93	0.31	9.2	.	.	.	940	.
SP-5	7 13 93	0.69	16.0	.	.	.	1209	.
SP-5	7 16 93	0.51	12.0	.	.	.	1291	.
SP-5	7 20 93	0.69	18.0	.	.	.	1230	6.2
SP-5	7 29 93	0.46	11.0	.	.	.	1020	6.0
SP-5	8 3 93	0.39	9.3	.	.	.	1199	7.1
SP-5	8 6 93	0.27	8.8	.	.	.	1150	6.5
SP-5	8 10 93	0.30	10.0	.	.	.	2513	6.3
SP-5	8 17 93	0.46	11.0	.	.	.	1507	6.6
SP-5	8 20 93	0.26	8.4	.	.	.	1431	6.8
SP-5	6 30 94	0.82	7.9	.	.	.	843	6.5
SP-5	7 15 94	0.84	9.9	.	.	.	1130	6.1
SP-5	7 28 94	0.31	.	.	.	.	1296	6.9
SP-6	6 7 93	0.07	7.0	.	.	.	1019	.
SP-6	6 11 93	0.05	8.3	.	.	.	1323	.
SP-6	6 15 93	0.17	12.0	.	.	.	1275	.
SP-6	6 25 93	0.12	11.0	.	.	.	1164	6.4
SP-6	6 29 93	0.08	9.0	.	.	.	1225	6.8
SP-6	7 2 93	0.09	12.0	.	.	.	1231	.
SP-6	7 7 93	0.33	11.0	.	.	.	1128	.
SP-6	7 9 93	0.08	7.4	.	.	.	914	.
SP-6	7 13 93	0.60	16.0	.	.	.	1230	.
SP-6	7 16 93	0.40	12.0	.	.	.	1252	.
SP-6	7 20 93	0.47	18.0	.	.	.	1161	6.3
SP-6	7 29 93	0.21	10.0	.	.	.	1095	6.2
SP-6	8 3 93	0.13	8.1	.	.	.	1106	7.3
SP-6	8 6 93	0.14	8.0	.	.	.	1150	6.6
SP-6	8 10 93	0.14	9.6	.	.	.	2502	6.5
SP-6	8 17 93	0.22	9.3	.	.	.	1322	7.0
SP-6	8 20 93	0.18	9.4	.	.	.	1414	7.0
SP-6	6 30 94	0.73	7.4	.	.	.	731	6.7
SP-6	7 15 94	0.68	9.2	.	.	.	1060	6.2
SP-6	7 28 94	0.04	.	.	.	.	1186	6.9

Note: pH values are standard units, other parameters are mg/L.

Table A1.7. T-tests of water quality data from the input and output of the study cell in the W1D treatment system.

The data used for these statistics were from samples collected by DNR in 1997-1999, and the data were matched up by date prior to running the t-tests. The site called W1D1 is the input site to the study cell, and W1D23 is the average of the two output sites from the cell (which are called W1D2 and W1D3). The data sets for the input and output have been altered so that they represent the same time periods each year.

```
PAIRED SAMPLES T-TEST ON      NI1      VS      NI23     WITH    21 CASES
MEAN DIFFERENCE =         0.076
SD DIFFERENCE =         0.103
T =        3.415 DF =    20 PROB =        0.003

PAIRED SAMPLES T-TEST ON      CU1      VS      CU23     WITH    14 CASES
MEAN DIFFERENCE =         0.002
SD DIFFERENCE =         0.003
T =        1.989 DF =    13 PROB =        0.068

PAIRED SAMPLES T-TEST ON      CO1      VS      CO23     WITH    21 CASES
MEAN DIFFERENCE =         0.002
SD DIFFERENCE =         0.004
T =        2.516 DF =    20 PROB =        0.021

PAIRED SAMPLES T-TEST ON      ZN1      VS      ZN23     WITH     8 CASES
MEAN DIFFERENCE =         0.002
SD DIFFERENCE =         0.014
T =        0.343 DF =     7 PROB =        0.742

PAIRED SAMPLES T-TEST ON    SO41       VS    SO423      WITH    18 CASES
MEAN DIFFERENCE =        43.044
SD DIFFERENCE =        57.702
T =        3.165 DF =    17 PROB =        0.006

PAIRED SAMPLES T-TEST ON      CA1      VS      CA23     WITH    12 CASES
MEAN DIFFERENCE =         9.583
SD DIFFERENCE =        11.239
T =        2.954 DF =    11 PROB =        0.013

PAIRED SAMPLES T-TEST ON      MG1      VS      MG23     WITH    12 CASES
MEAN DIFFERENCE =         2.792
SD DIFFERENCE =         4.003
T =        2.416 DF =    11 PROB =        0.034
```

Table A1.8. T-tests of 1997-99 water quality data from the vertical downflow section of the Seep 1 pretreatment system.

The data used for these statistics were from samples collected by DNR in 1997-1999, and the data were matched up by date prior to running the t-tests.

```
THE FOLLOWING RESULTS ARE FOR:
          YEAR      =       97.000


PAIRED SAMPLES T-TEST ON      SC6      VS      SCWB     WITH     12 CASES

MEAN DIFFERENCE =        87.500
SD DIFFERENCE =        305.536
T =        0.992 DF =    11 PROB =        0.342

THE FOLLOWING RESULTS ARE FOR:
          YEAR      =       98.000


PAIRED SAMPLES T-TEST ON      SC6      VS      SCWB     WITH     13 CASES

MEAN DIFFERENCE =       -15.385
SD DIFFERENCE =         68.874
T =       -0.805 DF =    12 PROB =        0.436

THE FOLLOWING RESULTS ARE FOR:
          YEAR      =       99.000


PAIRED SAMPLES T-TEST ON      SC6      VS      SCWB     WITH     10 CASES

MEAN DIFFERENCE =       -86.500
SD DIFFERENCE =        183.909
T =       -1.487 DF =     9 PROB =        0.171

THE FOLLOWING RESULTS ARE FOR:
          YEAR      =       97.000


PAIRED SAMPLES T-TEST ON      PH6      VS      PHWB     WITH     12 CASES

MEAN DIFFERENCE =        -0.122
SD DIFFERENCE =         0.117
T =       -3.595 DF =    11 PROB =        0.004

THE FOLLOWING RESULTS ARE FOR:
          YEAR      =       98.000


PAIRED SAMPLES T-TEST ON      PH6      VS      PHWB     WITH     12 CASES
```

Table A1.8. T-tests of 1997-99 water quality data from the vertical downflow section of the Seep 1 pretreatment system (continued).

```
MEAN DIFFERENCE =        -0.137
SD DIFFERENCE =         0.327
T =       -1.448 DF =    11 PROB =       0.175

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =       99.000


PAIRED SAMPLES T-TEST ON      PH6     VS     PHWB     WITH     10 CASES

MEAN DIFFERENCE =        -0.344
SD DIFFERENCE =         0.271
T =       -4.019 DF =     9 PROB =       0.003

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =       97.000


PAIRED SAMPLES T-TEST ON     SO46     VS     SO4WB    WITH     12 CASES

MEAN DIFFERENCE =        24.783
SD DIFFERENCE =        77.919
T =        1.102 DF =    11 PROB =       0.294

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =       98.000


PAIRED SAMPLES T-TEST ON     SO46     VS     SO4WB    WITH     13 CASES

MEAN DIFFERENCE =       -34.462
SD DIFFERENCE =       160.000
T =       -0.777 DF =    12 PROB =       0.452

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =       99.000


PAIRED SAMPLES T-TEST ON     SO46     VS     SO4WB    WITH      9 CASES

MEAN DIFFERENCE =       -38.011
SD DIFFERENCE =        64.983
T =       -1.755 DF =     8 PROB =       0.117

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =       97.000
```

Table A1.8. T-tests of 1997-99 water quality data from the vertical downflow section of the Seep 1 pretreatment system (continued).

```
PAIRED SAMPLES T-TEST ON       CU6      VS      CUWB     WITH     12 CASES

MEAN DIFFERENCE =         0.145
SD DIFFERENCE =         0.158
T =         3.187 DF =    11 PROB =        0.009

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =         98.000

PAIRED SAMPLES T-TEST ON       CU6      VS      CUWB     WITH     12 CASES

MEAN DIFFERENCE =         0.037
SD DIFFERENCE =         0.174
T =         0.739 DF =    11 PROB =        0.476

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =         99.000

PAIRED SAMPLES T-TEST ON       CU6      VS      CUWB     WITH      9 CASES

MEAN DIFFERENCE =         0.170
SD DIFFERENCE =         0.226
T =         2.256 DF =     8 PROB =        0.054

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =         97.000

PAIRED SAMPLES T-TEST ON       NI6      VS      NIWB     WITH     12 CASES

MEAN DIFFERENCE =         2.117
SD DIFFERENCE =         1.663
T =         4.408 DF =    11 PROB =        0.001

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =         98.000

PAIRED SAMPLES T-TEST ON       NI6      VS      NIWB     WITH     11 CASES

MEAN DIFFERENCE =         2.695
SD DIFFERENCE =         3.164
T =         2.825 DF =    10 PROB =        0.018

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =         99.000
```

Table A1.8. T-tests of 1997-99 water quality data from the vertical downflow section of the Seep 1 pretreatment system (continued).

```
PAIRED SAMPLES T-TEST ON       NI6      VS      NIWB    WITH      8 CASES

MEAN DIFFERENCE =        0.965
SD DIFFERENCE =        0.903
T =       3.021 DF =    7 PROB =       0.019


THE FOLLOWING RESULTS ARE FOR:
             YEAR      =       97.000


PAIRED SAMPLES T-TEST ON       ZN6      VS      ZNWB    WITH      5 CASES

MEAN DIFFERENCE =        0.110
SD DIFFERENCE =        0.376
T =       0.655 DF =    4 PROB =       0.548

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =       98.000


PAIRED SAMPLES T-TEST ON       ZN6      VS      ZNWB    WITH     11 CASES

MEAN DIFFERENCE =        0.250
SD DIFFERENCE =        0.402
T =       2.067 DF =   10 PROB =       0.066

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =       99.000


PAIRED SAMPLES T-TEST ON       ZN6      VS      ZNWB    WITH      8 CASES

MEAN DIFFERENCE =        0.225
SD DIFFERENCE =        0.147
T =       4.340 DF =    7 PROB =       0.003

THE FOLLOWING RESULTS ARE FOR:
             YEAR      =       97.000


PAIRED SAMPLES T-TEST ON       CA6      VS      CAWB    WITH      7 CASES

MEAN DIFFERENCE =        4.857
SD DIFFERENCE =       21.798
T =       0.590 DF =    6 PROB =       0.577
```

Table A1.8. T-tests of 1997-99 water quality data from the vertical downflow section of the Seep 1 pretreatment system (continued).

```
THE FOLLOWING RESULTS ARE FOR:

              YEAR      =        98.000

 PAIRED SAMPLES T-TEST ON       CA6      VS      CAWB     WITH     10 CASES

 MEAN DIFFERENCE =        -1.300
 SD DIFFERENCE =         4.990
 T =       -0.824 DF =     9 PROB =        0.431

 THE FOLLOWING RESULTS ARE FOR:
              YEAR      =        99.000

 PAIRED SAMPLES T-TEST ON       CA6      VS      CAWB     WITH      5 CASES

 MEAN DIFFERENCE =       -13.600
 SD DIFFERENCE =        11.803
 T =       -2.577 DF =     4 PROB =        0.062

 THE FOLLOWING RESULTS ARE FOR:
              YEAR      =        97.000

 PAIRED SAMPLES T-TEST ON       MG6      VS      MGWB     WITH      7 CASES

 MEAN DIFFERENCE =          6.714
 SD DIFFERENCE =        12.419
 T =        1.430 DF =     6 PROB =        0.203

 THE FOLLOWING RESULTS ARE FOR:
              YEAR      =        98.000

 PAIRED SAMPLES T-TEST ON       MG6      VS      MGWB     WITH     10 CASES

 MEAN DIFFERENCE =          0.200
 SD DIFFERENCE =         6.197
 T =        0.102 DF =     9 PROB =        0.921

 THE FOLLOWING RESULTS ARE FOR:
              YEAR      =        99.000

 PAIRED SAMPLES T-TEST ON       MG6      VS      MGWB     WITH      5 CASES

 MEAN DIFFERENCE =        -4.400
 SD DIFFERENCE =        11.459
 T =       -0.859 DF =     4 PROB =        0.439
```

Table A1.9. Anomalous data.

Site	Sample #	Date	Parameter	Reported value	Expected value
Seep 1					
043-1	18134	8/22/97	Mg	1.6 [A]	160
043-6	18244	10/16/98	Ni	0	9.0
043-6	18252	10/20/98	NI	0	9.0
043-6	18304	8/6/99	Ni	0.085	13.0
043-6	18304	8/6/99	Co	0.008	0.8
043-5	18020	5/15/97	SO4	3.5	300
043-5	18189	10/1/97	Ni	4.00	10.0
043-6	18232	9/4/98	Co	2.40	0.2
043-6	18252	10/20/98	Zn	0.001	1.0
043-6	18265	4/2/99	4" of water observed above ice; anomalously low values (SC=110, pH=6.67, Cu=0.06, Ni=0.30, Co=0.018, Zn=0.080, SO4=36.9) are probably due to dilution.		
043-6	18304	8/6/99	Ni	0.08	13.0
043-6	18304	8/6/99	Co	0.008	0.8
043-6	18322	10/8/99	SC, pH, Cu, Ni, Co, Zn, SO4, Ca and Mg were all anomalous (390, 6.77, 0.09, 1.31, 0.10, 0.21. 162, 44.2 and 24.4, respectively)		

[A] This value was changed to 160 in the file called DNRSEEP1.sys

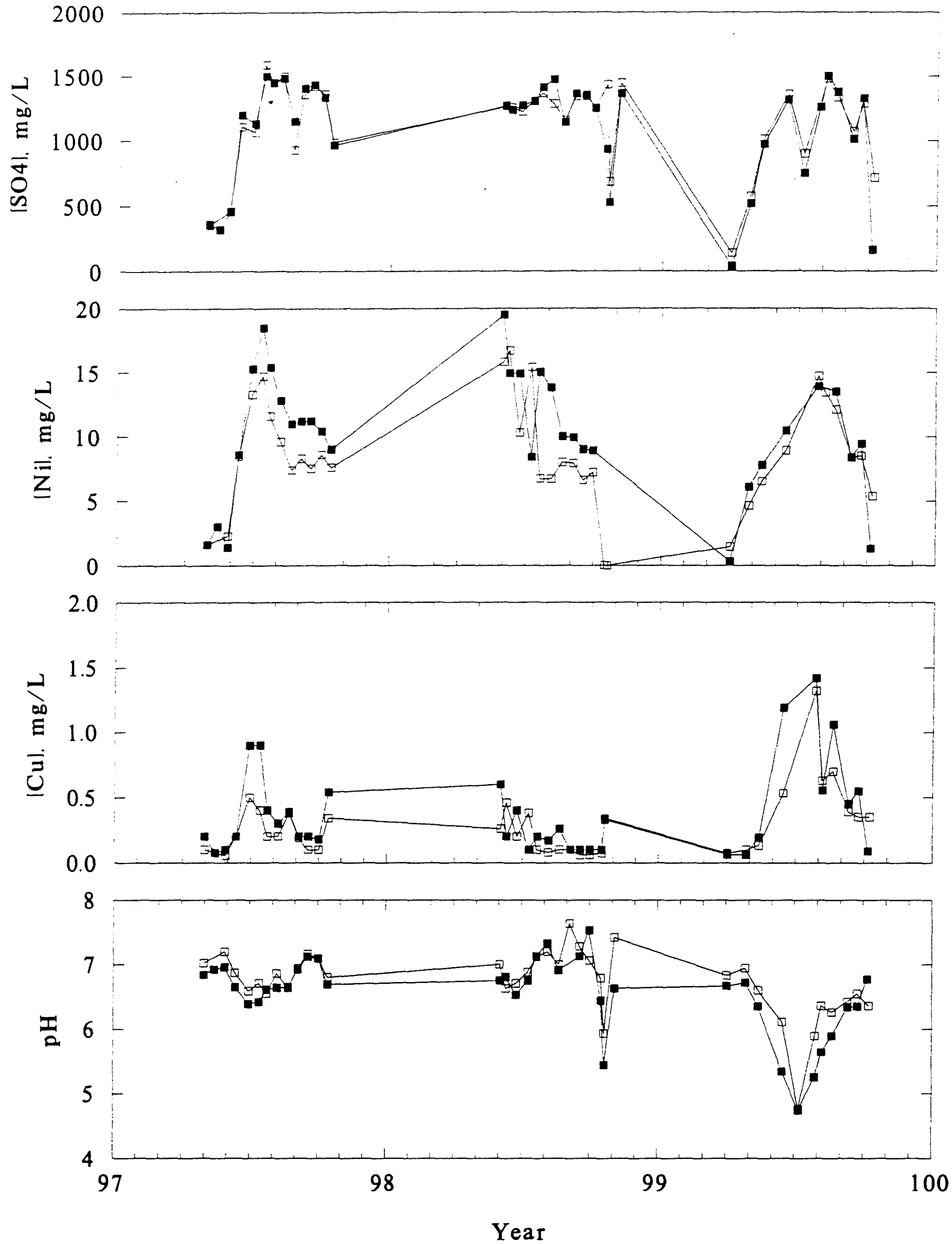


Figure A1.1. Comparison of pH, copper, nickel and sulfate concentrations at **043-6** (the site prior to the vertical flow section; dark squares) and **043-WB** (the weir; open squares) at Seep 1.

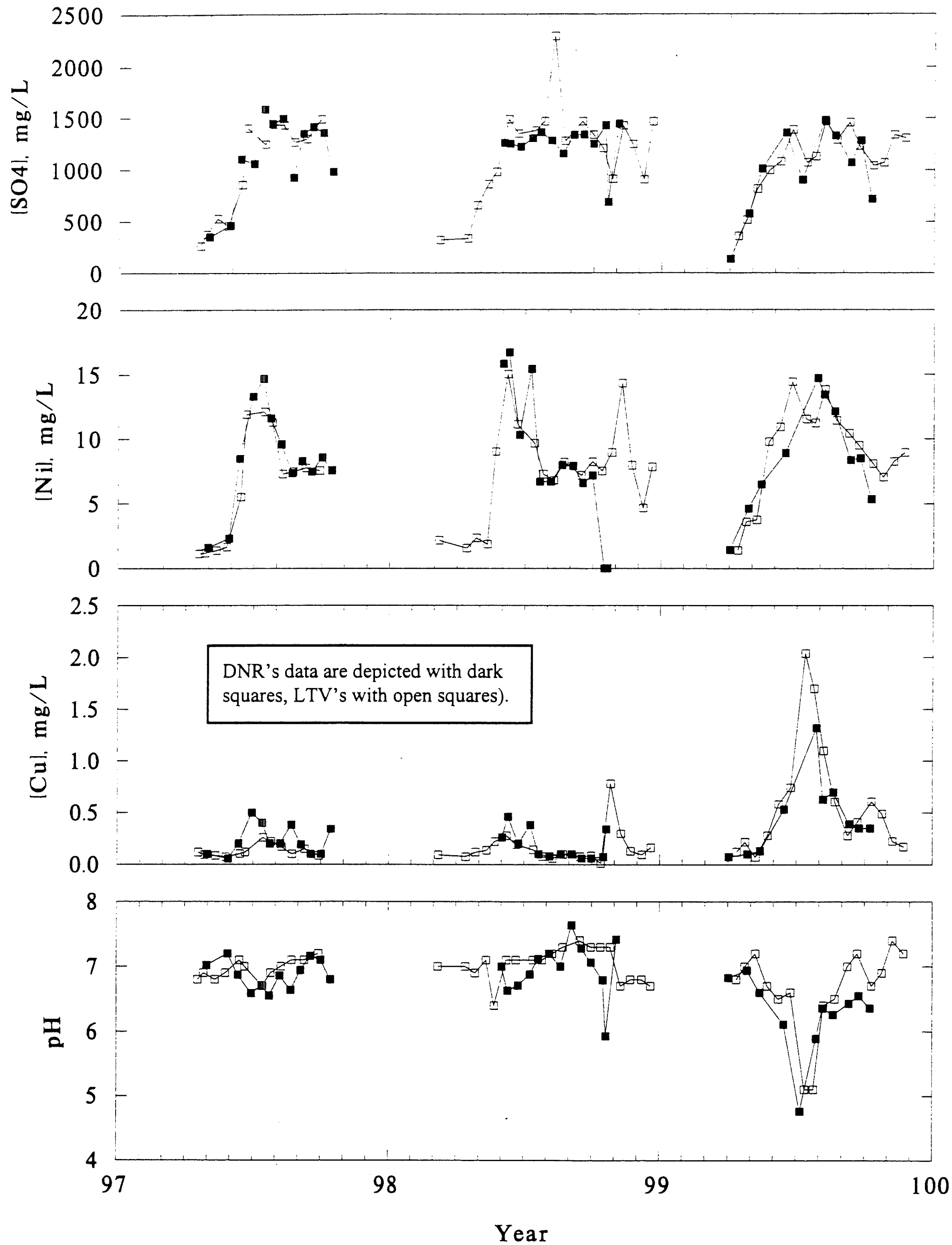


Figure A1.2. Comparison of LTV's and DNR's data (pH, Cu, Ni, SO_4) for 043, 1997-99.

Appendix 2

Summary statistics of W1D and Seep 1 water quality data

Page

Table A2.1. Summary statistics of water quality data from the input (W1D-051) of the W1D wetland treatment system, 1992-1999 data.

Site W1D-051

```
THE FOLLOWING RESULTS ARE FOR:
            SITE$     = W1D-051
            YEAR      =          92.000

TOTAL OBSERVATIONS:     43
```

	PH	SC	CUT	CUF	NIT
N OF CASES	32	0	43	0	43
MINIMUM	6.700	.	0.045	.	1.100
MAXIMUM	7.300	.	0.140	.	6.700
RANGE	0.600	.	0.095	.	5.600
MEAN	7.081	.	0.093	.	4.284
STANDARD DEV	0.135	.	0.025	.	1.584
MEDIAN	7.100	.	0.090	.	4.600

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	43	0	43	0
MINIMUM	.	0.001	.	0.010	.
MAXIMUM	.	0.060	.	0.110	.
RANGE	.	0.060	.	0.100	.
MEAN	.	0.016	.	0.054	.
STANDARD DEV	.	0.012	.	0.022	.
MEDIAN	.	0.012	.	0.050	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	17	11	42	0	31
MINIMUM	0.050	0.800	1064.000	.	130.000
MAXIMUM	0.200	5.600	3188.000	.	410.000
RANGE	0.150	4.800	2124.000	.	280.000
MEAN	0.079	2.618	2484.190	.	296.387
STANDARD DEV	0.050	1.401	518.189	.	66.920
MEDIAN	0.050	2.800	2629.000	.	300.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	31	43	43	0
MINIMUM	130.000	165.000	194.000	.
MAXIMUM	560.000	165.000	194.000	.
RANGE	430.000	0.000	0.000	.
MEAN	381.065	165.000	194.000	.
STANDARD DEV	99.514	0.000	0.000	.
MEDIAN	420.000	165.000	194.000	.

Table A2.1. Summary statistics of water quality data from the input (W1D-051) of the W1D wetland treatment system, 1992-1999 data (continued).

```
THE FOLLOWING RESULTS ARE FOR:
              SITE$     = W1D-051
              YEAR      =         93.000

 TOTAL OBSERVATIONS:      45
```

	PH	SC	CUT	CUF	NIT
N OF CASES	41	0	45	0	45
MINIMUM	6.800	.	0.007	.	0.790
MAXIMUM	8.300	.	0.090	.	7.300
RANGE	1.500	.	0.083	.	6.510
MEAN	7.112	.	0.051	.	3.139
STANDARD DEV	0.266	.	0.018	.	2.319
MEDIAN	7.100	.	0.050	.	2.300

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	32	0	33	0
MINIMUM	.	0.001	.	0.005	.
MAXIMUM	.	0.450	.	0.090	.
RANGE	.	0.450	.	0.085	.
MEAN	.	0.043	.	0.041	.
STANDARD DEV	.	0.104	.	0.023	.
MEDIAN	.	0.010	.	0.050	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	31	1	45	0	30
MINIMUM	0.005	4.400	622.000	.	70.000
MAXIMUM	0.500	4.400	2852.000	.	410.000
RANGE	0.495	0.000	2230.000	.	340.000
MEAN	0.097	4.400	1660.600	.	222.000
STANDARD DEV	0.099	.	735.401	.	107.588
MEDIAN	0.100	4.400	1461.000	.	175.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	30	45	45	0
MINIMUM	90.000	165.000	194.000	.
MAXIMUM	470.000	165.000	194.000	.
RANGE	380.000	0.000	0.000	.
MEAN	247.333	165.000	194.000	.
STANDARD DEV	146.357	0.000	0.000	.
MEDIAN	170.000	165.000	194.000	.

Table A2.1. Summary statistics of water quality data from the input (W1D-051) of the W1D wetland treatment system, 1992-1999 data (continued).

```
THE FOLLOWING RESULTS ARE FOR:
            SITE$     = W1D-051
            YEAR      =        94.000

TOTAL OBSERVATIONS:     36
```

	PH	SC	CUT	CUF	NIT
N OF CASES	29	0	33	2	36
MINIMUM	6.100	.	0.030	0.027	0.640
MAXIMUM	7.600	.	0.100	0.030	7.500
RANGE	1.500	.	0.070	0.003	6.860
MEAN	7.017	.	0.059	0.029	4.529
STANDARD DEV	0.289	.	0.018	0.002	1.914
MEDIAN	7.000	.	0.050	0.029	5.050

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	19	0	19	0
MINIMUM	1.300	0.001	.	0.010	.
MAXIMUM	3.100	0.160	.	0.200	.
RANGE	1.800	0.160	.	0.190	.
MEAN	2.200	0.049	.	0.061	.
STANDARD DEV	1.273	0.041	.	0.044	.
MEDIAN	2.200	0.050	.	0.060	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	19	0	33	2	16
MINIMUM	0.050	.	379.000	1292.000	130.000
MAXIMUM	0.810	.	2895.000	2381.000	360.000
RANGE	0.760	.	2516.000	1089.000	230.000
MEAN	0.140	.	2118.727	1836.500	312.813
STANDARD DEV	0.204	.	676.792	770.039	59.441
MEDIAN	0.100	.	2341.000	1836.500	335.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	16	36	36	0
MINIMUM	120.000	165.000	194.000	.
MAXIMUM	440.000	165.000	194.000	.
RANGE	320.000	0.000	0.000	.
MEAN	382.500	165.000	194.000	.
STANDARD DEV	82.745	0.000	0.000	.
MEDIAN	410.000	165.000	194.000	.

Table A2.1. Summary statistics of water quality data from the input (W1D-051) of the W1D wetland treatment system, 1992-1999 data (continued).

```
THE FOLLOWING RESULTS ARE FOR:
            SITE$     = W1D-051
            YEAR      =          95.000

TOTAL OBSERVATIONS:      17
```

	PH	SC	CUT	CUF	NIT
N OF CASES	17	0	17	0	17
MINIMUM	6.700	.	0.030	.	0.530
MAXIMUM	7.400	.	0.600	.	3.200
RANGE	0.700	.	0.570	.	2.670
MEAN	7.053	.	0.105	.	1.778
STANDARD DEV	0.191	.	0.132	.	0.684
MEDIAN	7.100	.	0.070	.	1.600

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	17	0	17	0
MINIMUM	.	0.017	.	0.010	.
MAXIMUM	.	0.210	.	0.040	.
RANGE	.	0.193	.	0.030	.
MEAN	.	0.049	.	0.022	.
STANDARD DEV	.	0.046	.	0.011	.
MEDIAN	.	0.037	.	0.020	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	17	0	17	0	17
MINIMUM	0.050	.	230.000	.	90.000
MAXIMUM	0.500	.	2449.000	.	356.000
RANGE	0.450	.	2219.000	.	266.000
MEAN	0.153	.	1401.294	.	236.529
STANDARD DEV	0.153	.	731.457	.	76.136
MEDIAN	0.100	.	1594.000	.	250.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	17	17	17	0
MINIMUM	80.000	165.000	194.000	.
MAXIMUM	409.000	165.000	194.000	.
RANGE	329.000	0.000	0.000	.
MEAN	248.176	165.000	194.000	.
STANDARD DEV	90.167	0.000	0.000	.

Table A2.1. Summary statistics of water quality data from the input (W1D-051) of the W1D wetland treatment system, 1992-1999 data (continued).

MEDIAN	230.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-051
YEAR = 96.000

TOTAL OBSERVATIONS: 18

	PH	SC	CUT	CUF	NIT
N OF CASES	18	0	18	0	18
MINIMUM	7.000	.	0.010	.	0.385
MAXIMUM	7.500	.	0.080	.	2.000
RANGE	0.500	.	0.070	.	1.615
MEAN	7.178	.	0.043	.	1.172
STANDARD DEV	0.131	.	0.019	.	0.475
MEDIAN	7.200	.	0.041	.	0.979

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	18	0	18	0
MINIMUM	.	0.001	.	0.005	.
MAXIMUM	.	0.040	.	0.056	.
RANGE	.	0.040	.	0.051	.
MEAN	.	0.009	.	0.030	.
STANDARD DEV	.	0.009	.	0.014	.
MEDIAN	.	0.007	.	0.028	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	18	0	18	0	17
MINIMUM	0.040	.	722.000	.	115.000
MAXIMUM	0.290	.	3001.000	.	350.000
RANGE	0.250	.	2279.000	.	235.000
MEAN	0.084	.	1598.167	.	258.176
STANDARD DEV	0.056	.	524.754	.	68.020
MEDIAN	0.070	.	1625.000	.	278.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	17	18	18	0
MINIMUM	110.000	165.000	194.000	.
MAXIMUM	320.000	165.000	194.000	.
RANGE	210.000	0.000	0.000	.

Table A2.1. Summary statistics of water quality data from the input (W1D-051) of the W1D wetland treatment system, 1992-1999 data (continued).

MEAN	257.412	165.000	194.000	.
STANDARD DEV	54.082	0.000	0.000	.
MEDIAN	269.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-051
YEAR = 97.000

TOTAL OBSERVATIONS: 18

	PH	SC	CUT	CUF	NIT
N OF CASES	18	0	18	0	18
MINIMUM	7.000	.	0.007	.	0.144
MAXIMUM	7.300	.	0.048	.	1.300
RANGE	0.300	.	0.041	.	1.156
MEAN	7.167	.	0.030	.	0.694
STANDARD DEV	0.091	.	0.012	.	0.293
MEDIAN	7.200	.	0.032	.	0.713

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	18	0	18	0
MINIMUM	.	0.001	.	0.005	.
MAXIMUM	.	0.045	.	0.028	.
RANGE	.	0.045	.	0.023	.
MEAN	.	0.012	.	0.017	.
STANDARD DEV	.	0.010	.	0.007	.
MEDIAN	.	0.010	.	0.020	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	18	0	18	0	18
MINIMUM	0.015	.	700.000	.	109.000
MAXIMUM	0.110	.	1210.000	.	246.000
RANGE	0.095	.	510.000	.	137.000
MEAN	0.059	.	1003.333	.	199.944
STANDARD DEV	0.022	.	141.040	.	41.113
MEDIAN	0.055	.	1045.000	.	209.500

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	18	18	18	0
MINIMUM	104.000	165.000	194.000	.
MAXIMUM	223.000	165.000	194.000	.

Table A2.1. Summary statistics of water quality data from the input (W1D-051) of the W1D wetland treatment system, 1992-1999 data (continued).

RANGE	119.000	0.000	0.000	.
MEAN	178.389	165.000	194.000	.
STANDARD DEV	34.563	0.000	0.000	.
MEDIAN	187.500	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-051
YEAR = 98.000

TOTAL OBSERVATIONS: 19

	PH	SC	CUT	CUF	NIT
N OF CASES	19	0	19	0	19
MINIMUM	6.900	.	0.014	.	0.170
MAXIMUM	7.400	.	0.069	.	0.799
RANGE	0.500	.	0.055	.	0.629
MEAN	7.232	.	0.031	.	0.491
STANDARD DEV	0.138	.	0.015	.	0.172
MEDIAN	7.300	.	0.026	.	0.546

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	19	0	19	0
MINIMUM	.	-0.001	.	-0.010	.
MAXIMUM	.	0.032	.	0.167	.
RANGE	.	0.033	.	0.177	.
MEAN	.	0.010	.	0.023	.
STANDARD DEV	.	0.008	.	0.036	.
MEDIAN	.	0.008	.	0.017	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	18	0	19	0	19
MINIMUM	-0.030	.	586.000	.	105.000
MAXIMUM	0.140	.	1250.000	.	263.000
RANGE	0.170	.	664.000	.	158.000
MEAN	0.029	.	966.211	.	196.316
STANDARD DEV	0.050	.	198.994	.	46.164
MEDIAN	0.040	.	1010.000	.	203.000

	MGT	TOTHARD	ALK	FLOWLM

Table A2.1. Summary statistics of water quality data from the input (W1D-051) of the W1D wetland treatment system, 1992-1999 data (continued).

N OF CASES	19	19	19	0
MINIMUM	99.800	165.000	194.000	.
MAXIMUM	237.000	165.000	194.000	.
RANGE	137.200	0.000	0.000	.
MEAN	177.568	165.000	194.000	.
STANDARD DEV	41.478	0.000	0.000	.
MEDIAN	184.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-051
YEAR = 99.000

TOTAL OBSERVATIONS: 16

	PH	SC	CUT	CUF	NIT
N OF CASES	16	0	16	0	16
MINIMUM	6.800	.	0.001	.	0.030
MAXIMUM	7.300	.	0.034	.	1.690
RANGE	0.500	.	0.033	.	1.661
MEAN	7.113	.	0.015	.	0.608
STANDARD DEV	0.154	.	0.010	.	0.533
MEDIAN	7.100	.	0.013	.	0.395

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	16	0	16	0
MINIMUM	.	0.001	.	-0.010	.
MAXIMUM	.	0.013	.	0.031	.
RANGE	.	0.012	.	0.041	.
MEAN	.	0.006	.	0.015	.
STANDARD DEV	.	0.004	.	0.014	.
MEDIAN	.	0.005	.	0.017	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	16	0	16	0	16
MINIMUM	-0.030	.	378.000	.	74.400
MAXIMUM	0.410	.	1570.000	.	284.000
RANGE	0.440	.	1192.000	.	209.600
MEAN	0.085	.	1138.125	.	213.963
STANDARD DEV	0.092	.	328.183	.	58.242
MEDIAN	0.070	.	1170.000	.	229.500

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	16	16	10	16
MINIMUM	61.700	165.000	194.000	10.514
MAXIMUM	264.000	1800.000	194.000	141.938

Table A2.1. Summary statistics of water quality data from the input (W1D-051) of the W1D wetland treatment system, 1992-1999 data (continued).

RANGE	202.300	1635.000	0.000	131.424
MEAN	198.981	718.125	194.000	59.305
STANDARD DEV	57.140	742.338	0.000	41.449
MEDIAN	211.500	165.000	194.000	56.512

Note: The parameters with a T suffix are total values, parameters with an F suffix are filtered values. TOTHARD is total hardness, FLOWLM is liters/min, and values preceded with a hyphen are less than the detection limit.

Table A2.2. Summary statistics of water quality data from the output (W1D-052) of the W1D wetland treatment system, 1992-1999 data.

Site W1D-052

```
THE FOLLOWING RESULTS ARE FOR:
           SITE$    = W1D-052
           YEAR     =        92.000

 TOTAL OBSERVATIONS:      52
```

	PH	SC	CUT	CUF	NIT
N OF CASES	46	2	52	0	52
MINIMUM	6.400	2480.000	0.000	.	0.020
MAXIMUM	7.600	2590.000	0.032	.	0.590
RANGE	1.200	110.000	0.032	.	0.570
MEAN	7.026	2535.000	0.012	.	0.315
STANDARD DEV	0.232	77.782	0.007	.	0.165
MEDIAN	7.000	2535.000	0.011	.	0.310

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	52	0	52	0
MINIMUM	.	0.001	.	0.005	.
MAXIMUM	.	0.060	.	0.060	.
RANGE	.	0.060	.	0.055	.
MEAN	.	0.016	.	0.013	.
STANDARD DEV	.	0.013	.	0.016	.
MEDIAN	.	0.011	.	0.005	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	20	13	48	0	35
MINIMUM	0.050	0.800	817.000	.	71.000
MAXIMUM	5.100	30.800	2811.000	.	300.000
RANGE	5.050	30.000	1994.000	.	229.000
MEAN	0.925	10.646	1840.875	.	193.429
STANDARD DEV	1.403	8.893	553.348	.	53.008
MEDIAN	0.200	9.600	1936.500	.	210.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	35	52	52	0
MINIMUM	90.000	165.000	194.000	.
MAXIMUM	350.000	165.000	194.000	.
RANGE	260.000	0.000	0.000	.
MEAN	234.914	165.000	194.000	.
STANDARD DEV	77.187	0.000	0.000	.

Table A2.2. Summary statistics of water quality data from the output (W1D-052) of the W1D wetland treatment system, 1992-1999 data (continued).

MEDIAN	260.000	165.000	194.000	.

```
THE FOLLOWING RESULTS ARE FOR:
            SITE$     = W1D-052
            YEAR      =         93.000

TOTAL OBSERVATIONS:      49
```

	PH	SC	CUT	CUF	NIT
N OF CASES	47	0	49	0	49
MINIMUM	6.800	.	-0.001	.	0.044
MAXIMUM	7.500	.	0.024	.	1.200
RANGE	0.700	.	0.025	.	1.156
MEAN	7.145	.	0.009	.	0.354
STANDARD DEV	0.180	.	0.006	.	0.320
MEDIAN	7.100	.	0.007	.	0.170

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	38	0	38	0
MINIMUM	.	0.001	.	0.005	.
MAXIMUM	.	0.010	.	0.050	.
RANGE	.	0.010	.	0.045	.
MEAN	.	0.004	.	0.009	.
STANDARD DEV	.	0.002	.	0.011	.
MEDIAN	.	0.003	.	0.005	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	35	34	49	0	36
MINIMUM	0.050	0.400	583.000	.	80.000
MAXIMUM	1.400	21.600	2221.000	.	320.000
RANGE	1.350	21.200	1638.000	.	240.000
MEAN	0.313	7.488	1286.776	.	192.778
STANDARD DEV	0.262	4.319	499.339	.	74.512
MEDIAN	0.200	6.800	1287.000	.	175.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	36	49	49	0
MINIMUM	70.000	165.000	194.000	.
MAXIMUM	420.000	165.000	194.000	.
RANGE	350.000	0.000	0.000	.
MEAN	222.806	165.000	194.000	.
STANDARD DEV	104.943	0.000	0.000	.
MEDIAN	175.000	165.000	194.000	.

Table A2.2. Summary statistics of water quality data from the output (W1D-052) of the W1D wetland treatment system, 1992-1999 data (continued).

```
THE FOLLOWING RESULTS ARE FOR:
            SITE$     = W1D-052
            YEAR      =          94.000

TOTAL OBSERVATIONS:      88
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	PH	SC	CUT	CUF	NIT
N OF CASES	31	0	33	2	87
MINIMUM	6.900	.	0.001	0.003	0.007
MAXIMUM	8.200	.	0.060	0.004	1.800
RANGE	1.300	.	0.060	0.001	1.793
MEAN	7.355	.	0.007	0.004	0.426
STANDARD DEV	0.266	.	0.010	0.001	0.432
MEDIAN	7.300	.	0.005	0.004	0.280

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	19	0	19	0
MINIMUM	0.110	0.001	.	0.005	.
MAXIMUM	0.110	0.021	.	0.200	.
RANGE	0.000	0.020	.	0.195	.
MEAN	0.110	0.004	.	0.017	.
STANDARD DEV	0.000	0.005	.	0.044	.
MEDIAN	0.110	0.002	.	0.005	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	19	19	33	2	19
MINIMUM	0.000	1.000	338.000	974.000	70.000
MAXIMUM	0.900	19.600	2208.000	1015.000	310.000
RANGE	0.900	18.600	1870.000	41.000	240.000
MEAN	0.209	5.947	1508.636	994.500	215.263
STANDARD DEV	0.258	4.355	491.458	28.991	71.598
MEDIAN	0.100	6.000	1693.000	994.500	240.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	19	88	88	0
MINIMUM	70.000	165.000	194.000	.
MAXIMUM	380.000	165.000	194.000	.
RANGE	310.000	0.000	0.000	.
MEAN	264.737	165.000	194.000	.
STANDARD DEV	95.357	0.000	0.000	.
MEDIAN	310.000	165.000	194.000	.

Table A2.2. Summary statistics of water quality data from the output (W1D-052) of the W1D wetland treatment system, 1992-1999 data (continued).

```
THE FOLLOWING RESULTS ARE FOR:
            SITE$     = W1D-052
            YEAR      =       95.000

TOTAL OBSERVATIONS:     13
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	PH	SC	CUT	CUF	NIT
N OF CASES	13	0	13	0	13
MINIMUM	6.900	.	0.001	.	0.120
MAXIMUM	7.600	.	0.007	.	0.880
RANGE	0.700	.	0.006	.	0.760
MEAN	7.300	.	0.003	.	0.392
STANDARD DEV	0.178	.	0.002	.	0.261
MEDIAN	7.400	.	0.003	.	0.360

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	13	0	13	0
MINIMUM	.	0.001	.	0.005	.
MAXIMUM	.	0.020	.	0.100	.
RANGE	.	0.020	.	0.095	.
MEAN	.	0.005	.	0.042	.
STANDARD DEV	.	0.005	.	0.048	.
MEDIAN	.	0.002	.	0.010	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	13	8	13	0	13
MINIMUM	0.050	-0.400	382.000	.	60.000
MAXIMUM	0.100	8.800	1658.000	.	285.000
RANGE	0.050	9.200	1276.000	.	225.000
MEAN	0.077	3.400	1103.308	.	175.846
STANDARD DEV	0.026	3.186	396.754	.	64.708
MEDIAN	0.100	3.600	1017.000	.	170.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	13	13	13	0
MINIMUM	60.000	165.000	194.000	.
MAXIMUM	319.000	165.000	194.000	.
RANGE	259.000	0.000	0.000	.
MEAN	203.769	165.000	194.000	.
STANDARD DEV	72.024	0.000	0.000	.
MEDIAN	200.000	165.000	194.000	.

Table A2.2. Summary statistics of water quality data from the output (W1D-052) of the W1D wetland treatment system, 1992-1999 data (continued).

```
THE FOLLOWING RESULTS ARE FOR:
            SITE$     = W1D-052
            YEAR      =          96.000

TOTAL OBSERVATIONS:       15
```

	PH	SC	CUT	CUF	NIT
N OF CASES	15	0	15	0	15
MINIMUM	7.000	.	-0.001	.	0.056
MAXIMUM	7.600	.	0.033	.	0.891
RANGE	0.600	.	0.034	.	0.835
MEAN	7.327	.	0.009	.	0.337
STANDARD DEV	0.162	.	0.009	.	0.246
MEDIAN	7.400	.	0.008	.	0.261

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	15	0	15	0
MINIMUM	.	-0.001	.	-0.010	.
MAXIMUM	.	0.007	.	0.025	.
RANGE	.	0.008	.	0.035	.
MEAN	.	0.002	.	0.003	.
STANDARD DEV	.	0.003	.	0.015	.
MEDIAN	.	0.002	.	-0.010	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	15	15	15	0	14
MINIMUM	0.050	-1.000	679.000	.	106.000
MAXIMUM	1.800	17.200	2380.000	.	272.000
RANGE	1.750	18.200	1701.000	.	166.000
MEAN	0.213	4.707	1324.067	.	196.857
STANDARD DEV	0.443	4.964	414.386	.	54.898
MEDIAN	0.090	3.200	1361.000	.	205.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	14	15	15	0
MINIMUM	116.000	165.000	194.000	.
MAXIMUM	260.000	165.000	194.000	.
RANGE	144.000	0.000	0.000	.
MEAN	195.500	165.000	194.000	.
STANDARD DEV	53.904	0.000	0.000	.
MEDIAN	202.500	165.000	194.000	.

```
THE FOLLOWING RESULTS ARE FOR:
            SITE$     = W1D-052
```

Table A2.2. Summary statistics of water quality data from the output (W1D-052) of the W1D wetland treatment system, 1992-1999 data (continued).

YEAR = 97.000

TOTAL OBSERVATIONS: 17

	PH	SC	CUT	CUF	NIT
N OF CASES	17	0	17	0	17
MINIMUM	7.100	.	-0.001	.	0.050
MAXIMUM	7.600	.	0.004	.	0.580
RANGE	0.500	.	0.005	.	0.530
MEAN	7.318	.	0.001	.	0.178
STANDARD DEV	0.170	.	0.002	.	0.148
MEDIAN	7.200	.	0.001	.	0.102

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	17	0	17	0
MINIMUM	.	0.001	.	0.005	.
MAXIMUM	.	0.004	.	0.017	.
RANGE	.	0.003	.	0.012	.
MEAN	.	0.001	.	0.007	.
STANDARD DEV	.	0.001	.	0.004	.
MEDIAN	.	0.001	.	0.005	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	17	17	17	0	17
MINIMUM	0.015	1.200	566.000	.	66.700
MAXIMUM	0.090	6.400	1000.000	.	188.000
RANGE	0.075	5.200	434.000	.	121.300
MEAN	0.055	3.153	790.765	.	146.747
STANDARD DEV	0.021	1.679	126.504	.	33.973
MEDIAN	0.050	2.800	808.000	.	149.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	17	17	17	0
MINIMUM	58.000	165.000	194.000	.
MAXIMUM	184.000	165.000	194.000	.
RANGE	126.000	0.000	0.000	.
MEAN	142.029	165.000	194.000	.
STANDARD DEV	34.317	0.000	0.000	.
MEDIAN	148.000	165.000	194.000	.

Table A2.2. Summary statistics of water quality data from the output (W1D-052) of the W1D wetland treatment system, 1992-1999 data (continued).

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-052
YEAR = 98.000

TOTAL OBSERVATIONS: 18

	PH	SC	CUT	CUF	NIT
N OF CASES	17	0	17	0	17
MINIMUM	7.100	.	-0.001	.	0.009
MAXIMUM	7.600	.	0.012	.	0.640
RANGE	0.500	.	0.013	.	0.631
MEAN	7:294	.	0.002	.	0.121
STANDARD DEV	0.125	.	0.003	.	0.159
MEDIAN	7.300	.	0.002	.	0.057

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	17	0	17	0
MINIMUM	.	-0.001	.	-0.010	.
MAXIMUM	.	0.006	.	0.030	.
RANGE	.	0.007	.	0.040	.
MEAN	.	0.000	.	0.006	.
STANDARD DEV	.	0.002	.	0.014	.
MEDIAN	.	-0.001	.	0.012	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	17	17	17	0	17
MINIMUM	-0.030	1.200	421.000	.	90.100
MAXIMUM	0.130	10.000	1160.000	.	199.000
RANGE	0.160	8.800	739.000	.	108.900
MEAN	0.026	4.353	816.647	.	147.476
STANDARD DEV	0.054	2.433	196.873	.	35.244
MEDIAN	0.040	4.000	808.000	.	149.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	17	18	18	0
MINIMUM	84.700	165.000	194.000	.
MAXIMUM	209.000	165.000	194.000	.
RANGE	124.300	0.000	0.000	.
MEAN	148.394	165.000	194.000	.
STANDARD DEV	38.836	0.000	0.000	.
MEDIAN	149.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-052

Table A2.2. Summary statistics of water quality data from the output (W1D-052) of the W1D wetland treatment system, 1992-1999 data (continued).

YEAR = 99.000
TOTAL OBSERVATIONS: 17

	PH	SC	CUT	CUF	NIT
N OF CASES	17	0	17	0	17
MINIMUM	6.800	.	-0.001	.	0.037
MAXIMUM	7.900	.	0.015	.	0.304
RANGE	1.100	.	0.016	.	0.267
MEAN	7.288	.	0.001	.	0.140
STANDARD DEV	0.287	.	0.004	.	0.072
MEDIAN	7.300	.	-0.001	.	0.117

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	17	0	17	0
MINIMUM	.	-0.001	.	-0.010	.
MAXIMUM	.	0.003	.	0.024	.
RANGE	.	0.004	.	0.034	.
MEAN	.	-0.000	.	0.007	.
STANDARD DEV	.	0.001	.	0.014	.
MEDIAN	.	-0.001	.	0.013	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	17	10	17	0	17
MINIMUM	0.020	-1.000	479.000	.	65.300
MAXIMUM	0.330	4.000	1090.000	.	206.000
RANGE	0.310	5.000	611.000	.	140.700
MEAN	0.074	2.620	773.706	.	141.000
STANDARD DEV	0.070	1.709	173.629	.	39.216
MEDIAN	0.060	3.250	765.000	.	142.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	17	17	11	6
MINIMUM	57.000	165.000	194.000	13.142
MAXIMUM	201.000	1340.000	194.000	91.997
RANGE	144.000	1175.000	0.000	78.854
MEAN	135.729	506.765	194.000	40.741
STANDARD DEV	39.848	482.655	0.000	28.782
MEDIAN	144.000	165.000	194.000	36.799

Note: The parameters with a T suffix are total values, parameters with an F suffix are filtered values. TOTHARD is total hardness, FLOWLM is liters/min, and values preceded with a hyphen are less than the detection limit.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052.

- The sites called Upstream1, etc. are from sites upstream of site W1D-051 (the input to the wetland system; see figure 4).
- The sites called W1D-1, W1D-2, etc. are profile sites within the original system, and
- The site called W1D-050 is the outfall from the enlarged W1D system.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Upstream1
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	9	0	14	0	14
MINIMUM	6.500	.	0.030	.	0.100
MAXIMUM	8.000	.	0.450	.	0.620
RANGE	1.500	.	0.420	.	0.520
MEAN	6.833	.	0.166	.	0.439
STANDARD DEV	0.469	.	0.127	.	0.147
MEDIAN	6.700	.	0.105	.	0.420

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	3	0
MINIMUM	.	0.007	.	0.060	.
MAXIMUM	.	0.008	.	0.070	.
RANGE	.	0.001	.	0.010	.
MEAN	.	0.008	.	0.067	.
STANDARD DEV	.	0.001	.	0.006	.
MEDIAN	.	0.008	.	0.070	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	599.000	.	240.000
MAXIMUM	.	.	2374.000	.	270.000
RANGE	.	.	1775.000	.	30.000
MEAN	.	.	1326.071	.	255.000
STANDARD DEV	.	.	413.263	.	21.213
MEDIAN	.	.	1316.000	.	255.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	160.000	165.000	194.000	.
MAXIMUM	290.000	165.000	194.000	.
RANGE	130.000	0.000	0.000	.
MEAN	225.000	165.000	194.000	.
STANDARD DEV	91.924	0.000	0.000	.
MEDIAN	225.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Upstream1
YEAR = 94.000

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	14	0	14	2	14
MINIMUM	6.500	.	0.030	0.070	0.240
MAXIMUM	7.400	.	0.190	0.180	0.460
RANGE	0.900	.	0.160	0.110	0.220
MEAN	6.936	.	0.089	0.125	0.335
STANDARD DEV	0.305	.	0.050	0.078	0.066
MEDIAN	6.900	.	0.070	0.125	0.310

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.420	.	.	.	.
MAXIMUM	0.450	.	.	.	.
RANGE	0.030	.	.	.	.
MEAN	0.435	.	.	.	.
STANDARD DEV	0.021	.	.	.	.
MEDIAN	0.435	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	1452.000	1945.000	.
MAXIMUM	.	.	2509.000	2265.000	.
RANGE	.	.	1057.000	320.000	.
MEAN	.	.	1999.714	2105.000	.
STANDARD DEV	.	.	276.788	226.274	.
MEDIAN	.	.	1985.500	2105.000	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	14	14	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Upstream2
YEAR = 92.000

TOTAL OBSERVATIONS: 5

	PH	SC	CUT	CUF	NIT
N OF CASES	1	0	5	0	5
MINIMUM	7.300	.	0.023	.	0.970
MAXIMUM	7.300	.	0.540	.	9.100
RANGE	0.000	.	0.517	.	8.130

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MEAN	7.300	.	0.283	.	4.734
STANDARD DEV	.	.	0.227	.	2.990
MEDIAN	7.300	.	0.310	.	3.900

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	5	0	5	0
MINIMUM	.	0.024	.	0.040	.
MAXIMUM	.	0.390	.	0.250	.
RANGE	.	0.366	.	0.210	.
MEAN	.	0.185	.	0.140	.
STANDARD DEV	.	0.135	.	0.077	.
MEDIAN	.	0.150	.	0.130	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	5	0	0
MINIMUM	.	.	1388.000	.	.
MAXIMUM	.	.	2554.000	.	.
RANGE	.	.	1166.000	.	.
MEAN	.	.	1979.600	.	.
STANDARD DEV	.	.	517.891	.	.
MEDIAN	.	.	2138.000	.	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	5	5	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Upstream2
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	0.030	.	0.790
MAXIMUM	.	.	0.210	.	5.400
RANGE	.	.	0.180	.	4.610
MEAN	.	.	0.091	.	3.002
STANDARD DEV	.	.	0.052	.	1.580
MEDIAN	.	.	0.070	.	3.300

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	2	0
MINIMUM	.	0.004	.	0.050	.
MAXIMUM	.	0.004	.	0.050	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

RANGE	.	0.000	.	0.000	.
MEAN	.	0.004	.	0.050	.
STANDARD DEV	.	0.000	.	0.000	.
MEDIAN	.	0.004	.	0.050	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	752.000	.	130.000
MAXIMUM	.	.	2395.000	.	160.000
RANGE	.	.	1643.000	.	30.000
MEAN	.	.	1643.929	.	145.000
STANDARD DEV	.	.	518.735	.	21.213
MEDIAN	.	.	1536.000	.	145.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	140.000	165.000	194.000	.
MAXIMUM	280.000	165.000	194.000	.
RANGE	140.000	0.000	0.000	.
MEAN	210.000	165.000	194.000	.
STANDARD DEV	98.995	0.000	0.000	.
MEDIAN	210.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Upstream2
YEAR = 94.000

TOTAL OBSERVATIONS: 15

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	15	2	15
MINIMUM	.	.	0.013	0.060	1.200
MAXIMUM	.	.	0.190	0.120	6.600
RANGE	.	.	0.177	0.060	5.400
MEAN	.	.	0.074	0.090	3.400
STANDARD DEV	.	.	0.058	0.042	1.531
MEDIAN	.	.	0.050	0.090	3.500

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	2.300	.	.	.	.
MAXIMUM	3.200	.	.	.	.
RANGE	0.900	.	.	.	.
MEAN	2.750	.	.	.	.
STANDARD DEV	0.636	.	.	.	.
MEDIAN	2.750	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	15	2	0
MINIMUM	.	.	1465.000	1924.000	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MAXIMUM	.	.	2545.000	2035.000	.
RANGE	.	.	1080.000	111.000	.
MEAN	.	.	2001.467	1979.500	.
STANDARD DEV	.	.	322.289	78.489	.
MEDIAN	.	.	2035.000	1979.500	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	15	15	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Upstream3
YEAR = 92.000

TOTAL OBSERVATIONS: 11

	PH	SC	CUT	CUF	NIT
N OF CASES	8	0	11	0	11
MINIMUM	6.400	.	0.029	.	2.700
MAXIMUM	7.200	.	0.310	.	6.900
RANGE	0.800	.	0.281	.	4.200
MEAN	6.863	.	0.132	.	4.991
STANDARD DEV	0.272	.	0.108	.	1.390
MEDIAN	6.950	.	0.110	.	4.600

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	11	0	11	0
MINIMUM	.	0.032	.	0.040	.
MAXIMUM	.	0.100	.	0.120	.
RANGE	.	0.068	.	0.080	.
MEAN	.	0.064	.	0.077	.
STANDARD DEV	.	0.021	.	0.025	.
MEDIAN	.	0.060	.	0.080	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	11	0	0
MINIMUM	.	.	2233.000	.	.
MAXIMUM	.	.	2983.000	.	.
RANGE	.	.	750.000	.	.
MEAN	.	.	2554.727	.	.
STANDARD DEV	.	.	224.492	.	.
MEDIAN	.	.	2541.000	.	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	11	11	0

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Upstream3
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	0.019	.	0.850
MAXIMUM	.	.	0.060	.	8.300
RANGE	.	.	0.041	.	7.450
MEAN	.	.	0.034	.	4.146
STANDARD DEV	.	.	0.011	.	2.500
MEDIAN	.	.	0.030	.	4.600

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	3	0	3	0
MINIMUM	.	0.002	.	0.060	.
MAXIMUM	.	0.006	.	0.070	.
RANGE	.	0.004	.	0.010	.
MEAN	.	0.004	.	0.063	.
STANDARD DEV	.	0.002	.	0.006	.
MEDIAN	.	0.005	.	0.060	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	1133.000	.	180.000
MAXIMUM	.	.	2708.000	.	200.000
RANGE	.	.	1575.000	.	20.000
MEAN	.	.	1986.357	.	190.000
STANDARD DEV	.	.	540.673	.	14.142
MEDIAN	.	.	2068.500	.	190.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	180.000	165.000	194.000	.
MAXIMUM	190.000	165.000	194.000	.
RANGE	10.000	0.000	0.000	.
MEAN	185.000	165.000	194.000	.
STANDARD DEV	7.071	0.000	0.000	.
MEDIAN	185.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

SITE$ = Upstream3
YEAR = 94.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	2	14
MINIMUM	.	.	0.015	0.060	0.880
MAXIMUM	.	.	0.140	0.070	7.400
RANGE	.	.	0.125	0.010	6.520
MEAN	.	.	0.060	0.065	4.456
STANDARD DEV	.	.	0.037	0.007	1.653
MEDIAN	.	.	0.040	0.065	4.650

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	2.800	.	.	.	.
MAXIMUM	3.800	.	.	.	.
RANGE	1.000	.	.	.	.
MEAN	3.300	.	.	.	.
STANDARD DEV	0.707	.	.	.	.
MEDIAN	3.300	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	1416.000	2169.000	.
MAXIMUM	.	.	2629.000	2359.000	.
RANGE	.	.	1213.000	190.000	.
MEAN	.	.	2261.357	2264.000	.
STANDARD DEV	.	.	293.720	134.350	.
MEDIAN	.	.	2305.500	2264.000	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	14	14	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-050
YEAR = 95.000

TOTAL OBSERVATIONS: 8

	PH	SC	CUT	CUF	NIT
N OF CASES	8	0	8	0	8
MINIMUM	7.000	.	0.002	.	0.039

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MAXIMUM	7.500	.	0.012	.	0.540
RANGE	0.500	.	0.010	.	0.501
MEAN	7.313	.	0.007	.	0.199
STANDARD DEV	0.181	.	0.004	.	0.208
MEDIAN	7.350	.	0.007	.	0.100

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	8	0	8	0
MINIMUM	.	0.001	.	0.005	.
MAXIMUM	.	0.002	.	0.010	.
RANGE	.	0.002	.	0.005	.
MEAN	.	0.001	.	0.006	.
STANDARD DEV	.	0.001	.	0.002	.
MEDIAN	.	0.001	.	0.005	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	8	8	8	0	8
MINIMUM	0.050	0.800	865.000	.	150.000
MAXIMUM	0.300	4.800	1187.000	.	197.000
RANGE	0.250	4.000	322.000	.	47.000
MEAN	0.131	2.650	974.250	.	174.250
STANDARD DEV	0.080	1.417	128.858	.	18.783
MEDIAN	0.100	3.200	898.000	.	178.500

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	8	8	8	0
MINIMUM	140.000	165.000	194.000	.
MAXIMUM	220.000	165.000	194.000	.
RANGE	80.000	0.000	0.000	.
MEAN	181.375	165.000	194.000	.
STANDARD DEV	27.375	0.000	0.000	.
MEDIAN	183.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-050
YEAR = 96.000

TOTAL OBSERVATIONS: 18

	PH	SC	CUT	CUF	NIT
N OF CASES	18	0	18	0	18
MINIMUM	7.000	.	-0.001	.	0.050
MAXIMUM	7.700	.	0.017	.	0.533
RANGE	0.700	.	0.018	.	0.483
MEAN	7.439	.	0.007	.	0.193
STANDARD DEV	0.185	.	0.005	.	0.135
MEDIAN	7.450	.	0.006	.	0.126

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	18	0	18	0

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MINIMUM	.	0.001	.	0.005	.
MAXIMUM	.	0.005	.	0.028	.
RANGE	.	0.005	.	0.023	.
MEAN	.	0.001	.	0.012	.
STANDARD DEV	.	0.001	.	0.008	.
MEDIAN	.	0.001	.	0.010	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	18	18	18	0	18
MINIMUM	0.040	-1.000	114.000	.	62.400
MAXIMUM	0.300	5.600	1580.000	.	240.000
RANGE	0.260	6.600	1466.000	.	177.600
MEAN	0.106	2.839	982.500	.	175.133
STANDARD DEV	0.058	1.665	353.075	.	48.035
MEDIAN	0.100	3.000	1042.500	.	179.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	18	18	18	0
MINIMUM	78.000	165.000	194.000	.
MAXIMUM	240.000	165.000	194.000	.
RANGE	162.000	0.000	0.000	.
MEAN	167.833	165.000	194.000	.
STANDARD DEV	40.083	0.000	0.000	.
MEDIAN	176.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-050
YEAR = 97.000

TOTAL OBSERVATIONS: 24

	PH	SC	CUT	CUF	NIT
N OF CASES	24	0	24	0	24
MINIMUM	7.000	.	-0.002	.	0.049
MAXIMUM	7.700	.	0.005	.	0.363
RANGE	0.700	.	0.007	.	0.314
MEAN	7.404	.	0.001	.	0.143
STANDARD DEV	0.220	.	0.002	.	0.077
MEDIAN	7.500	.	0.001	.	0.125

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	24	0	24	0
MINIMUM	.	0.001	.	0.005	.
MAXIMUM	.	0.004	.	0.038	.
RANGE	.	0.004	.	0.033	.
MEAN	.	0.001	.	0.009	.
STANDARD DEV	.	0.001	.	0.007	.
MEDIAN	.	0.001	.	0.005	.

FEF	TSS	SO4T	SO4F	CAT

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

N OF CASES	24	24	24	0	24
MINIMUM	0.030	-1.000	568.000	.	82.700
MAXIMUM	0.770	15.600	1300.000	.	205.000
RANGE	0.740	16.600	732.000	.	122.300
MEAN	0.134	3.667	896.958	.	154.971
STANDARD DEV	0.145	3.484	210.232	.	33.005
MEDIAN	0.100	2.400	832.000	.	156.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	24	24	24	0
MINIMUM	71.500	165.000	194.000	.
MAXIMUM	212.000	165.000	194.000	.
RANGE	140.500	0.000	0.000	.
MEAN	153.104	165.000	194.000	.
STANDARD DEV	37.511	0.000	0.000	.
MEDIAN	150.500	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-050
YEAR = 98.000

TOTAL OBSERVATIONS: 23

	PH	SC	CUT	CUF	NIT
N OF CASES	23	0	23	0	23
MINIMUM	6.900	.	-0.001	.	0.019
MAXIMUM	7.700	.	0.009	.	0.288
RANGE	0.800	.	0.010	.	0.270
MEAN	7.383	.	0.001	.	0.073
STANDARD DEV	0.229	.	0.003	.	0.061
MEDIAN	7.400	.	-0.001	.	0.054

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	23	0	23	0
MINIMUM	.	-0.001	.	-0.010	.
MAXIMUM	.	1.900	.	0.021	.
RANGE	.	1.901	.	0.031	.
MEAN	.	0.082	.	0.004	.
STANDARD DEV	.	0.396	.	0.013	.
MEDIAN	.	-0.001	.	0.011	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	23	23	23	0	23
MINIMUM	-0.030	-1.000	299.000	.	73.600
MAXIMUM	0.280	8.400	1060.000	.	201.000
RANGE	0.310	9.400	761.000	.	127.400
MEAN	0.070	1.722	779.913	.	147.722
STANDARD DEV	0.091	3.249	179.481	.	28.924
MEDIAN	0.050	1.000	776.000	.	143.000

MGT	TOTHARD	ALK	FLOWLM

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

N OF CASES	23	23	23	0
MINIMUM	70.400	165.000	194.000	.
MAXIMUM	194.000	165.000	194.000	.
RANGE	123.600	0.000	0.000	.
MEAN	147.974	165.000	194.000	.
STANDARD DEV	29.113	0.000	0.000	.
MEDIAN	145.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-050
YEAR = 99.000

TOTAL OBSERVATIONS: 22

	PH	SC	CUT	CUF	NIT
N OF CASES	22	0	22	0	22
MINIMUM	6.800	.	-0.001	.	0.038
MAXIMUM	7.800	.	0.008	.	0.209
RANGE	1.000	.	0.009	.	0.171
MEAN	7.382	.	0.001	.	0.098
STANDARD DEV	0.254	.	0.002	.	0.049
MEDIAN	7.400	.	0.001	.	0.093

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	22	0	22	0
MINIMUM	.	-0.001	.	-0.010	.
MAXIMUM	.	0.002	.	0.021	.
RANGE	.	0.003	.	0.031	.
MEAN	.	-0.000	.	0.005	.
STANDARD DEV	.	0.001	.	0.013	.
MEDIAN	.	-0.001	.	0.011	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	22	6	22	0	22
MINIMUM	-0.030	2.000	299.000	.	57.800
MAXIMUM	0.460	9.000	1120.000	.	200.000
RANGE	0.490	7.000	821.000	.	142.200
MEAN	0.082	4.133	789.273	.	144.745
STANDARD DEV	0.112	2.515	220.909	.	37.184
MEDIAN	0.060	3.650	814.000	.	145.500

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	22	22	16	22
MINIMUM	52.300	165.000	194.000	5.257
MAXIMUM	206.000	1100.000	194.000	935.739
RANGE	153.700	935.000	0.000	930.482
MEAN	143.255	400.045	194.000	155.678
STANDARD DEV	39.190	394.888	0.000	228.654
MEDIAN	144.500	165.000	194.000	88.054

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-1
YEAR = 92.000

TOTAL OBSERVATIONS: 11

	PH	SC	CUT	CUF	NIT
N OF CASES	2	0	11	0	11
MINIMUM	7.400	.	0.001	.	0.120
MAXIMUM	7.500	.	0.025	.	5.000
RANGE	0.100	.	0.024	.	4.880
MEAN	7.450	.	0.010	.	1.053
STANDARD DEV	0.071	.	0.008	.	1.723
MEDIAN	7.450	.	0.006	.	0.330

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	11	0	11	0
MINIMUM	.	0.000	.	0.005	.
MAXIMUM	.	0.029	.	0.080	.
RANGE	.	0.029	.	0.075	.
MEAN	.	0.005	.	0.040	.
STANDARD DEV	.	0.009	.	0.025	.
MEDIAN	.	0.000	.	0.040	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	11	0	0
MINIMUM	.	.	1171.000	.	.
MAXIMUM	.	.	2800.000	.	.
RANGE	.	.	1629.000	.	.
MEAN	.	.	1643.182	.	.
STANDARD DEV	.	.	543.279	.	.
MEDIAN	.	.	1411.000	.	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	11	11	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-1
YEAR = 93.000

TOTAL OBSERVATIONS: 14

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

	PH	SC	CUT	CUF	NIT
N OF CASES	1	0	14	0	14
MINIMUM	6.800	.	0.004	.	0.110
MAXIMUM	6.800	.	0.010	.	1.800
RANGE	0.000	.	0.006	.	1.690
MEAN	6.800	.	0.006	.	0.474
STANDARD DEV	.	.	0.002	.	0.500
MEDIAN	6.800	.	0.006	.	0.280

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	2	0
MINIMUM	.	0.001	.	0.040	.
MAXIMUM	.	0.001	.	0.040	.
RANGE	.	0.000	.	0.000	.
MEAN	.	0.001	.	0.040	.
STANDARD DEV	.	0.000	.	0.000	.
MEDIAN	.	0.001	.	0.040	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	125.000	.	70.000
MAXIMUM	.	.	1178.000	.	73.000
RANGE	.	.	1053.000	.	3.000
MEAN	.	.	617.786	.	71.500
STANDARD DEV	.	.	264.785	.	2.121
MEDIAN	.	.	587.000	.	71.500

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	60.000	165.000	194.000	.
MAXIMUM	64.000	165.000	194.000	.
RANGE	4.000	0.000	0.000	.
MEAN	62.000	165.000	194.000	.
STANDARD DEV	2.828	0.000	0.000	.
MEDIAN	62.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-1
YEAR = 94.000

TOTAL OBSERVATIONS: 17

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	2	17
MINIMUM	.	.	0.005	0.006	0.200
MAXIMUM	.	.	0.030	0.006	4.200
RANGE	.	.	0.025	0.000	4.000
MEAN	.	.	0.011	0.006	0.703
STANDARD DEV	.	.	0.006	0.000	0.975

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MEDIAN	.	.	0.009	0.006	0.400

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.220	.	.	.	.
MAXIMUM	0.420	.	.	.	.
RANGE	0.200	.	.	.	.
MEAN	0.320	.	.	.	.
STANDARD DEV	0.141	.	.	.	.
MEDIAN	0.320	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	398.000	451.000	.
MAXIMUM	.	.	3136.000	763.000	.
RANGE	.	.	2738.000	312.000	.
MEAN	.	.	950.000	607.000	.
STANDARD DEV	.	.	825.237	220.617	.
MEDIAN	.	.	535.500	607.000	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	17	17	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-10
YEAR = 92.000

TOTAL OBSERVATIONS: 11

	PH	SC	CUT	CUF	NIT
N OF CASES	2	0	11	0	11
MINIMUM	6.800	.	0.000	.	0.140
MAXIMUM	7.300	.	0.036	.	1.000
RANGE	0.500	.	0.036	.	0.860
MEAN	7.050	.	0.009	.	0.613
STANDARD DEV	0.354	.	0.011	.	0.288
MEDIAN	7.050	.	0.005	.	0.690

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	11	0	11	0
MINIMUM	.	0.000	.	0.005	.
MAXIMUM	.	0.014	.	0.070	.
RANGE	.	0.014	.	0.065	.
MEAN	.	0.004	.	0.037	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

STANDARD DEV	.	0.005	.	0.024	.
MEDIAN	.	0.002	.	0.040	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	11	0	0
MINIMUM	.	.	1981.000	.	.
MAXIMUM	.	.	2737.000	.	.
RANGE	.	.	756.000	.	.
MEAN	.	.	2225.545	.	.
STANDARD DEV	.	.	243.584	.	.
MEDIAN	.	.	2125.000	.	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	11	11	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-10
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	0.002	.	0.070
MAXIMUM	.	.	0.012	.	1.400
RANGE	.	.	0.010	.	1.330
MEAN	.	.	0.005	.	0.495
STANDARD DEV	.	.	0.002	.	0.430
MEDIAN	.	.	0.006	.	0.545

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	2	0
MINIMUM	.	0.001	.	0.030	.
MAXIMUM	.	0.001	.	0.050	.
RANGE	.	0.000	.	0.020	.
MEAN	.	0.001	.	0.040	.
STANDARD DEV	.	0.000	.	0.014	.
MEDIAN	.	0.001	.	0.040	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	714.000	.	120.000
MAXIMUM	.	.	1880.000	.	130.000
RANGE	.	.	1166.000	.	10.000

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MEAN	.	.	1314.357	.	125.000
STANDARD DEV	.	.	347.174	.	7.071
MEDIAN	.	.	1268.500	.	125.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	140.000	165.000	194.000	.
MAXIMUM	140.000	165.000	194.000	.
RANGE	0.000	0.000	0.000	.
MEAN	140.000	165.000	194.000	.
STANDARD DEV	0.000	0.000	0.000	.
MEDIAN	140.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-10
YEAR = 94.000

TOTAL OBSERVATIONS: 17

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	2	16
MINIMUM	.	.	0.002	0.004	0.130
MAXIMUM	.	.	0.010	0.005	1.200
RANGE	.	.	0.008	0.001	1.070
MEAN	.	.	0.005	0.005	0.616
STANDARD DEV	.	.	0.002	0.001	0.415
MEDIAN	.	.	0.005	0.005	0.495

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.130	.	.	.	.
MAXIMUM	0.130	.	.	.	.
RANGE	0.000	.	.	.	.
MEAN	0.130	.	.	.	.
STANDARD DEV	0.000	.	.	.	.
MEDIAN	0.130	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	1089.000	1089.000	.
MAXIMUM	.	.	2128.000	1110.000	.
RANGE	.	.	1039.000	21.000	.
MEAN	.	.	1682.929	1099.500	.
STANDARD DEV	.	.	345.618	14.849	.
MEDIAN	.	.	1794.000	1099.500	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	17	17	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-11
YEAR = 92.000

TOTAL OBSERVATIONS: 11

	PH	SC	CUT	CUF	NIT
N OF CASES	2	0	11	0	11
MINIMUM	6.800	.	0.000	.	0.160
MAXIMUM	7.300	.	0.010	.	0.870
RANGE	0.500	.	0.010	.	0.710
MEAN	7.050	.	0.005	.	0.547
STANDARD DEV	0.354	.	0.004	.	0.275
MEDIAN	7.050	.	0.003	.	0.590

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	11	0	11	0
MINIMUM	.	0.000	.	0.005	.
MAXIMUM	.	0.016	.	0.060	.
RANGE	.	0.016	.	0.055	.
MEAN	.	0.005	.	0.035	.
STANDARD DEV	.	0.005	.	0.022	.
MEDIAN	.	0.003	.	0.040	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	11	0	0
MINIMUM	.	.	1892.000	.	.
MAXIMUM	.	.	3015.000	.	.
RANGE	.	.	1123.000	.	.
MEAN	.	.	2215.636	.	.
STANDARD DEV	.	.	330.467	.	.
MEDIAN	.	.	2068.000	.	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	11	11	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-11
YEAR = 93.000

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	0.003	.	0.070
MAXIMUM	.	.	0.012	.	1.500
RANGE	.	.	0.009	.	1.430
MEAN	.	.	0.005	.	0.543
STANDARD DEV	.	.	0.003	.	0.467
MEDIAN	.	.	0.005	.	0.530

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	2	0
MINIMUM	.	0.001	.	0.040	.
MAXIMUM	.	0.001	.	0.050	.
RANGE	.	0.000	.	0.010	.
MEAN	.	0.001	.	0.045	.
STANDARD DEV	.	0.000	.	0.007	.
MEDIAN	.	0.001	.	0.045	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	708.000	.	120.000
MAXIMUM	.	.	1922.000	.	130.000
RANGE	.	.	1214.000	.	10.000
MEAN	.	.	1338.500	.	125.000
STANDARD DEV	.	.	347.428	.	7.071
MEDIAN	.	.	1278.000	.	125.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	130.000	165.000	194.000	.
MAXIMUM	140.000	165.000	194.000	.
RANGE	10.000	0.000	0.000	.
MEAN	135.000	165.000	194.000	.
STANDARD DEV	7.071	0.000	0.000	.
MEDIAN	135.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-11
YEAR = 94.000

TOTAL OBSERVATIONS: 22

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	19	2	22
MINIMUM	.	.	0.001	0.004	0.030
MAXIMUM	.	.	0.018	0.007	1.040
RANGE	.	.	0.017	0.003	1.010

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MEAN	.	.	0.005	0.006	0.395
STANDARD DEV	.	.	0.004	0.002	0.340
MEDIAN	.	.	0.004	0.006	0.340

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.160	.	.	.	.
MAXIMUM	0.160	.	.	.	.
RANGE	0.000	.	.	.	.
MEAN	0.160	.	.	.	.
STANDARD DEV	0.000	.	.	.	.
MEDIAN	0.160	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	19	2	0
MINIMUM	.	.	851.000	1077.000	.
MAXIMUM	.	.	2096.000	1117.000	.
RANGE	.	.	1245.000	40.000	.
MEAN	.	.	1688.211	1097.000	.
STANDARD DEV	.	.	384.771	28.284	.
MEDIAN	.	.	1829.000	1097.000	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	22	22	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-12
YEAR = 92.000

TOTAL OBSERVATIONS: 1

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	1	0	1
MINIMUM	.	.	0.003	.	0.370
MAXIMUM	.	.	0.003	.	0.370
RANGE	.	.	0.000	.	0.000
MEAN	.	.	0.003	.	0.370
STANDARD DEV	.	.	.	.	.
MEDIAN	.	.	0.003	.	0.370

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	1	0	1	0
MINIMUM	.	0.011	.	0.040	.
MAXIMUM	.	0.011	.	0.040	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

RANGE	.	0.000	.	0.000	.
MEAN	.	0.011	.	0.040	.
STANDARD DEV	.	.	.	.	.
MEDIAN	.	0.011	.	0.040	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	1	0	0
MINIMUM	.	.	2077.000	.	.
MAXIMUM	.	.	2077.000	.	.
RANGE	.	.	0.000	.	.
MEAN	.	.	2077.000	.	.
STANDARD DEV	.	.	.	.	.
MEDIAN	.	.	2077.000	.	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	1	1	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	.	.	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-12
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	0.002	.	0.047
MAXIMUM	.	.	0.080	.	0.690
RANGE	.	.	0.078	.	0.643
MEAN	.	.	0.010	.	0.243
STANDARD DEV	.	.	0.020	.	0.201
MEDIAN	.	.	0.005	.	0.215

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	2	0
MINIMUM	.	0.001	.	0.030	.
MAXIMUM	.	0.007	.	0.050	.
RANGE	.	0.006	.	0.020	.
MEAN	.	0.004	.	0.040	.
STANDARD DEV	.	0.004	.	0.014	.
MEDIAN	.	0.004	.	0.040	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	763.000	.	120.000

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MAXIMUM	.	.	1556.000	.	130.000
RANGE	.	.	793.000	.	10.000
MEAN	.	.	1165.357	.	125.000
STANDARD DEV	.	.	208.534	.	7.071
MEDIAN	.	.	1138.000	.	125.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	130.000	165.000	194.000	.
MAXIMUM	140.000	165.000	194.000	.
RANGE	10.000	0.000	0.000	.
MEAN	135.000	165.000	194.000	.
STANDARD DEV	7.071	0.000	0.000	.
MEDIAN	135.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-12
YEAR = 94.000

TOTAL OBSERVATIONS: 19

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	2	19
MINIMUM	.	.	0.001	0.004	0.030
MAXIMUM	.	.	0.014	0.005	0.850
RANGE	.	.	0.013	0.001	0.820
MEAN	.	.	0.005	0.005	0.215
STANDARD DEV	.	.	0.004	0.001	0.253
MEDIAN	.	.	0.005	0.005	0.120

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.070	.	.	.	.
MAXIMUM	0.100	.	.	.	.
RANGE	0.030	.	.	.	.
MEAN	0.085	.	.	.	.
STANDARD DEV	0.021	.	.	.	.
MEDIAN	0.085	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	363.000	948.000	.
MAXIMUM	.	.	1807.000	959.000	.
RANGE	.	.	1444.000	11.000	.
MEAN	.	.	1276.786	953.500	.
STANDARD DEV	.	.	370.329	7.778	.
MEDIAN	.	.	1344.500	953.500	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	19	19	0

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-2
YEAR = 92.000

TOTAL OBSERVATIONS: 11

	PH	SC	CUT	CUF	NIT
N OF CASES	2	0	11	0	11
MINIMUM	6.500	.	0.011	.	2.500
MAXIMUM	7.100	.	0.060	.	5.700
RANGE	0.600	.	0.049	.	3.200
MEAN	6.800	.	0.035	.	4.100
STANDARD DEV	0.424	.	0.014	.	1.055
MEDIAN	6.800	.	0.037	.	4.000

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	11	0	11	0
MINIMUM	.	0.001	.	0.030	.
MAXIMUM	.	0.023	.	0.090	.
RANGE	.	0.022	.	0.060	.
MEAN	.	0.009	.	0.065	.
STANDARD DEV	.	0.007	.	0.021	.
MEDIAN	.	0.005	.	0.070	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	11	0	0
MINIMUM	.	.	2049.000	.	.
MAXIMUM	.	.	2828.000	.	.
RANGE	.	.	779.000	.	.
MEAN	.	.	2451.818	.	.
STANDARD DEV	.	.	236.655	.	.
MEDIAN	.	.	2409.000	.	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	11	11	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

SITE$ = W1D-2
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	0.010	.	0.540
MAXIMUM	.	.	0.030	.	5.400
RANGE	.	.	0.020	.	4.860
MEAN	.	.	0.020	.	2.941
STANDARD DEV	.	.	0.005	.	1.897
MEDIAN	.	.	0.019	.	2.750

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	2	0
MINIMUM	.	0.001	.	0.040	.
MAXIMUM	.	0.002	.	0.050	.
RANGE	.	0.001	.	0.010	.
MEAN	.	0.002	.	0.045	.
STANDARD DEV	.	0.001	.	0.007	.
MEDIAN	.	0.002	.	0.045	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	796.000	.	120.000
MAXIMUM	.	.	2269.000	.	130.000
RANGE	.	.	1473.000	.	10.000
MEAN	.	.	1560.071	.	125.000
STANDARD DEV	.	.	480.226	.	7.071
MEDIAN	.	.	1511.000	.	125.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	130.000	165.000	194.000	.
MAXIMUM	130.000	165.000	194.000	.
RANGE	0.000	0.000	0.000	.
MEAN	130.000	165.000	194.000	.
STANDARD DEV	0.000	0.000	0.000	.
MEDIAN	130.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-2
YEAR = 94.000

TOTAL OBSERVATIONS: 17

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	2	17
MINIMUM	.	.	0.016	0.014	0.900

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MAXIMUM	.	.	0.050	0.016	6.100
RANGE	.	.	0.034	0.002	5.200
MEAN	.	.	0.029	0.015	3.932
STANDARD DEV	.	.	0.007	0.001	1.604
MEDIAN	.	.	0.029	0.015	4.000

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	1.300	.	.	.	.
MAXIMUM	1.600	.	.	.	.
RANGE	0.300	.	.	.	.
MEAN	1.450	.	.	.	.
STANDARD DEV	0.212	.	.	.	.
MEDIAN	1.450	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	1022.000	1525.000	.
MAXIMUM	.	.	2870.000	1781.000	.
RANGE	.	.	1848.000	256.000	.
MEAN	.	.	2009.286	1653.000	.
STANDARD DEV	.	.	444.371	181.019	.
MEDIAN	.	.	2068.000	1653.000	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	17	17	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-3
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	0.012	.	0.510
MAXIMUM	.	.	0.033	.	5.300
RANGE	.	.	0.021	.	4.790
MEAN	.	.	0.020	.	2.791
STANDARD DEV	.	.	0.006	.	1.779
MEDIAN	.	.	0.018	.	2.750

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	1	0	2	0

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MINIMUM	.	0.003	.	0.040	.
MAXIMUM	.	0.003	.	0.060	.
RANGE	.	0.000	.	0.020	.
MEAN	.	0.003	.	0.050	.
STANDARD DEV	.	.	.	0.014	.
MEDIAN	.	0.003	.	0.050	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	801.000	.	120.000
MAXIMUM	.	.	2364.000	.	130.000
RANGE	.	.	1563.000	.	10.000
MEAN	.	.	1612.143	.	125.000
STANDARD DEV	.	.	504.415	.	7.071
MEDIAN	.	.	1535.000	.	125.000

	MGT	TOTHARD	ALK	FLOWLM	
N OF CASES	2	14	14	0	.
MINIMUM	130.000	165.000	194.000	.	
MAXIMUM	130.000	165.000	194.000	.	
RANGE	0.000	0.000	0.000	.	
MEAN	130.000	165.000	194.000	.	
STANDARD DEV	0.000	0.000	0.000	.	
MEDIAN	130.000	165.000	194.000	.	

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-3
YEAR = 94.000

TOTAL OBSERVATIONS: 17

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	2	17
MINIMUM	.	.	0.017	0.007	0.400
MAXIMUM	.	.	0.040	0.016	5.300
RANGE	.	.	0.023	0.009	4.900
MEAN	.	.	0.024	0.012	3.495
STANDARD DEV	.	.	0.006	0.006	1.480
MEDIAN	.	.	0.024	0.012	3.600

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.360	.	.	.	.
MAXIMUM	1.300	.	.	.	.
RANGE	0.940	.	.	.	.
MEAN	0.830	.	.	.	.
STANDARD DEV	0.665	.	.	.	.
MEDIAN	0.830	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

N OF CASES	0	0	14	2	0
MINIMUM	.	.	1304.000	1415.000	.
MAXIMUM	.	.	2557.000	1628.000	.
RANGE	.	.	1253.000	213.000	.
MEAN	.	.	1962.357	1521.500	.
STANDARD DEV	.	.	361.960	150.614	.
MEDIAN	.	.	1968.000	1521.500	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	17	17	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-4
YEAR = 92.000

TOTAL OBSERVATIONS: 11

	PH	SC	CUT	CUF	NIT
N OF CASES	2	0	11	0	11
MINIMUM	6.800	.	0.007	.	1.900
MAXIMUM	7.300	.	0.050	.	4.500
RANGE	0.500	.	0.043	.	2.600
MEAN	7.050	.	0.024	.	3.345
STANDARD DEV	0.354	.	0.015	.	0.857
MEDIAN	7.050	.	0.018	.	3.600

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	11	0	11	0
MINIMUM	.	0.001	.	0.030	.
MAXIMUM	.	0.034	.	0.090	.
RANGE	.	0.033	.	0.060	.
MEAN	.	0.010	.	0.055	.
STANDARD DEV	.	0.009	.	0.018	.
MEDIAN	.	0.010	.	0.050	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	11	0	0
MINIMUM	.	.	2078.000	.	.
MAXIMUM	.	.	2686.000	.	.
RANGE	.	.	608.000	.	.
MEAN	.	.	2404.364	.	.
STANDARD DEV	.	.	210.282	.	.
MEDIAN	.	.	2395.000	.	.

	MGT	TOTHARD	ALK	FLOWLM

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

N OF CASES	0	11	11	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-4
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	-0.001	.	0.390
MAXIMUM	.	.	0.030	.	5.200
RANGE	.	.	0.031	.	4.810
MEAN	.	.	0.017	.	2.691
STANDARD DEV	.	.	0.007	.	1.781
MEDIAN	.	.	0.016	.	2.900

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	2	0
MINIMUM	.	0.001	.	0.040	.
MAXIMUM	.	0.002	.	0.050	.
RANGE	.	0.002	.	0.010	.
MEAN	.	0.001	.	0.045	.
STANDARD DEV	.	0.001	.	0.007	.
MEDIAN	.	0.001	.	0.045	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	741.000	.	120.000
MAXIMUM	.	.	2289.000	.	130.000
RANGE	.	.	1548.000	.	10.000
MEAN	.	.	1560.214	.	125.000
STANDARD DEV	.	.	481.412	.	7.071
MEDIAN	.	.	1508.500	.	125.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	120.000	165.000	194.000	.
MAXIMUM	130.000	165.000	194.000	.
RANGE	10.000	0.000	0.000	.
MEAN	125.000	165.000	194.000	.
STANDARD DEV	7.071	0.000	0.000	.
MEDIAN	125.000	165.000	194.000	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

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THE FOLLOWING RESULTS ARE FOR:
            SITE$     = W1D-4
            YEAR      =        94.000

TOTAL OBSERVATIONS:      19
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	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	2	18
MINIMUM	.	.	0.002	0.003	0.060
MAXIMUM	.	.	0.023	0.009	4.700
RANGE	.	.	0.021	0.006	4.640
MEAN	.	.	0.016	0.006	2.685
STANDARD DEV	.	.	0.005	0.004	1.662
MEDIAN	.	.	0.016	0.006	2.900

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.080	.	.	.	.
MAXIMUM	1.100	.	.	.	.
RANGE	1.020	.	.	.	.
MEAN	0.590	.	.	.	.
STANDARD DEV	0.721	.	.	.	.
MEDIAN	0.590	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	1008.000	1222.000	.
MAXIMUM	.	.	2569.000	1408.000	.
RANGE	.	.	1561.000	186.000	.
MEAN	.	.	1874.214	1315.000	.
STANDARD DEV	.	.	459.528	131.522	.
MEDIAN	.	.	2002.500	1315.000	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	19	19	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

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THE FOLLOWING RESULTS ARE FOR:
            SITE$     = W1D-5
            YEAR      =        92.000

TOTAL OBSERVATIONS:      11
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	PH	SC	CUT	CUF	NIT

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

N OF CASES	2	0	11	0	11
MINIMUM	6.500	.	0.003	.	1.600
MAXIMUM	7.300	.	0.051	.	3.200
RANGE	0.800	.	0.048	.	1.600
MEAN	6.900	.	0.015	.	2.255
STANDARD DEV	0.566	.	0.015	.	0.545
MEDIAN	6.900	.	0.008	.	2.100

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	11	0	11	0
MINIMUM	.	0.003	.	0.020	.
MAXIMUM	.	0.015	.	0.090	.
RANGE	.	0.012	.	0.070	.
MEAN	.	0.009	.	0.053	.
STANDARD DEV	.	0.004	.	0.021	.
MEDIAN	.	0.009	.	0.050	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	11	0	0
MINIMUM	.	.	2128.000	.	.
MAXIMUM	.	.	2770.000	.	.
RANGE	.	.	642.000	.	.
MEAN	.	.	2407.636	.	.
STANDARD DEV	.	.	238.491	.	.
MEDIAN	.	.	2461.000	.	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	11	11	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-5
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	-0.001	.	0.230
MAXIMUM	.	.	0.011	.	3.700
RANGE	.	.	0.012	.	3.470
MEAN	.	.	0.007	.	1.592
STANDARD DEV	.	.	0.003	.	1.139
MEDIAN	.	.	0.007	.	1.800

NIF	COT	COF	ZNT	ZNF

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

N OF CASES	0	2	0	2	0
MINIMUM	.	0.001	.	0.060	.
MAXIMUM	.	0.002	.	0.060	.
RANGE	.	0.002	.	0.000	.
MEAN	.	0.001	.	0.060	.
STANDARD DEV	.	0.001	.	0.000	.
MEDIAN	.	0.001	.	0.060	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	752.000	.	120.000
MAXIMUM	.	.	2237.000	.	130.000
RANGE	.	.	1485.000	.	10.000
MEAN	.	.	1466.429	.	125.000
STANDARD DEV	.	.	402.774	.	7.071
MEDIAN	.	.	1366.500	.	125.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	130.000	165.000	194.000	.
MAXIMUM	140.000	165.000	194.000	.
RANGE	10.000	0.000	0.000	.
MEAN	135.000	165.000	194.000	.
STANDARD DEV	7.071	0.000	0.000	.
MEDIAN	135.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-5
YEAR = 94.000

TOTAL OBSERVATIONS: 17

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	2	17
MINIMUM	.	.	0.003	0.003	0.170
MAXIMUM	.	.	0.069	0.009	2.300
RANGE	.	.	0.066	0.006	2.130
MEAN	.	.	0.013	0.006	1.532
STANDARD DEV	.	.	0.016	0.004	0.628
MEDIAN	.	.	0.010	0.006	1.800

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.150	.	.	.	.
MAXIMUM	0.660	.	.	.	.
RANGE	0.510	.	.	.	.
MEAN	0.405	.	.	.	.
STANDARD DEV	0.361	.	.	.	.
MEDIAN	0.405	.	.	.	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	1121.000	1292.000	.
MAXIMUM	.	.	2967.000	1403.000	.
RANGE	.	.	1846.000	111.000	.
MEAN	.	.	1843.357	1347.500	.
STANDARD DEV	.	.	463.534	78.489	.
MEDIAN	.	.	1880.000	1347.500	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	17	17	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-6
YEAR = 92.000

TOTAL OBSERVATIONS: 11

	PH	SC	CUT	CUF	NIT
N OF CASES	2	0	11	0	11
MINIMUM	6.300	.	0.001	.	0.140
MAXIMUM	6.400	.	0.035	.	7.300
RANGE	0.100	.	0.034	.	7.160
MEAN	6.350	.	0.008	.	1.716
STANDARD DEV	0.071	.	0.010	.	1.922
MEDIAN	6.350	.	0.005	.	1.300

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	11	0	11	0
MINIMUM	.	0.002	.	0.005	.
MAXIMUM	.	0.009	.	0.060	.
RANGE	.	0.007	.	0.055	.
MEAN	.	0.006	.	0.041	.
STANDARD DEV	.	0.002	.	0.022	.
MEDIAN	.	0.005	.	0.050	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	11	0	0
MINIMUM	.	.	2000.000	.	.
MAXIMUM	.	.	2669.000	.	.
RANGE	.	.	669.000	.	.
MEAN	.	.	2337.000	.	.
STANDARD DEV	.	.	230.618	.	.
MEDIAN	.	.	2283.000	.	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	11	11	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

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THE FOLLOWING RESULTS ARE FOR:
            SITE$     = W1D-6
            YEAR      =          93.000

TOTAL OBSERVATIONS:     14
```

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	0.004	.	0.170
MAXIMUM	.	.	0.008	.	2.100
RANGE	.	.	0.004	.	1.930
MEAN	.	.	0.006	.	0.980
STANDARD DEV	.	.	0.002	.	0.721
MEDIAN	.	.	0.007	.	1.100

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	2	0
MINIMUM	.	0.001	.	0.040	.
MAXIMUM	.	0.002	.	0.060	.
RANGE	.	0.002	.	0.020	.
MEAN	.	0.001	.	0.050	.
STANDARD DEV	.	0.001	.	0.014	.
MEDIAN	.	0.001	.	0.050	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	779.000	.	120.000
MAXIMUM	.	.	2058.000	.	130.000
RANGE	.	.	1279.000	.	10.000
MEAN	.	.	1409.143	.	125.000
STANDARD DEV	.	.	365.302	.	7.071
MEDIAN	.	.	1345.000	.	125.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	140.000	165.000	194.000	.
MAXIMUM	140.000	165.000	194.000	.
RANGE	0.000	0.000	0.000	.
MEAN	140.000	165.000	194.000	.
STANDARD DEV	0.000	0.000	0.000	.
MEDIAN	140.000	165.000	194.000	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-6
YEAR = 94.000

TOTAL OBSERVATIONS: 17

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	2	17
MINIMUM	.	.	0.003	0.001	0.140
MAXIMUM	.	.	0.025	0.005	2.000
RANGE	.	.	0.022	0.004	1.860
MEAN	.	.	0.008	0.003	1.170
STANDARD DEV	.	.	0.006	0.003	0.640
MEDIAN	.	.	0.007	0.003	1.200

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.140	.	.	.	.
MAXIMUM	0.310	.	.	.	.
RANGE	0.170	.	.	.	.
MEAN	0.225	.	.	.	.
STANDARD DEV	0.120	.	.	.	.
MEDIAN	0.225	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	1155.000	1184.000	.
MAXIMUM	.	.	2318.000	1309.000	.
RANGE	.	.	1163.000	125.000	.
MEAN	.	.	1772.643	1246.500	.
STANDARD DEV	.	.	377.547	88.388	.
MEDIAN	.	.	1848.000	1246.500	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	17	17	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-7
YEAR = 92.000

TOTAL OBSERVATIONS: 11

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

	PH	SC	CUT	CUF	NIT
N OF CASES	2	0	11	0	11
MINIMUM	6.600	.	0.000	.	0.140
MAXIMUM	6.600	.	0.009	.	1.800
RANGE	0.000	.	0.009	.	1.660
MEAN	6.600	.	0.004	.	0.874
STANDARD DEV	0.000	.	0.002	.	0.469
MEDIAN	6.600	.	0.004	.	0.800

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	11	0	11	0
MINIMUM	.	0.000	.	0.005	.
MAXIMUM	.	0.011	.	0.070	.
RANGE	.	0.011	.	0.065	.
MEAN	.	0.005	.	0.039	.
STANDARD DEV	.	0.003	.	0.023	.
MEDIAN	.	0.003	.	0.040	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	11	0	0
MINIMUM	.	.	1960.000	.	.
MAXIMUM	.	.	2669.000	.	.
RANGE	.	.	709.000	.	.
MEAN	.	.	2308.545	.	.
STANDARD DEV	.	.	199.233	.	.
MEDIAN	.	.	2299.000	.	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	11	11	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-7
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	12	0	14	0	14
MINIMUM	6.800	.	-0.001	.	0.060
MAXIMUM	7.200	.	0.008	.	1.600
RANGE	0.400	.	0.009	.	1.540
MEAN	6.975	.	0.004	.	0.695
STANDARD DEV	0.166	.	0.002	.	0.595
MEDIAN	6.950	.	0.004	.	0.640

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	2	0
MINIMUM	.	0.001	.	0.040	.
MAXIMUM	.	0.002	.	0.070	.
RANGE	.	0.002	.	0.030	.
MEAN	.	0.001	.	0.055	.
STANDARD DEV	.	0.001	.	0.021	.
MEDIAN	.	0.001	.	0.055	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	790.000	.	130.000
MAXIMUM	.	.	1880.000	.	130.000
RANGE	.	.	1090.000	.	0.000
MEAN	.	.	1347.857	.	130.000
STANDARD DEV	.	.	325.726	.	0.000
MEDIAN	.	.	1278.500	.	130.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	140.000	165.000	194.000	.
MAXIMUM	140.000	165.000	194.000	.
RANGE	0.000	0.000	0.000	.
MEAN	140.000	165.000	194.000	.
STANDARD DEV	0.000	0.000	0.000	.
MEDIAN	140.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-7
YEAR = 94.000

TOTAL OBSERVATIONS: 17

	PH	SC	CUT	CUF	NIT
N OF CASES	12	0	14	2	17
MINIMUM	7.100	.	0.002	0.003	0.120
MAXIMUM	7.500	.	0.009	0.003	1.600
RANGE	0.400	.	0.007	0.000	1.480
MEAN	7.317	.	0.006	0.003	0.889
STANDARD DEV	0.127	.	0.002	0.000	0.541
MEDIAN	7.300	.	0.007	0.003	1.100

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.140	.	.	.	.
MAXIMUM	0.200	.	.	.	.
RANGE	0.060	.	.	.	.
MEAN	0.170	.	.	.	.
STANDARD DEV	0.042	.	.	.	.
MEDIAN	0.170	.	.	.	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	1121.000	1171.000	.
MAXIMUM	.	.	2272.000	1229.000	.
RANGE	.	.	1151.000	58.000	.
MEAN	.	.	1744.286	1200.000	.
STANDARD DEV	.	.	370.630	41.012	.
MEDIAN	.	.	1854.000	1200.000	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	17	17	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-8
YEAR = 92.000

TOTAL OBSERVATIONS: 11

	PH	SC	CUT	CUF	NIT
N OF CASES	2	0	11	0	11
MINIMUM	6.700	.	0.001	.	0.140
MAXIMUM	6.800	.	0.014	.	1.400
RANGE	0.100	.	0.013	.	1.260
MEAN	6.750	.	0.006	.	0.741
STANDARD DEV	0.071	.	0.004	.	0.359
MEDIAN	6.750	.	0.006	.	0.760

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	11	0	11	0
MINIMUM	.	0.001	.	0.005	.
MAXIMUM	.	0.012	.	0.090	.
RANGE	.	0.011	.	0.085	.
MEAN	.	0.005	.	0.042	.
STANDARD DEV	.	0.004	.	0.028	.
MEDIAN	.	0.003	.	0.040	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	11	0	0
MINIMUM	.	.	1953.000	.	.
MAXIMUM	.	.	2661.000	.	.
RANGE	.	.	708.000	.	.
MEAN	.	.	2268.909	.	.
STANDARD DEV	.	.	221.499	.	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MEDIAN	.	.	2246.000	.	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	11	11	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-8
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	0.002	.	0.090
MAXIMUM	.	.	0.006	.	1.400
RANGE	.	.	0.004	.	1.310
MEAN	.	.	0.004	.	0.637
STANDARD DEV	.	.	0.001	.	0.534
MEDIAN	.	.	0.004	.	0.580

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	2	0
MINIMUM	.	0.001	.	0.040	.
MAXIMUM	.	0.001	.	0.090	.
RANGE	.	0.000	.	0.050	.
MEAN	.	0.001	.	0.065	.
STANDARD DEV	.	0.000	.	0.035	.
MEDIAN	.	0.001	.	0.065	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	730.000	.	120.000
MAXIMUM	.	.	1922.000	.	130.000
RANGE	.	.	1192.000	.	10.000
MEAN	.	.	1296.929	.	125.000
STANDARD DEV	.	.	321.395	.	7.071
MEDIAN	.	.	1221.000	.	125.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	140.000	165.000	194.000	.
MAXIMUM	140.000	165.000	194.000	.
RANGE	0.000	0.000	0.000	.
MEAN	140.000	165.000	194.000	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

STANDARD DEV	0.000	0.000	0.000	.
MEDIAN	140.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-8
YEAR = 94.000

TOTAL OBSERVATIONS: 17

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	2	17
MINIMUM	.	.	0.002	0.003	0.180
MAXIMUM	.	.	0.024	0.004	1.600
RANGE	.	.	0.022	0.001	1.420
MEAN	.	.	0.006	0.004	0.784
STANDARD DEV	.	.	0.006	0.001	0.485
MEDIAN	.	.	0.006	0.004	0.930

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.160	.	.	.	.
MAXIMUM	0.200	.	.	.	.
RANGE	0.040	.	.	.	.
MEAN	0.180	.	.	.	.
STANDARD DEV	0.028	.	.	.	.
MEDIAN	0.180	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	1114.000	1114.000	.
MAXIMUM	.	.	2123.000	1249.000	.
RANGE	.	.	1009.000	135.000	.
MEAN	.	.	1714.714	1181.500	.
STANDARD DEV	.	.	339.042	95.459	.
MEDIAN	.	.	1794.000	1181.500	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	17	17	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-9
YEAR = 92.000

TOTAL OBSERVATIONS: 11

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

	PH	SC	CUT	CUF	NIT
N OF CASES	2	0	11	0	11
MINIMUM	6.700	.	0.001	.	0.130
MAXIMUM	7.100	.	0.020	.	1.100
RANGE	0.400	.	0.019	.	0.970
MEAN	6.900	.	0.008	.	0.645
STANDARD DEV	0.283	.	0.007	.	0.333
MEDIAN	6.900	.	0.005	.	0.560

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	11	0	11	0
MINIMUM	.	0.000	.	0.005	.
MAXIMUM	.	0.015	.	0.060	.
RANGE	.	0.015	.	0.055	.
MEAN	.	0.005	.	0.039	.
STANDARD DEV	.	0.005	.	0.023	.
MEDIAN	.	0.005	.	0.040	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	11	0	0
MINIMUM	.	.	1983.000	.	.
MAXIMUM	.	.	2575.000	.	.
RANGE	.	.	592.000	.	.
MEAN	.	.	2261.000	.	.
STANDARD DEV	.	.	215.911	.	.
MEDIAN	.	.	2255.000	.	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	11	11	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-9
YEAR = 93.000

TOTAL OBSERVATIONS: 14

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	0	14
MINIMUM	.	.	0.003	.	0.060
MAXIMUM	.	.	0.008	.	1.500
RANGE	.	.	0.005	.	1.440
MEAN	.	.	0.005	.	0.599
STANDARD DEV	.	.	0.002	.	0.523

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

MEDIAN	.	.	0.006	.	0.575

	NIF	COT	COF	ZNT	ZNF
N OF CASES	0	2	0	2	0
MINIMUM	.	0.001	.	0.040	.
MAXIMUM	.	0.001	.	0.050	.
RANGE	.	0.000	.	0.010	.
MEAN	.	0.001	.	0.045	.
STANDARD DEV	.	0.000	.	0.007	.
MEDIAN	.	0.001	.	0.045	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	0	2
MINIMUM	.	.	736.000	.	120.000
MAXIMUM	.	.	2005.000	.	130.000
RANGE	.	.	1269.000	.	10.000
MEAN	.	.	1330.643	.	125.000
STANDARD DEV	.	.	346.237	.	7.071
MEDIAN	.	.	1263.000	.	125.000

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	2	14	14	0
MINIMUM	130.000	165.000	194.000	.
MAXIMUM	140.000	165.000	194.000	.
RANGE	10.000	0.000	0.000	.
MEAN	135.000	165.000	194.000	.
STANDARD DEV	7.071	0.000	0.000	.
MEDIAN	135.000	165.000	194.000	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D-9
YEAR = 94.000

TOTAL OBSERVATIONS: 17

	PH	SC	CUT	CUF	NIT
N OF CASES	0	0	14	2	17
MINIMUM	.	.	0.002	0.004	0.100
MAXIMUM	.	.	0.015	0.004	1.400
RANGE	.	.	0.013	0.000	1.300
MEAN	.	.	0.006	0.004	0.728
STANDARD DEV	.	.	0.003	0.000	0.453
MEDIAN	.	.	0.006	0.004	0.900

	NIF	COT	COF	ZNT	ZNF
N OF CASES	2	0	0	0	0
MINIMUM	0.110	.	.	.	.
MAXIMUM	0.160	.	.	.	.
RANGE	0.050	.	.	.	.
MEAN	0.135	.	.	.	.

Table A2.3. Summary statistics of water quality data from W1D sites other than 051 and 052 (continued).

STANDARD DEV	0.035	.	.	.	.
MEDIAN	0.135	.	.	.	.

	FEF	TSS	SO4T	SO4F	CAT
N OF CASES	0	0	14	2	0
MINIMUM	.	.	1177.000	1177.000	.
MAXIMUM	.	.	2143.000	1262.000	.
RANGE	.	.	966.000	85.000	.
MEAN	.	.	1716.571	1219.500	.
STANDARD DEV	.	.	340.578	60.104	.
MEDIAN	.	.	1798.000	1219.500	.

	MGT	TOTHARD	ALK	FLOWLM
N OF CASES	0	17	17	0
MINIMUM	.	165.000	194.000	.
MAXIMUM	.	165.000	194.000	.
RANGE	.	0.000	0.000	.
MEAN	.	165.000	194.000	.
STANDARD DEV	.	0.000	0.000	.
MEDIAN	.	165.000	194.000	.

Note: The parameters with a T suffix are total values, parameters with an F suffix are filtered values. TOTHARD is total hardness, FLOWLM is liters/min, and values preceded with a hyphen are less than the detection limit. pH values are in standard units, specific conductance (SC) values are in microsiemens, flow (FLOWLM) values are liters/min, and all other parameters are mg/L.

Table A2.4 Summary statistics of water quality data from the DNR study cell of the W1D treatment system.

Input (DNR Site# W1D-1)

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D1

TOTAL OBSERVATIONS: 25

	SC	PH	CU	NI	CO
N OF CASES	24	23	23	23	16
MINIMUM	900.000	6.670	0.001	0.100	0.001
MAXIMUM	2275.000	7.840	0.047	0.933	0.050
RANGE	1375.000	1.170	0.046	0.833	0.049
MEAN	1649.583	7.157	0.015	0.324	0.017
STANDARD DEV	392.087	0.275	0.012	0.194	0.022
MEDIAN	1600.000	7.110	0.008	0.300	0.003

	ZN	SO4	CA	MG
N OF CASES	10	20	14	14
MINIMUM	0.020	441.100	140.000	121.000
MAXIMUM	0.081	1179.000	247.000	249.000
RANGE	0.061	737.900	107.000	128.000
MEAN	0.035	879.355	198.214	188.500
STANDARD DEV	0.017	241.999	31.981	41.398
MEDIAN	0.030	888.500	209.000	190.000

Output (DNR Site# W1D-2)

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D2

TOTAL OBSERVATIONS: 23

	SC	PH	CU	NI	CO
N OF CASES	22	22	21	21	14
MINIMUM	1000.000	6.860	0.001	0.050	0.001
MAXIMUM	2100.000	7.770	0.035	0.875	0.050
RANGE	1100.000	0.910	0.035	0.825	0.050
MEAN	1557.955	7.250	0.012	0.257	0.011
STANDARD DEV	324.164	0.188	0.012	0.186	0.018
MEDIAN	1500.000	7.250	0.004	0.210	0.001

Table A2.4 Summary statistics of water quality data from the DNR study cell of the W1D treatment system.

	ZN	SO4	CA	MG
N OF CASES	9	18	12	12
MINIMUM	0.010	506.100	134.000	115.000
MAXIMUM	0.064	1172.000	244.000	249.000
RANGE	0.054	665.900	110.000	134.000
MEAN	0.030	822.728	185.667	181.000
STANDARD DEV	0.016	213.440	35.605	42.980
MEDIAN	0.023	799.500	195.000	186.500

Output (DNR Site# W1D-3)

THE FOLLOWING RESULTS ARE FOR:
SITE$ = W1D3

TOTAL OBSERVATIONS: 23

	SC	PH	CU	NI	CO
N OF CASES	22	22	20	20	14
MINIMUM	900.000	6.860	0.001	0.001	0.001
MAXIMUM	2200.000	7.500	0.029	0.793	0.050
RANGE	1300.000	0.640	0.029	0.792	0.050
MEAN	1551.136	7.226	0.011	0.269	0.010
STANDARD DEV	345.677	0.151	0.011	0.174	0.018
MEDIAN	1500.000	7.225	0.004	0.295	0.001

	ZN	SO4	CA	MG
N OF CASES	8	17	11	11
MINIMUM	0.019	499.000	130.000	116.000
MAXIMUM	0.100	1068.000	238.000	246.000
RANGE	0.081	569.000	108.000	130.000
MEAN	0.040	780.382	181.364	177.182
STANDARD DEV	0.028	184.110	36.269	42.951
MEDIAN	0.030	793.000	190.000	182.000

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

Note: The site called Seep 1 (043) was originally the actual Seep 1 outfall, but a pretreatment system was started in 1992, and starting in August 1992 the data shown for 043 are actually for the effluent from the limestone pretreatment system.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 76.000

TOTAL OBSERVATIONS: 9

	pH	ALK	SC	SO4	CUT
N OF CASES	9	9	9	9	9
MINIMUM	7.000	161.000	2324.000	1839.000	0.004
MAXIMUM	7.500	229.000	4600.000	3000.000	0.091
MEAN	7.289	201.889	3545.000	2404.444	0.029
STANDARD DEV	0.190	22.784	628.336	367.369	0.027

	NIT	COT	ZNT	FEF	CA
N OF CASES	9	4	8	9	7
MINIMUM	0.670	0.110	0.100	0.700	194.000
MAXIMUM	1.920	0.132	0.690	7.200	396.000
MEAN	1.143	0.124	0.254	4.744	252.714
STANDARD DEV	0.379	0.010	0.190	2.091	65.711

	MG	FLOWMGD
N OF CASES	3	0
MINIMUM	451.000	.
MAXIMUM	528.000	.
MEAN	481.000	.
STANDARD DEV	41.219	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 77.000

TOTAL OBSERVATIONS: 17

	pH	ALK	SC	SO4	CUT

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

N OF CASES	17	17	17	11	17
MINIMUM	6.500	46.000	500.000	149.000	0.003
MAXIMUM	7.400	441.000	7700.000	5636.000	0.329
MEAN	6.812	104.706	3105.941	2552.000	0.034
STANDARD DEV	0.226	91.436	2473.321	2007.647	0.077

	NIT	COT	ZNT	FEF	CA
N OF CASES	17	5	5	15	8
MINIMUM	0.053	0.110	0.040	0.600	46.000
MAXIMUM	12.000	0.870	2.400	8.700	346.000
MEAN	3.471	0.478	1.290	2.320	175.625
STANDARD DEV	3.867	0.340	1.169	2.493	116.402

	MG	FLOWMGD
N OF CASES	7	0
MINIMUM	119.000	.
MAXIMUM	652.000	.
MEAN	307.714	.
STANDARD DEV	223.442	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 78.000

TOTAL OBSERVATIONS: 10

	pH	ALK	SC	SO4	CUT
N OF CASES	10	0	10	10	10
MINIMUM	6.300	.	5000.000	3275.000	0.034
MAXIMUM	7.500	.	5000.000	5000.000	0.119
MEAN	6.660	.	5000.000	4315.000	0.063
STANDARD DEV	0.327	.	0.000	584.190	0.030

	NIT	COT	ZNT	FEF	CA
N OF CASES	10	10	10	0	10
MINIMUM	2.800	0.300	0.180	.	38.000
MAXIMUM	12.500	1.000	2.300	.	350.000
MEAN	8.270	0.752	1.420	.	268.800
STANDARD DEV	2.699	0.216	0.600	.	85.706

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

	MG	FLOWMGD
N OF CASES	10	0
MINIMUM	400.000	.
MAXIMUM	1100.000	.
MEAN	728.000	.
STANDARD DEV	230.063	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 79.000

TOTAL OBSERVATIONS: 16

	pH	ALK	SC	SO4	CUT
N OF CASES	16	16	15	16	16
MINIMUM	4.500	-2.000	1500.000	1100.000	0.020
MAXIMUM	6.900	80.000	5000.000	10000.000	0.300
MEAN	6.106	38.500	4720.000	4281.250	0.106
STANDARD DEV	0.772	28.636	904.118	1920.840	0.070

	NIT	COT	ZNT	FEF	CA
N OF CASES	16	0	16	16	16
MINIMUM	1.500	.	0.250	0.400	-1.000
MAXIMUM	32.000	.	17.000	8.500	640.000
MEAN	11.231	.	3.348	2.219	136.313
STANDARD DEV	7.841	.	4.153	2.075	216.538

	MG	FLOWMGD
N OF CASES	16	0
MINIMUM	1.000	.
MAXIMUM	9999.000	.
MEAN	1555.438	.
STANDARD DEV	2320.214	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 80.000

TOTAL OBSERVATIONS: 18

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

	pH	ALK	SC	SO4	CUT
N OF CASES	14	15	15	15	17
MINIMUM	6.200	28.000	2050.000	2500.000	-0.010
MAXIMUM	8.300	68.000	4300.000	3700.000	0.400
MEAN	7.107	49.733	3866.667	3166.667	0.075
STANDARD DEV	0.763	11.997	594.218	359.894	0.089

	NIT	COT	ZNT	FEF	CA
N OF CASES	17	2	17	16	17
MINIMUM	2.200	0.690	0.580	0.200	200.000
MAXIMUM	14.000	0.900	2.300	3.800	410.000
MEAN	9.669	0.795	1.118	0.731	308.706
STANDARD DEV	3.011	0.148	0.426	0.870	57.250

	MG	FLOWMGD
N OF CASES	17	0
MINIMUM	340.000	.
MAXIMUM	763.000	.
MEAN	599.706	.
STANDARD DEV	117.811	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 81.000

TOTAL OBSERVATIONS: 18

	pH	ALK	SC	SO4	CUT
N OF CASES	16	18	17	18	18
MINIMUM	6.000	14.000	1650.000	440.000	0.060
MAXIMUM	7.300	96.000	5000.000	4500.000	0.300
MEAN	6.550	32.333	4406.471	3263.333	0.144
STANDARD DEV	0.327	18.458	995.314	1378.733	0.058

	NIT	COT	ZNT	FEF	CA
N OF CASES	18	15	17	2	18
MINIMUM	2.600	0.050	0.540	0.300	140.000
MAXIMUM	26.000	2.300	5.000	0.400	380.000
MEAN	14.506	0.995	3.205	0.350	302.222
STANDARD DEV	5.491	0.458	1.521	0.071	63.483

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

	MG	FLOWMGD
N OF CASES	18	0
MINIMUM	180.000	.
MAXIMUM	860.000	.
MEAN	695.556	.
STANDARD DEV	177.175	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 82.000

TOTAL OBSERVATIONS: 18

	pH	ALK	SC	SO4	CUT
N OF CASES	18	0	16	18	18
MINIMUM	5.700	.	750.000	360.000	0.014
MAXIMUM	7.400	.	5000.000	4504.000	0.350
MEAN	6.494	.	3421.875	2790.222	0.142
STANDARD DEV	0.505	.	1727.519	1547.159	0.106

	NIT	COT	ZNT	FEF	CA
N OF CASES	18	18	18	0	18
MINIMUM	1.100	-0.100	0.160	.	45.000
MAXIMUM	66.000	2.400	6.300	.	460.000
MEAN	15.306	0.831	2.949	.	267.222
STANDARD DEV	14.659	0.617	1.824	.	138.810

	MG	FLOWMGD
N OF CASES	18	0
MINIMUM	62.000	.
MAXIMUM	960.000	.
MEAN	524.556	.
STANDARD DEV	298.170	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 83.000

TOTAL OBSERVATIONS: 11

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

	pH	ALK	SC	SO4	CUT
N OF CASES	10	0	11	11	11
MINIMUM	5.200	.	1550.000	1100.000	0.016
MAXIMUM	6.800	.	4600.000	3700.000	1.100
MEAN	5.660	.	3468.182	2686.364	0.469
STANDARD DEV	0.470	.	981.586	831.893	0.289

	NIT	COT	ZNT	FEF	CA
N OF CASES	11	11	11	8	11
MINIMUM	3.400	0.540	0.840	0.200	110.000
MAXIMUM	32.000	2.400	6.200	1.600	360.000
MEAN	18.127	1.325	3.485	0.675	260.273
STANDARD DEV	8.573	0.684	1.492	0.585	86.433

	MG	FLOWMGD
N OF CASES	11	0
MINIMUM	190.000	.
MAXIMUM	710.000	.
MEAN	459.545	.
STANDARD DEV	146.739	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 84.000

TOTAL OBSERVATIONS: 14

	pH	ALK	SC	SO4	CUT
N OF CASES	14	0	14	14	14
MINIMUM	5.100	.	775.000	700.000	0.050
MAXIMUM	5.700	.	3100.000	3100.000	0.820
MEAN	5.471	.	2187.500	1597.143	0.387
STANDARD DEV	0.220	.	840.830	784.341	0.263

	NIT	COT	ZNT	FEF	CA
N OF CASES	14	14	14	13	14
MINIMUM	3.400	0.300	0.780	-0.100	9.000
MAXIMUM	34.000	2.500	3.600	0.600	340.000
MEAN	18.514	1.330	2.141	0.223	184.643
STANDARD DEV	10.469	0.775	0.917	0.183	95.477

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

	MG	FLOWMGD
N OF CASES	14	0
MINIMUM	84.000	.
MAXIMUM	450.000	.
MEAN	282.857	.
STANDARD DEV	128.604	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 85.000

TOTAL OBSERVATIONS: 15

	pH	ALK	SC	SO4	CUT
N OF CASES	15	0	15	15	15
MINIMUM	4.900	.	385.000	200.000	0.038
MAXIMUM	5.900	.	2700.000	2000.000	0.810
MEAN	5.360	.	1999.000	1356.667	0.393
STANDARD DEV	0.253	.	620.381	413.118	0.226

	NIT	COT	ZNT	FEF	CA
N OF CASES	15	15	15	15	15
MINIMUM	1.200	0.120	0.300	0.100	28.000
MAXIMUM	32.000	2.100	2.400	1.100	240.000
MEAN	15.747	1.101	1.451	0.440	173.200
STANDARD DEV	7.877	0.510	0.505	0.329	52.311

	MG	FLOWMGD
N OF CASES	15	0
MINIMUM	30.000	.
MAXIMUM	380.000	.
MEAN	226.667	.
STANDARD DEV	88.694	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 86.000

TOTAL OBSERVATIONS: 15

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

	pH	ALK	SC	SO4	CUT
N OF CASES	15	0	15	15	15
MINIMUM	5.100	.	960.000	60.000	0.070
MAXIMUM	5.800	.	2550.000	1800.000	1.100
MEAN	5.440	.	1930.667	1198.000	0.529
STANDARD DEV	0.213	.	491.771	432.488	0.350

	NIT	COT	ZNT	FEF	CA
N OF CASES	15	15	15	15	15
MINIMUM	2.700	0.300	0.500	0.200	75.000
MAXIMUM	30.000	2.100	3.000	1.100	220.000
MEAN	14.493	1.045	1.361	0.400	152.267
STANDARD DEV	8.493	0.598	0.723	0.245	50.286

	MG	FLOWMGD
N OF CASES	15	0
MINIMUM	80.000	.
MAXIMUM	300.000	.
MEAN	203.867	.
STANDARD DEV	69.395	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 87.000

TOTAL OBSERVATIONS: 15

	pH	ALK	SC	SO4	CUT
N OF CASES	15	0	15	15	15
MINIMUM	4.800	.	1225.000	700.000	0.090
MAXIMUM	6.200	.	2900.000	2650.000	1.100
MEAN	5.473	.	2263.333	1502.333	0.449
STANDARD DEV	0.339	.	402.987	433.803	0.379

	NIT	COT	ZNT	FEF	CA
N OF CASES	15	15	15	15	0
MINIMUM	2.500	0.200	0.330	0.200	.
MAXIMUM	32.000	2.800	2.800	2.900	.
MEAN	14.827	1.216	1.133	0.640	.
STANDARD DEV	9.387	0.657	0.741	0.729	.

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

	MG	FLOWMGD
N OF CASES	0	0
MINIMUM	.	.
MAXIMUM	.	.
MEAN	.	.
STANDARD DEV	.	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 88.000

TOTAL OBSERVATIONS: 17

	pH	ALK	SC	SO4	CUT
N OF CASES	17	1	17	17	17
MINIMUM	5.200	3.000	625.000	340.000	0.017
MAXIMUM	7.600	3.000	2925.000	2100.000	0.810
MEAN	6.088	3.000	2050.882	1330.882	0.332
STANDARD DEV	0.882	.	642.770	492.079	0.271

	NIT	COT	ZNT	FEF	CA
N OF CASES	17	17	17	17	0
MINIMUM	1.000	0.090	0.250	-0.100	.
MAXIMUM	32.000	2.500	2.600	1.000	.
MEAN	14.324	1.114	1.268	0.211	.
STANDARD DEV	9.548	0.712	0.686	0.258	.

	MG	FLOWMGD
N OF CASES	0	0
MINIMUM	.	.
MAXIMUM	.	.
MEAN	.	.
STANDARD DEV	.	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 89.000

TOTAL OBSERVATIONS: 14

pH	ALK	SC	SO4	CUT

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

N OF CASES	14	0	14	14	14
MINIMUM	4.800	.	640.000	430.000	0.060
MAXIMUM	5.900	.	2525.000	1725.000	1.800
MEAN	5.193	.	1894.286	1271.071	0.922
STANDARD DEV	0.354	.	576.264	417.079	0.593

	NIT	COT	ZNT	FEF	CA
N OF CASES	14	14	14	14	0
MINIMUM	1.600	0.160	0.250	0.100	.
MAXIMUM	26.000	1.900	3.000	0.500	.
MEAN	14.971	1.057	1.673	0.144	.
STANDARD DEV	7.923	0.574	0.773	0.115	.

	MG	FLOWMGD
N OF CASES	0	0
MINIMUM	.	.
MAXIMUM	.	.
MEAN	.	.
STANDARD DEV	.	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 90.000

TOTAL OBSERVATIONS: 13

	pH	ALK	SC	SO4	CUT
N OF CASES	13	0	13	13	13
MINIMUM	4.700	.	720.000	425.000	0.150
MAXIMUM	5.400	.	2750.000	1700.000	2.100
MEAN	5.031	.	2053.462	1182.308	1.177
STANDARD DEV	0.210	.	621.079	391.384	0.550

	NIT	COT	ZNT	FEF	CA
N OF CASES	13	13	13	13	0
MINIMUM	2.400	0.220	0.390	0.100	.
MAXIMUM	31.000	1.800	2.900	0.300	.
MEAN	15.389	1.112	1.590	0.169	.
STANDARD DEV	7.161	0.458	0.754	0.063	.

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

	MG	FLOWMGD
N OF CASES	0	0
MINIMUM	.	.
MAXIMUM	.	.
MEAN	.	.
STANDARD DEV	.	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 91.000

TOTAL OBSERVATIONS: 15

	pH	ALK	SC	SO4	CUT
N OF CASES	15	0	10	15	15
MINIMUM	4.600	.	840.000	674.000	0.160
MAXIMUM	5.700	.	3260.000	1927.000	2.500
MEAN	5.013	.	2220.000	1376.200	1.167
STANDARD DEV	0.318	.	976.058	406.959	0.652

	NIT	COT	ZNT	FEF	CA
N OF CASES	15	15	15	15	0
MINIMUM	2.100	0.150	0.030	0.100	.
MAXIMUM	26.000	2.700	3.000	0.400	.
MEAN	13.240	0.911	1.469	0.133	.
STANDARD DEV	7.054	0.708	0.917	0.082	.

	MG	FLOWMGD
N OF CASES	0	0
MINIMUM	.	.
MAXIMUM	.	.
MEAN	.	.
STANDARD DEV	.	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 92.000

TOTAL OBSERVATIONS: 18

	pH	ALK	SC	SO4	CUT

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

N OF CASES	18	13	0	15	18
MINIMUM	4.200	7.000	.	741.000	0.008
MAXIMUM	7.200	180.000	.	2575.000	2.200
MEAN	5.928	47.077	.	1770.400	0.686
STANDARD DEV	1.123	54.680	.	533.258	0.804

	NIT	COT	ZNT	FEF	CA
N OF CASES	18	18	18	15	16
MINIMUM	0.640	0.050	0.050	-0.100	40.000
MAXIMUM	30.000	2.000	2.900	2.300	300.000
MEAN	9.766	0.544	1.095	0.300	187.188
STANDARD DEV	9.169	0.527	0.954	0.621	67.181

	MG	FLOWMGD
N OF CASES	16	0
MINIMUM	40.000	.
MAXIMUM	310.000	.
MEAN	178.313	.
STANDARD DEV	69.572	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 93.000

TOTAL OBSERVATIONS: 15

	pH	ALK	SC	SO4	CUT
N OF CASES	15	0	0	15	15
MINIMUM	6.500	.	.	894.000	0.040
MAXIMUM	7.600	.	.	2483.000	0.350
MEAN	7.147	.	.	1302.133	0.135
STANDARD DEV	0.288	.	.	374.947	0.088

	NIT	COT	ZNT	FEF	CA
N OF CASES	15	15	15	15	15
MINIMUM	3.600	0.080	0.350	-0.100	140.000
MAXIMUM	12.000	0.680	1.100	0.300	260.000
MEAN	7.047	0.260	0.695	0.013	213.333
STANDARD DEV	2.157	0.172	0.224	0.136	33.736

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

	MG	FLOWMGD
N OF CASES	15	0
MINIMUM	120.000	.
MAXIMUM	210.000	.
MEAN	173.333	.
STANDARD DEV	28.702	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 94.000

TOTAL OBSERVATIONS: 21

	pH	ALK	SC	SO4	CUT
N OF CASES	21	0	0	21	21
MINIMUM	6.700	.	.	102.000	0.050
MAXIMUM	7.500	.	.	1869.000	0.370
MEAN	7.019	.	.	1063.571	0.153
STANDARD DEV	0.256	.	.	429.591	0.070

	NIT	COT	ZNT	FEF	CA
N OF CASES	21	21	21	21	21
MINIMUM	0.400	0.030	0.080	-0.100	26.000
MAXIMUM	11.000	0.570	1.100	0.900	270.000
MEAN	6.233	0.226	0.621	0.048	191.762
STANDARD DEV	2.663	0.138	0.333	0.223	63.219

	MG	FLOWMGD
N OF CASES	21	0
MINIMUM	10.000	.
MAXIMUM	270.000	.
MEAN	156.571	.
STANDARD DEV	57.783	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 95.000

TOTAL OBSERVATIONS: 16

	pH	ALK	SC	SO4	CUT

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

N OF CASES	16	0	0	16	16
MINIMUM	6.600	.	.	215.000	0.026
MAXIMUM	7.200	.	.	1679.000	0.310
MEAN	6.919	.	.	872.188	0.085
STANDARD DEV	0.187	.	.	488.060	0.071

	NIT	COT	ZNT	FEF	CA
N OF CASES	16	16	16	16	16
MINIMUM	0.150	0.011	-0.010	-0.100	60.000
MAXIMUM	9.900	0.290	1.700	1.300	309.000
MEAN	3.483	0.100	0.426	0.150	169.938
STANDARD DEV	3.427	0.086	0.540	0.337	77.698

	MG	FLOWMGD
N OF CASES	16	0
MINIMUM	30.000	.
MAXIMUM	280.000	.
MEAN	145.750	.
STANDARD DEV	68.945	.

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 96.000

TOTAL OBSERVATIONS: 15

	pH	ALK	SC	SO4	CUT
N OF CASES	15	0	0	15	15
MINIMUM	6.400	.	.	248.000	0.103
MAXIMUM	7.300	.	.	1350.000	0.489
MEAN	6.940	.	.	929.267	0.237
STANDARD DEV	0.247	.	.	360.121	0.137

	NIT	COT	ZNT	FEF	CA
N OF CASES	15	15	15	15	15
MINIMUM	1.440	-0.001	0.137	-0.030	85.600
MAXIMUM	10.100	0.429	1.370	2.550	289.000
MEAN	6.325	0.182	0.773	0.205	190.907
STANDARD DEV	2.858	0.109	0.383	0.650	66.091

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

	MG	FLOWMGD
N OF CASES	15	14
MINIMUM	31.200	0.008
MAXIMUM	195.000	0.032
MEAN	127.500	0.014
STANDARD DEV	54.551	0.007

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 97.000

TOTAL OBSERVATIONS: 12

	pH	ALK	SC	SO4	CUT
N OF CASES	12	0	0	12	12
MINIMUM	6.700	.	.	263.000	0.071
MAXIMUM	7.200	.	.	1490.000	0.258
MEAN	6.958	.	.	1006.083	0.130
STANDARD DEV	0.151	.	.	475.037	0.058

	NIT	COT	ZNT	FEF	CA
N OF CASES	12	12	12	12	12
MINIMUM	1.120	0.020	0.102	-0.030	46.800
MAXIMUM	12.100	0.331	1.777	0.060	290.000
MEAN	6.358	0.123	0.764	0.038	193.717
STANDARD DEV	4.220	0.095	0.522	0.023	94.795

	MG	FLOWMGD
N OF CASES	12	12
MINIMUM	28.100	0.000
MAXIMUM	210.000	0.021
MEAN	136.142	0.005
STANDARD DEV	68.971	0.006

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 98.000

TOTAL OBSERVATIONS: 19

pH	ALK	SC	SO4	CUT

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

N OF CASES	19	0	0	19	19
MINIMUM	6.400	.	.	321.000	0.011
MAXIMUM	7.400	.	.	2290.000	0.783
MEAN	7.032	.	.	1179.316	0.164
STANDARD DEV	0.260	.	.	457.224	0.167

	NIT	COT	ZNT	FEF	CA
N OF CASES	19	19	19	0	19
MINIMUM	1.550	0.014	0.183	.	64.300
MAXIMUM	15.000	0.403	1.830	.	325.000
MEAN	7.459	0.136	0.891	.	229.363
STANDARD DEV	3.776	0.103	0.486	.	77.252

	MG	FLOWMGD
N OF CASES	19	19
MINIMUM	41.300	0.000
MAXIMUM	208.000	0.026
MEAN	155.032	0.005
STANDARD DEV	50.782	0.006

THE FOLLOWING RESULTS ARE FOR:
SITE$ = Seep1
YEAR = 99.000

TOTAL OBSERVATIONS: 16

	pH	ALK	SC	SO4	CUT
N OF CASES	16	0	0	16	16
MINIMUM	5.100	.	.	358.000	0.070
MAXIMUM	7.400	.	.	1470.000	2.040
MEAN	6.644	.	.	1098.000	0.603
STANDARD DEV	0.669	.	.	315.622	0.565

	NIT	COT	ZNT	FEF	CA
N OF CASES	16	16	16	16	16
MINIMUM	1.380	0.033	0.319	-0.030	43.500
MAXIMUM	14.400	0.666	1.990	0.400	295.000
MEAN	8.998	0.319	1.362	0.085	210.531
STANDARD DEV	3.608	0.182	0.524	0.111	66.516

Table A2.5. Summary statistics of Seep 1 (site 043) water quality statistics, 1992-1999.

	MG	FLOWMGD
N OF CASES	16	16
MINIMUM	30.100	0.000
MAXIMUM	199.000	0.042
MEAN	142.388	0.010
STANDARD DEV	46.111	0.009

Note: The parameters with a T suffix are total values, parameters with an F suffix are filtered values, FLOWMGD is flow in mgd, and values preceded with a hyphen are less than the detection limit.

Table A2.6. Summary statistics of water quality data from surface water sites within the Seep 1 pretreatment system.

(This table includes the 1993-94 data collected by LTV, as well as the 1997-99 data collected by DNR.)

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-1

TOTAL OBSERVATIONS: 33

	SC	PH	Cu	Ni	CO
N OF CASES	13	28	33	32	6
MINIMUM	800.000	4.600	0.100	1.800	0.065
MAXIMUM	3000.000	6.690	4.400	26.700	1.400
RANGE	2200.000	2.090	4.300	24.900	1.335
MEAN	1772.308	5.904	1.064	11.719	0.511
STANDARD DEV	668.495	0.635	0.796	5.411	0.510
MEDIAN	1800.000	6.100	0.980	11.000	0.400

	Zn	SO4	CA	MG
N OF CASES	6	33	7	7
MINIMUM	0.280	284.400	178.000	80.900
MAXIMUM	2.640	1796.000	287.000	217.000
RANGE	2.360	1511.600	109.000	136.100
MEAN	1.180	1237.315	250.429	168.271
STANDARD DEV	0.877	326.295	37.801	50.218
MEDIAN	1.010	1302.000	267.000	181.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-2

TOTAL OBSERVATIONS: 33

	SC	PH	Cu	Ni	Co
N OF CASES	13	29	33	32	6
MINIMUM	600.000	4.800	0.100	1.800	0.050
MAXIMUM	2700.000	7.200	2.100	25.400	1.300
RANGE	2100.000	2.400	2.000	23.600	1.250
MEAN	1682.692	6.310	0.716	10.975	0.475

Table A2.6. Summary statistics of water quality data from surface water sites within the Seep 1 pretreatment system (continued).

STANDARD DEV	710.222	0.570	0.525	5.184	0.492
MEDIAN	2000.000	6.400	0.640	10.500	0.350

	Zn	SO4	CA	MG
N OF CASES	6	33	7	7
MINIMUM	0.300	272.900	116.000	65.700
MAXIMUM	2.680	2311.000	277.000	191.000
RANGE	2.380	2038.100	161.000	125.300
MEAN	1.233	1124.512	220.714	153.243
STANDARD DEV	0.996	463.571	61.378	49.078
MEDIAN	1.065	1154.000	246.000	177.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-3

TOTAL OBSERVATIONS: 33

	SC	PH	Cu	Ni	Co
N OF CASES	13	29	33	32	6
MINIMUM	400.000	5.000	0.039	0.300	0.007
MAXIMUM	2600.000	7.170	3.200	31.000	1.900
RANGE	2200.000	2.170	3.161	30.700	1.893
MEAN	1755.769	6.100	1.071	14.441	0.647
STANDARD DEV	819.626	0.640	0.771	6.571	0.769
MEDIAN	2200.000	6.200	0.870	15.000	0.428

	Zn	SO4	CA	MG
N OF CASES	6	33	7	7
MINIMUM	0.060	133.000	178.000	94.600
MAXIMUM	3.170	1982.000	300.000	228.000
RANGE	3.110	1849.000	122.000	133.400
MEAN	1.408	1283.033	260.571	186.086
STANDARD DEV	1.417	452.127	42.182	55.203
MEDIAN	1.330	1333.000	275.000	213.000

Table A2.6. Summary statistics of water quality data from surface water sites within the Seep 1 pretreatment system (continued).

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-4

TOTAL OBSERVATIONS: 33

	SC	PH	Cu	Ni	Co
N OF CASES	12	25	33	32	6
MINIMUM	750.000	5.380	0.074	1.700	0.042
MAXIMUM	2600.000	7.000	2.200	21.000	1.000
RANGE	1850.000	1.620	2.126	19.300	0.958
MEAN	1913.750	6.384	0.541	11.238	0.378
STANDARD DEV	563.246	0.441	0.493	4.390	0.390
MEDIAN	2025.000	6.400	0.460	11.050	0.283

	Zn	SO4	CA	MG
N OF CASES	6	32	7	7
MINIMUM	0.270	370.000	162.000	110.000
MAXIMUM	2.580	2481.000	285.000	221.000
RANGE	2.310	2111.000	123.000	111.000
MEAN	1.162	1253.094	247.571	179.429
STANDARD DEV	0.926	356.639	43.146	37.868
MEDIAN	1.020	1285.000	264.000	196.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-5

TOTAL OBSERVATIONS: 33

	SC	PH	Cu	Ni	Co
N OF CASES	13	25	33	31	6
MINIMUM	650.000	5.560	0.077	1.300	0.039
MAXIMUM	2500.000	7.100	2.300	27.400	1.400
RANGE	1850.000	1.540	2.223	26.100	1.361
MEAN	1762.308	6.505	0.559	11.487	0.466
STANDARD DEV	644.634	0.381	0.498	5.032	0.512
MEDIAN	2100.000	6.510	0.400	11.000	0.350

Table A2.6. Summary statistics of water quality data from surface water sites within the Seep 1 pretreatment system (continued).

	Zn	SO4	CA	MG
N OF CASES	6	32	7	7
MINIMUM	0.260	294.400	166.000	111.000
MAXIMUM	2.820	2513.000	275.000	203.000
RANGE	2.560	2218.600	109.000	92.000
MEAN	1.217	1234.356	242.000	175.286
STANDARD DEV	1.025	363.673	42.887	35.032
MEDIAN	1.075	1250.000	271.000	187.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-6

TOTAL OBSERVATIONS: 57

	SC	PH	Cu	Ni	Co
N OF CASES	36	47	55	53	27
MINIMUM	110.000	4.740	0.040	1.400	0.008
MAXIMUM	2400.000	7.530	1.420	19.500	2.400
RANGE	2290.000	2.790	1.380	18.100	2.392
MEAN	1750.972	6.563	0.324	10.466	0.348
STANDARD DEV	533.625	0.559	0.308	3.723	0.477
MEDIAN	1950.000	6.650	0.200	10.000	0.200

	Zn	SO4	CA	MG
N OF CASES	27	55	22	22
MINIMUM	0.001	318.000	177.000	124.000
MAXIMUM	2.130	2502.000	326.000	223.000
RANGE	2.129	2184.000	149.000	99.000
MEAN	1.054	1174.505	260.000	187.045
STANDARD DEV	0.633	339.513	34.734	25.706
MEDIAN	1.100	1231.000	266.000	191.500

Table A2.6. Summary statistics of water quality data from surface water sites within the Seep 1 pretreatment system (continued).

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-7

TOTAL OBSERVATIONS: 13

	SC	PH	Cu	Ni	Co
N OF CASES	13	13	13	13	6
MINIMUM	750.000	6.320	0.066	1.500	0.032
MAXIMUM	2400.000	7.090	1.100	17.800	0.500
RANGE	1650.000	0.770	1.034	16.300	0.468
MEAN	1726.154	6.789	0.400	10.592	0.261
STANDARD DEV	570.633	0.244	0.303	5.404	0.229
MEDIAN	2000.000	6.740	0.300	11.500	0.236

	Zn	SO4	CA	MG
N OF CASES	6	13	7	7
MINIMUM	0.260	352.000	175.000	119.000
MAXIMUM	1.600	1486.000	278.000	206.000
RANGE	1.340	1134.000	103.000	87.000
MEAN	0.892	1086.377	245.143	171.714
STANDARD DEV	0.664	424.844	35.951	29.250
MEDIAN	0.810	1228.000	260.000	178.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-8

TOTAL OBSERVATIONS: 13

	SC	PH	Cu	Ni	Co
N OF CASES	13	13	13	13	6
MINIMUM	750.000	6.060	0.066	1.400	0.036
MAXIMUM	2800.000	7.030	1.600	18.400	0.500
RANGE	2050.000	0.970	1.534	17.000	0.464
MEAN	1735.000	6.733	0.502	10.685	0.282
STANDARD DEV	642.900	0.300	0.414	5.586	0.213
MEDIAN	2000.000	6.700	0.400	11.900	0.300

Table A2.6. Summary statistics of water quality data from surface water sites within the Seep 1 pretreatment system (continuied).

	Zn	SO4	CA	MG
N OF CASES	6	13	7	7
MINIMUM	0.240	336.000	147.000	99.800
MAXIMUM	1.700	1494.000	278.000	201.000
RANGE	1.460	1158.000	131.000	101.200
MEAN	0.930	1068.538	229.429	164.971
STANDARD DEV	0.679	444.785	53.376	39.983
MEDIAN	0.890	1290.000	262.000	180.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-W

TOTAL OBSERVATIONS: 32

	SC	PH	Cu	Ni	Co
N OF CASES	9	24	29	28	3
MINIMUM	300.000	6.200	0.030	1.500	0.050
MAXIMUM	2700.000	7.300	0.450	15.000	0.300
RANGE	2400.000	1.100	0.420	13.500	0.250
MEAN	1689.444	6.839	0.159	8.993	0.183
STANDARD DEV	743.011	0.275	0.108	2.679	0.126
MEDIAN	2050.000	6.865	0.130	8.400	0.200

	Zn	SO4	CA	MG
N OF CASES	3	32	6	6
MINIMUM	0.200	138.000	182.000	127.000
MAXIMUM	1.000	2492.000	275.000	197.000
RANGE	0.800	2354.000	93.000	70.000
MEAN	0.627	1148.922	241.500	166.667
STANDARD DEV	0.403	388.430	42.824	30.559
MEDIAN	0.680	1168.500	266.000	180.500

Table A2.6. Summary statistics of water quality data from surface water sites within the Seep 1 pretreatment system (continued).

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-WB

TOTAL OBSERVATIONS: 36

	SC	PH	Cu	Ni	Co
N OF CASES	36	36	34	35	27
MINIMUM	300.000	4.760	0.055	1.434	0.027
MAXIMUM	2350.000	7.640	1.320	16.700	0.880
RANGE	2050.000	2.880	1.265	15.266	0.853
MEAN	1765.278	6.728	0.281	8.886	0.248
STANDARD DEV	465.460	0.517	0.255	3.832	0.215
MEDIAN	1925.000	6.815	0.200	8.360	0.200

	Zn	SO4	CA	MG
N OF CASES	27	35	23	23
MINIMUM	0.001	138.000	151.000	99.300
MAXIMUM	1.970	1589.000	321.000	213.000
RANGE	1.969	1451.000	170.000	113.700
MEAN	0.961	1136.497	257.304	182.057
STANDARD DEV	0.519	350.083	40.966	30.087
MEDIAN	0.918	1262.000	269.000	187.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = Historic

TOTAL OBSERVATIONS: 44

	SC	PH	Cu	Ni	Co
N OF CASES	0	44	44	44	44
MINIMUM	.	4.600	0.420	11.100	0.520
MAXIMUM	.	5.600	2.500	32.000	2.700
RANGE	.	1.000	2.080	20.900	2.180
MEAN	.	5.118	1.053	20.568	1.476
STANDARD DEV	.	0.251	0.513	5.882	0.495
MEDIAN	.	5.200	0.825	21.000	1.450

Table A2.6. Summary statistics of water quality data from surface water sites within the Seep 1 pretreatment system (continued).

	Zn	SO4	CA	MG
N OF CASES	44	44	12	0
MINIMUM	0.880	605.000	130.000	.
MAXIMUM	3.000	2650.000	240.000	.
RANGE	2.120	2045.000	110.000	.
MEAN	1.923	1501.091	190.833	.
STANDARD DEV	0.532	370.618	31.176	.
MEDIAN	1.950	1486.000	200.000	.

Table A2.7. Summary statistics of all 1993 surface water quality data for the outer pool of the Seep 1 pretreatment system.

Note: All 1993-94 data from sites 043-1, 04302 and 043-3 were included in these statistics.

THE FOLLOWING RESULTS ARE FOR:
MONTH = June

TOTAL OBSERVATIONS: 18

	CU	NI	CO	ZN	CA
N OF CASES	18	18	0	0	0
MINIMUM	0.140	6.000	.	.	.
MAXIMUM	1.800	15.000	.	.	.
RANGE	1.660	9.000	.	.	.
MEAN	0.653	10.411	.	.	.
STANDARD DEV	0.371	2.618	.	.	.
MEDIAN	0.570	11.000	.	.	.

	MG	SO4
N OF CASES	0	18
MINIMUM	.	708.000
MAXIMUM	.	1579.000
RANGE	.	871.000
MEAN	.	1155.222
STANDARD DEV	.	236.504
MEDIAN	.	1176.000

THE FOLLOWING RESULTS ARE FOR:
MONTH = July

TOTAL OBSERVATIONS: 27

	CU	NI	CO	ZN	CA
N OF CASES	27	24	0	0	0
MINIMUM	0.360	9.100	.	.	.
MAXIMUM	1.600	20.000	.	.	.
RANGE	1.240	10.900	.	.	.
MEAN	0.993	13.346	.	.	.
STANDARD DEV	0.368	3.529	.	.	.
MEDIAN	0.980	12.500	.	.	.

Table A2.7. Summary statistics of all 1993 surface water quality data for the outer pool of the Seep 1 pretreatment system (continued).

	MG	SO4
N OF CASES	0	27
MINIMUM	.	717.000
MAXIMUM	.	1734.000
RANGE	.	1017.000
MEAN	.	1255.704
STANDARD DEV	.	215.419
MEDIAN	.	1254.000

THE FOLLOWING RESULTS ARE FOR:
MONTH = August

TOTAL OBSERVATIONS: 15

	CU	NI	CO	ZN	CA
N OF CASES	15	15	0	0	0
MINIMUM	0.140	3.000	.	.	.
MAXIMUM	1.200	17.000	.	.	.
RANGE	1.060	14.000	.	.	.
MEAN	0.679	11.233	.	.	.
STANDARD DEV	0.389	3.824	.	.	.
MEDIAN	0.720	11.000	.	.	.

	MG	SO4
N OF CASES	0	15
MINIMUM	.	558.000
MAXIMUM	.	2311.000
RANGE	.	1753.000
MEAN	.	1506.200
STANDARD DEV	.	478.565
MEDIAN	.	1443.000

Note: values are mg/L

Table A2.8. Summary statistics of all 1997 surface water quality data for the outer pool of the Seep 1 pretreatment system.

Note: All 1997 data from sites 043-1, 04302 and 043-3 were included in these statistics.

THE FOLLOWING RESULTS ARE FOR:
MONTH = May

TOTAL OBSERVATIONS: 9

	Cu	Ni	Co	Zn	CA
N OF CASES	9	9	9	9	0
MINIMUM	0.039	0.300	0.007	0.060	.
MAXIMUM	0.200	4.600	0.200	0.650	.
RANGE	0.161	4.300	0.193	0.590	.
MEAN	0.122	2.100	0.077	0.336	.
STANDARD DEV	0.062	1.440	0.058	0.192	.
MEDIAN	0.100	1.800	0.065	0.300	.

	MG	SO4
N OF CASES	0	9
MINIMUM	.	133.000
MAXIMUM	.	601.000
RANGE	.	468.000
MEAN	.	325.378
STANDARD DEV	.	157.361
MEDIAN	.	284.400

THE FOLLOWING RESULTS ARE FOR:
MONTH = June

TOTAL OBSERVATIONS: 6

	Cu	Ni	Co	Zn	CA
N OF CASES	6	6	3	3	3
MINIMUM	1.900	18.200	1.300	2.640	218.000
MAXIMUM	4.400	31.000	1.900	3.170	276.000
RANGE	2.500	12.800	0.600	0.530	58.000
MEAN	2.717	25.433	1.533	2.830	251.333
STANDARD DEV	0.962	4.151	0.321	0.295	29.956
MEDIAN	2.400	25.900	1.400	2.680	260.000

Table A2.8. Summary statistics of all 1997 surface water quality data for the outer pool of the Seep 1 pretreatment system (continued).

	MG	SO4
N OF CASES	3	6
MINIMUM	170.000	1230.000
MAXIMUM	217.000	1760.000
RANGE	47.000	530.000
MEAN	200.667	1539.500
STANDARD DEV	26.577	173.848
MEDIAN	215.000	1562.500

THE FOLLOWING RESULTS ARE FOR:
MONTH = July

TOTAL OBSERVATIONS: 6

	Cu	Ni	Co	Zn	CA
N OF CASES	6	6	3	3	3
MINIMUM	1.000	14.900	0.700	1.600	246.000
MAXIMUM	2.900	24.300	1.100	2.400	300.000
RANGE	1.900	9.400	0.400	0.800	54.000
MEAN	1.867	18.600	0.833	1.967	277.667
STANDARD DEV	0.766	3.486	0.231	0.404	28.184
MEDIAN	1.800	18.550	0.700	1.900	287.000

	MG	SO4
N OF CASES	3	6
MINIMUM	178.000	1295.000
MAXIMUM	228.000	1627.000
RANGE	50.000	332.000
MEAN	201.667	1445.000
STANDARD DEV	25.106	139.021
MEDIAN	199.000	1441.500

Table A2.8. Summary statistics of all 1997 surface water quality data for the outer pool of the Seep 1 pretreatment system (continued).

THE FOLLOWING RESULTS ARE FOR:
MONTH = August

TOTAL OBSERVATIONS: 6

	Cu	Ni	Co	Zn	CA
N OF CASES	6	6	3	3	3
MINIMUM	0.370	7.200	0.600	1.370	116.000
MAXIMUM	1.600	16.000	0.800	2.460	236.000
RANGE	1.230	8.800	0.200	1.090	120.000
MEAN	1.012	11.733	0.667	1.840	194.000
STANDARD DEV	0.435	3.659	0.115	0.560	67.617
MEDIAN	0.900	12.850	0.600	1.690	230.000

	MG	SO4
N OF CASES	3	6
MINIMUM	65.700	519.000
MAXIMUM	161.000	1538.000
RANGE	95.300	1019.000
MEAN	107.100	1108.667
STANDARD DEV	48.864	417.802
MEDIAN	94.600	1237.000

THE FOLLOWING RESULTS ARE FOR:
MONTH = September

TOTAL OBSERVATIONS: 6

	Cu	Ni	Co	Zn	CA
N OF CASES	6	6	0	0	6
MINIMUM	0.500	13.200	.	.	241.000
MAXIMUM	1.610	17.000	.	.	283.000
RANGE	1.110	3.800	.	.	42.000
MEAN	1.040	14.883	.	.	266.333
STANDARD DEV	0.379	1.291	.	.	15.731
MEDIAN	1.035	14.600	.	.	271.000

Table A2.8. Summary statistics of all 1997 surface water quality data for the outer pool of the Seep 1 pretreatment system (continued).

	MG	SO4
N OF CASES	6	6
MINIMUM	125.000	1116.000
MAXIMUM	222.000	1604.000
RANGE	97.000	488.000
MEAN	184.667	1404.167
STANDARD DEV	34.098	165.051
MEDIAN	186.000	1397.500

THE FOLLOWING RESULTS ARE FOR:
MONTH = October

TOTAL OBSERVATIONS: 6

	Cu	Ni	Co	Zn	CA
N OF CASES	6	6	0	0	6
MINIMUM	0.340	6.800	.	.	159.000
MAXIMUM	1.100	16.200	.	.	292.000
RANGE	0.760	9.400	.	.	133.000
MEAN	0.737	11.550	.	.	225.833
STANDARD DEV	0.337	4.100	.	.	60.101
MEDIAN	0.760	11.200	.	.	226.000

	MG	SO4
N OF CASES	6	6
MINIMUM	80.900	795.000
MAXIMUM	214.000	1572.000
RANGE	133.100	777.000
MEAN	152.817	1179.500
STANDARD DEV	59.399	374.898
MEDIAN	153.500	1169.500

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August.

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THE FOLLOWING RESULTS ARE FOR:
         DNRSITE$     = 043-1
            YEAR      =          93.000

TOTAL OBSERVATIONS:      17
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	SC	PH	Cu	Ni	Co
N OF CASES	0	12	17	17	0
MINIMUM	.	4.600	0.250	8.500	.
MAXIMUM	.	6.600	1.600	18.000	.
RANGE	.	2.000	1.350	9.500	.
MEAN	.	5.733	0.879	11.000	.
STANDARD DEV	.	0.724	0.391	2.378	.
MEDIAN	.	5.800	0.820	11.000	.

	Zn	SO4	CA	MG
N OF CASES	0	17	0	0
MINIMUM	.	1058.000	.	.
MAXIMUM	.	1796.000	.	.
RANGE	.	738.000	.	.
MEAN	.	1320.529	.	.
STANDARD DEV	.	180.875	.	.
MEDIAN	.	1316.000	.	.

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THE FOLLOWING RESULTS ARE FOR:
         DNRSITE$     = 043-1
            YEAR      =          94.000

TOTAL OBSERVATIONS:      3
```

	SC	PH	Cu	Ni	Co
N OF CASES	0	3	3	2	0
MINIMUM	.	5.300	0.660	6.200	.
MAXIMUM	.	6.200	1.400	9.900	.
RANGE	.	0.900	0.740	3.700	.
MEAN	.	5.600	1.020	8.050	.
STANDARD DEV	.	0.520	0.370	2.616	.
MEDIAN	.	5.300	1.000	8.050	.

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

	Zn	SO4	CA	MG
N OF CASES	0	3	0	0
MINIMUM	.	939.000	.	.
MAXIMUM	.	1435.000	.	.
RANGE	.	496.000	.	.
MEAN	.	1199.667	.	.
STANDARD DEV	.	248.969	.	.
MEDIAN	.	1225.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-1
YEAR = 97.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	6	6	6	6	3
MINIMUM	1790.000	4.930	0.900	11.700	0.600
MAXIMUM	3000.000	6.300	4.400	26.700	1.400
RANGE	1210.000	1.370	3.500	15.000	0.800
MEAN	2231.667	5.765	2.050	18.900	0.900
STANDARD DEV	460.887	0.520	1.286	6.474	0.436
MEDIAN	2150.000	5.825	1.800	17.300	0.700

	Zn	SO4	CA	MG
N OF CASES	3	6	3	3
MINIMUM	1.370	1150.000	230.000	161.000
MAXIMUM	2.640	1598.000	287.000	217.000
RANGE	1.270	448.000	57.000	56.000
MEAN	1.870	1430.500	264.333	192.333
STANDARD DEV	0.677	175.934	30.238	28.589
MEDIAN	1.600	1469.500	276.000	199.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-2
YEAR = 93.000

TOTAL OBSERVATIONS: 17

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

	SC	PH	Cu	Ni	Co
N OF CASES	0	13	17	17	0
MINIMUM	.	4.800	0.140	3.000	.
MAXIMUM	.	7.200	1.500	16.000	.
RANGE	.	2.400	1.360	13.000	.
MEAN	.	6.269	0.539	10.329	.
STANDARD DEV	.	0.724	0.406	3.334	.
MEDIAN	.	6.400	0.410	10.000	.

	Zn	SO4	CA	MG
N OF CASES	0	17	0	0
MINIMUM	.	558.000	.	.
MAXIMUM	.	2311.000	.	.
RANGE	.	1753.000	.	.
MEAN	.	1225.941	.	.
STANDARD DEV	.	485.683	.	.
MEDIAN	.	1154.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-2
YEAR = 94.000

TOTAL OBSERVATIONS: 3

	SC	PH	Cu	Ni	Co
N OF CASES	0	3	3	2	0
MINIMUM	.	5.600	0.640	7.400	.
MAXIMUM	.	6.700	0.820	9.100	.
RANGE	.	1.100	0.180	1.700	.
MEAN	.	6.200	0.720	8.250	.
STANDARD DEV	.	0.557	0.092	1.202	.
MEDIAN	.	6.300	0.700	8.250	.

	Zn	SO4	CA	MG
N OF CASES	0	3	0	0
MINIMUM	.	708.000	.	.
MAXIMUM	.	1153.000	.	.
RANGE	.	445.000	.	.

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

MEAN	.	952.000	.	.
STANDARD DEV	.	225.595	.	.
MEDIAN	.	995.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-2
YEAR = 97.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	6	6	6	6	3
MINIMUM	975.000	5.390	0.900	7.500	0.600
MAXIMUM	2700.000	6.440	2.100	25.400	1.300
RANGE	1725.000	1.050	1.200	17.900	0.700
MEAN	2016.667	6.068	1.400	16.317	0.867
STANDARD DEV	602.840	0.386	0.502	5.851	0.379
MEDIAN	2037.500	6.165	1.300	16.400	0.700

	Zn	SO4	CA	MG
N OF CASES	3	6	3	3
MINIMUM	1.690	519.000	116.000	65.700
MAXIMUM	2.680	1524.000	246.000	178.000
RANGE	0.990	1005.000	130.000	112.300
MEAN	2.090	1212.667	193.333	137.900
STANDARD DEV	0.522	354.099	68.420	62.655
MEDIAN	1.900	1309.500	218.000	170.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-3
YEAR = 93.000

TOTAL OBSERVATIONS: 17

	SC	PH	Cu	Ni	Co
N OF CASES	0	13	17	17	0
MINIMUM	.	5.000	0.430	11.000	.
MAXIMUM	.	7.100	1.500	20.000	.
RANGE	.	2.100	1.070	9.000	.

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

MEAN	.	6.000	0.942	15.059	.
STANDARD DEV	.	0.566	0.302	2.883	.
MEDIAN	.	6.100	0.910	15.000	.

	Zn	SO4	CA	MG
N OF CASES	0	17	0	0
MINIMUM	.	1090.000	.	.
MAXIMUM	.	1982.000	.	.
RANGE	.	892.000	.	.
MEAN	.	1426.824	.	.
STANDARD DEV	.	246.888	.	.
MEDIAN	.	1333.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-3
YEAR = 94.000

TOTAL OBSERVATIONS: 3

	SC	PH	Cu	Ni	Co
N OF CASES	0	3	3	2	0
MINIMUM	.	5.900	0.730	10.000	.
MAXIMUM	.	6.200	1.800	15.000	.
RANGE	.	0.300	1.070	5.000	.
MEAN	.	6.100	1.133	12.500	.
STANDARD DEV	.	0.173	0.582	3.536	.
MEDIAN	.	6.200	0.870	12.500	.

	Zn	SO4	CA	MG
N OF CASES	0	3	0	0
MINIMUM	.	970.000	.	.
MAXIMUM	.	1254.000	.	.
RANGE	.	284.000	.	.
MEAN	.	1096.667	.	.
STANDARD DEV	.	144.462	.	.
MEDIAN	.	1066.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-3

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

YEAR = 97.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	6	6	6	6	3
MINIMUM	1325.000	5.040	0.370	7.200	0.800
MAXIMUM	2600.000	6.700	3.200	31.000	1.900
RANGE	1275.000	1.660	2.830	23.800	1.100
MEAN	2183.333	5.570	2.145	20.550	1.267
STANDARD DEV	466.280	0.665	1.070	8.265	0.569
MEDIAN	2312.500	5.270	2.500	22.100	1.100

	Zn	SO4	CA	MG
N OF CASES	3	6	3	3
MINIMUM	2.400	681.000	236.000	94.600
MAXIMUM	3.170	1760.000	300.000	228.000
RANGE	0.770	1079.000	64.000	133.400
MEAN	2.677	1450.000	265.333	179.200
STANDARD DEV	0.428	386.229	32.332	73.554
MEDIAN	2.460	1550.500	260.000	215.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-4
YEAR = 93.000

TOTAL OBSERVATIONS: 17

	SC	PH	Cu	Ni	Co
N OF CASES	0	10	17	17	0
MINIMUM	.	5.800	0.120	7.700	.
MAXIMUM	.	7.000	0.570	17.000	.
RANGE	.	1.200	0.450	9.300	.
MEAN	.	6.430	0.327	11.453	.
STANDARD DEV	.	0.424	0.152	2.618	.
MEDIAN	.	6.350	0.320	11.000	.

	Zn	SO4	CA	MG
N OF CASES	0	17	0	0

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

MINIMUM	.	1041.000	.	.
MAXIMUM	.	2481.000	.	.
RANGE	.	1440.000	.	.
MEAN	.	1335.118	.	.
STANDARD DEV	.	311.856	.	.
MEDIAN	.	1279.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-4
YEAR = 94.000

TOTAL OBSERVATIONS: 3

	SC	PH	Cu	Ni	Co
N OF CASES	0	3	3	2	0
MINIMUM	.	6.100	0.250	6.100	.
MAXIMUM	.	6.700	0.660	8.100	.
RANGE	.	0.600	0.410	2.000	.
MEAN	.	6.500	0.467	7.100	.
STANDARD DEV	.	0.346	0.206	1.414	.
MEDIAN	.	6.700	0.490	7.100	.

	Zn	SO4	CA	MG
N OF CASES	0	3	0	0
MINIMUM	.	644.000	.	.
MAXIMUM	.	1177.000	.	.
RANGE	.	533.000	.	.
MEAN	.	901.000	.	.
STANDARD DEV	.	267.007	.	.
MEDIAN	.	882.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-4
YEAR = 97.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	6	6	6	6	3

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

MINIMUM	1775.000	5.380	0.500	11.100	0.500
MAXIMUM	2600.000	6.560	2.200	21.000	1.000
RANGE	825.000	1.180	1.700	9.900	0.500
MEAN	2202.500	5.995	1.317	16.017	0.700
STANDARD DEV	309.576	0.401	0.624	3.602	0.265
MEDIAN	2220.000	5.945	1.450	16.050	0.600

	Zn	SO4	CA	MG
N OF CASES	3	6	3	3
MINIMUM	1.540	1092.000	224.000	150.000
MAXIMUM	2.580	1609.000	285.000	221.000
RANGE	1.040	517.000	61.000	71.000
MEAN	1.940	1422.500	252.000	191.667
STANDARD DEV	0.560	182.602	30.806	37.072
MEDIAN	1.700	1456.500	247.000	204.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-5
YEAR = 93.000

TOTAL OBSERVATIONS: 17

	SC	PH	Cu	Ni	Co
N OF CASES	0	9	17	17	0
MINIMUM	.	6.000	0.130	8.400	.
MAXIMUM	.	7.100	0.690	18.000	.
RANGE	.	1.100	0.560	9.600	.
MEAN	.	6.500	0.356	11.106	.
STANDARD DEV	.	0.339	0.164	2.542	.
MEDIAN	.	6.500	0.300	11.000	.

	Zn	SO4	CA	MG
N OF CASES	0	17	0	0
MINIMUM	.	940.000	.	.
MAXIMUM	.	2513.000	.	.
RANGE	.	1573.000	.	.
MEAN	.	1291.471	.	.
STANDARD DEV	.	342.856	.	.
MEDIAN	.	1209.000	.	.

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-5
YEAR = 94.000

TOTAL OBSERVATIONS: 3

	SC	PH	Cu	Ni	Co
N OF CASES	0	3	3	2	0
MINIMUM	.	6.100	0.310	7.900	.
MAXIMUM	.	6.900	0.840	9.900	.
RANGE	.	0.800	0.530	2.000	.
MEAN	.	6.500	0.657	8.900	.
STANDARD DEV	.	0.400	0.300	1.414	.
MEDIAN	.	6.500	0.820	8.900	.

	Zn	SO4	CA	MG
N OF CASES	0	3	0	0
MINIMUM	.	843.000	.	.
MAXIMUM	.	1296.000	.	.
RANGE	.	453.000	.	.
MEAN	.	1089.667	.	.
STANDARD DEV	.	229.178	.	.
MEDIAN	.	1130.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-5
YEAR = 97.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	6	6	6	6	3
MINIMUM	1600.000	5.560	0.600	11.100	0.500
MAXIMUM	2500.000	6.510	2.300	27.400	1.400
RANGE	900.000	0.950	1.700	16.300	0.900
MEAN	2135.000	6.143	1.330	17.650	0.833
STANDARD DEV	339.632	0.371	0.706	5.617	0.493
MEDIAN	2205.000	6.250	1.100	17.350	0.600

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

	Zn	SO4	CA	MG
N OF CASES	3	6	3	3
MINIMUM	1.570	1015.000	209.000	144.000
MAXIMUM	2.820	1601.000	275.000	200.000
RANGE	1.250	586.000	66.000	56.000
MEAN	2.063	1374.167	236.667	174.667
STANDARD DEV	0.665	204.539	34.269	28.378
MEDIAN	1.800	1431.500	226.000	180.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-6
YEAR = 93.000

TOTAL OBSERVATIONS: 17

	SC	PH	Cu	Ni	Co
N OF CASES	0	9	17	17	0
MINIMUM	.	6.200	0.050	7.000	.
MAXIMUM	.	7.300	0.600	18.000	.
RANGE	.	1.100	0.550	11.000	.
MEAN	.	6.678	0.205	10.476	.
STANDARD DEV	.	0.370	0.156	2.941	.
MEDIAN	.	6.600	0.140	9.600	.

	Zn	SO4	CA	MG
N OF CASES	0	17	0	0
MINIMUM	.	914.000	.	.
MAXIMUM	.	2502.000	.	.
RANGE	.	1588.000	.	.
MEAN	.	1265.353	.	.
STANDARD DEV	.	340.417	.	.
MEDIAN	.	1225.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-6
YEAR = 94.000

TOTAL OBSERVATIONS: 3

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

	SC	PH	Cu	Ni	Co
N OF CASES	0	3	3	2	0
MINIMUM	.	6.200	0.040	7.400	.
MAXIMUM	.	6.900	0.730	9.200	.
RANGE	.	0.700	0.690	1.800	.
MEAN	.	6.600	0.483	8.300	.
STANDARD DEV	.	0.361	0.385	1.273	.
MEDIAN	.	6.700	0.680	8.300	.

	Zn	SO4	CA	MG
N OF CASES	0	3	0	0
MINIMUM	.	731.000	.	.
MAXIMUM	.	1186.000	.	.
RANGE	.	455.000	.	.
MEAN	.	992.333	.	.
STANDARD DEV	.	234.926	.	.
MEDIAN	.	1060.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-6
YEAR = 97.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	6	6	6	6	3
MINIMUM	1700.000	6.390	0.200	8.600	0.052
MAXIMUM	2400.000	6.650	0.900	18.500	0.400
RANGE	700.000	0.260	0.700	9.900	0.348
MEAN	2020.833	6.560	0.515	13.600	0.251
STANDARD DEV	303.487	0.121	0.307	3.537	0.179
MEDIAN	1950.000	6.625	0.395	14.050	0.300

	Zn	SO4	CA	MG
N OF CASES	3	6	3	3
MINIMUM	0.270	1128.000	210.000	157.000
MAXIMUM	1.500	1500.000	281.000	205.000
RANGE	1.230	372.000	71.000	48.000
MEAN	1.077	1317.167	243.333	173.333
STANDARD DEV	0.699	176.612	35.698	27.429

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

MEDIAN	1.460	1322.000	239.000	158.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-6
YEAR = 98.000

TOTAL OBSERVATIONS: 7

	SC	PH	Cu	Ni	Co
N OF CASES	7	7	7	7	7
MINIMUM	1850.000	6.530	0.100	8.400	0.100
MAXIMUM	2300.000	7.330	0.600	19.500	0.600
RANGE	450.000	0.800	0.500	11.100	0.500
MEAN	2078.571	6.887	0.276	13.786	0.243
STANDARD DEV	157.737	0.267	0.170	3.650	0.172
MEDIAN	2100.000	6.810	0.200	14.900	0.200

	Zn	SO4	CA	MG
N OF CASES	7	7	7	7
MINIMUM	0.920	1143.000	231.000	173.000
MAXIMUM	1.960	1475.000	326.000	223.000
RANGE	1.040	332.000	95.000	50.000
MEAN	1.399	1301.143	272.857	202.143
STANDARD DEV	0.339	111.109	30.372	18.916
MEDIAN	1.400	1272.000	269.000	206.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-6
YEAR = 99.000

TOTAL OBSERVATIONS: 5

	SC	PH	Cu	Ni	Co
N OF CASES	5	5	4	4	3
MINIMUM	1275.000	4.740	0.555	10.470	0.533
MAXIMUM	2150.000	5.890	1.420	13.900	0.890
RANGE	875.000	1.150	0.865	3.430	0.357
MEAN	1805.000	5.372	1.057	12.193	0.738
STANDARD DEV	338.378	0.435	0.366	1.757	0.184

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

MEDIAN	1900.000	5.340	1.126	12.200	0.790

	Zn	SO4	CA	MG
N OF CASES	3	5	3	3
MINIMUM	1.513	752.000	231.000	183.000
MAXIMUM	2.130	1500.000	276.000	220.000
RANGE	0.617	748.000	45.000	37.000
MEAN	1.878	1241.800	253.333	202.000
STANDARD DEV	0.323	287.792	22.502	18.520
MEDIAN	1.990	1318.000	253.000	203.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-7
YEAR = 97.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	6	6	6	6	3
MINIMUM	1690.000	6.320	0.300	11.100	0.400
MAXIMUM	2400.000	6.740	1.100	17.800	0.500
RANGE	710.000	0.420	0.800	6.700	0.100
MEAN	2035.833	6.577	0.612	14.750	0.467
STANDARD DEV	280.721	0.153	0.293	2.389	0.058
MEDIAN	2000.000	6.575	0.535	15.400	0.500

	Zn	SO4	CA	MG
N OF CASES	3	6	3	3
MINIMUM	1.260	1136.000	231.000	152.000
MAXIMUM	1.600	1486.000	278.000	206.000
RANGE	0.340	350.000	47.000	54.000
MEAN	1.487	1309.167	247.333	174.667
STANDARD DEV	0.196	158.481	26.577	28.024
MEDIAN	1.600	1308.000	233.000	166.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-8
YEAR = 97.000

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	6	6	6	6	3
MINIMUM	1225.000	6.060	0.400	8.000	0.400
MAXIMUM	2800.000	6.690	1.600	18.400	0.500
RANGE	1575.000	0.630	1.200	10.400	0.100
MEAN	2041.667	6.478	0.800	14.683	0.467
STANDARD DEV	510.065	0.234	0.438	3.692	0.058
MEDIAN	2050.000	6.510	0.600	15.950	0.500

	Zn	SO4	CA	MG
N OF CASES	3	6	3	3
MINIMUM	1.330	754.000	147.000	99.800
MAXIMUM	1.700	1494.000	278.000	201.000
RANGE	0.370	740.000	131.000	101.200
MEAN	1.537	1272.500	211.333	155.933
STANDARD DEV	0.189	280.572	65.531	51.500
MEDIAN	1.580	1366.000	209.000	167.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-W
YEAR = 93.000

TOTAL OBSERVATIONS: 17

	SC	PH	Cu	Ni	Co
N OF CASES	0	12	17	17	0
MINIMUM	.	6.200	0.030	6.200	.
MAXIMUM	.	7.300	0.210	15.000	.
RANGE	.	1.100	0.180	8.800	.
MEAN	.	6.833	0.115	9.582	.
STANDARD DEV	.	0.339	0.050	2.378	.
MEDIAN	.	6.800	0.110	8.900	.

	Zn	SO4	CA	MG
N OF CASES	0	17	0	0
MINIMUM	.	1002.000	.	.
MAXIMUM	.	2492.000	.	.

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

RANGE	.	1490.000	.	.
MEAN	.	1247.294	.	.
STANDARD DEV	.	333.784	.	.
MEDIAN	.	1172.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-W
YEAR = 94.000

TOTAL OBSERVATIONS: 3

	SC	PH	Cu	Ni	Co
N OF CASES	0	3	3	2	0
MINIMUM	.	6.400	0.050	6.800	.
MAXIMUM	.	6.900	0.450	8.000	.
RANGE	.	0.500	0.400	1.200	.
MEAN	.	6.667	0.267	7.400	.
STANDARD DEV	.	0.252	0.202	0.849	.
MEDIAN	.	6.700	0.300	7.400	.

	Zn	SO4	CA	MG
N OF CASES	0	3	0	0
MINIMUM	.	745.000	.	.
MAXIMUM	.	1237.000	.	.
RANGE	.	492.000	.	.
MEAN	.	1014.000	.	.
STANDARD DEV	.	249.205	.	.
MEDIAN	.	1060.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-W
YEAR = 97.000

TOTAL OBSERVATIONS: 4

	SC	PH	Cu	Ni	Co
N OF CASES	3	3	4	4	2
MINIMUM	1475.000	6.680	0.100	7.200	0.200
MAXIMUM	2700.000	6.910	0.400	14.000	0.300

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

RANGE	1225.000	0.230	0.300	6.800	0.100
MEAN	2075.000	6.757	0.263	10.125	0.250
STANDARD DEV	612.883	0.133	0.138	2.957	0.071
MEDIAN	2050.000	6.680	0.275	9.650	0.250

	Zn	SO4	CA	MG
N OF CASES	2	4	2	2
MINIMUM	0.680	936.000	191.000	129.000
MAXIMUM	1.000	1521.000	275.000	197.000
RANGE	0.320	585.000	84.000	68.000
MEAN	0.840	1347.250	233.000	163.000
STANDARD DEV	0.226	276.086	59.397	48.083
MEDIAN	0.840	1466.000	233.000	163.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-WB
YEAR = 97.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	6	6	6	6	3
MINIMUM	1400.000	6.550	0.200	7.400	0.094
MAXIMUM	2350.000	6.870	0.500	14.700	0.300
RANGE	950.000	0.320	0.300	7.300	0.206
MEAN	1816.667	6.703	0.313	10.850	0.198
STANDARD DEV	350.238	0.136	0.131	2.842	0.103
MEDIAN	1800.000	6.675	0.290	10.600	0.200

	Zn	SO4	CA	MG
N OF CASES	3	6	3	3
MINIMUM	0.570	927.000	187.000	125.000
MAXIMUM	1.100	1589.000	277.000	199.000
RANGE	0.530	662.000	90.000	74.000
MEAN	0.843	1271.667	225.667	161.333
STANDARD DEV	0.265	273.175	46.318	37.018
MEDIAN	0.860	1277.500	213.000	160.000

THE FOLLOWING RESULTS ARE FOR:

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

DNRSITE$ = 043-WB
YEAR = 98.000

TOTAL OBSERVATIONS: 7

	SC	PH	Cu	Ni	Co
N OF CASES	7	7	7	7	7
MINIMUM	1800.000	6.630	0.080	6.700	0.050
MAXIMUM	2300.000	7.200	0.460	16.700	0.300
RANGE	500.000	0.570	0.380	10.000	0.250
MEAN	2071.429	6.934	0.226	11.371	0.186
STANDARD DEV	188.982	0.208	0.149	4.479	0.118
MEDIAN	2100.000	7.000	0.200	10.300	0.200

	Zn	SO4	CA	MG
N OF CASES	7	7	7	7
MINIMUM	0.590	1157.000	238.000	181.000
MAXIMUM	1.730	1364.000	321.000	213.000
RANGE	1.140	207.000	83.000	32.000
MEAN	1.183	1264.143	274.286	201.000
STANDARD DEV	0.455	64.878	29.279	12.715
MEDIAN	1.240	1262.000	275.000	207.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = 043-WB
YEAR = 99.000

TOTAL OBSERVATIONS: 5

	SC	PH	Cu	Ni	Co
N OF CASES	5	5	4	5	4
MINIMUM	1525.000	4.760	0.533	8.912	0.340
MAXIMUM	2100.000	6.360	1.320	14.700	0.880
RANGE	575.000	1.600	0.787	5.788	0.540
MEAN	1930.000	5.876	0.796	11.622	0.610
STANDARD DEV	230.082	0.648	0.356	2.602	0.221
MEDIAN	2000.000	6.110	0.665	12.100	0.610

	Zn	SO4	CA	MG

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

N OF CASES	4	4	3	3
MINIMUM	1.168	901.000	250.000	199.000
MAXIMUM	1.970	1480.000	282.000	208.000
RANGE	0.802	579.000	32.000	9.000
MEAN	1.607	1268.500	263.333	203.000
STANDARD DEV	0.336	253.194	16.653	4.583
MEDIAN	1.645	1346.500	258.000	202.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = Historic
YEAR = 85.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	0	6	6	6	6
MINIMUM	.	4.900	0.420	19.000	1.300
MAXIMUM	.	5.300	0.810	32.000	2.100
RANGE	.	0.400	0.390	13.000	0.800
MEAN	.	5.167	0.615	23.333	1.583
STANDARD DEV	.	0.151	0.164	5.086	0.331
MEDIAN	.	5.200	0.585	21.000	1.400

	Zn	SO4	CA	MG
N OF CASES	6	6	6	0
MINIMUM	1.500	1300.000	150.000	.
MAXIMUM	2.400	1850.000	240.000	.
RANGE	0.900	550.000	90.000	.
MEAN	1.833	1525.000	200.000	.
STANDARD DEV	0.350	227.486	32.863	.
MEDIAN	1.700	1500.000	200.000	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = Historic
YEAR = 86.000

TOTAL OBSERVATIONS: 6

SC	PH	Cu	Ni	Co

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

N OF CASES	0	6	6	6	6
MINIMUM	.	5.100	0.560	12.000	1.400
MAXIMUM	.	5.600	1.100	25.000	1.800
RANGE	.	0.500	0.540	13.000	0.400
MEAN	.	5.333	0.827	20.333	1.533
STANDARD DEV	.	0.186	0.209	4.761	0.151
MEDIAN	.	5.300	0.840	21.500	1.500

	Zn	SO4	CA	MG
N OF CASES	6	6	6	0
MINIMUM	1.300	1200.000	130.000	.
MAXIMUM	2.200	1600.000	210.000	.
RANGE	0.900	400.000	80.000	.
MEAN	1.800	1391.667	181.667	.
STANDARD DEV	0.400	135.708	29.269	.
MEDIAN	1.950	1400.000	190.000	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = Historic
YEAR = 87.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	0	6	6	6	6
MINIMUM	.	5.300	0.440	14.000	1.000
MAXIMUM	.	5.500	1.100	31.000	2.200
RANGE	.	0.200	0.660	17.000	1.200
MEAN	.	5.383	0.747	21.500	1.483
STANDARD DEV	.	0.075	0.238	6.221	0.431
MEDIAN	.	5.400	0.745	20.500	1.500

	Zn	SO4	CA	MG
N OF CASES	6	6	0	0
MINIMUM	1.100	1400.000	.	.
MAXIMUM	2.300	2650.000	.	.
RANGE	1.200	1250.000	.	.
MEAN	1.600	1813.333	.	.
STANDARD DEV	0.429	432.281	.	.
MEDIAN	1.550	1725.000	.	.

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = Historic
YEAR = 88.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	0	6	6	6	6
MINIMUM	.	5.200	0.490	15.000	1.000
MAXIMUM	.	5.500	0.810	32.000	2.500
RANGE	.	0.300	0.320	17.000	1.500
MEAN	.	5.300	0.643	25.167	1.900
STANDARD DEV	.	0.110	0.114	5.981	0.569
MEDIAN	.	5.300	0.610	25.500	2.000

	Zn	SO4	CA	MG
N OF CASES	6	6	0	0
MINIMUM	1.500	1275.000	.	.
MAXIMUM	2.600	2100.000	.	.
RANGE	1.100	825.000	.	.
MEAN	1.950	1791.667	.	.
STANDARD DEV	0.394	287.518	.	.
MEDIAN	1.950	1862.500	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = Historic
YEAR = 89.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	0	6	6	6	6
MINIMUM	.	4.800	0.800	12.000	0.750
MAXIMUM	.	5.100	1.800	24.000	1.900
RANGE	.	0.300	1.000	12.000	1.150
MEAN	.	4.967	1.383	20.333	1.458
STANDARD DEV	.	0.103	0.360	4.457	0.395
MEDIAN	.	5.000	1.450	21.000	1.500

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

	Zn	SO4	CA	MG
N OF CASES	6	6	0	0
MINIMUM	1.100	765.000	.	.
MAXIMUM	3.000	1725.000	.	.
RANGE	1.900	960.000	.	.
MEAN	2.117	1410.833	.	.
STANDARD DEV	0.634	343.153	.	.
MEDIAN	2.100	1450.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = Historic
YEAR = 90.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	0	6	6	6	6
MINIMUM	.	4.700	0.760	11.100	0.840
MAXIMUM	.	5.000	2.100	31.000	1.800
RANGE	.	0.300	1.340	19.900	0.960
MEAN	.	4.850	1.482	18.567	1.332
STANDARD DEV	.	0.105	0.498	7.397	0.414
MEDIAN	.	4.850	1.525	18.500	1.400

	Zn	SO4	CA	MG
N OF CASES	6	6	0	0
MINIMUM	1.500	605.000	.	.
MAXIMUM	2.900	1700.000	.	.
RANGE	1.400	1095.000	.	.
MEAN	2.100	1175.000	.	.
STANDARD DEV	0.551	387.840	.	.
MEDIAN	2.000	1292.500	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = Historic
YEAR = 91.000

TOTAL OBSERVATIONS: 8

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

	SC	PH	Cu	Ni	Co
N OF CASES	0	8	8	8	8
MINIMUM	.	4.600	0.780	12.000	0.520
MAXIMUM	.	5.200	2.500	23.000	2.700
RANGE	.	0.600	1.720	11.000	2.180
MEAN	.	4.900	1.520	16.200	1.153
STANDARD DEV	.	0.227	0.560	4.546	0.714
MEDIAN	.	4.900	1.600	15.000	0.990

	Zn	SO4	CA	MG
N OF CASES	8	8	0	0
MINIMUM	0.880	890.000	.	.
MAXIMUM	3.000	1732.000	.	.
RANGE	2.120	842.000	.	.
MEAN	2.026	1425.375	.	.
STANDARD DEV	0.781	371.756	.	.
MEDIAN	2.170	1616.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = Inf-1
YEAR = 93.000

TOTAL OBSERVATIONS: 17

	SC	PH	Cu	Ni	Co
N OF CASES	0	11	17	17	0
MINIMUM	.	4.600	0.090	2.600	.
MAXIMUM	.	6.800	1.500	13.000	.
RANGE	.	2.200	1.410	10.400	.
MEAN	.	5.555	0.749	9.041	.
STANDARD DEV	.	0.680	0.378	2.750	.
MEDIAN	.	5.700	0.820	10.000	.

	Zn	SO4	CA	MG
N OF CASES	0	17	0	0
MINIMUM	.	971.000	.	.
MAXIMUM	.	1655.000	.	.
RANGE	.	684.000	.	.
MEAN	.	1297.000	.	.

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

STANDARD DEV	.	173.614	.	.
MEDIAN	.	1329.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = Inf-1
YEAR = 94.000

TOTAL OBSERVATIONS: 3

	SC	PH	Cu	Ni	Co
N OF CASES	0	3	3	2	0
MINIMUM	.	5.300	0.730	6.100	.
MAXIMUM	.	5.800	1.400	9.400	.
RANGE	.	0.500	0.670	3.300	.
MEAN	.	5.500	1.033	7.750	.
STANDARD DEV	.	0.265	0.339	2.333	.
MEDIAN	.	5.400	0.970	7.750	.

	Zn	SO4	CA	MG
N OF CASES	0	3	0	0
MINIMUM	.	1031.000	.	.
MAXIMUM	.	1496.000	.	.
RANGE	.	465.000	.	.
MEAN	.	1306.333	.	.
STANDARD DEV	.	244.050	.	.
MEDIAN	.	1392.000	.	.

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S2
YEAR = 97.000

TOTAL OBSERVATIONS: 6

	SC	PH	Cu	Ni	Co
N OF CASES	6	6	6	6	3
MINIMUM	1950.000	4.430	1.400	13.600	1.200
MAXIMUM	3300.000	4.700	3.700	38.400	2.400
RANGE	1350.000	0.270	2.300	24.800	1.200
MEAN	2591.667	4.495	2.250	22.600	1.600

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

STANDARD DEV	525.753	0.102	0.771	8.374	0.693
MEDIAN	2700.000	4.465	2.050	20.150	1.200

	Zn	SO4	CA	MG
N OF CASES	3	6	3	3
MINIMUM	4.200	1411.000	207.000	192.000
MAXIMUM	4.940	2335.000	294.000	264.000
RANGE	0.740	924.000	87.000	72.000
MEAN	4.613	1989.000	262.667	232.000
STANDARD DEV	0.378	320.809	48.336	36.661
MEDIAN	4.700	2019.000	287.000	240.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S2
YEAR = 98.000

TOTAL OBSERVATIONS: 1

	SC	PH	Cu	Ni	Co
N OF CASES	1	1	1	1	1
MINIMUM	2100.000	4.610	1.750	18.300	1.100
MAXIMUM	2100.000	4.610	1.750	18.300	1.100
RANGE	0.000	0.000	0.000	0.000	0.000
MEAN	2100.000	4.610	1.750	18.300	1.100
STANDARD DEV	.	.	.	.	.
MEDIAN	2100.000	4.610	1.750	18.300	1.100

	Zn	SO4	CA	MG
N OF CASES	1	1	1	1
MINIMUM	2.470	1200.000	219.000	194.000
MAXIMUM	2.470	1200.000	219.000	194.000
RANGE	0.000	0.000	0.000	0.000
MEAN	2.470	1200.000	219.000	194.000
STANDARD DEV	.	.	.	.
MEDIAN	2.470	1200.000	219.000	194.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S2
YEAR = 99.000

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

TOTAL OBSERVATIONS: 2

	SC	PH	Cu	Ni	Co
N OF CASES	2	2	1	2	1
MINIMUM	1900.000	4.470	1.710	4.500	1.080
MAXIMUM	2150.000	4.580	1.710	14.100	1.080
RANGE	250.000	0.110	0.000	9.600	0.000
MEAN	2025.000	4.525	1.710	9.300	1.080
STANDARD DEV	176.777	0.078	.	6.788	.
MEDIAN	2025.000	4.525	1.710	9.300	1.080

	Zn	SO4	CA	MG
N OF CASES	1	2	1	1
MINIMUM	2.540	1141.000	276.000	196.000
MAXIMUM	2.540	1385.000	276.000	196.000
RANGE	0.000	244.000	0.000	0.000
MEAN	2.540	1263.000	276.000	196.000
STANDARD DEV	.	172.534	.	.
MEDIAN	2.540	1263.000	276.000	196.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S3
YEAR = 97.000

TOTAL OBSERVATIONS: 5

	SC	PH	Cu	Ni	Co
N OF CASES	5	5	5	5	3
MINIMUM	2200.000	4.380	1.950	19.500	1.600
MAXIMUM	4000.000	4.510	4.300	54.300	3.700
RANGE	1800.000	0.130	2.350	34.800	2.100
MEAN	2970.000	4.424	2.650	30.260	2.333
STANDARD DEV	676.018	0.051	0.941	13.828	1.185
MEDIAN	2750.000	4.420	2.400	24.600	1.700

	Zn	SO4	CA	MG
N OF CASES	3	5	2	2
MINIMUM	4.100	1678.000	217.000	229.000

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

MAXIMUM	5.990	2959.000	363.000	330.000
RANGE	1.890	1281.000	146.000	101.000
MEAN	4.950	2239.000	290.000	279.500
STANDARD DEV	0.959	485.034	103.238	71.418
MEDIAN	4.760	2182.000	290.000	279.500

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S3
YEAR = 99.000

TOTAL OBSERVATIONS: 1

	SC	PH	Cu	Ni	Co
N OF CASES	1	1	1	1	1
MINIMUM	2750.000	4.350	2.400	21.000	1.640
MAXIMUM	2750.000	4.350	2.400	21.000	1.640
RANGE	0.000	0.000	0.000	0.000	0.000
MEAN	2750.000	4.350	2.400	21.000	1.640
STANDARD DEV	.	.	.	.	.
MEDIAN	2750.000	4.350	2.400	21.000	1.640

	Zn	SO4	CA	MG
N OF CASES	1	1	1	1
MINIMUM	3.910	1847.000	311.000	253.000
MAXIMUM	3.910	1847.000	311.000	253.000
RANGE	0.000	0.000	0.000	0.000
MEAN	3.910	1847.000	311.000	253.000
STANDARD DEV	.	.	.	.
MEDIAN	3.910	1847.000	311.000	253.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S4
YEAR = 97.000

TOTAL OBSERVATIONS: 2

	SC	PH	Cu	Ni	Co
N OF CASES	2	2	2	2	1
MINIMUM	1725.000	4.520	2.900	21.100	1.500

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

MAXIMUM	1850.000	4.630	3.000	23.900	1.500
RANGE	125.000	0.110	0.100	2.800	0.000
MEAN	1787.500	4.575	2.950	22.500	1.500
STANDARD DEV	88.388	0.078	0.071	1.980	.
MEDIAN	1787.500	4.575	2.950	22.500	1.500

	Zn	SO4	CA	MG
N OF CASES	1	2	1	1
MINIMUM	2.040	1196.000	195.000	150.000
MAXIMUM	2.040	1430.000	195.000	150.000
RANGE	0.000	234.000	0.000	0.000
MEAN	2.040	1313.000	195.000	150.000
STANDARD DEV	.	165.463	.	.
MEDIAN	2.040	1313.000	195.000	150.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S5
YEAR = 97.000

TOTAL OBSERVATIONS: 1

	SC	PH	Cu	Ni	Co
N OF CASES	1	1	1	1	0
MINIMUM	2125.000	4.560	5.700	27.000	.
MAXIMUM	2125.000	4.560	5.700	27.000	.
RANGE	0.000	0.000	0.000	0.000	.
MEAN	2125.000	4.560	5.700	27.000	.
STANDARD DEV	.	.	.	.	.
MEDIAN	2125.000	4.560	5.700	27.000	.

	Zn	SO4	CA	MG
N OF CASES	0	1	1	1
MINIMUM	.	1572.000	287.000	164.000
MAXIMUM	.	1572.000	287.000	164.000
RANGE	.	0.000	0.000	0.000
MEAN	.	1572.000	287.000	164.000
STANDARD DEV	.	.	.	.
MEDIAN	.	1572.000	287.000	164.000

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

```
THE FOLLOWING RESULTS ARE FOR:
          DNRSITE$    = S5
             YEAR     =         99.000

TOTAL OBSERVATIONS:       1
```

	SC	PH	Cu	Ni	Co
N OF CASES	1	1	1	1	1
MINIMUM	2225.000	4.580	4.320	23.500	2.020
MAXIMUM	2225.000	4.580	4.320	23.500	2.020
RANGE	0.000	0.000	0.000	0.000	0.000
MEAN	2225.000	4.580	4.320	23.500	2.020
STANDARD DEV	.	.	.	.	.
MEDIAN	2225.000	4.580	4.320	23.500	2.020

	Zn	SO4	CA	MG
N OF CASES	1	1	1	1
MINIMUM	2.140	1426.000	219.000	200.000
MAXIMUM	2.140	1426.000	219.000	200.000
RANGE	0.000	0.000	0.000	0.000
MEAN	2.140	1426.000	219.000	200.000
STANDARD DEV	.	.	.	.
MEDIAN	2.140	1426.000	219.000	200.000

```
THE FOLLOWING RESULTS ARE FOR:
          DNRSITE$    = S6
             YEAR     =         97.000

TOTAL OBSERVATIONS:       2
```

	SC	PH	Cu	Ni	Co
N OF CASES	2	2	2	2	1
MINIMUM	1325.000	4.520	3.480	14.600	1.200
MAXIMUM	1490.000	4.620	3.900	14.700	1.200
RANGE	165.000	0.100	0.420	0.100	0.000
MEAN	1407.500	4.570	3.690	14.650	1.200
STANDARD DEV	116.673	0.071	0.297	0.071	.
MEDIAN	1407.500	4.570	3.690	14.650	1.200

	Zn	SO4	CA	MG

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

N OF CASES	1	2	1	1
MINIMUM	1.180	985.000	183.000	76.500
MAXIMUM	1.180	1063.000	183.000	76.500
RANGE	0.000	78.000	0.000	0.000
MEAN	1.180	1024.000	183.000	76.500
STANDARD DEV	.	55.154	.	.
MEDIAN	1.180	1024.000	183.000	76.500

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S6
YEAR = 99.000

TOTAL OBSERVATIONS: 1

	SC	PH	Cu	Ni	Co
N OF CASES	1	1	1	1	1
MINIMUM	1825.000	4.510	4.590	16.100	1.520
MAXIMUM	1825.000	4.510	4.590	16.100	1.520
RANGE	0.000	0.000	0.000	0.000	0.000
MEAN	1825.000	4.510	4.590	16.100	1.520
STANDARD DEV	.	.	.	.	.
MEDIAN	1825.000	4.510	4.590	16.100	1.520

	Zn	SO4	CA	MG
N OF CASES	1	1	1	1
MINIMUM	1.660	1135.000	274.000	112.000
MAXIMUM	1.660	1135.000	274.000	112.000
RANGE	0.000	0.000	0.000	0.000
MEAN	1.660	1135.000	274.000	112.000
STANDARD DEV	.	.	.	.
MEDIAN	1.660	1135.000	274.000	112.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S7
YEAR = 97.000

TOTAL OBSERVATIONS: 3

SC	PH	Cu	Ni	Co

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

N OF CASES	3	3	3	3	2
MINIMUM	1650.000	4.350	4.100	15.000	1.700
MAXIMUM	2600.000	4.570	7.300	22.700	2.000
RANGE	950.000	0.220	3.200	7.700	0.300
MEAN	2166.667	4.453	5.900	19.167	1.850
STANDARD DEV	480.451	0.111	1.637	3.889	0.212
MEDIAN	2250.000	4.440	6.300	19.800	1.850

	Zn	SO4	CA	MG
N OF CASES	2	3	1	1
MINIMUM	2.220	1201.000	240.000	100.000
MAXIMUM	2.400	1889.000	240.000	100.000
RANGE	0.180	688.000	0.000	0.000
MEAN	2.310	1613.667	240.000	100.000
STANDARD DEV	0.127	363.980	.	.
MEDIAN	2.310	1751.000	240.000	100.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S7
YEAR = 99.000

TOTAL OBSERVATIONS: 1

	SC	PH	Cu	Ni	Co
N OF CASES	1	1	1	1	1
MINIMUM	2675.000	4.370	6.680	28.400	2.510
MAXIMUM	2675.000	4.370	6.680	28.400	2.510
RANGE	0.000	0.000	0.000	0.000	0.000
MEAN	2675.000	4.370	6.680	28.400	2.510
STANDARD DEV	.	.	.	.	.
MEDIAN	2675.000	4.370	6.680	28.400	2.510

	Zn	SO4	CA	MG
N OF CASES	1	1	1	1
MINIMUM	2.480	1777.000	380.000	206.000
MAXIMUM	2.480	1777.000	380.000	206.000
RANGE	0.000	0.000	0.000	0.000
MEAN	2.480	1777.000	380.000	206.000
STANDARD DEV	.	.	.	.
MEDIAN	2.480	1777.000	380.000	206.000

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S8
YEAR = 97.000

TOTAL OBSERVATIONS: 1

	SC	PH	Cu	Ni	Co
N OF CASES	1	1	1	1	0
MINIMUM	1900.000	4.700	1.400	10.900	.
MAXIMUM	1900.000	4.700	1.400	10.900	.
RANGE	0.000	0.000	0.000	0.000	.
MEAN	1900.000	4.700	1.400	10.900	.
STANDARD DEV	.	.	.	.	.
MEDIAN	1900.000	4.700	1.400	10.900	.

	Zn	SO4	CA	MG
N OF CASES	0	1	1	1
MINIMUM	.	1496.000	230.000	196.000
MAXIMUM	.	1496.000	230.000	196.000
RANGE	.	0.000	0.000	0.000
MEAN	.	1496.000	230.000	196.000
STANDARD DEV	.	.	.	.
MEDIAN	.	1496.000	230.000	196.000

THE FOLLOWING RESULTS ARE FOR:
DNRSITE$ = S9
YEAR = 97.000

TOTAL OBSERVATIONS: 1

	SC	PH	Cu	Ni	Co
N OF CASES	1	1	1	1	1
MINIMUM	2300.000	4.460	1.800	18.100	1.200
MAXIMUM	2300.000	4.460	1.800	18.100	1.200
RANGE	0.000	0.000	0.000	0.000	0.000
MEAN	2300.000	4.460	1.800	18.100	1.200
STANDARD DEV	.	.	.	.	.
MEDIAN	2300.000	4.460	1.800	18.100	1.200

Table A2.9. Summary statistics of Seep 1 data broken down by year, and using only data from June through August (continued).

	Zn	SO4	CA	MG
N OF CASES	1	1	0	0
MINIMUM	3.500	1577.000	.	.
MAXIMUM	3.500	1577.000	.	.
RANGE	0.000	0.000	.	.
MEAN	3.500	1577.000	.	.
STANDARD DEV	.	.	.	.
MEDIAN	3.500	1577.000	.	.

Note: pH values are in standard units, specific conductance values are in microsiemens, and all other values are mg/L.

Appendix 3

Stockpile Information

Section A3.1.

W1D Wetland Treatment System and the 8018 Stockpile

General History of the 8018 Stockpile

The 8018 was started in 1979. The stockpile would receive Duluth Complex material that contained more than about 0.20% CuO or 0.08% NiO. Most of the stockpile would be placed on upland soils, and any wetland areas would be covered with waste rock that did not contain copper or nickel prior to stockpiling mineralized Duluth Complex.

Both surface and groundwater samples were collected prior to stockpile construction, but only surface water continues to be sampled at the W1D weir site.

Chemical composition of the 8018 was determined by analysis of drill hole samples. Prior to blasting, a series of holes were drilled. The cutting from each of these holes was collected and analyzed, and provides an estimate of the composition of each blast.

The average original composition of the stockpile was 0.28% CuO, 0.09 NiO, and 0.98% S. Based on previous laboratory and field studies with Duluth Complex material, it was believed that this stockpile would eventually produce acid drainage. If acid conditions developed, the overland wetland treatment system would not effectively treat the seepage.

As part of the closure plan, LTV selected stockpile caps based on the potential for long-term water quality problems. Since this pile could potentially produce acid, a 30 mil synthetic membrane LLDPE was selected as the cap. The stockpile was not designed to be capped at closure, and was built with angles of repose side slopes (slope ~ 1:1). These slopes could not be covered, so LTV initiated a program to cover and extend these slopes with inert material. Reject material (cobbles and larger) from the screening of surface material were used to extend the stockpile to eliminate the bottom lift. A silty material was then added as the final cover. The goal was to extend the side slopes far enough so that the top cover would extend over all the mineralized material. This was completed in 1992. Based on a visual inspection, about 50 percent of the side slopes were covered with the silty material.

Water that infiltrates the side slopes will not come in contact with any mineralized material and by covering the slopes with soil, the entry of oxygen into the pile can be restricted. In large rock stockpile, oxygen can enter at the toe through the coarse rubble zone and move upward through the pile like a chimney. The fine soil layer can reduce this effect and slow the oxygen supply to the pile. Capping of the top of the stockpile with low density polyethylene was completed September 1, 1995.

History of 8018 Stockpile

May 1979: Construction of stockpile begins

November 1979: Initial water and peat samples collected (for background see Appendix **xx**)

1992: Reject cobbles from screening operation at 8006 stockpile placed on second lift of stockpile to create single lift – eastern side slope eliminated grade southern half of lift 2 to life 1 cover eastern side slope with silty soil, based on visual estimates about 50% of the slope was covered

1995: Install flexible membrane cover (LLDPE, linear low density polyethylene, 30 mil)

History of W1D Wetland Treatment System

1992: System was constructed in March – went on-line spring melt.
Modifications to system (during flow season):
- rip raps placed on first berm
- installed 4x40 treated lumber across berms, 2, 3, 4
- installed pretreatment system

1992: A pretreatment system was installed upstream of 051 (input to the wetland system). An attempt was made to reduce channelization at each of the berms by placing wood beams to across each dike. The peat in the system was also regraded to correct channelization.

1993: Replaced peat in last 4 cells. (press to melt) Added drop pipe. Raised berm 5 (larger glacial till berm). Raised berm to decrease head in upper section. Several berms at the downstream end of the system utilized a different peat mixture (Michigan/Peatrex peat), LTV felt that this mixture did not provide good metal removal. These peats were replaced with a peat mixture consisting of one-part processing screenings (sphagnum) and one-part Mining Area 2WX peat (reed sedge).

1994: Hay bale added to two berms near outflow of system in June (see field notes from Dunka visit, Appendix 9).

More detailed information on the initial construction and monitoring can be found in the DNR report "The Environmental Leaching of Stockpiles Containing Copper-Nickel Sulfide Minerals" (DNR 1981).

Section A3.2.

Seep 1 Wetland Treatment System and the 8013 Stockpile

Seep 1 is located at the NE corner of the top of stockpile 8013. 8013 is a waste rock stockpile (0.09% CuO, 0.03% NiO, 0.24% S) that was started in 1967 and completed in 1991. At the time of the completion it contained approximately 17,750,000 long tons of material, and covered 2,300,000 ft^2 (52.8 acres; 21.37 ha).

The seep exits the toe of the 8013 over a wide area in the form of many small seepages, which originally formed a large wet area adjacent to 8013. In 1992, a peat/limestone pretreatment system was constructed to capture this diffuse seepage and treat it, and in 1995 a wetland treatment system was constructed to receive the effluent from the pretreatment system and provide further treatment.

October 1974:	8013 very small, growing from west, not in Seep 1 watershed yet.
Prior to April 1976:	Entire first lift of 8013 complete.
1977-1980:	Filing first lift on south end of stockpile (out of watershed).
1981:	Started second lift from south (small unit in watershed).
1982-1985:	90% of second life completed.
1986-1988:	No activity.
1989:	First ditching activity intended to influence flow rate at Seep 1 (Closure Report, Vol. 1, p. 63).
1990-1991:	The ditching of Unnamed Creek past the grassy meadow and through the bedrock outcrop occurred, and cut-off ditches were constructed on both sides of the grassy meadow.
May 1991:	Remainder of second lift (NW area) had been added by this time. This remainder was probably added late 1990 or early 1991.
Fall 1991:	Capping completed.
Spring 1992:	Stockpile hydroseed was fertilized. Barrier layer compacted -1/2 inch screened till from 8006 stockpile; cover -3 inches glacial till.

August 11, 1992:	Peat/limestone pretreatment system was started. This is located between 8013 and the weir. The site historically called 043 (i.e., the raw seepage) is now located at the effluent of the pretreatment system, and can, therefore, not be considered representative of raw, untreated Seep 1 seepage. 8013 was capped in the fall of 1991 by local contractors with compacted fill with a runoff drainage conveyance system with discharge culverts to collect and convey precipitation off the stockpile. Two basic materials were used: 3 inch compacted till, 1/2 inch till (see page 4 of "review of 8013"). 8013 was then planted with oats and a standard mineland reclamation mix of grasses and clover to increase evaportranspiration.
June 1994:	Three hay bales were scattered in the pretreatment system to encourage sulfate reduction.
August 1994:	Hay bales were placed above the vertical down-flow section.
1996:	Peat samples collected from pretreatment system
1997:	DNR started monitoring program of pretreatment system. Peat samples collected from pretreatment system (see detailed timeline, Appendix 6).

Table A3.1. Stockpile characteristics.

Stockpile	Type	Size - Footprint (acres)	Mass (long tons)	Chemical Composition			Deposition History	
				% CuO	% NiO	% S	Start	End
8013	Waste rock	78	17,750,000	0.09	0.03	0.24	1967	1991
8018	Gabbro	18	2,200,000	0.28	0.09	0.98	1979	1985

All data except footprint is from the Dunka Closure Plan submitted 2/11/93.

The footprint of each stockpile was calculated by Steve Dewar from a May 1991 air photo using a dot grid.

Chemical data for the 8018 stockpile was based on drill hole cutting chemical analysis for almost the entire stockpile and should be quite accurate.

Chemical data for the 8013 stockpile was based on drill hole cutting chemical analysis. No drill cutting analysis for sulfur was available prior to 1980 so the sulfur composition of the 8013 is based only on data after 1980. Prior to 19809 some samples were analyzed to determine if the material was "waste rock" < 0.20% CuO or "gabbro" 0.20% CuO. Hornfels, which are higher in sulfur S > 1%, but low in copper and nickel and are acid generating, have been observed on the slope of the 8013 stockpile and likely contribute to the low pH of the small surface seeps.

Table A3.2. Watershed estimates.

Seep #	Pre-Ditching Watershed size (10^6 ft^2)	Post-Ditching Watershed size (10^6 ft^2)	% Reduction	Stockpile Watershed Under Stockpile	Pre-Ditching Watershed Under Stockpile	Post-Ditching Watershed Under Stockpile
EM8	16.6	10/7.7[a]	40/54[a]	8011	3.6	3.6
				8014	1.9	1.9
				8012	0.5	0
Seep 3	1.9	1.9	0	8013	0.35	0.35
				8014	0.4	0.4
Seep X	1.7	1.7	0	8013	1.7	1.7
Seep X (likely)	2.4	2.1	13	8013	2.1	2.1
Seep 1 (low)	.47	.47	0	8013	.35	.35
Seep 1 (high)	.82	.82	0	8013	.65	.65
W1D (historical) weir (input to wetland)	1.9	1.9	0	8018	.75	.75
				8031	.35	.35
W1D, Original Outflow[b] of first wetland	1.4	1.4	0	8031	.10	.10
				8018	.10	.10
				8022	.4	.4
EM1	99	89.5	10			

[a]First value is the result of ditching the environmental sump. The second value is with the addition of the ditch along the south side of 8011.
[b]This is the additional watershed area that contribute to outflow of the wetland. (This does not include the 1995 extension.) To get the total watershed area add the W1D historical value.

Appendix 4

Section A4.1.
Collection of frozen and unfrozen peat cores/samples at W1D, Dunka

DEPARTMENT: Natural Resources
Division of Minerals

STATE OF MINNESOTA
Office Memorandum

DATE: March 26, 1996

TO: Paul Eger, Principal Engineer

FROM: Glenn Melchert, Hydrologist

PHONE: (218) 262-7343 FAX: (218) 262-7328

SUBJECT: Collection of frozen and unfrozen peat cores/samples at W1D, Dunka.

Core R1-4 was collected on 3/13 and the rest of rows 1 and 4 were collected on 3/18/96. About 3' of snow covered the area. Mike Ellett provided assistance.

The numbering convention was four rows (lines) from berm 2 to berm 3 numbered in order with row 1 being the farthest across the wetland and row 4 being closest to the parking/road area. There were five sample sites along each row, labeled so that the most upstream site was 1 and the farthest downstream site was 5 (see attached figure).

A 300' tape was stretched between the rebar stakes at either end of the berms. Then the locations of each row were staked. The spacing was 13.1 m, 26.15 m, 39.2 m and 48.2 m along berm 2 and 13.4 m, 26.8 m, 40.2 m and 49,4 m along berm 3. A rod was used to assure the stakes were directly over the wooden plank running the length of each berm. These stakes were used to align the sample locations along each row. Samples 1 and 2 were collected 10 ft. upstream and 10 ft. downstream of berm 2. Samples 4 and 5 were located similarly on either side of berm 3. Sample 3 was the midpoint between the berms.

H_2S odors were frequently observed. The odors were the strongest in areas where there was ice or water above the peat. This was common at sites 3, 4 and 1. The odor usually was not detected until after augering through the ice.

Sample R1-2 was sampled 15 ft. downstream of berm 2 instead of 10 ft. Later, the stake marking this site was found. The stake was located 21' downstream and no sample was taken at that site.

Sample R1-3 and R4-3 were sampled 25.0 m and 13.5 m, respectively, downstream from berm 2.

Sample #	Ice/H_2O Above Peat (cm)	Sample Collected[1] (cm)	Sampling Device	Comments
R1-1	40 cm	0-10 10-20 20-30	M.C. M.C. M.C.	no roots no roots no roots
R1-2	4 cm	0-18 20-30	C.B. M.C.	roots
R1-3	15-20	0-10 10-20 20-30	M.C. M.C. M.C.	no roots no roots no roots
R1-4	11 cm	0-18	C.B.	roots throughout/gravel at 18 cm.
R1-5	0	0-10	C.B.	roots in upper half/tree roots stopped auger at 10 cm.
R4-1		0-13 13-20 20-30	C.B. M.C. M.C.	roots throughout
R4-2	0	0-14 14-20 20-30	C.B. M.C. M.C.	roots throughout silt at 40 cm.
R4-3	4-13	0-13* 13-23 23-33 33-43	C.B. M.C. M.C. M.C.	clear ice and duckweed mats few to no roots/13 cm. is top of peat
R4-4	15	0-10 10-20	M.C. M.C.	no roots no roots/silt at 22 cm.
R4-5	4	0-23* 20-30	C.B. M.C.	cattail and some roots/top 4 cm. is clear ice silt at 30 cm.

[1]Measured from top of peat.
*Includes ice at top of core. Must be removed.
M.C. = Macaulay sampler. Sample typically is composite of 2 cores.
C.B. = Power auger core barrel. 4" diam.

cc: Jon Wagner

Section A4.2. Peat Sampling - W1D and Seep 1 Pretreatment

DEPARTMENT: Natural Resources
Division of Minerals

STATE OF MINNESOTA

Office Memorandum

DATE: April 22, 1996

TO: Paul Eger, Principal Engineer

FROM: Glenn Melchert, Hydrologist

PHONE: (218) 262-7343 FAX: (218) 262-7328

SUBJECT: Collection of additional peat cores/samples on April 4, 1996, at W1D and Seep 1, Dunka

There was about two feet of snow on the wetland. Most of the snow was firm enough to walk on. Although the snow pack has decreased by about 1/3, no significant runoff has occurred yet. Mike Ellett assisted with sampling.

The sample numbering convention is the same as indicated in my March 26, 1996, memo.

Samples R2-3 and R3-3 were sampled 22.0 m and 17.8 m (mid-points), respectively, downstream from berm 2.

Three samples were collected at the Seep 1 pre-treatment under drain bed. Sites were spaced in a row 6 feet apart with site 3 being about 6 feet from the toe of the dam (see attached figure).

Flow was not detected at either wetland.

GM:djm

cc: J. Wagner

Sample #	Ice/H_2O Above Peat (cm)	Sample Collected[1] (cm)	Sampling Device	Comments
R2-2	0	0-20 20-30	C.B. M.C.	Unfrozen, grassy area, water at surface of peat. Roots in top 12 cm.
R2-3	15	0-10 10-20 20-30	M.C. M.C. M.C.	Strong H_2S after breaking through ice.
R2-4	21	0-10 10-20 20-30	M.C. M.C. M.C.	Occasional white hair-like roots from 0-30 cm.
R3-2	0	0-20 20-25	C.B. Grab	Site has cattails, grass and dogwood. Grass and cattail roots in sample. Some roots. Gravel at 25 cm.
R3-3	14	0-10 10-20 20-30	M.C. M.C. M.C.	Strong H_2S after breaking through ice. No roots. No roots. No roots.
R3-4	10	0-10 10-20 20-28	M.C. M.C. M.C.	Sparse roots 0-28 cm. Gravel at 28 cm.
S1-1 (Seep 1)	40	0-10 10-20	M.C. M.C.	Peat. Has yellow-green blobs at surface. Has some quartz and feldspar grains. Black peat, rock at 22 cm.
S1-2	10	0-10 10-20 20-30 30-40	M.C. M.C. M.C. M.C.	Hay. Hay. Hay/peat mix. Peat. Rock at 60 cm.
S1-3	24	0-25* 15-40	C.B. M.C.	Top 10 cm. is ice. Bottom 15 cm. is hay. Mostly hay. Rock at 42 cm.

[1] Measured from top of peat except where *.
* Includes ice at top of core which must be removed.
M.C. Macaulay sampler. Sample typically is composite of 2-3 cores.
C.B. Power auger core barrel. 4" ID.

DEPARTMENT: Natural Resources
Division of Minerals

STATE OF MINNESOTA

Office Memorandum

DATE: May 15, 1997
March 13, 1998

TO: Paul Eger, Principal Engineer

FROM: Glenn Melchert, Hydrologist

PHONE: (218)262-7343 FAX: (218)262-7328

SUBJECT: Peat sampling: W1D and seep 1 pretreatment. April 11, 14, 17, 24 and May 1, 1997

I was assisted by Julie McCormick on April 24 and May 1.

A major runoff event from snow melt occurred April 4-6. This was followed by a cold snap on April 7 & 8 where lows were near 0°F. By April 17, most of the ice was gone from W1d except near site 3 which still had about 6" of ice (this area receives less sun). Sites 1, 4, and 6 are about 1 meter upstream of a silt fence. Site 11 is at the edge of the upland peninsula. All samples were collected at intervals of 10 cm with a Macaulay sampler.

<u>W1D.</u> On April 11, ice was thickest at the southeastern portion (sites 2, 3, 5), around 12 inches or more, and was thinnest or absent near point A where the flow occurs. Most of the ponded area was covered with a medium density of cattails. Holes about 20 cm in diameter were chiseled to give access for sampling with the Macaulay sampler. The diameter of the Macaulay sample chamber was 4.0 cm in diameter and 50 cm long. The leading drive point was about 10 cm long -- the sample chamber began above this. Usually 4 samples of each interval were composited to give a wet sample weight of at least 70 grams. Only near sites 2, 3, and 5 and 6, 9, 11, did the ice extend into the upper portion of the peat. For site 9 and 11, there was a few cm of ice then frozen peat. Below the surface ice the peat was completely unfrozen. H_2S was detected at nearly every site after a hole was chopped through the ice.

The total peat thickness at the various sites indicates there was probably less than a foot of peat that existed naturally prior to construction of the system. Two feet of loose, fresh peat, more or less, was placed over the existing soil when the system was built. At some sample locations, black peat was encountered just above the mineral sediments. The black peat is interpreted to be original peat/soil. This was found at sites 2 (5 cm thick), 5 (10 cm thick), and 13 (25 cm thick).

Metals analyses of the black peat indicates substantially higher levels than the peat immediately overlying it. This phenomenon also occurred at site 7.

Site 4 appears to be an area that washed out shortly after construction and was subsequently filled with hay bales and more peat.

May 15, 1997
March 13, 1998

Seep 1. No H_2S was detected at any of the sample sites except for a minor amount at sites 4, 7, and 16. Upon turning the Macaulay, air bubbles up welled around the sampler at most of the sites. The greatest amount of bubbles were at sites 4 and 7. Most of the bubbles are believed to be H_2S, but is only detectable immediately downwind of the site due to sparse vegetation.

On April 11, water levels had dropped back to near normal. Perched ice ledges were observed in the pretreatment pool indicating approximate maximum water depth from snow melt a few days prior. Staff gauge reading was 1.44'. The perched ice mark was at 2.70', which is about 0.6' below the overflow spill notch. There was not any perched ice in the weir pool.

By April 17, the northeast pool (site 1) and along the east edge, the ice was less than an inch thick, whereas the west edge along the stockpile was over a foot thick.

On April 24, there was still thick ice on the west and southern portions of the outer pool. By May 1, all the ice had melted.

Generally, some of the white precipitate (up to about 2 cm) overlying the peat was included with the 0-10 cm sample.

GM/djm

W1D Sample Sites.

Sample #	Date	Sample Device	Water Depth (cm)	Peat Thickness (cm)	Peat Intervals Sampled	Comments (Depths are from top of peat)
1					NS	
2	4/14/97	MC	17	31	0-30	Gray silt, peat has brown tint from 10-27 cm. Black peat below 27 cm.
3	4/17/97	MC	23	10	0-10	H_2S odor. Brown gravel at 10 cm. Numerous cattails. Numerous fine roots 0-10 cm.
4	4/14/97	MC	15	47±	0-40	Reed canary and cattails. This is an area of primary flow although not channelized. High H_2S. Hay? from 25-40 cm. Brown peat 18-25 cm. Sample brown peat 20-28 cm. (separate sample). Resistance at 47 cm.
5	4/11/97	MC	26	30-44	0-40	Rock at 30 cm. Few roots. Black peat with woody roots at 35-45 cm.
6	4/11/97		10±		NS	
7	4/11/97	MC	19	58	0-58	Gray brown silt at 58 cm. Few roots in upper 10 cm. Lowest sample is 40-58 cm.
8	4/11/97		20±		NS	
9	4/11/97		2±		NS	
10	4/11/97	MC	22	53	0-30	Rock at 53 cm. Few to no roots. Wood fragments 0-30 cm. Sparse cattails.
11	4/11/97		2±		NS	Edge of high ground.
12	4/11/97	MC	15	59	0-30	Rock at 59 cm.
13	4/11/97	MC	14	71-76	0-76	Brown silt at 76 cm. Numerous fibrous white roots 0-20 cm. Few roots 20-30. Black peat with plant fragments at 50-75 cm. Cattail patch.
14	4/11/97	MC	22	48	0-30	Few to no roots. Soupy. Little recovery from 0-10 cm. Rock at 48 cm. This is the same site as R2-3 sample (#20) from 1996.

MC = Macaulay sediment sampler

Seep 1 Sample Sites -- Pretreatment Bed.

Sample #	Date	Sample Device	Water Depth (cm)	Peat Thickness (cm)	Intervals Sampled	Comments (Depths are from top of peat)
1	4/17/97	MC	28	57	0-50	No ice here. Waded from north bank. 3 cm. of creamy precipitate. Sparse to medium cattails with few other plants. Sand at 57 cm. Took ppt sample.
2	4/17/97	MC	42	26	0-6 ppt[a] 6-10 peat 10-20 20-26	Upper 6 cm. is cream, orange and brown precipitate. Mostly cream colored. Brown material is fine sand comprising 25% by volume. Some roots 10-20 cm. 2 cm. cream blob at 10 cm. probably pulled down by sampler.
3	4/17/97	MC	42	48	0-48	2-3 cm. precipitate at surface. Brown sand at 48 cm. Moderate cattails. Spare roots 0-20 cm.
4	4/17/97	MC	42	39	0-39	6 cm. precipitate at surface. Upper 5 cm. is cream colored then 1 cm. orange layer adjacent to black peat/goo for 1 cm. then fibrous peat. Lots of wood at 25-40 cm. Gray sand at 39 cm.
5					NS	
6					NS	
7	5/1/97	MC	19-24	46	0-46	Site midway between seeps 5 & 6 and 70 cm. from waters edge. Gray coarse sand at 46 cm. 2 cm. of cream colored ppt with orange surface coat. Medium cattails, few roots at 10-20 cm. Numerous H2S bubbles occurred when sampler penetrated near the peat/mineral interface.
8	5/1/97	MC	23	44	0-40	Near seep 4. Area has about 5 cm. ppt like #7. Sparse to no vegetation. Gray sand at 44 cm. Gray silt 20-21 cm. discarded. Peat often washed out at 18-26 and 34-40 cm. due to sticks in upper 10 cm. Some ppt contamination in 30-40 cm.
9					NS	

Sample #	Date	Sample Device	Water Depth (cm)	Peat Thickness (cm)	Intervals Sampled	Comments (Depths are from top of peat)
10	4/14/97	MC	53	19-30	0-30	Black peat with fibrous roots decreasing to sparse roots at 30 cm. Occasional white blobs 0-20 cm (probably vertical mixing from MC). Peat at 10-30 cm. had brown tint. Cattails. Very little wood in the peat compared to W1d.
11	4/14/97	MC	32	42	0-40	Roots in top 15 cm. Silt at 42 cm.
12	4/14/97	MC	34	61	0-50	Roots 0-20 cm., sparse cattails. Lots of orange flocculent stirred up. Some had deposited on lower ice layer. Silt at 61 cm.
13	4/14/97	MC	38	41	0-40	0-10 cm is darker with roots. Generated air bubbles when turning the sampler causing suspension of white flocculent. Gray sand/silt at 41 cm.
14	4/14/97	MC	53	11	0-11	Black muck. One sample had cream colored amorphores globs in the upper 2-3 cm. In a separate sample, the globs spilled as sampler was pulled from the water. Orange-brown silt/clay at 11-13; gray silt/clay 13-16. 2 ppt samples. Brown sand at 16-20. Grades to dark gray sand/silt from 20-24 cm.
15	4/17/97	MC	32	23	0-20	Small amount of precipitate on peat. Medium stand of cattails (1-1.5' spacing). Hard gray sand/silt.
16	4/24/97	MC	8	67	0-67	Thick cattail patch. Gas bubbling when sampling, H2S odor. Heavy roots to 7 cm. Sparse roots 7-24 cm. Peat was loose and wet from 50-67 cm. Gray sand. 0-10 cm. interval is grab sample. Samples taken 1.3-1.6 m. from berm center. Exposed portion of berm was about 1 m. wide.
17	4/24/97	MC	12	78	0-78	Medium cattail patch. Sparse roots 0-20 cm. Dirty sand layer at 64-68 cm. Gray to brown sand/silt. Sampled 1.6-1.9 m. from berm center. Berm was .95 m. wide. Ppt sample.

[a]split in field

Note: There was some whitish precipitate in most of the samples. The precipitate was colloidal, so tended to stick to substrate, so it is generally included in samples.

Section A4.3.
Seep 1 - Notes for Peat Samples

Samples in Vertical Down-flow Section

The power auger was used to cut through the hay and collect the substrate samples. The hay was black below the water, but stems were still visible. On a volumetric basis, the stems made up the majority of the sample. The blackest material was probably a combination of decomposition and precipitation and comprised most of the -80 mesh materials.

The samples were dried and crushed manually with a mortar and pestle. Normally substrate samples are processed in a Wiley mill, but this would have turned all the stems into a -80 mesh powder and would tend to lower the metal concentrations. Each sample was processed by the same person and each sample was ground approximately the same (visual observation).

Samples were screened to -80 mesh, and most of the hay stayed in the +80 mesh fraction and was discarded. Several samples of the +80 mesh fraction were analyzed. Metal concentrations were lower than in the -80 mesh material. Nickel concentrations ranged from 4082 to 5235 mg/Kg in the +80 mesh, and from 6510 to 9998 mg/Kg in the -80 mesh material.

April 1996 Seep 1 peat samples

Sample	Depth	Lab #	Calculated +80 Fraction (%)
S1-1	0-10	10627	52
	10-20	10628	60
S1-2	0-10	10629	57
	10-20	30	56
	20-30	31	47
	30-40	32	47
S1-3	0-10	53	61
	10-15	54	61
	15-40	10633	74

Sample 10656 and 10657 are +80 fractions for 51-2 (0-10) and 51-2 (10-20), respectively.

The % are up to 5% higher due to probably losses during sieving that is not accounted for here because the +80 was not actually weighed, but calculated as a residual.

Table A4.1. Peat samples, comparison of metal levels in +80 mesh with -80 mesh size fraction.

Row	Sample		-80 mesh					+80 mesh					
	Lab IO	#	Depth	Ni	Cu	Co	Zn	Sample #	Depth	Ni	Cu	Co	Zn
S1	10629	2	0-10	6510	6034	995	1626	10656	0-10	4082	3838	769	1098
S1	10630	2	10-20	9998	8392	1397	2620	10657	10-20	5235	4713	1178	1619

Section A4.4.
Dunka Peat Processing

Dunka Peat Processing 1996 (W1d & Seep 1) 3/98

- Use Mettler electronic scale in lab.

Note: Samples consist of 1) core barrel samples : 4" dia core 10 cm long collected frozen -- approx. 750 g. and 2) Macauley samples: composite unfrozen cores collected "field moist" meaning free water has drained off. Approx. 40-60 g samples.

Processing Procedures:

1) Thaw enough samples for 1 or 2 days work.
2) The core barrel samples need to be quartered lengthwise using a sharp knife or the clean bandsaw. Place one quarter into a labeled baggie and refreeze the remaining core. (Original plans were to blend the wet peat in a blender, but this did not work -- probably due to insufficient water content).
3) Use entire contents of Macauley (1 quart baggie) samples.
4) Take first sample. Remove large roots, stones and wood.
5) Squeeze baggie to thoroughly mix blended peat.
6) Withdraw a sample -- about 20 grams (range 20-22 g.) -- use 40 g. for large samples -- and place in small aluminum pie tin. (Weigh pie tin prior to this (to 0.00 g.) and record tin weight on tin lip.) Precisely weigh peat and tin together and record on data sheet. Set aside to place in oven.
7) Sequential sample. Using a plastic boat, tare this to zero on electronic scale. Place exactly 10.00 g. (range 9.90-10.10) of wet peat into the plastic boat. Then pour the peat into a new quart size baggie. Seal baggie after removing all air and freeze. Pre-label baggie with 1) sample date, 2) sample site (e.g. R1-4 10-20 cm.), and 3) actual weight of peat (e.g. 10.05 g.)
8) pH sample. Leave remaining sample in original baggie, remove all air and seal. Then freeze.
9) Repeat above process for each sample (do only enough for 1 days batch).
10) Take tins with peat and place in oven (in lab). Set temp. at 105° C., turn on and let dry for 24 hours. Ask for assistance with oven. Place all of the tins from the day in at the same time.
11) After 24 hours remove tins from oven, weigh peat and tin together and record. Place dry peat in brown envelope and label with lab # only. Calculate the peat dry weight by subtracting the "tin wt." from the "peat and tin dry wt.")
12) Place dry peat in blender and mix. If sample volume is too small, blender process will not work, which was the case for spring 1996 samples. Instead, dry peat was manually ground in a large porcelain mortal and pastel. Every sample was ground to approximately the same consistency. The only problem occurred in a few samples that had 1-3 mm size sand grains, which made it difficult to crush all the material. Note which samples have sand or pebbles. Return material to the brown envelope.

Sample for Ashing

13) If dry peat is less than 2.1 g., then remove 0.500 g. of peat from the envelope and place into the white crucible. If peat weight is more than 2.1 g., then remove 1.00° g. and place into the

white crucible.

- Procedure for removing peat sample from the envelope: Hold envelope so all the peat goes to one corner. Take the stainless steel spatula and obtain a representative sample by pushing the spatula to the bottom of the envelope and withdraw the sample. This way there should be some heavy and some light peat on the spatula. Weigh the empty white ashing dish and record its weight to 3 decimals. Then tare the scale (Mettler) and gradually sprinkle the peat into the ashing dish until 0.500 or 1.000 g is added. Record actual weight. Note: Recording to 3 decimals gives ±2% error.

14) Set the ashing dishes aside in pans and cover until ready to put into the ashing oven.
15) Place dry blended or crushed peat into stainless steel 80 mesh sieve (don't use brass or bronze ones) with a stainless steel collection pan under the sieve. Sieve the peat by hand by tapping and rubbing your fingers over the peat.
16) Weigh the dry peat that has passed through the 80 mesh sieve. Use aluminum pans. The plastic boats have too much static. If the peat weighs more than 1.5 g. (although it is desirable to get at least 2.1 g.), then discard the coarser peat. Try to sieve each sample the same way. Place fine peat in envelope (reuse same one) after weighing. Record the final weight of the sieved peat placed in the envelope.
17) Clean sieve and pan with compressed air and repeat steps 13-16 for each sample.
18) The samples in the brown envelopes are now done and can be sent to Ag. labeled with lab # only. Enter lab # , date, sample #, and -80 mesh metals in red lab book.

Ashing Method

1. Weigh each porcelain dish. Keep in order.
2. Weigh out 0.50 or 1.00 g of dry, unsieved peat into porcelain dishes.
3. Peat is ignited in a muffle furnace at 550°C for 1 hour.
4. After 1 hour, turn off oven and let cool for an hour or so.
5. Weigh crucible and ash together.
6. Subtract the crucible weight from this to get the ash weight.
7. Percent ash (mineral residue) = $\dfrac{ash\ wt.}{sample\ wt.} \times 100$

pH Measurement

1. Place 15 g of wet peat in 50 or 100 ml beaker.
2. Add 15 ml of distilled water.
3. Stir peat and water with a glass rod and let sit.
4. Stir again at 15 min. and 30 min.
5. Let sit for 30 minutes. Total time is 60 minutes.
6. Measure pH by placing the probe about half way into the solution. Ask for assistance with the pH meter/probe.

Percent Moisture

$$\frac{wet\ weight\ (g)\ -\ dry\ weight\ (g)}{wet\ weight\ (g)} \times 100$$

Digestion Method

1. About 0.5 g dry sample.
2. Digested in microwave with 5 mL RO water, 10 mL HNO_3, 2 ml HCL at 40, 80, 120 and 160 psi sequentially for 10 minutes at each pressure.
3. Samples were filtered and brought to 50 mL volume.
4. Analyzed on AA.

Listed below are peat digestion methods used previously for analysis of total metals.

Date: **9/88**
Ref: 1991 and 1996 DNR Wetland Treatment Reports.
Preparation: 0-20 cm peat samples
20-50 cm peat samples
105°C for 24 hrs. -- oven
processed with blender to break up clumps
sieved to -80 mesh (>70% of spl was -80)

Total Digestion — ref: 1991 and 1996 Wetland Treatment Reports.

0.5 g sample
1 mL HCl
2 mL HNO_3
0.5 mL HF
digested at 90°C for 2 hr.
adjusted to 50 mL vol., then AA

Date: **5/91**
Ref: 1996 DNR Wetland Treatment Report.
Preparation: 0-20 & 20-50 cm peat samples
- Same process as 9/88 except a microwave digestion was used.

- Reruns in 4/93

Total digestion (from lab sheet)

0.5 g sample
5 mL H_2O DD
10 mL HNO_3
2 mL HCL
microwave 15 min.
final volume 50 mL
analyze

Date: **3/92**
Ref: Zena's writeup
- frozen peat core, 2-4 cm segments.
sequential according to Wieder, 1991

Total Digestion

10 g wet peat -- ash for 1 hr. at 300°C and 3 hrs. at 800°C
Add 10 mL H_2O_2 and evap. at 90°C -- repeat until no more effervescence with H_2O_2 addition.

Digestion: (Weider 92)
Add 10 mL HCl to dry peat.
Place in block digester or sand bath -- raising T to 200°C and evap.
Add 25 mL DDW and filter thru Whatman 42 filter.
Bring vol. to 100 mL with DDW.
Analyze.

Plant Tissue Digestions (Typha, Lemna, Sedge, etc.)
Ref: 1991 DNR Wetland Treatment Report, Appendix 13

Sedge and grass leaves and lemna
Date: 1988-89
- oven dry 24 hrs. @ 80°C.
- dry ashed 2 hrs. at 550°C.
- add 2N HCl -- warmed, filtered and brought to vol.

AA analysis.

Typha
Date: 1987, 1989
- rinsed, sectioned into leaves, roots, rhizomes
- air dry
- oven dry 24 hrs. @ 80°C.
- ground in Wiley mill with 20 mesh screen.
- Ashed 2 hrs. At 550°C.

Digested with HNO_3
AA

Peat Processing Procedure - 2 Days (Spring 1997)

DAY ONE

1. Thaw baggies of frozen peat. Organize according to site and depth of sample.

2. Mix contents of baggie well and remove any sticks and/or rocks from sample.

3. Tare plastic weighing dish to zero using the analytical scale and measure out 10.000g (9.900-10.100) of peat. Pour this sample into a new baggie labeled with date, site, and actual weight.(ex. 5/23/97, S1-1, 10-20cm, 10.002g) Seal baggie, making sure to remove all air, and freeze. This sample will be used for sequential analysis.

4. Place 15g of peat in 50ml or 100ml beaker. Set aside for pH.

5. Label a metal tin and record weight to three decimal places. Place approximately 40g of wet peat into tin. Record actual weight of tin + wet peat. Set aside.

6. Repeat steps 1-5 for remaining samples. (You can usually complete approximately 35-45 samples a day.)

7. Place tins with wet peat in oven at 100C overnight.

8. pH: Add 15ml of distilled water to each beaker and stir with glass rod. Stir all beakers again at 15min and again at 30min. At 60min measure and record pH. To measure pH, tip beaker so that the peat solution is deep enough for the pH probe. Make sure to immerse probe completely in solution, but do not allow the probe to touch the bottom of the beaker.

DAY TWO

9. Remove tins with dry peat from oven and cool, measure and record dry weight of each tin, (tin + dry sample). Remove dry peat from tin using a spatula and place into small manilla envelope labeled with lab # only.

10. Blend peat sample in Oster blender for 15 seconds. Use brush to remove fine particles from side and lid of blender and place ground peat back into envelope. Clean blender, lid and brush with compressed air. Repeat for each sample.

11. Ashing: Place 1.00g of ground peat from envelope into preweighed/predried ashing crucible, record actual sample weight. Ash at 550C for one hour. Remove crucibles from muffle using tongs and place into dessicator, let cool one hour. Measure and record ash weight.

<u>Procedure for removing peat sample from the envelope</u>: Hold envelope so all the peat goes to one corner. Take the stainless steel spatula and obtain a representative sample by pushing the spatula to the bottom of the envelope and withdraw the sample. This way there should be some heavy and some light peat on the spatula. Weigh the empty white ashing dish and record its weight to 3 decimals.

Then tare the scale (Mettler) and gradually sprinkle the peat into the ashing dish until 0.500 or 1.000 g is added. Record actual weight. Note: Recording to 3 decimals gives ±2% error.

12. Place remaining dry blended peat from envelope into an 80 mesh SS sieve with collection pan underneath, seive with hands for approximately 15 seconds by tapping and rubbing.

13. Tare empty envelope, place -80 mesh peat from the collection pan into envelope weigh and record sample weight. This should give the -80 sample weight only.

14. Tare new envelope labeled with lab# and "+80". Place +80 mesh peat (that which did not go through mesh) into envelope, weigh and record. This should give the +80 sample weight only.

15. Clean mesh and pan with compressed air and repeat for each sample.

17. Send -80 mesh samples to Ag department for metals.

Calculations

Calculate % moisture and % ash;

$$\% \text{ moisture} = \frac{((\text{tin+wetpeat wt})-(\text{tin wt}))-((\text{tin+drypeat wt})-(\text{tin wt}))}{((\text{tin+wetpeat wt})-(\text{tin wt}))} \times 100$$

$$\% \text{ ash} = \frac{(\text{ash wt - crucible wt})}{(\text{preash wt - crucible wt})} \times 100$$

Table A4.2. Metal concentrations in peat samples collected from the DNR study cell W1D treatment system in March-April 1996.

Row	Site	Sample #	Peat depth (cm)			Metal concentration in peat (mg/kg)			
			Min	Max	Avg.	Cu	Ni	Co	Zn
1	1	10597	0	10	5	351.8	5325.9	52.6	180.8
1	1	10598	10	20	15	183.0	10145.2	105.4	206.8
1	1	10599	20	30	25	205.7	20683.2	181.1	254.9
1	2	10641	0	10	5	59.9	2995.8	10.9	127.8
1	2	10642	10	18	14	37.8	2329.6	16.9	67.7
1	2	10600	20	30	25	41.8	6720.1	28.9	130.6
1	3	10601	0	10	5	41.7	4296.5	35.7	95.3
1	3	10602	10	20	15	24.5	486.5	16.7	35.3
1	3	10603	20	30	25	68.6	3049.5	58.6	91.5
1	4	10643	0	10	5	17.8	298.8	6.7	22.6
1	4	10644	10	18	14	32.9	328.1	11.9	26.9
2	2	10649	0	10	5	107.8	2223.4	49.4	93.0
2	2	10650	10	20	15	20.9	2475.0	11.9	55.8
2	2	10610	20	30	25	31.6	597.5	16.8	46.4
2	3	10611	0	10	5	229.9	14585.8	153.3	212.0
2	3	10612	10	20	15	45.5	1272.0	18.8	50.4
2	3	10613	20	30	25	79.7	3451.9	51.8	86.7
2	4	10614	0	10	5	22.7	567.6	13.8	48.4
2	4	10615	10	20	15	24.8	331.6	12.9	32.8
2	4	10616	20	30	25	20.6	173.1	9.8	32.4

Table A4.2. Metal concentrations in peat samples collected from the DNR study cell W1D treatment system in March-April1996 (continued).

Row	Site	Sample #	Peat depth (cm)			Metal concentration in peat (mg/kg)			
			Min	Max	Avg.	Cu	Ni	Co	Zn
3	2	10651	0	10	5	18.8	68.4	7.9	23.8
3	2	10652	10	20	15	17.8	212.2	10.9	25.7
3	2	10623	20	25	22	113.5	321.6	18.9	39.8
3	3	10617	0	10	5	123.4	11422.7	80.9	167.8
3	3	10618	10	20	15	47.4	2631.0	29.6	60.3
3	3	10619	20	30	25	31.6	1723.6	21.7	42.5
3	4	10624	0	10	5	46.5	1694.0	30.7	75.3
3	4	10625	10	20	15	34.9	977.6	18.9	48.9
3	4	10626	20	30	25	55.8	530.6	15.9	43.8

Row	Site	Sample #	Peat depth (cm)			Metal concentration in peat (mg/kg)			
			Min	Max	Avg.	Cu	Ni	Co	Zn
4	1	10645	0	10	5	105.6	98.6	19.9	37.8
4	1	10639	13	20	16	29.8	254.0	10.9	27.9
4	1	10634	20	30	25	22.8	118.3	11.9	35.7
4	2	10646	0	10	5	20.9	973.3	22.9	76.7
4	2	10640	14	20	17	22.8	231.7	9.9	30.8
4	2	10635	20	30	25	27.9	65.8	12.9	32.9
4	3	10638	0	8	4	252.3	131.0	395.0	306.2
4	3	10604	0	10	5	20.8	187.4	11.9	39.6
4	3	10605	10	20	15	34.7	931.7	27.7	60.5
4	3	10606	20	30	25	18.8	62.6	7.9	38.7
4	4	10607	0	10	5	113.7	450.7	62.3	166.2
4	4	10608	10	20	15	45.5	607.9	14.8	51.4
4	5	10647	0	10	5	43.8	006.5	16.9	150.3
4	5	10648	10	23	16	73.9	975.5	17.7	49.3
4	5	10609	20	30	25	67.2	453.6	17.7	41.5

Table A4.3. Metal concentrations in peat samples collected from the DNR study cell of the W1D treatment system, April 1997.

Date	Site	Depth (cm) min	max	mean	#	pH	Cu	Ni	Co	Zn	Ash	Moisture
4 14 97	2	0	10	5	10793	6.31	68.6	2690	27.1	113.0	32.60	92.11
4 14 97	2	10	20	15	10794	6.73	28.7	382	5.0	53.0	56.78	80.97
4 14 97	2	20	30	25	10795	6.94	39.3	184	5.0	54.4	54.90	81.19
4 17 97	3	0	10	5	10792	7.03	156.6	4990	71.4	174.6	67.44	86.66
4 14 97	4	0	10	5	10796	6.53	263.8	10930	95.0	416.7	33.43	88.87
4 14 97	4	10	20	15	10797	6.47	147.3	5840	45.0	186.2	39.48	87.40
4 14 97	4	20	30	25	10798	6.66	73.7	2000	22.0	103.5	44.25	84.36
4 14 97	4	30	40	35	10799	6.82	92.6	1496	38.4	111.0	41.46	85.16
4 14 97	4	20	28	24	10800	6.61	43.8	915	8.0	67.2	54.75	80.85
4 11 97	5	0	10	5	10801	6.89	70.2	5845	46.5	139.4	48.17	80.87
4 11 97	5	10	20	15	10802	6.93	34.6	1402	23.9	57.7	66.37	79.30
4 11 97	5	20	30	25	10803	7.09	63.4	1429	44.5	68.9	45.99	84.02
4 11 97	5	30	40	35	10804	6.79	264.9	2240	185.3	156.7	54.27	81.79
4 11 97	7	0	10	5	10805	6.84	42.0	3010	17.6	86.1	39.34	87.51
4 11 97	7	10	20	15	10806	6.94	24.9	1095	5.0	59.8	57.92	82.91
4 11 97	7	20	30	25	10807	7.01	23.4	609	4.0	58.2	50.05	83.76
4 11 97	7	30	40	35	10808	7.13	22.0	488	4.0	49.2	61.58	82.45
4 11 97	7	40	58	49	10809	6.99	36.4	1187	19.1	63.7	53.98	82.72
4 11 97	10	0	10	5	10810	6.99	63.0	5680	30.4	115.6	51.72	85.18
4 11 97	10	10	20	15	10811	7.21	28.3	653	4.0	53.6	47.12	83.34
4 11 97	10	20	30	25	10812	6.95	35.0	520	5.0	60.0	60.76	82.85
4 11 97	12	0	10	5	10813	7.29	65.6	6090	30.2	113.4	62.58	77.65
4 11 97	12	10	20	15	10814	7.22	40.2	1747	8.0	68.0	50.50	81.50
4 11 97	12	20	30	25	10815	7.17	29.7	878	4.0	55.4	51.20	82.61

Table A4.3. Metal concentrations in peat samples collected from the DNR study cell of the W1D treatment system, April 1997 (continued).

Date	Site	Depth (cm) min	Depth (cm) max	Depth (cm) mean	#	pH	Cu	Ni	Co	Zn	Ash	Moisture
4 11 97	13	0	10	5	10816	7.00	30.6	391	4.0	48.2	47.84	82.72
4 11 97	13	10	20	15	10817	7.02	39.1	115	4.0	45.8	69.11	76.99
4 11 97	13	20	30	25	10818	6.89	46.9	92	4.0	54.8	66.76	74.84
4 11 97	13	30	40	35	10819	7.01	47.3	111	4.0	54.8	59.09	73.94
4 11 97	13	40	50	45	10820	7.10	38.7	82	4.0	51.7	63.86	73.38
4 11 97	13	50	60	55	10821	7.15	118.6	600	33.3	81.0	52.64	82.94
4 11 97	13	60	76	68	10822	7.35	154.8	508	40.1	86.4	54.14	85.37
4 11 97	14	0	10	5	10823	6.87	215.2	21010	142.4	373.6	53.42	85.06
4 11 97	14	10	20	15	10824	6.88	159.0	15230	96.4	238.7	43.56	88.21
4 11 97	14	20	30	25	10825	6.90	106.9	91	80.5	155.6	46.04	88.06

Table A4.4. 1997 peat samples collected from the Seep 1 pretreatment area.

Date	Site	Depth (cm) min	max	mean	#	pH	Cu	Ni	Co	Zn	Ash	Moisture
4 17 97	1	0	10	5	10828	6.38	1451.0	5151	327.0	643.0	55.01	82.05
4 17 97	1	10	20	15	10829	6.55	424.0	1196	73.1	192.0	58.31	79.58
4 17 97	1	20	30	25	10830	6.27	210.0	494	36.0	90.1	73.78	70.00
4 17 97	1	30	40	35	10831	6.49	219.0	248	17.0	59.0	83.80	63.91
4 17 97	1	40	50	45	10832	6.81	216.0	198	11.0	52.5	90.76	49.38
4 17 97	2	6	10	8	10833	6.82	633.0	938	72.7	178.0	77.61	72.52
4 17 97	2	10	20	15	10834	6.99	226.0	249	12.8	64.2	76.87	69.86
4 17 97	2	20	26	23	10835	7.10	220.0	192	9.5	53.9	84.62	55.75
4 17 97	3	0	10	5	10836	6.56	724.0	2159	149.0	260.0	77.79	68.80
4 17 97	3	10	20	15	10837	6.68	146.0	774	60.0	84.8	58.07	78.00
4 17 97	3	20	30	25	10838	6.70	96.0	221	23.2	54.0	69.19	67.73
4 17 97	3	30	40	35	10839	6.39	82.0	109	13.2	47.0	64.75	73.08
4 17 97	3	40	48	44	10840	6.39	305.0	256	40.2	77.5	84.29	59.04
4 14 97	4	0	10	5	10841	6.71	1334.0	1056	72.5	211.0	70.90	77.60
4 14 97	4	10	20	15	10842	6.81	106.0	93	10.5	44.0	64.59	73.86
4 14 97	4	20	30	25	10843	6.86	96.2	68	9.2	42.6	71.10	72.09
4 14 97	4	30	40	35	10844	6.68	155.0	113	29.7	46.3	80.87	67.31
5 1 97	7	0	10	5	10845	6.76	637.0	1427	97.0	180.0	74.02	74.41
5 1 97	7	10	20	15	10846	6.87	235.0	470	38.6	91.5	63.50	79.67
5 1 97	7	20	30	25	10847	6.99	198.0	224	23.0	58.6	65.49	77.27
5 1 97	7	30	40	35	10848	6.89	234.0	196	20.0	48.1	75.31	71.66
5 1 97	7	40	50	45	10849	6.67	247.0	179	23.5	85.4	78.99	66.13

Table A4.4. 1997 peat samples collected from the Seep 1 pretreatment area (continued).

Date	Site	Depth (cm) min	max	mean	#	pH	Cu	Ni	Co	Zn	Ash	Moisture
5 1 97	8	0	10	5	10850	6.91	730.0	3045	243.0	329.0	73.38	73.98
5 1 97	8	10	20	15	10851	6.97	172.0	256	28.4	60.7	66.54	75.28
5 1 97	8	20	30	25	10852	6.98	258.0	530	48.1	79.2	51.09	75.53
5 1 97	8	30	40	35	10853	7.07	105.0	682	65.2	38.9	59.68	73.81
4 14 97	10	0	10	5	10854	6.83	418.0	1850	111.0	277.0	70.61	76.31
4 14 97	10	10	20	15	10855	6.70	253.0	427	27.0	88.8	79.68	70.81
4 14 97	10	20	30	25	10856	6.79	234.0	291	21.2	64.7	79.30	62.59
4 14 97	11	0	10	5	10857	6.72	1256.0	3655	222.0	568.0	62.28	81.80
4 14 97	11	10	20	15	10858	6.78	127.0	369	22.0	63.2	62.87	75.53
4 14 97	11	20	30	25	10859	6.59	81.8	179	9.1	41.8	77.43	74.31
4 14 97	11	30	40	35	10860	6.35	97.5	135	16.7	44.1	69.69	73.94
4 14 97	12	0	10	5	10861	6.70	599.0	1775	122.0	325.0	59.26	81.69
4 14 97	12	10	20	15	10862	6.91	243.0	575	45.6	107.0	73.68	77.98
4 14 97	12	20	30	25	10863	6.88	138.0	238	18.1	55.4	63.92	75.14
4 14 97	12	30	40	35	10864	6.85	90.8	155	8.6	40.1	71.46	72.74
4 14 97	12	40	50	45	10865	6.66	124.0	145	10.1	35.8	75.93	67.27
4 14 97	13	0	10	5	10866	6.89	367.0	2067	122.0	337.0	66.87	80.56
4 14 97	13	10	20	15	10867	6.99	130.0	359	21.3	74.8	64.98	78.83
4 14 97	13	20	30	25	10868	6.91	96.1	254	14.3	62.9	60.62	75.71
4 14 97	13	30	40	35	10869	6.76	134.0	297	22.2	70.4	73.18	73.90

Table A4.4. 1997 peat samples collected from the Seep 1 pretreatment area (continued).

Date	Site	Depth (cm) min	Depth (cm) max	Depth (cm) mean	#	pH	Cu	Ni	Co	Zn	Ash	Moisture
4 14 97	14	0	10	5	10870	6.65	606.0	2980	155.0	444.0	80.71	72.55
4 17 97	15	0	10	5	10871	6.79	454.0	1617	102.0	294.0	78.84	69.87
4 17 97	15	10	20	15	10872	6.65	158.0	278	28.8	136.0	82.88	62.49

Note: pH values are standard units, metals are mg/kg (ppm).

Table A4.5 Total metal concentrations in substrate vertical down-flow section, April 1996.

Sample	Distance From Terminal Berm (m)	Depth of Sample (cm)	Substrate Type	Metal concentrations (μ g metal/gm dry substrate)			
				Ni	Co	Cu	Zn
Initial Material	NA_p	NA_p	Peat	5	2	5	7
S1-1	6	0-10	Peat	3667	325	1759	984
		10-20		4606	202	458	1461
S1-2	4	0-10	Hay	6510	995	6034	1626
		10-20		9998	1347	8392	2620
		20-30	Hay/Peat	11853	671	4573	2926
		30-40	Peat	8674	354	648	1727
S1-3	2	0-10	Hay	11451	1302	3448	3162
		10-15		14180	768.5	3917	3299
		15-40	Hay/Peat	10654	489	2471	1928

NA_p = Not applicable

Appendix 5

Flow, W1D

Note: This appendix contains information on how flow measurements and flow estimates were made, as well as information on OSS readings and LTV's rating equation. Average daily flow and total flow per month for both W1D and Seep 1 are included in the mass release tables in Appendix 7.

Section A5.1. Description of flow measurement and estimates.

Daily flow measurements are generally only available from May 1 to October 31. The type of water level recorders used by LTV (Stevens Model F) use a float system which does not work well under freezing conditions. In order to standardize data collection and to minimize equipment problems, LTV decided to install the recorders on or near May 1 and remove them around October 31.

Flow at the seep generally begins in late March or early April and can continue into November. Fall flow typically can be characterized by a linear decrease from the last flow measurement to zero at freeze-up.

Spring melt flows are much more difficult to estimate. Flow depends on the amount of moisture in the snow pack, temperature, and rainfall. Limited annual data existed for site EM8 (seepage from Stockpile 8011) in 1979 and 1980. Although these years may not represent "average" conditions, they provide a range of conditions. In 1979 the snow pack contained 4.39 inches of water, spring flow began around April 10, and peaked around the 20^{th} of April. Rainfall for the rest of the year was below normal and there were no major rain events during the year. For this year, spring melt accounted for 18% of the total annual flow.

In 1980, the snow pack contained only 2.74 inches of water and the spring flow was much less than in 1979. Large rain events (daily rainfall > 2 inches) in September and October produced a large amount of runoff, and for this year spring melt accounted for only 2% of the total flow.

<u>Calculation of annual average flow values</u>. LTV reports monthly flow values as part of their NPDES permit. During May to October, these are based on daily measurements obtained from water level recorders. During April, November, and December, the staff gage is read when samples are collected (about twice per month) and a monthly average is calculated based on the spot readings. Total annual flow is estimated by adding all the values reported by LTV in their NPDES report. No corrections have been made for spring or fall flow.

To calculate an average annual daily flow, it is assumed that all the reported monthly volumes are reasonable estimates of the flow and that there are 244 days of flow (April 1 - November 30).

There are several problems with the method:

1. While two staff readings in November may give a reasonable estimate of average flow, it is unlikely that two readings accurately estimates spring melt.

2. Flow measurements are estimated from a standard weir equation. No actual flow measurements are taken to verify the equation. It is not clear how often the gages are surveyed to ensure that there has not been any movement of the staff gage and/or the basin. In 1993, the DNR made flow measurements at the inlet and outlet of the original W1D wetland treatment system. There was about a 15% difference between measured values and values using LTV's standard equation.

3. The number of days of flow is not constant, but varies. In some years, there has been flow out of the wetland into December.

May to October is the more accurate flow data, while total annual flows are estimates. Based on data from small uncovered stockpiles at the AMAX exploration site near Babbitt (about two miles southwest of the Dunka Mine), flow for May through October accounted for 77% of the total annual flow.

To calculate an average flow for the May through October data, the total flow for each month reported on the NPDES forms were added and divided by the total number of days:

$$\text{Average daily flow (gal/min)} = \frac{\text{total flow (gal)}}{\text{244 days (1440 min/day)}}$$

Often flow data for April was not estimated on the NPDES forms.

Table A5.1. Annual precipitation and flow at W1D.

Year	Annual Precip.	May-Oct Precip	Annual volume (m^3)		Cumulative volume (m^3)	
			Input (051)	Output (052)	Input (051)	Output (052)
1992	26.90	17.30	35,602[a]	47,039	35,602	47,039
1993	29.64	17.43	32,306	40,760	66,111	67,600
1994	28.66	19.16	40,772	50,507	106,663	136,307
1995	25.60	18.49	31,320	56,941	156,479	195,249
1996	34.15	18.23	37,157	37,726	193,636	232,978
1997	22.91	15.46	11,673	16,724	205,510	249,702
1998	31.12	19.16	10,571	6,166	216,081	255,667
1999	35.17	28.80	28,327	32,434	244,409	288,301
Avg. Precip.[b]	28.57	20.84				

Note: These values include all flow measured and reported by LTV. The precipitation data are based on a composite of various data sources; see Table A11.1 for details.

In an average year there is ~ 244 days of flow (April 1 - November 30), then to convert from m^3/year to gpm, multiply entries by:

$$\frac{x \ m^3/\text{year} \times 10^3 \ L/m^3}{244 \ \text{days/year} \times 3.785 \ L/\text{gal} \times 1440 \ \text{min/day}} = 0.00076$$

[a]No flow reported for April, average flow based on May 1 - November 15.

[b]Based on 56 years of data from Babbitt (Watson, 1978).

Section A5.2. July 1999 staff gage readings and flow calculations for W1D.

The table on this page presents staff gage readings and flow calculations for W1D-051 for July 1999 (approximately 7 inches of rain fell during the July 4th weekend.) The chart on the next page (page A5.6) is the corresponding strip chart for this time period. (These data were not changed; the information is presented to chronicle peak flow during this period of high precipitation.)

LTV Mining Company- Dunka

Wetland Flow Monitoring

Month of July, 1999

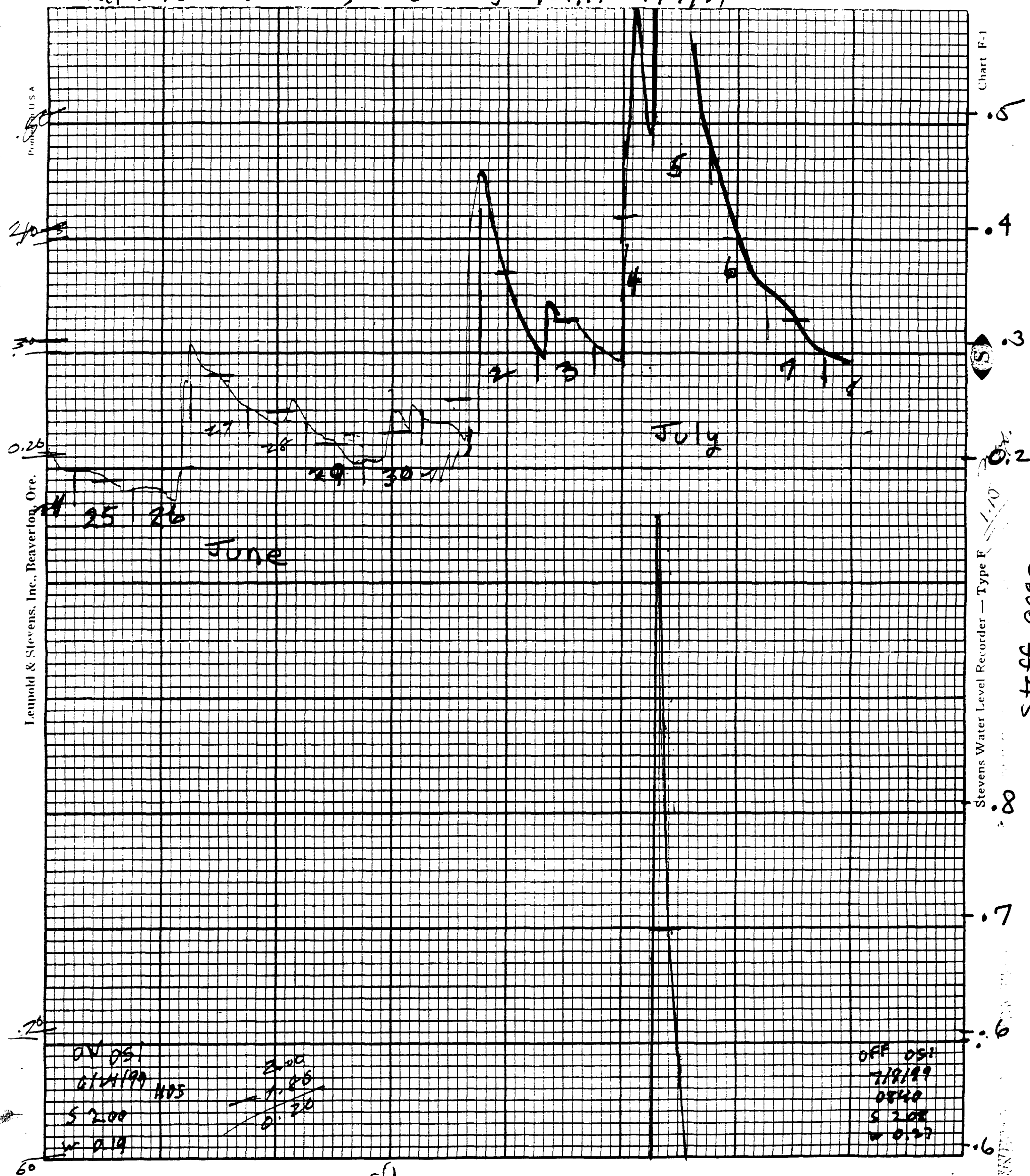
Location: 051 60 degree V-notch Weir

Date:	Head Feet	CFS	GPM	MGD
07/01/1999	0.25	0.0451	20.24	0.0291
07/02/1999	0.36	0.1122	50.36	0.0725
07/03/1999	0.33	0.0903	40.51	0.0583
07/04/1999	0.42	0.1650	74.04	0.1066
07/05/1999	0.79	0.8004	359.24	0.5173
07/06/1999	0.39	0.1371	61.51	0.0886
07/07/1999	0.32	0.0836	37.51	0.0540
07/08/1999	0.32	0.0836	37.51	0.0540
07/09/1999	0.35	0.1046	46.93	0.0676
07/10/1999	0.31	0.0772	34.65	0.0499
07/11/1999	0.27	0.0547	24.53	0.0353
07/12/1999	0.25	0.0451	20.24	0.0291
07/13/1999	0.29	0.0654	29.33	0.0422
07/14/1999	0.26	0.0497	22.32	0.0321
07/15/1999	0.26	0.0497	22.32	0.0321
07/16/1999	0.37	0.1202	53.93	0.0777
07/17/1999	0.28	0.0599	26.87	0.0387
07/18/1999	0.26	0.0497	22.32	0.0321
07/19/1999	0.25	0.0451	20.24	0.0291
07/20/1999	0.24	0.0407	18.27	0.0263
07/21/1999	0.23	0.0366	16.43	0.0237
07/22/1999	0.22	0.0328	14.70	0.0212
07/23/1999	0.26	0.0497	22.32	0.0321
07/24/1999	0.23	0.0366	16.43	0.0237
07/25/1999	0.23	0.0366	16.43	0.0237
07/26/1999	0.22	0.0328	14.70	0.0212
07/27/1999	0.22	0.0328	14.70	0.0212
07/28/1999	0.24	0.0407	18.27	0.0263
07/29/1999	0.22	0.0328	14.70	0.0212
07/30/1999	0.22	0.0328	14.70	0.0212
07/31/1999	0.21	0.0292	13.09	0.0188

6/24 ...

WID-051, 6/24/99 - 7/7/99

Water level vs time; WID-051; 6/24/99 - 7/7/99



1999

Section A5.3. W1D Flow corrections; September 30 and October 1, 1995; October 11-13, 1997.

LTV misread the strip charts for W1D-051 on September 30-October 1, 1995, and from October 11-13, 1997. The tables on this page present LTV's staff gage readings and flow calculations for the 1995 data, with the corresponding strip chart on the next page (page A5.8). LTV's data for October 11-13, 1997 are presented on page A5.9, with the corresponding strip chart presented on page A5.10.

Flow Worksheet For 051

ENTER NUMBER OF DAYS IN THE MONTH 30

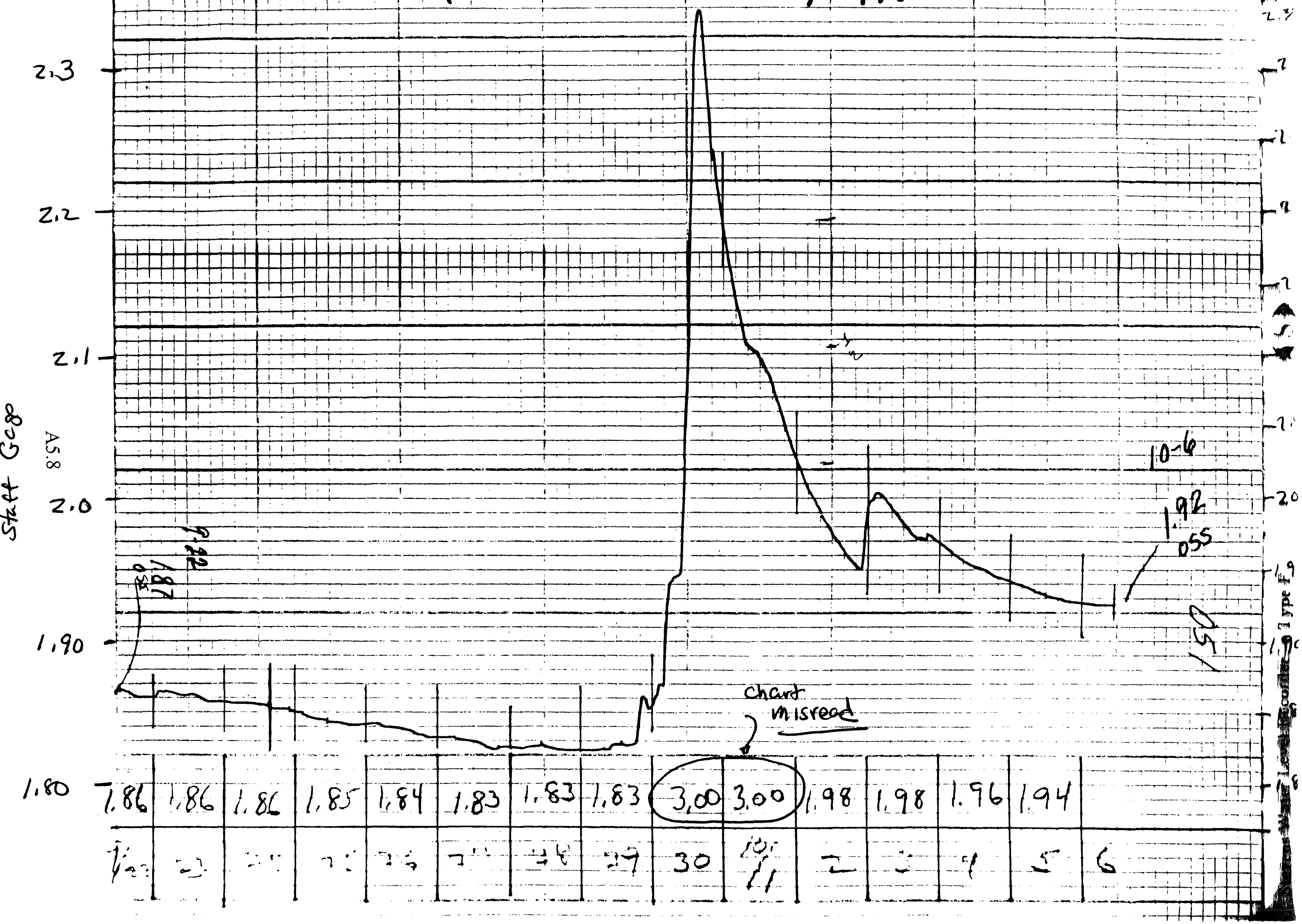
Date:	Height	GPM:	MGD:
Sept 1-5	1.89	40.43	0.058
2	1.87	34.58	0.050
3	1.89	40.43	0.058
4	1.9	43.56	0.063
5	1.87	34.58	0.050
6	1.94	57.53	0.083
7	1.99	78.36	0.113
8	1.91	46.84	0.067
9	1.89	40.43	0.058
10	1.88	37.44	0.054
11	1.87	34.58	0.050
12	1.87	34.58	0.050
13	1.87	34.58	0.050
14	1.87	34.58	0.050
Sept 15-5	1.89	40.43	0.058
16	1.92	50.25	0.072
17	1.88	37.44	0.054
18	1.87	34.58	0.050
19	1.88	37.44	0.054
20	1.87	34.58	0.050
21	1.87	34.58	0.050
22	1.86	31.86	0.046
23	1.86	31.86	0.046
24	1.86	31.86	0.046
25	1.85	29.27	0.042
26	1.84	26.81	0.039
27	1.83	24.48	0.035
28	1.83	24.48	0.035
29	1.83	24.48	0.035
Sept 30-5	3	1608.13	2.316

Flow Worksheet For 051

ENTER NUMBER OF DAYS IN THE MONTH 31

Date:	Height	GPM:	MGD:
Oct 1-5	2.1 3	1608.13	2.316
2	1.98	117 73.88	0.167 0.106
3	1.98	73.88	0.106
4	1.96	65.40	0.094
5	1.94	57.53	0.083
6	1.92	50.25	0.072
7	1.92	50.25	0.072
8	1.91	46.84	0.067
9	1.91	46.84	0.067
10	1.91	46.84	0.067
11	1.9	43.56	0.063
12	1.9	43.56	0.063
13	1.9	43.56	0.063
14	1.9	43.56	0.063
Oct 15-5	1.88	37.44	0.054
16	1.88	37.44	0.054
17	1.87	34.58	0.050
18	1.86	31.86	0.046
19	1.87	34.58	0.050
20	1.87	34.58	0.050
21	1.87	34.58	0.050
22	1.87	34.58	0.050
23	1.88	37.44	0.054
24	1.91	46.84	0.067
25	1.93	53.82	0.077
26	1.93	53.82	0.077
27	1.96	65.40	0.094
28	1.95	61.39	0.088
29	1.9	43.56	0.063
Oct 30-5	1.88	37.44	0.054
31	1.86	31.86	0.046

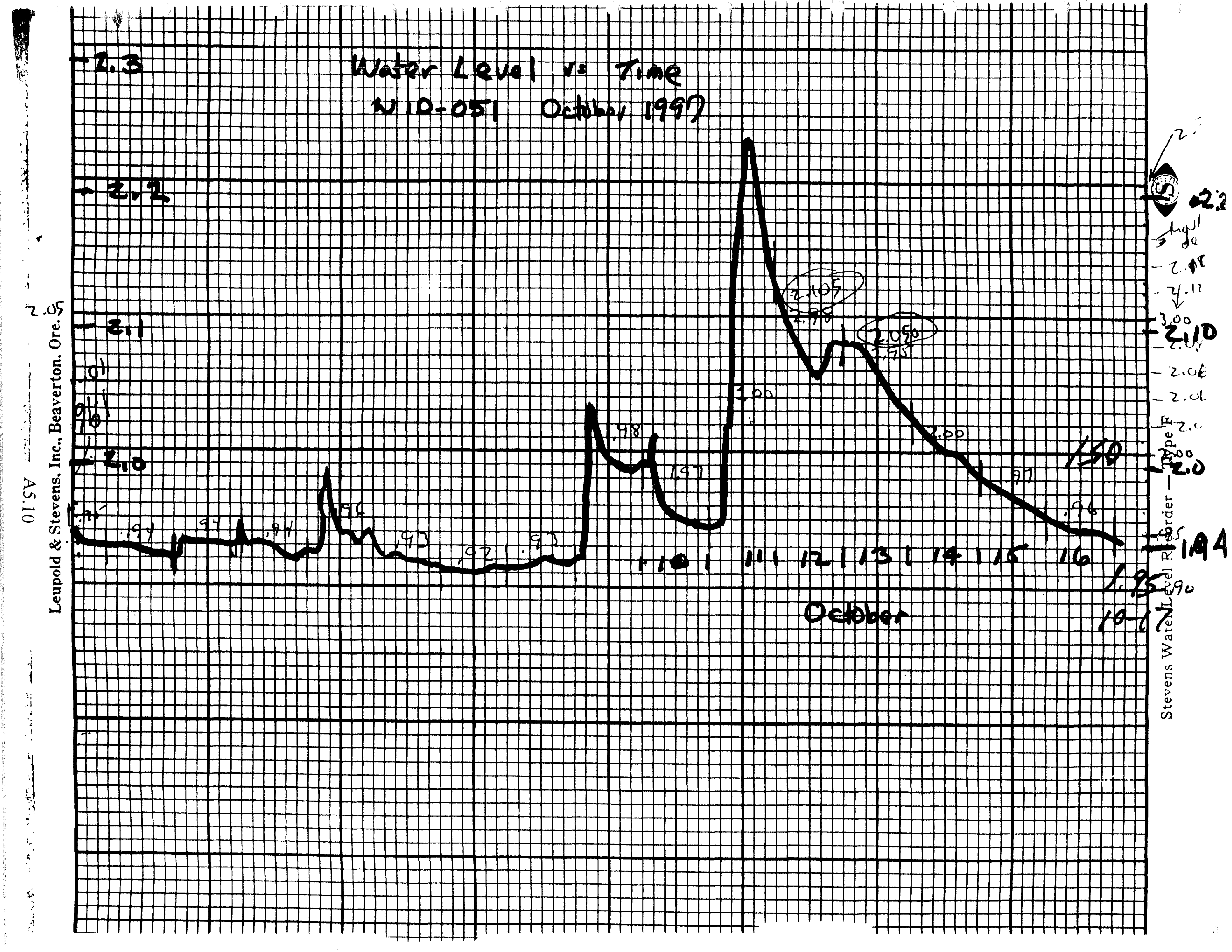
Water Level vs Time; W1D-051; [redacted]
September 22 - October 6, 1995



Flow Worksheet For 051 O=1.76

ENTER NUMBER OF DAYS IN THE MONT 31

Date:		Height	GPM:		MGD:
Oct 1, 1997		1.95	10.17		0.015
2		1.94	8.88		0.013
3		1.94	8.88		0.013
4		1.94	8.88		0.013
5		1.96	11.56		0.017
6		1.93	7.70		0.011
7		1.92	6.62		0.010
8	055	1.93	7.70		0.011
9	(Correct Values)	1.98	14.67	MGD	0.021
10		1.97	13.06	Ø	0.019
11	2.09	3	1106.55	0.041	1.593
12	2.105	2.98	1062.47	0.043	1.530
13	2.050	2.95	998.35	.032	1.438
14		2	18.24		0.026
Oct 15, 1997		1.97	13.06		0.019
16		1.96	11.56		0.017
17		1.95	10.17		0.015
18		1.95	10.17		0.015
19		1.94	8.88		0.013
20		1.93	7.70		0.011
21		1.92	6.62		0.010
22		1.92	6.62		0.010
23		1.92	6.62		0.010
24		1.91	5.63		0.008
25		1.9	4.74		0.007
26		1.9	4.74		0.007
27		1.9	4.74		0.007
28		1.9	4.74		0.007
29		1.9	4.74		0.007
Oct 30, 1997		1.9	4.74		0.007
31		1.9	4.74		0.007


Water Level vs Time
W10-051 October 1997
2.3
2.2
2.1
2.0
October
10
11
12
13
14
15
16
Leupold & Stevens, Inc., Beaverton, Ore.
Stevens Water Level Recorder — Type F
A5.10

Appendix 6

Timeline for 1997-1999 W1D and Seep 1 Monitoring Program

1997-99 DNR Monitoring program of the Seep 1 pretreatment and the W1D wetland treatment system

10/5/95
Survey of W1D to identify flow paths and water levels in study cell (see Appendix 9).

3/13/95 and 3/18/96
Collected peat samples in W1D study cell.

8/21/96
W1D: Walked berms 2 and 3. The flow paths appeared the same as last fall. Noted vegetation types.

Seep 1: Sampled pH, SC and total metals from seeps 2-9 except for #8.

10/29/96
W1D: Took SC and water (total nickel) samples at one location on berm 2 (42.0 m from west stake) and two locations on berm 3 (5.0 and 44.2 m from west stake).

4/11/97
W1D: Collected peat samples.

Seep 1: Peak snow melt runoff probably occurred 4/5-6. A cold snap started the evening of 4/6. Perched ice in the pretreatment system indicated water had risen to about 0.6 ft (ice on the staff gauge was at 2.70') below the overflow invert this past week. No perched ice was observed in the weir pool.

4/14/97
W1D: Collected peat samples. Downstream weir was washed out (bypassing about 30 gpm est).

Seep 1: Observed flow in the adjacent capping culvert. Collected peat samples. Observed flow in all the capping culverts (stockpile 8013) except culvert 4. The top of stockpile 8013 in the vicinity of culvert 4 has no snow. I saw some snow patches in the swales of stockpile 8014.

4/17/97
W1D: Collected a peat sample. The weir below the peat berms (middle weir) is still washed out.

Seep 1: Collected peat samples. Observed some flow in the capping culvert adjacent to seep 1. Observed 3-4 cm of precipitate in the vicinity of peat sample #1. The material was really fluffy and was layered. It was described from the surface downward as follows: brown layer (1mm), white cream color (1 cm), brown layer (1mm), white cream color (1 cm), brown layer (4mm), orange layer (2mm), brownish cream layer (5mm), orange layer (1mm), then black peat.

4/24/97

W1D: Took weir and drop pipe measurements only.

Seep 1: There still is some ice on the west and south perimeters. There was also some frost in the hay bales yet. Noted flow at seeps 2, 3, and 6-9. No water samples were collected. Collected peat samples from sites 16 and 17.

5/1/97

W1D: Routine water sampling. Site 2 (W1D-2) on berm 3 is a new site this year.

Seep 1: Seeps 2, 8, and 9 had flow (sampled). Routine water sampling. The system has no snow or ice remaining except a small amount of snow at the base of the stockpile. Collected peat samples at sites 7 and 8.

5/15/97

W1D: Routine sampling. The measured distances from the west rebar rod to sample points W1D-1, W1D-2, and W1D-3 are 41.9 m, 32.6 m, and 44.4 m, respectively.

Seep 1: Only seeps 2 and 9 had flow (sampled). Routine sampling.

5/29/97

W1D: Routine sampling.

Seep 1: Seeps 2, 3, and 9 had flow (sampled). Routine sampling. Lots of cattail growth. Noticed an orange, oil-like scum floating on the water surface in the vicinity of 043-1.

6/12/97

W1D: First stop was at the drop pipe. Both notches were obstructed with debris so we cleared it and allowed the water level to equalize. The west notch (left--facing upstream) was at .05 feet and the east notch (right) was at .07 feet. Samples were taken at W1D-1 and W1D-2; a sample was taken just upstream of the planck at W1D-3 because there was no water flowing over the planck. The flow at W1D-1 was estimated to be 5 gpm with a water depth on the planck of .05 feet. The flow at W1D-2 was minimal, and the crack between the plancks was almost clogged. The weir oss was at 4.17 feet with a water depth (weir notch) of 0.07 feet. No debris obstructed the weir, and the flow was gauged at 0.5 liters per 6 seconds.

Seep 1: Last stop of the day was at seep 1. The weir oss was at 1.44 feet with a water depth of 0.12 feet. No debris obstructed the weir, and the flow was gauged at 0.5 liters per 2 seconds. The weir oss is on the downstream side of the black bag of peat with a head drop across the bag of 0.13 feet. In the pretreatment pond, the OSS was 1.50 feet. The distance to the water from the right (east) and left notches of the drop pipe were 2.14 and 2.15 feet, respectively, and 2.92 feet to the top of the pipe. Samples were taken at 043-1 thru 043-8 and at the weir upstream of the black bag. Flow estimates at the seeps were as follows: Seep 2 1 gpm, seep 3 0.3 gpm, seep 4 damp, seep 5 trickle, seep 6 trickle 100-500 ml/min., seep 7 slightly more than seep 6, seep 8 damp, seep 9 1 gpm. Seep 7 had rusty rocks at the edge of water. Noticed a white/blue/green ppt in the outer pool. Noticed underwater "streams" between seeps 4 and 5 with a partly eroded channel with a brown ppt on top and a white ppt underneath. Noticed evidence of other underwater flow 2 meters east of seep 4 and at the peninsula by seep 3. Each flow appears to emerge at the base (about 1 ft under water) of the rip rap supporting the outer slope. Noted aquatic insects throughout the treatment site.

<u>6/30/97</u>
W1D: The weather on this day was extremely humid with a temp. of 75 - 80 degrees and overcast sky. The drop pipe at W1D was blocked with debris so I cleaned it out and took samples at W1D-1, W1D-2, W1D-3 while it equalized. The flow at W1D-1 was approx. 10-15 gpm with a depth of water on the planck of 1 inch. W1D-2 had a flow of approx. 5 gpm and a depth of water on the plank of 0.02 inches. W1D-3 had a flow of less than 1 gpm and no water flowing over the planck. All samples were taken up stream of the sampling points. The cattails in the wetland were in full bloom. When I would bump against them, I noticed that they would discharge large amounts of yellow pollen into the air. The depth of water had greatly increased from 6/12/97 because of the increase in precipitation events during the two-week period. After I allowed the flow to equalize in the drop pipe, I took measurements of the depth of water flowing over the notch. The west notch (left) was at 0.12 feet and the east notch (right) was at 0.15 feet. Next I stopped at the weir between the treatment wetlands and discharge to the stream. The weir oss was at 4.28 feet, and the depth of water flowing over the weir was .19 feet. The weir was level and in good working order. There was no debris obstructing the flow over the weir, which indicates that the flow was high enough to keep it open. I gauged the flow coming out of the weir using a 15-liter bucket and a stop watch. The flow was 10.3 liters per 11.55 seconds.

Seep 1: At 1220 I arrived at seep 1 with the weather changing to light showers. The weir oss was at 1.48 feet with a depth of water flowing over the weir of 0.16 feet. I gauged the flow coming over the weir to be 500 ml/1.5 seconds. Seep 1 oss was at 1.6 feet, and it appeared to be level and in good working order. I sampled pool spls 043-1 through 043-8 and seeps 2 and 3. I also estimated the flow coming from the seeps around the treatment site as follows: Seep 2 5 - 7 gpm, seep 3 less than 1 gpm, seep 4 less than 1 gpm, seep 5 less than 1 gpm, seep 6 was wet, seep 7 less than 1 gpm, seep 8 less than 1 gpm, seep 9 was dry. The water level in the treatment cell was much higher than it was in the previous sampling event. The cattails were not as far along in blooming as they were at W1D treatment site. Only a few of the cattails were blooming and not as much pollen as at W1D. I observed an increase in aquatic insects and amphibians. I did not observe the submerged "streams" by seeps 4 and 5 as I did on 6/12/97.

<u>7/14/97</u>
W1D: The weather was 70 degrees with cloudy skies and the possibility of thunder storms. I sampled Wld-1, W1D-2, and W1D-3 and estimated the flow at W1D-1 to be 1-2 gpm There was no water flowing over the planck at W1D-2 and W1D-3. The drop pipe at W1D was .05 feet at

the west (left) notch and .07 at the east (right) notch. The water level at W1D was considerably lower than during the past weeks. The cattails were approximately 6 feet tall, and the reproductive portion of the cattail was close to maturity. The weir oss was at 4.18 feet with a flow gauged at 500 ml/4.84 seconds. The weir was not obstructed and had a depth of water on it of .08 feet.

Seep 1: Seep 1 was the last stop I made at Dunka. I sampled pool samples 043-1 through 043-8 plus weir before black bag. The weir oss was at 1.45 feet and had a depth of water on it of 0.12 feet. The seep 1 oss was at 1.60 feet. Seeps 2 and 7 were the only seeps that had enough flow to sample. I estimated the flow at seep 2 to be 1-2 gpm and seep 7 to be less than 1 gpm

7/24/97
W1D: Routine sampling. The reproductive portion of the cattails were mature with a long narrow part on top of the structure. There was a slight trickle coming over the weir.

Seep 1: The water at the weir/before the black bag smelled organic (slight hydrogen sulfide smell). After the weir, the water was building up and becoming stagnate. The flow going through the weir was stopping in the pipe, and a weak eddy was forming. The outer part of the horseshoe had an organic film on top of the water. The precipitate was lightest on the outer portion of the horseshoe with it getting increasingly darker as one progresses through to the effluent. That could indicate increased decay at end of treatment. I was able to use the flow trough to gauge accurately the flows at the seeps. I sampled seeps 2, 3, and 7. There was a stream of "dry" ppt. coming from the ground at seep 2 and between seeps 2 and 3, but smaller than the first.

7/28/97
Seep 1: Eger and Knuckey conduct a pH and SC survey in the pretreatment pond. Collected total metals samples at new sites.

8/7/97
W1D: Recorded flow measurements for the first time this summer at the upstream weir (historical LTV weir). Flow was gauged at 35 liters/minute. The water level has increased considerably since last sampling period. Vegetation has also increased. Weir—no flow going over the weir, only slightly damp. Flow appears to be bypassing the weir on the right as seepage due to the porous material used in construction. I observed an increase in frogs at the weir.

Seep 1: The water is backing up at the downstream side of the weir. It could be that the drain pipe going under the road is plugged. At 043-4 there is a trail of rust leading back to the limestone berm. Used the flow trough to gauge the flow at the seeps. Sampled seeps 2 through 7.

8/21/97

W1D: Routine sampling of W1D and Seep 1. LTV weir—flow was gauged at 104 liters/minute. W1D—water level was much higher than in past sampling periods. The water was flowing over the planck at all the sampling sites.

Seep 1: There was no head drop at the weir so the water was still backing up. No smell of hydrogen sulfide. The inner horseshoe had approximately 0.5 feet of water over the limestone berm. The outer most horseshoe had approximately 0.2 feet over the limestone berm. I observed an increase in amphibians and aquatic insects. The water level in the pretreatment area was the highest that it had been all season. I sampled seeps 2 through 8 and used the flow trough to gauge the flow of the seeps.

9/4/97

W1D: LTV weir—flow was gauged at 22 liters/minute. W1D—water has decreased substantially since last sampling period. The cattails were starting to turn light brown, and some were starting to seed (seeds were blowing off in the wind). Weir--some water is seeping through the berm at the toe on the right side facing the road. There was no channelized flow, but I estimated the flow lost to the leak to be 150 milliliters/minute.

Seep 1: The water was not backing up at the weir as in the past few months. No smell of hydrogen sulfide, possibly because of the decrease in water levels. Was not able to use flow trough to gauge flow because there was no flow at the end of the seeps. All the water was infiltrating into soil before it could reach the treatment cell, but I was able to sample seeps 2 and 3. Conducted a specific conductivity and pH survey of Seep 1 using a peristaltic pump to pull samples. I collected the sample in a lab bottle and did S.C. and pH on-site. I was not able to finish survey because of time constraints, and it was very difficult to obtain sample. It would be better if I had an extra person to help conduct survey using this method.

9/17/97

W1D: LTV weir—flow was gauged at 36 liters/minute. W1D—no change since last sampling period. Weir—still having bypassing problems at weir.

Seep 1: Flow was backing up at the weir again. I sampled seeps 2 and 7; all other seeps not able to sample because lack of water. I estimated the flow at the seeps because I forgot the flow trough although flow was very low, and I probably could not have used it. Was not able to conduct S.C. profile of Seep 1. Next sampling period I will bring a pipe to mount the S.C. probe so I don't have to wade in the water. This method proved to be a disaster because the water in the seep is about 4 feet deep.

10/1/97

W1D: LTV weir—flow was gauged at 60 liters/minute. W1D—cattails are mostly brown with slight green left. Some heads on the cattails were missing indicating seeding has begun. Water has come up since last sample period. Weir—could not get graduated cylinder all the way under the flow from the weir, so I measured only about 80% of the flow.

Seep 1: Water is over 043-8 berm. Cattails are mostly brown with some green left. PPT has not changed significantly since the start of fall. There was no head drop across the weir. Water was backing up at the weir, and the water depth in the outlet pond is the highest I have seen it this year. Treatment system across the road is also high—high oss does not mean high flow. Conducted S.C. survey at seep 1.

10/14/97

W1D: LTV weir—the flow was gauged at 102 liter/minute. W1D—there was an organic smell throughout the treatment cell. The cattails are completely dead and seeding is occurring. Weir—the flow was gauged at 240 liters/minute, the highest this year.

*Seep 1:*Water level is very high, but seeps are not flowing; this could be because of the high precipitation events last weekend. On the average there were 8 inches of water on the limestone berm throughout the treatment area. The cattails are dead but not as far along as W1D; they were not seeding yet. Pumped ppt into bucket for a wet analysis. Finished SC survey of points I missed last sampling period.

3/17/98

W1D: G. Melchert and M. Lubotina collected peat samples with a Macaulay sampler from the W1D vertical flow peat bed (pretreatment).

4/30/98

W1D: Measured flow of historical and middle weirs, drop pipe, and W1D(1-3).

Seep 1: Measured flow of S-1 weir, pond weir, and collected weir-B and 043-6 samples. Only Seep 2 and Seep 9 were flowing.

5/8/98

8013: installed culvert ring, tripod, and battery. Slope of culvert = 0.09'/2' (1st full segment), 0.10'/2' (2nd full segment in).

8018: installed culvert band in South culvert. Slope=0.10'/2'. Water in culvert but no flow. North culvert had flow, water coming from the soil approximately 1 Lpm.

W1D: usual flow measurements, Historical weir Ni=1.4mg/L (HACH kit). Middle weir was clogged with a clump of algae, did not wait to stabilize.

5/29/98

8013: Melchert started CR500 data logger approximately 1330. Starflow not hooked up yet.

W1D: usual flow measurements Ni for W1D-1 was 0.67mg/L (HACH).

Seep 1: usual flow measurements, samples collected 043 wier before and 043-6. Seeps 2-5, and Seep 9 were flowing.

6/10/98

Seep 1: usual flow measurements, collected samples at 043-WB and 043-6. Removed metal pole from pipe near 043-6. Seeps 2, 4, 5 & 9 were flowing.

W1D: usual flow measurements, Ni sample @ W1D-1 = 0.61 mg/l (HACH).

6/24/98

W1D: usual flow meas., Ni sample @ W1D-1 = 0.66 mg/l. Water is up but not much compared to last weeks rain. Cattails over 6' tall and have seed heads.

Seep 1: usual flow meas., 043-6 & 043- WB samples collected, strong sulphur smell. All of Seeps 2 - 9 (except S7) had some flow.

7/10/98

Seep 1: usual flow measurements, collected samples at 043-WB and 043-6. Seeps 2 - 9 (except S4 & 8) had some flow.

W1D: usual flow measurements, drop pipe clogged by cattails, water may be flowing around middle weir when flow is high.

7/21/98

W1D: usual measurements for flow.

Seep 1: usual measurements for flow. Seeps 2-9 all some flow except S 8 & S 9. Water in pond unusually clear, sulphur smell is gone.

<u>8/4/98</u>
W1D: usual measurements for flow (dead fish odor at drop pipe). Samples collected @ W1D-1 & 3, wetland very dry, samples collected at puddles within 1 m of sampling sites. Standing water in wetland below middle weir.

Seep 1: Unable to measure flow due to blocked culvert (11.5 cm deep), flow seems to be circular, berms that are not supposed to be covered with water are covered. 043-6 and 043-WB samples collected. Seeps 4, 5 & 6 are flowing.

<u>8/19/98</u>
W1D: usual measurements for flow, and water samples.

Seep 1: usual measurements for flow.

<u>9/3/98</u>
P. Eger, G. Melchert, and M.Crozier visited wetland cells at treatment plant. GM downloaded flow data from 8018 and 8013. Visited pre-treatment area (of W1D), measured specific conductance, Ni and water level

<u>9/4/98</u>
Ni sampling at W1D pre-treatment area. Ni ranged from 0 - 1.63 mg/L

<u>9/16/98</u>
W1D: usual measurements for flow, and water samples at W1D-1, W1D-2, and W1D-3

Seep 1: wier pipe clogged, minuscule new flow <0.3cm headdrop across weir
Piezometers installed

<u>9/29/98</u>
W1D: usual measurements for flow (clogged exit point middle weir, seep still moving through on right), samples at W1D-1, W1D-2, and W1D-3

Seep 1: weir backed up again
Piezometers sampled

<u>10/15/98</u>
W1D: usual measurements for flow, samples at W1D-1 W1D-, and W1D-3.

Seep 1: weir backed up a little, water samples, seeps dry
Piezometers sampled

10/20/98
Big rain last Friday
W1D: usual measurements for flow, samples at W1D-1, W1D-2, and W1D-3. Pre-treatment samples

Seep 1: weir is very backed up, < 1cm drop at weir, seeps flowing

11/3/98
Frost and ice covered ponds.

W1D: usual measurements for flow, samples at W1D-1, W1D-2, and W1D-3.

Seep 1: routine flow measurements water level has come down, ice thick enough to stand on Piezometers depth measured but not sampled

1999
4/2/99
G. Melchert and A. Johnson spring site visit.
8013 capping: culvert flowing, approximately 0.07 feet ± 0.02, uncovered rain gage tripped once @ 1200. Ground saturated with water, frost just starting to come out of the ground.
8018 capping: Solar panel face down on ground, culvert 0.06 feet water flowing through

Seep 1: usual measurements for flow, ice in way of normal 043-WB site so sampled just before weir. Seep 1-2 flowing about 100mls/min.

W1D: usual measurements for flow, samples at W1D-1, W1D-2, and W1D-3, middle weir some flow around right side, historical weir 2 to 3 inch hole under weir flowing around steel part of weir.

4/27/99
8018 capping: no flow in culvert, computer battery died so unable to donwload flow data, unmeasurable water in culvert.
8013 capping: rain gage empty, downloaded rain data at 1057

Seep 1: read staff gages, sampled 043-6 and 043-WB.

W1D: sampled historical weir.

5/7/99
8018 capping: unmeasurable flow in culvert, reprogrammed flow datalogger with 8018Dec8.scm program at 1234.
8013 capping: download of rain gage data at 1416, flow datalogger not responding to computer program so no information of flow data through the culvert, some water in ridges of the culvert.

5/14/99

8018 capping: little bit of water in gullies of culvert

Seep 1: read staff gages, water level lower, algae and plants growing near weir, sampled 043-6 and 043-WB, seeps in order of flow seep1-2,7,5,6,8.

W1D: historical weir had green algae all over, had to clear out prior to measuring flow depth, algae in wetland and cattail seeds made it difficult to get clean samples for W1D-1, W1D-2 and W1D-3 difficult.

6/15/99

light rain

8018 capping: downloaded flow data at 1410, little bit of water in culvert ridges with green slime.

8013: culvert dry, still unable to get flow datalogger to respond to computer, downloaded rain data at 1500.

Seep 1: routine recording of flow an collection of water samples, water over limestone berms.

W1D: routine flow data and water measurements W1D-1, W1D-2 and W1D-3

7/7/99

Heavy rainstorm on 4th of July.

8018 capping: computer not working no flow data downloaded, little bit of water in culvert ridges.

8013: culvert dry, some debree over grate so flow must have been fast and/or high, still unable to get datalogger to respond to computer, downloaded rain data at 1443.

Seep 1:routine flow measurements and water samples, pond very full, overflow pipe (pond side) partially in the water but not overflowing at this time, horsetail grown up around the boardwalk to the weir, sampled seeps

W1D: routine flow measurements, good flow over boardwalk at sampling sites in wetland.

7/13/99

thunderstorms in AM

8018 capping: download of flow data at 1438, slight flow into culvert from right side

7/28/99

rain earlier in week

8018 capping: download of flow data at 1148, slight flow into culvert from right side

8013 capping: download of rain gage data 1212

Seep 1:routine sampling of flow data and water samples, water level down in pond and precipitate and decaying plants.

W1D: routine flow measurements.

<u>8/6/99</u>
8018 capping: download of flow data at 1408, no flow into culvert
8013 capping: download of rain gage data 1430, removed flow meter from culvert for repairs

Seep 1:routine flow measurements and water samples.

W1D: routine flow measurements, and water samples in wetland

<u>8/20/99</u>
Seep 1:routine flow measurements and water samples

W1D: routine flow measurements

<u>9/10/99</u>
Seep 1:routine flow measurements and water samples

W1D: routine flow measurements, and water samples in wetland

<u>9/23/99</u>
8018 capping: download of flow data at 0850, no flow into culvert
8013 capping: download of rain gage data

Seep 1:routine flow measurements and water samples

W1D: routine flow measurements, and water samples in wetland

<u>10/8/99</u>
Seep 1:routine flow measurements and water samples.
W1D: routine flow measurements

<u>10/28/99</u>
8018 capping: download of flow data at 1024, no flow into culvert
8013 capping: download of rain gage data, emptied rain gage and covered with plastic for the winter.

Seep 1:routine flow measurements

W1D: routine flow measurements

<u>11/16/99</u>
8018 capping: downloaded flow data before winter

Appendix 7

Mass removal calculations

Attachment A7.1. Methods used to estimate mass removal in the W1D wetland, using input/output flow and concentration data.

Nickel and sulfate mass removal was calculated for the W1D wetland treatment system using flow and water quality data from the historical input to the system (W1D-051) and from the outfall of the system (W1D-052).

An extension to the system was added in 1995, and the outfall from the extension area is now called W1D-050, which is the same named used for the original outfall (now called W1D-052) before the extension was added. This report focuses solely on the original portion of the system, so sites W1D-051 and W1D-052 are the relevant sites.

Flow at this site is recorded by level recorders (Stephens Type F), which record the staff gage reading at each weir, and which operate continuously once they are installed. The data from the strip chart is broken down into 24-hour increments, and then an estimate is made of the average flow for each time period. (These estimates appear to be based on visual approximations of the charts.) These daily values are then converted into flow values via a standard weir equation, and the total flow for the month is determined by totaling these daily values. The value LTV reports in their NPDES reports are these total monthly values divided by the number of days in the month.

For accurate flow measurements, elevation measurements of the staff gage and v-notch should be taken every year after ice out. If the staff gage has shifted it should be reset or corrections should be made. Flow measurements should be made and a rating curve developed which relates staff readings to flow.

LTV does not take any flow measurements, and it is unclear how often elevation measurements are made. In 1993 a comparison of actual flow measurements with LTV'standard weir equation indicated that there was about a 15% difference between measured and estimated flow.

The level recorders typically don't get installed until late April or early May, and are typically removed at the end of October, after freezing conditions resume. The flow values reported for April, November and December are generally the result of two or three visual observations made of the staff gage at the time that water quality samples are collected, and are therefore much more prone to error than data from the level recorders. However, since there is generally little flow or precipitation in November and December, an average value based on spot readings provides a reasonable estimate of average flow.

A more imporant question is how much flow goes unrecorded in the spring, prior to micrologger installation. When the snowpack in the W1D watershed melts (typically in April), there is usually a spike in flow through both monitoring sites (051 and 052). If the visual staff gage observations in the spring happen to coincide with this spike, the flow reported as the average flow for that month may be too high, since it assumes this 'spike' condition persists for two weeks (until the next observation is made). And if this flow spike occurs when no one is there to observe it, the flow reported as average flow for that month will be too low, and could be significantly higher.

In the W1D system, however, input (i.e. W1D-051) concentrations have historically been low in the spring (approximately 1 mg/L before watershed manipulations began at W1D), and increased dramatically in June and July, to about 7-10 mg/L in July. The fact that most of the potentially unrecorded flow at this site occurs at the time of year when input nickel concentrations are low means that the unreported nickel mass is probably minor in comparison to the summer mass load.

(The possibility exists that nickel concentrations in the first melt water may be somewhat elevated, since it may rinse off some of the oxidation products that occur in the sulfide-bearing waste rock stockpiles in the W1D watershed. In general, however, nickel concentrations have been at their lowest in April, leading to the assumption that this rinse-off nickel load is probably low.)

There were also two time periods when the flow data reported for a particular month seemed too high in relation to the corresponding precipitation and to the data from the other weir:

> 1. September 30 and October 1, 1995. The flow values reported for W1D-051 were too high because the strip chart was misread. The staff gage values for both days was reported as 3.00, while the correct value for both days was approximately 2.1. This means that the reported value of 2.316 mgd (for both days) was actually 0.164 mgd, dropping the total flow for September from 14,647 to 6,586 m^3, and dropping the total October flow from 16427 to 8213 m^3. This in turn dropped the annual total for 1995 from 56,941 m^3 to 31,319 m^3.
>
> (The corresponding values for 052 were also high for these two days, but those values appear to accurately reflect flow that resulted from precipitation during that time period, and are not the result of a misread chart.)
>
> 2. October 11-13, 1997. Reported values were 2.98 and 2.95, corresponding to flow rates of 1.593, 1.530 and 1.438 mgd, respectively. It appears that the correct values are 2.09, 2.105 and 2.050, which correspond to 0.041, 0.043 and 0.034, respectively. This changed the total monthly flow from 4902 m^3 to 1756 m^3, and the annual total from 15,019 to 11,874 m^3.

Using these adjusted flow values, the total input and output mass load to the system was calculated. The average monthly flows were multiplied by the average monthly concentration, using all available concentration data. (For the spring and fall periods, when a value was reported for that month, flow was assumed to have occurred for the entire month.) While the flow data generally reflect daily values, however, the water quality data used in these mass calculations consist primarily of two grab samples collected each month, meaning that concentration increases and decreases may not have been reflected in the monthly averages. Table A7.1 and A7.2 summarize overall mass removal for the original W1D treatment system. Table A7.3 compares annual flow and mass estimates with values calculated for May to October (the period of accurate flow data).

Table A7.1. Nickel input, output and mass removal in the W1D wetland treatment system, 1992-99.

Date	Volume (m^3) In	Volume (m^3) Out	[Ni], mg/L In	[Ni], mg/L Out	Input mass (kg) Month	Input mass (kg) Annual	Input mass (kg) Cum.	Output mass (kg) Month	Output mass (kg) Annual	Output mass (kg) Cum.	Removed (kg)	Cum. Rem. (kg)
may 92	5162.7	6922.7	2.850	0.306	14.714	14.714	14.714	2.118	2.118	2.118	12.595	12.595
june 92	4996.2	6585.9	5.180	0.289	25.880	40.594	40.594	1.903	4.022	4.022	23.977	36.572
july 92	6101.4	8096.1	5.750	0.323	35.083	75.677	75.677	2.615	6.637	6.637	32.468	69.041
aug 92	5045.4	6805.4	3.560	0.113	17.962	93.639	93.639	0.769	7.406	7.406	17.193	86.233
sept 92	7494.3	9992.4	4.150	0.454	31.101	124.740	124.740	4.537	11.942	11.942	26.565	112.798
oct 92	4458.7	5984.0	5.450	0.464	24.300	149.040	149.040	2.777	14.719	14.719	21.523	134.321
nov 92	1135.5	1362.6	3.600	0.525	4.088	153.128	153.128	0.715	15.434	15.434	3.372	137.694
dec 92	1408.0	1290.6	3.750	0.370	5.280	158.408	158.408	0.478	15.912	15.912	4.803	142.496
may 93	1642.6	8448.1	0.901	0.121	1.480	1.480	159.888	1.022	1.022	16.934	0.458	142.954
jun 93	2611.6	3292.9	1.496	0.063	3.907	5.387	163.795	0.207	1.230	17.142	3.700	146.654
jul 93	9386.8	14432.2	5.278	0.626	49.544	54.931	213.339	9.035	10.264	26.176	40.509	187.163
aug 93	7157.4	5162.7	5.975	0.563	42.766	97.697	256.105	2.907	13.171	29.083	39.859	227.022
sep 93	4655.5	5109.7	6.550	0.830	30.494	128.190	286.598	4.241	17.412	33.324	26.253	253.275
oct 93	3285.3	2933.3	5.550	0.780	18.234	146.424	304.832	2.288	19.700	35.612	15.946	269.220
nov 93	2043.9	794.8	4.900	0.800	10.015	156.439	314.847	0.636	20.336	36.248	9.379	278.600
dec 93	1525.3	586.6	3.550	0.380	5.415	161.854	320.262	0.223	20.559	36.471	5.192	283.792
may 94	2933.3	4106.7	1.175	0.165	3.447	3.447	323.709	0.678	0.677	37.148	2.769	286.561
jun 94	10219.5	13626.0	3.014	0.280	30.802	34.249	354.511	3.815	4.493	40.964	26.986	313.547
jul 94	8096.1	9738.8	6.250	0.154	50.601	84.849	405.111	1.500	5.992	42.463	49.101	362.648
aug 94	5632.0	4576.0	5.517	0.113	31.072	115.922	436.184	0.517	6.509	42.980	30.555	393.203
sep 94	6131.7	9992.4	5.100	0.375	31.272	147.193	467.455	3.747	10.257	46.728	27.525	420.728
oct 94	2933.3	3989.3	5.668	0.743	16.626	163.820	484.082	2.964	13.221	49.692	13.662	434.390
nov 94	3065.8	2952.3	5.750	1.288	17.629	181.448	501.710	3.803	17.023	53.494	13.826	448.216
dec 94	1760.0	1525.3	5.250	1.550	9.240	190.688	510.950	2.364	19.388	55.859	6.876	455.092
apr 95	794.8	2157.4	1.550	0.670	1.232	1.232	512.182	1.445	1.445	57.304	-0.213	454.878
may 95	586.6	7626.7	1.200	0.190	0.704	1.936	512.886	1.449	2.894	58.753	-0.745	454.133
jun 95	113.5	6699.4	1.400	0.130	0.159	2.095	513.045	0.871	3.765	59.624	-0.712	453.421
jul 95	4928.0	6570.7	1.800	0.525	8.871	10.966	521.916	3.450	7.215	63.074	5.421	458.842
aug 95	6453.4	6218.7	2.150	0.135	13.875	24.841	535.791	0.840	8.054	63.913	13.035	471.878
sep 95	6586.0	8629.8	2.200	0.345	14.489	39.330	550.280	2.977	11.031	66.890	11.512	483.389
oct 95	8213.0	15722.8	2.950	0.800	24.228	63.558	574.508	12.578	23.610	79.469	11.650	495.039
nov 95	3292.9	2611.6	3.450	0.800	11.361	74.918	585.868	2.089	25.699	81.558	9.271	504.310
dec 95	352.0	704.0	2.350	0.800	0.827	75.746	586.696	0.563	26.262	82.121	0.264	504.574

Table A7.1. Nickel input, output and mass removal in the W1D wetland treatment system, 1992-99 (continued).

Date	Volume (m^3) In	Volume (m^3) Out	$[SO_4]$, mg/L In	$[SO_4]$, mg/L Out	Input mass (kg) Month	Input mass (kg) Annual	Input mass (kg) Cum.	Output mass (kg) Month	Output mass (kg) Annual	Output mass (kg) Cum.	Removed (kg)	Cum. Rem. (kg)
apr 96	12036.3	13739.5	0.853	0.599	10.267	10.267	596.963	8.230	8.230	90.351	2.037	506.611
may 96	2698.7	2698.7	0.873	0.594	2.356	12.623	599.319	1.603	9.833	91.954	0.753	507.364
jun 96	3747.1	1135.5	1.195	0.372	4.478	17.100	603.796	0.422	10.256	92.377	4.055	511.420
jul 96	5045.4	5162.7	0.918	0.272	4.632	21.732	608.428	1.404	11.660	93.781	3.227	514.647
aug 96	3637.3	3050.7	0.505	0.138	1.837	23.569	610.265	0.421	12.081	94.202	1.416	516.063
sep 96	3065.8	2838.7	0.922	0.073	2.827	26.396	613.092	0.207	12.288	94.409	2.619	518.682
oct 96	3520.0	7626.7	1.478	0.253	5.203	31.598	618.294	1.930	14.218	96.339	3.273	521.955
nov 96	3406.5	1476.1	1.377	0.670	4.691	36.289	622.985	0.989	15.207	97.328	3.702	525.657
apr 97	2611.6	6245.2	0.787	0.468	2.055	2.055	625.040	2.923	2.923	100.251	-0.867	524.790
may 97	1408.0	2112.0	0.663	0.260	0.934	2.989	625.974	0.549	3.472	100.800	0.384	525.174
jun 97	1703.2	2157.4	0.685	0.090	1.167	4.156	627.141	0.194	3.666	100.994	0.973	526.147
jul 97	821.3	352.0	0.728	0.109	0.598	4.754	627.739	0.038	3.704	101.032	0.560	526.706
aug 97	1290.6	704.0	0.422	0.067	0.545	5.298	628.283	0.047	3.751	101.079	0.498	527.204
sep 97	794.8	113.5	0.330	0.058	0.262	5.561	628.546	0.007	3.758	101.086	0.256	527.460
oct 97	1756.2	3050.7	0.476	0.190	0.836	6.397	629.382	0.580	4.338	101.666	0.256	527.716
nov 97	1135.5	1930.3	0.953	0.248	1.082	7.479	630.464	0.479	4.816	102.144	0.603	528.319
dec 97	352.0	58.6	0.808	0.050	0.284	7.763	630.748	0.003	4.819	102.147	0.281	528.601
may 98	1290.6	1290.6	0.503	0.158	0.649	0.649	631.397	0.204	0.204	102.351	0.445	529.046
jun 98	1135.5	908.4	0.386	0.057	0.438	1.088	631.836	0.052	0.256	102.403	0.387	529.433
jul 98	938.6	117.3	0.462	0.024	0.434	1.521	632.269	0.003	0.259	102.406	0.431	529.863
aug 98	1290.6	352.0	0.398	0.009	0.514	2.035	632.783	0.003	0.262	102.409	0.511	530.374
sep 98	1249.0	227.1	0.190	0.017	0.237	2.272	633.020	0.004	0.266	102.413	0.233	530.607
oct 98	2581.3	2464.0	0.432	0.143	1.115	3.387	634.135	0.352	0.618	102.765	0.763	531.370
nov 98	794.8	454.2	0.622	0.066	0.494	3.882	634.630	0.030	0.648	102.795	0.464	531.835
dec 98	1290.6	352.0	0.682	0.050	0.880	4.762	635.510	0.018	0.666	102.813	0.863	532.697
may 99	1760.0	4106.7	0.419	0.115	0.737	0.738	636.248	0.472	0.472	103.285	0.265	532.962
jun 99	1589.7	2384.5	0.303	0.140	0.482	1.219	636.729	0.334	0.806	103.619	0.148	533.110
jul 99	6570.7	12554.8	0.255	0.208	1.676	2.895	638.405	2.611	3.417	106.230	-0.936	532.174
aug 99	2346.7	1760.0	0.162	0.093	0.380	3.275	638.785	0.164	3.581	106.394	0.216	532.391
sep 99	4882.6	5791.0	0.347	0.061	1.694	4.969	640.479	0.353	3.934	106.747	1.341	533.732
oct 99	4458.7	3754.7	1.455	0.145	6.487	11.457	646.967	0.544	4.479	107.292	5.943	539.675
nov 99	2611.6	908.4	1.470	0.128	3.839	15.296	650.806	0.116	4.595	107.408	3.723	543.398
dec 99	4106.7	1173.3	0.063	.	0.259	15.555	651.065	.	.	.	.	.

Note: The original flow data for Sept and Oct 1995 (for 0510 were mis-read from the strip charts. The data in this table include the corrected data.

Table A7.2. Sulfate input, output and mass removal in the W1D wetland treatment system, 1992-99.

Date	Volume (m^3) In	Volume (m^3) Out	[SO_4], mg/L In	[SO_4], mg/L Out	Input mass (kg) Month	Input mass (kg) Annual	Input mass (kg) Cum.	Output mass (kg) Month	Output mass (kg) Annual	Output mass (kg) Cum.	Removed (kg)	Cum. Rem. (kg)
may 92	5162.7	6922.765	1649	1027	8513.3	8513.3	8513.3	7109.6	7109.6	7109.6	1403.6	1403.6
june 92	4996.2	6585.900	2691	1769	13444.7	21958.1	21958.1	11650.4	18760.1	18760.1	1794.3	3197.9
july 92	6101.4	8096.115	2536	1772	15473.2	37431.3	37431.3	14346.3	33106.4	33106.4	1126.8	4324.8
aug 92	5045.4	6805.430	2923	2234	14747.7	52179.0	52179.0	15203.3	48309.7	48309.7	0.0	4324.8
sept 92	7494.3	9992.400	2927	2593	21935.8	74114.8	74114.8	25910.2	74220.0	74220.0	0.0	4324.8
oct 92	4458.7	5984.085	2600	2380	11592.6	85707.5	85707.5	14242.1	88462.1	88462.1	0.0	4324.8
nov 92	1135.5	1362.600	2536	2246	2879.6	88587.1	88587.1	3060.4	91522.5	91522.5	0.0	4324.8
dec 92	1408.0	1290.685	2236	1414	3148.3	91735.5	91735.5	1825.0	93347.6	93347.6	1323.3	5648.1
may 93	1642.6	8448.120	931	911	1529.3	1529.3	93264.8	7696.2	7696.2	101043.8	0.0	5648.1
jun 93	2611.6	3292.950	1305	771	3408.2	4937.5	96673.0	2538.8	10235.1	103582.7	869.3	6517.5
jul 93	9386.8	14432.205	2094	1367	19655.9	24593.5	116329.0	19728.8	29963.9	123311.5	0.0	6517.5
aug 93	7157.4	5162.740	2069	1803	14808.7	39402.2	131137.7	9308.4	39272.3	132619.9	5500.3	12017.8
sep 93	4655.5	5109.750	2809	1987	13077.4	52479.6	144215.2	10153.0	49425.4	142773.0	2924.3	14942.2
oct 93	3285.3	2933.375	2637	2093	8663.5	61143.2	152878.7	6139.5	55564.9	148912.6	2523.9	17466.1
nov 93	2043.9	794.850	2727	2118	5573.7	66716.9	158452.4	1683.4	57248.4	150596.0	3890.2	21356.4
dec 93	1525.3	586.675	2451	2088	3738.6	70455.5	162191.1	1224.9	58473.4	151821.0	2513.6	23870.0
may 94	2933.3	4106.725	1093	620	3206.1	3206.1	165397.2	2546.1	2546.1	154367.2	660.0	24530.0
jun 94	10219.5	13626.000	1994	1155	20377.6	23583.8	185774.9	15738.0	18284.1	170105.2	4639.6	29169.7
jul 94	8096.1	9738.805	2641	1702	21381.8	44965.7	207156.8	16575.4	34859.6	186680.7	4806.3	33976.1
aug 94	5632.0	4576.065	2440	1814	13742.2	58707.9	220899.0	8300.9	43160.6	194981.6	5441.2	39417.4
sep 94	6131.7	9992.400	2351	1860	14415.6	73123.6	235314.7	18585.8	61746.4	213567.5	0.0	39417.4
oct 94	2933.3	3989.390	2282	1764	6693.9	79817.5	242008.6	7037.2	68783.7	220604.8	0.0	39417.4
nov 94	3065.8	2952.300	2515	1704	7710.6	87528.1	249719.2	5030.7	73814.4	225635.5	2679.8	42097.3
dec 94	1760.0	1525.355	2196	2154	3865.0	91393.1	253584.3	3285.6	77100.1	228921.1	579.4	42676.7
apr 95	794.8	2157.450	697	766	554.0	554.0	254138.3	1652.6	1652.6	230573.7	0.0	42676.7
may 95	586.6	7626.775	1297	1248	760.9	1314.9	254899.2	9518.2	11170.8	240092.0	0.0	42676.7
jun 95	113.5	6699.450	1448	1017	164.4	1479.3	255063.6	6813.3	17984.1	246905.3	0.0	42676.7
jul 95	4928.0	6570.760	1716	1125	8456.5	9935.9	263520.2	7392.1	25376.2	254297.4	1064.4	43741.1
aug 95	6453.4	6218.755	2046	1601	13203.7	23139.6	276723.9	9956.2	35332.4	264253.6	3247.4	46988.6
sep 95	6586.0	8629.800	2031	1395	13376.0	36515.6	306473.9	12038.5	47371.0	276292.2	1337.4	48326.1
oct 95	8213.0	15722.890	2193	884	18011.0	54526.6	342498.1	13899.0	61270.1	290191.2	4111.9	52438.0
nov 95	3292.9	2611.650	2193	884	7221.4	61748.0	349719.5	2308.6	63578.7	292499.9	4912.7	57350.8
dec 95	352.0	704.010	2193	884	771.9	62520.0	350491.4	622.3	64201.1	293122.3	149.6	57500.4

Table A7.2. Sulfate input, output and mass removal in the W1D wetland treatment system, 1992-99 (continued).

Date	Volume (m^3) In	Volume (m^3) Out	[SO_4], mg/L In	[SO_4], mg/L Out	Input mass (kg) Month	Input mass (kg) Annual	Input mass (kg) Cum.	Output mass (kg) Month	Output mass (kg) Annual	Output mass (kg) Cum.	Removed (kg)	Cum. Rem. (kg)
apr 96	12036.3	13739.550	809	679	9737.3	9737.3	360228.8	9329.1	9329.1	302451.4	408.2	57908.6
may 96	2698.7	2698.705	1100	1597	2968.5	12705.9	363197.4	4309.8	13638.9	306761.3	0.0	57908.6
jun 96	3747.1	1135.500	1525	1340	5714.4	18420.3	368911.8	1521.5	15160.5	308282.8	4192.8	62101.4
jul 96	5045.4	5162.740	1450	1073	7315.8	25736.1	376227.6	5539.6	20700.1	313822.4	1776.2	63877.6
aug 96	3637.3	3050.710	1940	1460	7056.5	32792.7	383284.2	4454.0	25154.2	318276.5	2602.4	66480.1
sep 96	3065.8	2838.750	1837	1535	5631.9	38424.6	388916.1	4357.4	29511.6	322634.0	1274.4	67754.6
oct 96	3520.0	7626.775	1780	1540	6265.6	44690.3	395181.8	11745.2	41256.9	334379.2	0.0	67754.6
nov 96	3406.5	1476.150	1161	1035	3954.9	48645.3	399136.8	1527.8	42784.7	335907.0	2427.1	70181.7
apr 97	2611.6	6245.250	785	595	2050.1	2050.1	401186.9	3715.9	3715.9	339622.9	0.0	70181.7
may 97	1408.0	2112.030	892	783	1255.9	3306.0	402442.9	1653.7	5369.6	341276.7	0.0	70181.7
jun 97	1703.2	2157.450	1067	758	1817.3	5123.4	404260.2	1635.3	7004.9	342912.0	182.0	70363.8
jul 97	821.3	352.005	1060	760	870.6	5994.0	405130.9	267.5	7272.5	343179.5	603.1	70966.9
aug 97	1290.6	704.010	1075	780	1387.4	7381.5	406518.3	549.1	7821.6	343728.7	838.3	71805.2
sep 97	794.8	113.550	1145	946	910.1	8291.6	407428.4	107.4	7929.0	343836.1	802.6	72607.9
oct 97	1756.2	3050.710	1060	933	1861.6	10153.2	409290.1	2846.3	10775.3	346682.4	0.0	72607.9
nov 97	1135.5	1930.350	973	781	1104.8	11258.1	410394.9	1507.6	12282.9	348190.0	0.0	72607.9
dec 97	352.0	58.668	993	769	349.5	11607.6	410744.4	45.1	12328.0	348235.1	304.4	72912.3
may 98	1290.6	1290.685	794	751	1024.8	1024.8	411769.2	969.3	969.3	349204.4	55.4	72967.8
jun 98	1135.5	908.400	1050	737	1192.2	2217.0	412961.5	669.4	1638.7	349873.9	522.7	73490.6
jul 98	938.6	117.335	1082	808	1015.6	3232.7	413977.2	94.8	1733.6	349968.7	920.8	74411.5
aug 98	1290.6	352.005	1065	574	1374.5	4607.3	415351.7	202.0	1935.6	350170.8	1172.5	75584.0
sep 98	1249.0	227.100	1135	937	1417.6	6024.9	416769.4	212.7	2148.4	350383.6	1204.8	76788.9
oct 98	2581.3	2464.035	859	841	2217.3	8242.3	418986.8	2072.2	4220.6	352455.8	145.1	76934.0
nov 98	794.8	454.200	1175	1055	933.9	9176.3	419920.8	479.1	4699.8	352935.0	454.7	77388.8
dec 98	1290.6	352.005	979	1016	1263.5	10439.9	421184.3	357.6	5057.5	353292.6	905.9	78294.7
may 99	1760.0	4106.725	936	710	1647.3	1647.3	422831.7	2915.7	2915.7	356208.4	0.0	78294.7
jun 99	1589.7	2384.550	1115	765	1772.5	3419.8	424604.2	1824.1	4739.9	358032.6	0.0	78294.7
jul 99	6570.7	12554.845	1043	629	6853.3	10273.2	431457.5	7896.9	12636.9	365929.6	0.0	78294.7
aug 99	2346.7	1760.025	1465	857	3437.9	13711.1	434895.5	1508.3	14145.2	367437.9	1929.5	80224.3
sep 99	4882.6	5791.050	1440	890	7031.0	20742.1	441926.5	5154.0	19299.3	372592.0	1876.9	82101.3
oct 99	4458.7	3754.720	1140	760	5082.9	25825.0	447009.4	2853.5	22152.9	375445.5	2229.3	84330.6
nov 99	2611.6	908.400	1450	1080	3786.8	29611.9	450796.3	981.0	23133.9	376426.6	2805.8	87136.5

Note: The original flow data for Sept and Oct 1995 (for 0510 were mis-read from the strip charts. The data in this table include the corrected data.

Table A7.3. Comparison of May-October flow and mass vs. annual estimates, W1D, 1992-1999.

Year	Precipitation (in)			Input Flow (10^3 L)			Output Flow (10^3 L)			Input Nickel Mass (kg)			Output Nickel Mass (kg)		
	May-Oct	Annual	% Diff.	May-Oct	Annual	% Diff.	May-Oct	Annual	% Diff.	May-Oct	Annual	% Diff.	May-Oct	Annual	% Diff.
1992	17.3	26.9	35.7	33,258	35,802	7.1	44,386	47,039	5.6	134.3	158.4	15.2	14.7	15.9	7.5
1993	17.4	29.7	41.4	28,739	32,308	11.0	39,379	40,760	3.4	146.4	161.9	9.6	19.7	20.6	4.4
1994	19.2	28.7	33.1	35,946	40,772	11.8	46,029	50,507	8.9	163.8	190.7	14.1	13.2	19.4	31.9
1995	18.5	25.6	27.7	26,881	31,320	17.4	51,468	56,941	9.6	63.6	75.7	16.0	22.2	26.3	15.6
1996	18.2	34.2	46.8	21,714	37,157	41.5	22,513	37,728	40.3	21.3	36.3	41.3	6.0	15.2	60.5
1997	15.5	22.9	32.3	7,775	11,873	34.5	8,490	16,724	49.2	4.3	7.8	44.9	1.4	4.8	70.8
1998	19.2	31.1	38.3	8,485	10,571	19.7	5,359	6,165	13.1	3.4	4.8	29.2	0.6	0.7	14.3
1999	28.8	35.2	18.2	21,608	28,326	23.7	30,351	32,433	6.4	11.5	15.6	26.3	4.4	4.7	6.4
Ave. 92-99	20.8	28.6	34.2	23,051	28,516	20.8	28,497	36,037	17.0	68.6	81.4	24.6	10.3	13.4	26.4

* Flow at W1D is monitored with level recorders that, due to freezing conditions, are typically installed in early May and removed by early November. The "annual" columns include any data reported for the spring (i.e. before May) and fall (i.e. after October), which are generally based on visual observations of staff gage levels made when personnel are collecting the (usually twice monthly) water quality samples, with the assumption that flow occurred for the entire month at the reported flow rate.

Attachment A7.2. Methods used to estimate mass removal in the DNR study cell of the W1D wetland.

Section A7.2.1 Using input/output flow and concentration data.

The W1D system was started in 1992. The original outfall was called W1D-050, but when the extension to the system was put on-line in July 1995, the name of the original outfall was changed from 050 to 052. The site now referred to as 050 is the outfall from the expansion area.

An estimate of nickel removal was made using average monthly flow and nickel concentrations in the input (051) and output (052). The flow values reflect the average of the daily values, while the water quality samples usually reflect two grab samples that were collected each month. Table A7.2 summarizes the nickel mass removal calculations made from the water quality/quantity data.

As depicted in Figure A7.1, 526 kg of nickel was calculated to have been removed in the entire system (not including the extension) from the start of the system in 1992 until the completion of the 1996 season. Profiles water quality samples were collected from 1992 through 1994 in the original system, when samples were collected simultaneously throughout the system. After excluding any data prior to July (since input nickel concentrations were typically low prior to July), the portion of the system focused on in this report was found to be responsible for 25.8% of the overall removal by the system.

$$526 \text{ kg} \times 0.258 = 135.7 \text{ kg nickel}$$

Section A7.2.2 Multiplying the peat mass in the cell by the mean nickel concentration in each peat layer.

The second method used to calculate nickel removal in the DNR study cell was to multiply the mass of peat present in the cell by the average nickel concentration of all samples (in each peat layer).

<u>Area</u> Planimeter measurements of the DNR stucy cell indicated an area of approximately 15,000 square feet. (This value is for the entire segment, and didn't exclude the dry peninsula that exists on the west side of the segment.)

The computer model (Tech Base) used to estimate the nickel mass in the peat came up with a similar number (16,000 square feet). But it appears that because the computer model didn't extrapolate past the final data points on the west side, Tech Base may have underestimated the actual area. Some of this excluded area is the dry peninsula on the north side of the section, but some should probably have been included. But for these mass calculations we assume there are 16,000 square feet.

$16000 \text{ ft}^2 = 1487 \text{ m}^2$ $1487 \text{ m}^2 \times 0.1 \text{ m}$ (in each 10 cm segment of the peat) $= 148.7 \text{ m}^3$

Figure A7.1. Nickel mass input, output and removal in the original W1D wetland treatment system.

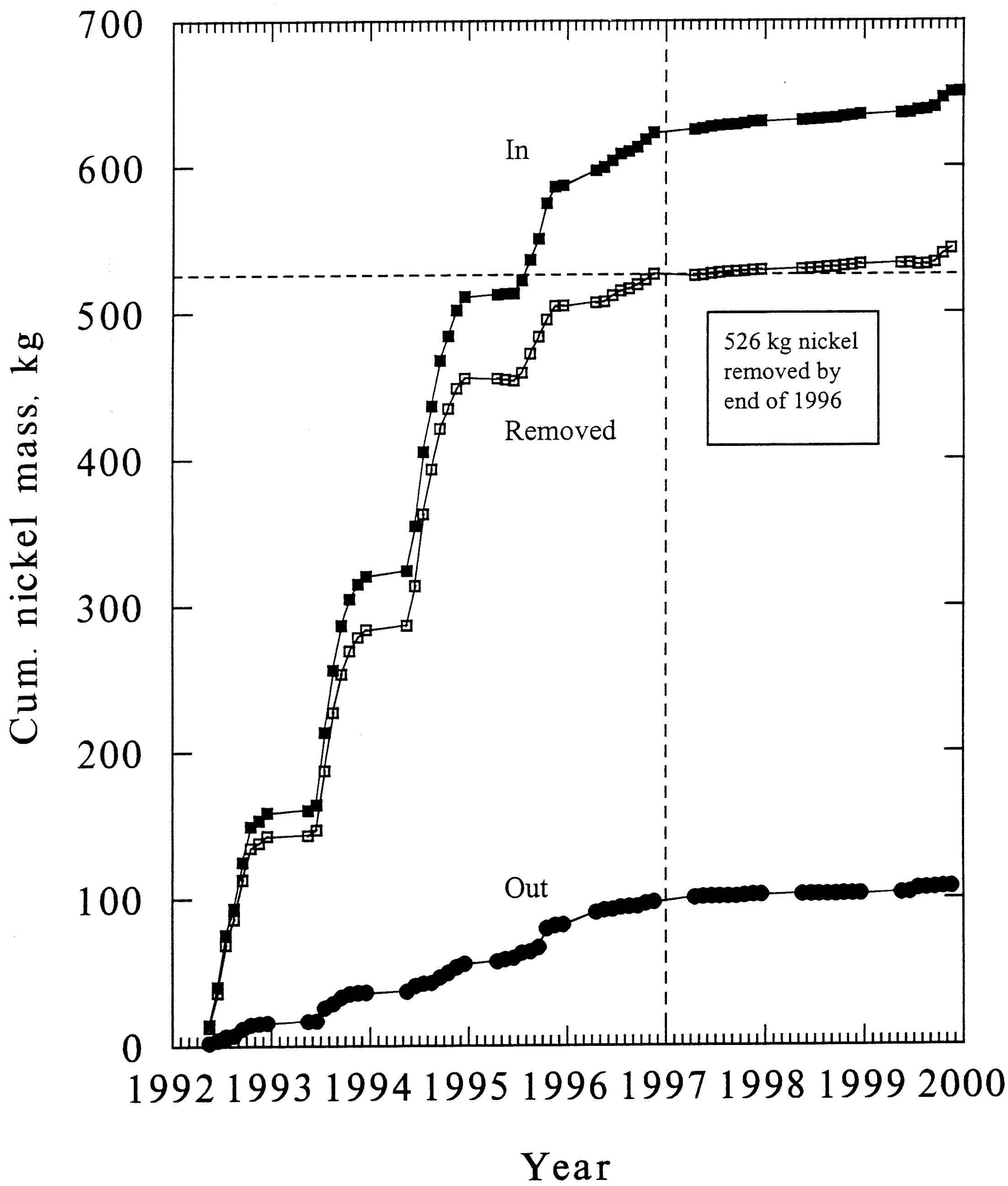


Table A7.4. Mass removal estimates for the DNR study cell of the original W1D system.

Calculation method	Peat layer	Nickel mass (kg)
(A) Combining input/output flow and nickel concentration data.	---	135.7
(B) Peat mass x mean nickel concentration of each layer	0 - 10 cm	65.0
	10 - 20 cm	33.7
	20 - 30 cm	27.7
	Total:	126.4
(C) Peat mass x concentration (as determined by Tech Base)	0 - 10 cm	71.5
	10 - 20 cm	27.1
	20 - 30 cm	13.9
	Total:	112.5
(D) Average (This includes methods A and B for the individual layers, and methods A, B and C for the total values)	0 - 10 cm	68.2
	10 - 20 cm	30.4
	20 - 30 cm	20.8
	Total:	124.9

(A) Based on the results of profiles studies carried out within the W1D wetland from 1992 through 1994, it was determined that 25.8% of the overall removal within the system occurs in this single segment. The overall removal value for 1992-1996 (526 kg) was multiplied by 0.258 to yield 135.7 kg of nickel removed in the study segment.

(B) The average nickel concentration of each peat layer (0-10, 10-20 and 20-30 cm) was multiplied by the mass of dry peat assumed to be present in each 10-cm layer (13100 kg). This was based on an area of 1310 m^2 (14,098 ft^2), which was the value used in the Tech Base model (method 3), and on the assumption that the wet peat was 90% water. All available 1996 and 1997 peat data was used to calculate the means (4959 mg/kg in 0-10 cm layer, 2571 mg/kg in 10-20 cm layer, and 2112 mg/klg in 20-30 cm layer). These estimates exclude the dry peninsula area (i.e. removal is assumed to be zero in the peninsula). A few miscellaneous peat samples had unusual peat lengths (i.e. 0 - 8 cm instead of the usual 0-10 cm length), and these were grouped together with the standard core segments prior to calculating the means for each layer.

(C) Dan Steinbrink of the MDNR used a software program used Tech Base to calculate concentration contours within the W1D study segment, and then to calculate nickel mass in each layers based on these contours. These estimates also exclude peninsula area.

(D) Overall results from all three methods were used to calculate average value of 1218.5.

Density The peat was assumed to be 90% water, so there are 100 kg of dry peat for every cubic meter of peat. 148.7 m^3 x 100 = 14870 kg of dry peat.

Average nickel concentrations The mean nickel concentration of the 0-10 cm segments of the 1997 peat samples was 6740mg/kg, or 6.74 g/kg (see appendix 4 for data about metals in peat). The nickel mass in this layer would be 100.2 kg. The mean nickel concentration of the 20-30 cm segment was 3310 mg/kg, or 49.2 kg. The mean nickel in the 0-30 layer was 910, or 13.5 kg. The total for these three segments, which the pilot study at W2d/3D had shown to be responsible for the vast majority of nickel removal via adsorption in the peat, is 162.9 kg nickel.

Section A7.2.3 Tech Base calculations, which are based on concentration contour lines.

The third method used to estimate nickel mass present in the DNR study cell was a software program called Tech Base, which calculates concentration contour lines, and then uses those contour lines to calculate the mass of nickel present in each contour interval (Appedix 4).

The wetland was divided into 20 ft by 20 ft grid and the model determined an average concentration for each cell (Ni mg/gm).

To convert into mass, a bulk density of 0.1 g dry peat/cm^3 was assumed.

The area of each cell is 20 ft x 20 ft and the sampling interval is 10 cm (.328 ft) so the volume of a cell is

$$20 \text{ ft} \times 20 \text{ ft} \times 0.328 \text{ ft} = 131.2 \text{ ft}^3$$

The mass of metal in grams in each cell is

$$\frac{2.83 \text{ kg dry peat}}{\text{ft}^3 \text{ of wetland}} \times 132.2 \text{ ft}^3 \text{ wetland} \times \frac{\text{mg metal}}{\text{kg dry peat}} \times \frac{1}{1000 \text{ mg/yr}}$$

Tech Base calculated that a total of 112.5 kg of nickel is present in the top 30 cm of the peat in the study cell (Table A7.2). This is low in comparison to the 146.5 kg estimate arrived at via the input/output data, and to the 126.4 kg value arrived at if you simply multiply the peat mass by the average metal concentrations. But the three estimates are remarkably similar when you take into account the limitations and assumptions inherent in simple models such as these, which include the relatively low number of water and peat samples, the potential for hydrological short-circuiting, and the always real possibility of laboratory/field error.

Attachment A7.3 Mass loads at Seep 1 (site 043, which is now the outfall of the pre-treatment system).

Until 1992, when the Seep 1 pretreatment system was built, the site called 043 was the actual seepage from the 8013 stockpile. But when the pretreatment system was put on line, the location of site 043 became the output of the pretreatment system (and prior to the wetland treatment system, which was started in 1995, and which is not discussed in this report). Thus all data reported for 043 from 1993 and on represents the effluent from the pretreatment system, and not the actual raw seepage.

A flow recorder was installed at the Seep 1 weir in 1986, so accurate estimations of flow are available from 1986-1991. The construction of the pretreatment system in 1992, however, makes it now impossible to collect truly representative "input" water quality and flow data. The seepage at this site occurs at a variety of small, diffuse seepages along the toe of 8013, and it is difficult to capture all of this diffuse flow. Attempts have been made to measure flow using small hand-held flumes, but only estimated data from 1993 are available. Two different methods were thus used to estimate the mass removed by the pretreatment system from the time of its construction through the 1996 field season.

1. <u>Peat metal mass.</u> Peat cores were collected in January 1996 from the vertical flow portion of the pretreatment system (Figure 8), and from the inner pool, middle pool and outer pool of the system in January 1997. Each peat core was divided into 10 cm segments (0-10 cm, 10-20 cm, 20-30 cm, etc.), and then those peat splits were processed and analyzed for metals content. Some individual cores had peat deeper than 30 cm, but those deeper layers were omitted from these calculations. Metal concentrations generally decreased with depth, so including deeper layers would add little to the total mass.

Mean concentrations were calculated for each peat layer in each pool, using all available data, and then mass calculations were made by multiplying the mean concentration in each segment by the dry peat weight estimated for that segment (Table 10). The total mass in the system was then estimated by adding the values from each 10 cm peat layer.

2. <u>Using water quality data.</u> **Output mass** was calculated for each month after the pretreatment system was started in 1992. This was done by multiplying the average concentration for that month by the total flow reported for 043 during that month in LTV's NPDES reports. These values should be quite accurate since they are based on daily flow data recorded at the weir.

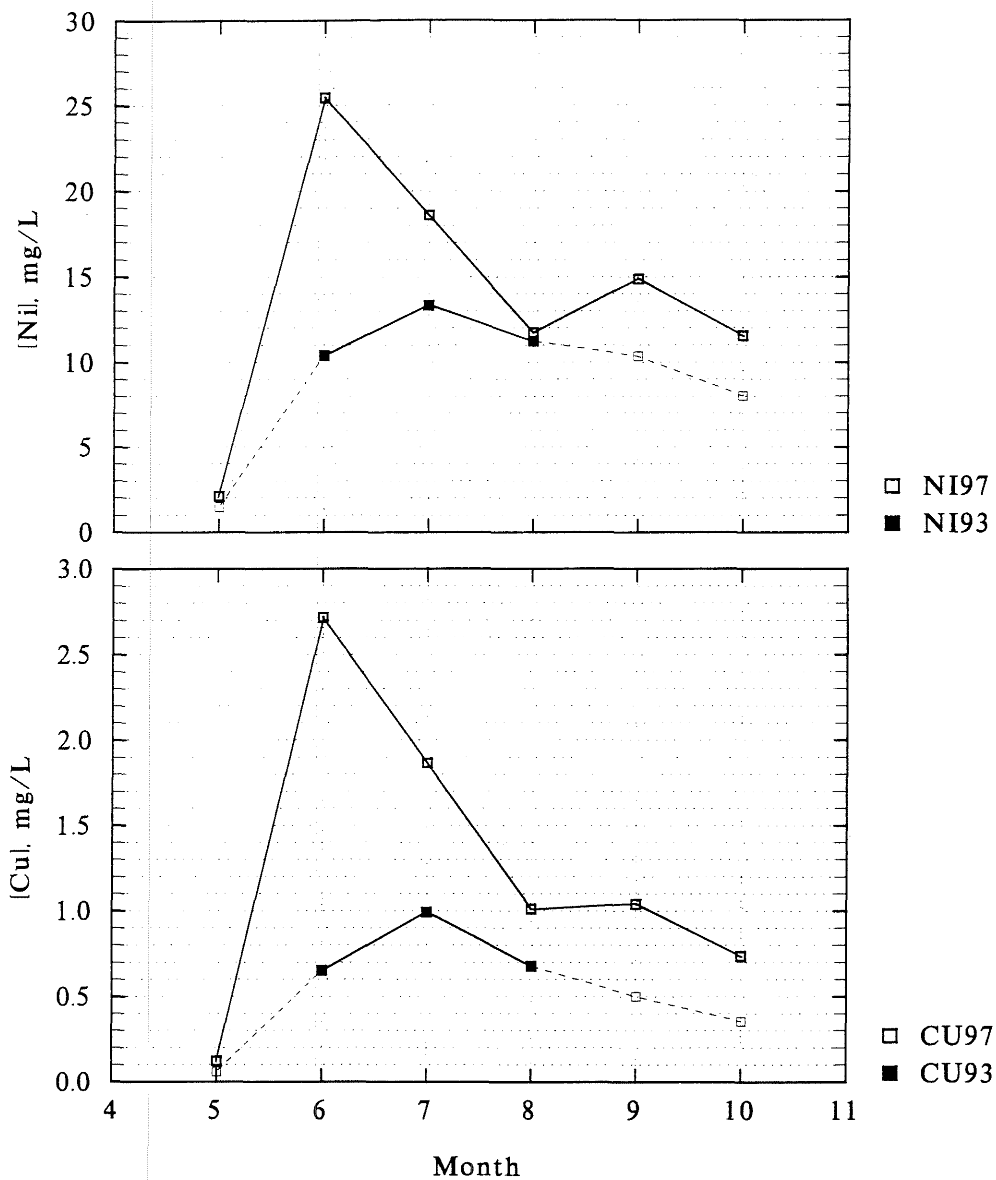
To estimate **input mass**, however, two assumptions were made. First, the average monthly input concentrations were assumed to be the same as the average monthly value observed in 1993-94 in the outer pool. This assumes that the samples around the edge of the outer pool represent the metal input to the pretreatment system. Based on water level data from the piezometers, groundwater enters the system in the outer pool. Since metal concentrations in substrate samples decreased with depth, there did not appear to be any removal until water had entered the pretreatment system.

Samples were also collected from the outer pool in 1997, but these samples were collected a year after the first of the peat samples were collected, while the 1993-94 samples were collected prior to peat collection. The 1997 values were also substantially higher than the 1993-94 values. Unfortunately, the 1993-94 samples were collected only during June, July and August. To estimate the "mean" values for May, September and October to be used in calculating the input masses, the average difference between the two sets of samples for June-August was calculated for each parameter. For copper the average 1993 value was 48.1% of the 1997 values, while the nickel value was 69.5% of the 1997 value (Figure A7.2).

To calculate the "mean" values to be used for May, September and October in the input mass calculations, the average value observed in 1997 was multiplied by these conversion factors. The values calculated for May, September and October were 1.46, 10.34 and 8.03 mg/L, respectively, while the copper values were 0.05, 0.50 and 0.35 mg/L, respectively. These monthly averages were then multiplied by the monthly flow reported for each month to arrive at a monthly input mass value, and then the monthly values were added to arrive at the annual mass removal.

An alternative estimation method would be to use the average monthly values observed before the system was constructed (i.e. using 1986-91 data), but this was rejected because nickel concentrations in the outer pool in 1993-94 were significantly less than the historical values from the seep. Since there was no evidence of removal from groundwater, it is likely that the nickel concentrations have decreased since 1991 due to the capping of 8013, which was completed in the fall of 1991. Also, while some flow occurs via discrete seeps at the toe of 8013, using these as an indicator of flow into the pretreatment system is unrealistic because a substantial portion of the flow observed at the weir results from groundwater flow.

Initially, mass removal calculations were done using the average of the 1993-94 and 1997 values. Using this approach, the total nickel removal was calculated as 130.5 kg. All mass removal estimates using the water quality data were at least twice the amound of nickel calculated to be in the substrate.



Notes: The only 1993 data available is from June through August. The averages for these months (using all available data from 043-1, 043-2 and 043-3) are depicted by the dark squares in the bottom line of each figure. To estimate 1993 concentrations for the other months, the average difference between the 1993 and 1997 data was calculated for each parameter (for June, July and August). For copper the average 1993 value was 48.1% of the 1997 values, while the nickel value was 69.5% of the 1997 value. The 1997 values were then multiplied by these conversion factors to get the estimated values for May, September and October. The exception was September, when the 1997 value was anomalously high; the value calculated for 1993 omits the anomalous value.

Figure A7.2. Mean copper and nickel concentrations in the surface water of the outer pool in 1993-94 and in 1997.

Table A7.5. Monthly mass load calculations for Seep 1, 1992-99.

	Monthly flow		Average Conc. (mg/L)			Mass (kg)			Cum. mass (kg)		
Date	MGD	Liters	Ni	Cu	SO4	Ni	Cu	SO4	Ni	Cu	SO4
May 1992	0.015	1760025	14.450	1.270	1200	25.43	2.235	2112.0	25.432	2.235	2112.0
June 1992	0.009	1021950	24.000	1.800	1820	24.52	1.840	1859.9	49.959	4.075	3971.9
July 1992	0.009	1056015	13.800	1.400	1340	14.57	1.478	1415.0	64.532	5.553	5387.0
Aug 1992	0.006	704010	3.763	0.278	1540	2.64	0.196	1084.1	67.181	5.749	6471.2
Sept 1992	0.016	1816800	4.725	0.100	1980	8.58	0.182	3597.2	75.766	5.931	10068.4
Oct 1992	0.005	586675	5.233	0.071	2320	3.07	0.042	1361.0	78.836	5.972	11429.5
May 1993	0.010	1173350	7.467	0.073	1080	8.76	0.086	1267.2	8.761	0.086	1267.2
Jun 1993	0.011	1249050	7.467	0.073	1080	9.32	0.091	1348.9	18.088	0.177	2616.1
Jul 1993	0.019	2229365	8.850	0.320	1120	19.73	0.713	2496.8	37.818	0.890	5113.0
Aug 1993	0.007	821345	8.650	0.190	1350	7.10	0.156	1108.8	44.922	1.046	6221.8
Sep 1993	0.004	454200	7.200	0.130	1840	3.27	0.059	835.7	48.193	1.106	7057.6
Oct 1993	0.003	352005	6.467	0.090	1360	2.27	0.032	478.7	50.469	1.137	7536.3
May 1994	0.004	469340	1.350	0.105	300	0.63	0.049	140.8	0.634	0.050	140.8
Jun 1994	0.011	1249050	8.575	0.130	1490	10.71	0.162	1861.0	11.344	0.212	2001.8
Jul 1994	0.003	352005	8.950	0.320	1220	3.15	0.113	429.4	14.495	0.325	2431.3
Aug 1994	0.001	117335	6.750	0.115	1160	0.79	0.013	136.1	15.287	0.338	2567.4
Sep 1994	0.008	908400	7.200	0.210	1130	6.54	0.191	1026.4	21.827	0.529	3593.9
Oct 1994	0.004	469340	5.967	0.167	1120	2.80	0.078	525.6	24.628	0.607	4119.5
May 1995	0.001	117335	0.700	0.040	480	0.08	0.005	56.3	0.082	0.005	56.3
Jun 1995	0.001	113550	0.230	0.040	1240	0.02	0.005	140.8	0.108	0.009	197.1
Jul 1995	0.008	938680	4.550	0.070	1230	4.27	0.066	1154.5	4.379	0.075	1351.6
Aug 1995	0.007	821345	3.350	0.058	1390	2.75	0.048	1141.6	7.130	0.123	2493.3
Sep 1995	0.011	1249050	7.650	0.125	1120	9.55	0.156	1398.9	16.686	0.279	3892.3
Oct 1995	0.022	2581370	9.450	0.235	1020	24.39	0.607	2632.9	41.080	0.885	6525.3
May 1996	0.010	1173350	2.795	0.161	460	3.28	0.189	539.7	3.279	0.189	539.7
Jun 1996	0.010	1135500	5.920	0.193	970	6.72	0.219	1101.4	10.001	0.409	1641.1
Jul 1996	0.012	1408020	9.045	0.482	960	12.73	0.679	1351.6	22.737	1.087	2992.8
Aug 1996	0.006	704010	8.425	0.256	1240	5.93	0.180	872.9	28.668	1.267	3865.8
Sep 1996	0.004	454200	7.335	0.117	1320	3.33	0.053	599.5	32.000	1.321	4465.3
Oct 1996	0.008	938680	8.565	0.292	1200	8.04	0.274	1126.4	40.040	1.595	5591.8

Table A7.5. Monthly mass load calculations for Seep 1, 1992-99 (continued).

Date	Monthly flow		Average Conc. (mg/L)			Mass (kg)			Cum. mass (kg)		
	MGD	Liters	Ni	Cu	SO^4	Ni	Cu	SO^4	Ni	Cu	SO^4
May 1997	0.007	821345	1.500	0.078	490	1.23	0.064	402.4	1.232	0.064	402.4
Jun 1997	0.012	1362600	8.715	0.110	1130	11.87	0.150	1539.7	13.107	0.214	1942.1
Jul 1997	0.004	469340	11.700	0.239	1340	5.49	0.112	628.9	18.598	0.326	2571.1
Aug 1997	0.003	352005	7.400	0.135	1350	2.60	0.048	475.2	21.203	0.373	3046.3
Sep 1997	0.001	113550	7.680	0.116	1400	0.87	0.013	158.9	22.075	0.387	3205.2
Oct 1997	0.004	469340	7.680	0.116	1400	3.60	0.054	657.0	25.679	0.441	3862.3
May 1998	0.005	586675	5.443	0.178	920	3.19	0.104	539.7	3.194	0.104	539.7
Jun 1998	0.004	454200	13.050	0.234	1420	5.92	0.106	644.9	9.121	0.211	1184.7
Jul 1998	0.001	117335	8.465	0.109	1420	0.99	0.013	166.6	10.114	0.223	1351.3
Aug 1998	0.000	46934	7.510	0.079	1780	0.35	0.004	83.5	10.467	0.227	1434.8
Sep 1998	0.001	113550	7.725	0.080	1400	0.87	0.009	158.9	11.344	0.236	1593.8
Oct 1998	0.009	1056015	8.240	0.397	1060	8.70	0.419	1119.3	20.045	0.655	2713.2
May 1999	0.016	1877360	6.770	0.175	910	12.71	0.329	1708.3	12.710	0.329	1708.3
Jun 1999	0.007	794850	12.650	0.665	1240	10.05	0.529	985.6	22.765	0.858	2694.0
Jul 1999	0.022	2581370	11.350	1.870	1100	29.29	4.827	2839.5	52.063	5.685	5533.5
Aug 1999	0.005	586675	12.600	0.854	1380	7.39	0.501	809.6	59.456	6.186	6343.1
Sep 1999	0.009	1021950	9.940	0.344	1340	10.15	0.352	1369.4	69.614	6.537	7712.5
Oct 1999	0.009	1056015	7.580	0.550	1060	8.00	0.581	1119.3	77.618	7.118	8831.9

Note: The values given for "MGD" are the average monthly flow rates, which were calculated by totaling the flow during the month, and then dividing by the number of days in the month.

Table A7.6. Flow, nickel and sulfate mass at Seep 1; comparison between May-October data and annual estimates.

Year	Precipitation (cm)			Flow (m3)			Nickel mass (kg)			Sulfate mass (kg)		
	May-oct	Annual	% Diff.	May-oct	Annual	% Diff.	May-oct	Annual	% Diff.	May-oct	Annual	% Diff.
1986	50.8	67.8	25.0	6,628	8,104	18.2	114.7	120.7	5.0	8,899	9,824	9.4
1987	54.0	60.3	10.4	5,942	6,397	7.1	110.5	112.6	1.9	9,478	9,919	4.4
1988	62.3	81.1	23.2	9,697	10,265	5.5	177.4	179.4	1.1	14,508	14,871	2.4
1989	56.1	69.2	19.0	20,693	21,487	3.7	343.2	346.1	0.8	26,878	27,468	2.1
1990	42.2	64.5	34.5	3,478	4,955	29.8	51.2	54.7	6.4	4,185	4,812	13.0
1991	57.8	73.0	20.8	10,613	11,749	9.7	148.2	151.6	2.2	13,928	14,723	5.4
1992	43.9	61.3	28.4	3,107	3,902	20.4	14.3	15.4	7.1	6,043	6,599	8.4
1993	44.3	63.8	30.6	6,279	7,218	13.0	50.5	53.8	6.1	7,536	8,728	13.7
1994	48.7	67.6	28.0	3,565	7,661	53.5	24.6	28.8	14.6	4,120	4,965	17.0
1995	47.0	60.6	22.5	5,821	6,631	12.2	41.1	43.7	6.0	6,525	6,903	5.5
1996	46.3	77.7	40.4	5,813	8,653	32.8	40.0	47.3	15.4	5,592	6,710	16.7
1997	39.3	56.7	30.7	3,588	5,405	33.6	25.7	32.2	20.2	3,862	5,180	25.4
1998	48.7	69.0	29.4	2,375	2,719	12.7	20.0	23.2	13.8	2,713	3,152	13.9
1999	73.2	90.0	18.7	7,918	9,512	16.8	77.6	88.7	12.5	8,832	10,334	14.5
Ave. 1987-99	51.0	68.8	25.8	6,823	8,190	19.2	88.5	92.7	8.1	8,793	9,585	10.9

Note: The pretreatment system was constructed in 1992, during which time flow measurements were not made. The data shown here for 1992 includes only data from April, August, September and October.

Table A7.7. Nickel and copper mass removal in the Seep 1 pretreatment system, using 1993-94 data from the outer pool to represent input concentrations.

Date	Liters	Output [Ni], mg/L	Input [Ni], mg/L	Output [Cu], mg/L	Input [Cu], mg/L	Nickel mass (kg) In	Nickel mass (kg) Out	Nickel mass (kg) Rem.	Nickel mass (kg) Cum.rem.	Nickel mass (kg) Annual	Copper mass (kg) In	Copper mass (kg) Out	Copper mass (kg) Rem.	Copper mass (kg) Cum. rem.	Copper mass (kg) Annual
aug 1992	704010	3.763	11.5	0.278	0.850	8.096	2.649	5.447	5.447	5.447	0.598	0.196	0.403	0.403	0.403
sept 1992	1816800	4.725	12.6	0.100	0.770	22.892	8.584	14.307	19.754	19.754	1.399	0.182	1.217	1.620	1.620
oct 1992	586675	5.233	9.8	0.071	0.550	5.749	3.070	2.679	22.434	22.434	0.323	0.042	0.281	1.901	1.901
may 1993	1173350	7.467	1.8	0.073	0.090	2.112	8.761	0.000	22.434	0.000	0.106	0.086	0.020	1.921	0.020
jun 1993	1249050	7.467	17.9	0.073	1.680	22.358	9.327	13.031	35.465	13.031	2.098	0.091	2.007	3.928	2.027
jul 1993	2229365	8.850	16.0	0.320	1.430	35.670	19.730	15.940	51.405	28.971	3.188	0.713	2.475	6.403	4.502
aug 1993	821345	8.650	11.5	0.190	0.850	9.445	7.105	2.341	53.746	31.312	0.698	0.156	0.542	6.945	5.044
sep 1993	454200	7.200	12.6	0.130	0.770	5.723	3.270	2.453	56.198	33.764	0.350	0.059	0.291	7.236	5.335
oct 1993	352005	6.467	9.8	0.090	0.550	3.450	2.276	1.173	57.372	34.938	0.194	0.032	0.162	7.397	5.496
may 1994	469340	1.350	1.8	0.105	0.090	0.845	0.634	0.211	57.583	1.385	0.042	0.049	0.000	7.397	0.000
jun 1994	1249050	8.575	17.9	0.130	1.680	22.358	10.711	11.647	69.230	13.032	2.098	0.162	1.936	9.333	1.936
jul 1994	352005	8.950	16.0	0.320	1.430	5.632	3.150	2.482	71.712	15.514	0.503	0.113	0.391	9.724	2.327
aug 1994	117335	6.750	11.5	0.115	0.850	1.349	0.792	0.557	72.269	16.071	0.100	0.013	0.086	9.810	2.413
sep 1994	908400	7.200	12.6	0.210	0.770	11.446	6.540	4.905	77.175	20.977	0.699	0.191	0.509	10.319	2.922
oct 1994	469340	5.967	9.8	0.167	0.550	4.600	2.801	1.799	78.974	22.776	0.258	0.078	0.180	10.499	3.102
may 1995	117335	0.700	1.8	0.040	0.090	0.211	0.082	0.129	79.103	0.129	0.011	0.005	0.006	10.505	0.006
jun 1995	113550	0.230	17.9	0.040	1.680	2.033	0.026	2.006	81.109	2.135	0.191	0.005	0.186	10.691	0.192
jul 1995	938680	4.550	16.0	0.070	1.430	15.019	4.271	10.748	91.857	12.883	1.342	0.066	1.277	11.968	1.469
aug 1995	821345	3.350	11.5	0.058	0.850	9.445	2.752	6.694	98.551	19.577	0.698	0.048	0.651	12.618	2.119
sep 1995	1249050	7.650	12.6	0.125	0.770	15.738	9.555	6.183	104.734	25.760	0.962	0.156	0.806	13.424	2.925
oct 1995	2581370	9.450	9.8	0.235	0.550	25.297	24.394	0.903	105.637	26.663	1.420	0.607	0.813	14.237	3.738
may 1996	1173350	2.795	1.8	0.161	0.090	2.112	3.280	0.000	105.637	0.000	0.106	0.189	0.000	14.237	0.000
jun 1996	1135500	5.920	17.9	0.193	1.680	20.325	6.722	13.603	119.240	13.603	1.908	0.219	1.688	15.925	1.688
jul 1996	1408020	9.045	16.0	0.482	1.430	22.528	12.736	9.793	129.033	23.396	2.013	0.679	1.335	17.260	3.023
aug 1996	704010	8.425	11.5	0.256	0.850	8.096	5.931	2.165	131.198	25.561	0.598	0.180	0.418	17.678	3.441
sep 1996	454200	7.335	12.6	0.117	0.770	5.723	3.332	2.391	133.589	27.952	0.350	0.053	0.297	17.975	3.738
oct 1996	938680	8.565	9.8	0.292	0.550	9.199	8.040	1.159	134.749	29.112	0.516	0.274	0.242	18.217	3.980
may 1997	821345	1.500	1.8	0.078	0.090	1.478	1.232	0.246	134.995	0.246	0.074	0.064	0.010	18.227	0.010
jun 1997	1362600	8.715	17.9	0.110	1.680	24.391	11.875	12.515	147.511	12.762	2.289	0.150	2.139	20.366	2.149
jul 1997	469340	11.700	16.0	0.239	1.430	7.509	5.491	2.018	149.529	14.780	0.671	0.112	0.559	20.925	2.708
aug 1997	352005	7.400	11.5	0.135	0.850	4.048	2.605	1.443	150.972	16.223	0.299	0.048	0.252	21.177	2.960
sep 1997	113550	7.680	12.6	0.116	0.770	1.431	0.872	0.559	151.531	16.782	0.087	0.013	0.074	21.251	3.034
oct 1997	469340	7.680	9.8	0.116	0.550	4.600	3.605	0.995	152.526	17.777	0.258	0.054	0.204	21.455	3.238

Table A7.7. Nickel and copper mass removal in the Seep 1 pretreatment system, using 1993-94 data from the outer pool to represent input concentrations (continued).

Date	Liters	Output [Ni], mg/L	Input [Ni], mg/L	Output [Cu], mg/L	Input [Cu], mg/L	Nickel mass (kg) In	Out	Rem.	Cum.rem.	Annual	Copper mass (kg) In	Out	Rem.	Cum. rem.	Annual
may 1998	586675	5.443	1.8	0.178	0.090	1.056	3.193	0.000	152.526	0.000	0.053	0.104	0.000	21.455	0.000
jun 1998	454200	13.050	17.9	0.234	1.680	8.130	5.927	2.203	154.728	2.202	0.763	0.106	0.657	22.112	0.657
jul 1998	117335	8.465	16.0	0.109	1.430	1.877	0.993	0.884	155.613	3.087	0.168	0.013	0.155	22.267	0.812
aug 1998	46934	7.510	11.5	0.079	0.850	0.540	0.352	0.187	155.800	3.274	0.040	0.004	0.036	22.303	0.848
sep 1998	113550	7.725	12.6	0.080	0.770	1.431	0.877	0.554	156.353	3.827	0.087	0.009	0.078	22.381	0.926
oct 1998	1056015	8.240	9.8	0.397	0.550	10.349	8.702	1.647	158.001	5.475	0.581	0.419	0.162	22.543	1.088
may 1999	1877360	6.770	1.8	0.175	0.090	3.379	12.710	0.000	158.001	0.000	0.169	0.329	0.000	22.543	0.000
jun 1999	794850	12.650	17.9	0.665	1.680	14.228	10.055	4.173	162.174	4.173	1.335	0.529	0.807	23.350	0.807
jul 1999	2581370	11.350	16.0	1.870	1.430	41.302	29.299	12.003	174.177	16.176	3.691	4.827	0.000	23.350	0.807
aug 1999	586675	12.600	11.5	0.854	0.850	6.747	7.392	0.000	174.177	16.176	0.499	0.501	0.000	23.350	0.807
sep 1999	1021950	9.940	12.6	0.344	0.770	12.877	10.158	2.718	176.896	18.895	0.787	0.352	0.435	23.785	1.242
oct 1999	1056015	7.580	9.8	0.550	0.550	10.349	8.005	2.344	179.240	21.239	0.581	0.581	0.000	23.785	1.242

Figure A7.8. Comparison of load from surface seeps to pretreatment system with overall load at weir, August, September, 1993.

8/17/93

Site	Flow (L/sec)	Concentrations - Mg/L			Loading Rate - Mg/sec		
		Cu	Ni	Mg	Cu	Ni	Mg
S-2	.023	1.46	17	252	.034	.39	5.8
S-3	.006	2.51	30	370	.015	.18	2.2
S-4	.017	4.68	42	338	.080	.71	5.7
S-5,6,7[a]	.002e	2.3	18	103	.005	.04	.2
S-8	.014	1.44	12	210	.02	.17	2.9
S-9	.008e[b]	1.16	11	204	.01	.09	1.6
Total	.070				.16	1.58	18.4
Seep 1	.3	0.22	10	190	.066	3	57

$\sum$Seeps; Q ~ 23% of Seep 1

[a] No flow was reported, but samples were collected, concentrations are averaged for the sites, lowest reported flow for an individual seep was 0.002 L/sec, assume flow from each seep is less than 0.002, assume total flow from all 3 seeps = 0.002, overall contribution to total load is small.

[b]No flow was reported on 8/17 - assumed flow was same as on 8/30 and 9/16.

8/30/93

Site	Flow (L/sec)	Concentrations - Mg/L			Loading Rate - Mg/sec		
		Cu	Ni	Mg	Cu	Ni	Mg
S-2	.023	1.3	17	248	.03	.39	5.7
S-3	.004	1.9	28	338	.008	.11	1.4
S-4	.006	2.97	36	318	.018	.22	1.9
S-8	.023	1.5	14	230	.034	.32	5.3
S-9	.008	1.18	12	228	.009	.10	1.8
Total	.064				.099	1.14	16.1
Seep 1	.368e[a]	.13	8.97	204	.048	3.3	75

[a]Estimated from LTV daily flow data, by multiplying LTV flow by 0.875, which was the average ratio for 8/17 and 9/16 of DNR gaged flow/LTV reported.

Table A7.8. Comparison of load from surface of seeps to pretreatment system with overall load at weir, August, September, 1993 (continued).

9/16/93

Site	Flow (L/sec)	Concentrations - Mg/L			Loading Rate - Mg/sec		
		Cu	Ni	Mg	Cu	Ni	Mg
S-2	.009	1.04	16	238	.009	.14	2.1
S-3	No data reported						
S-4	.002	2.57	30	316	.005	.06	.6
S-8	.015	1.14	9.9	190	.017	.15	2.8
S-9	.008	.088	8.7	186	.007	.07	1.5
Total	.034				.0387	.42	7
Seep 1	.27	0.12	6.4	160	.03	1.7	43

$\sum$ Seeps Q ~ 13% Seep 1

Table A7.9. Flow estimates, Seep 1, August 1993.

Date	Flow (L/sec)		
	DNR gaged value	LTV's reported value	DNR/LTV
8/17/93	0.30	0.35	0.86
8/30/93	0.368 (est.)	0.42	$\bar{x} = 0.875$
9/16/93	0.267	0.30	0.89

Notes: To compute the contribution of the small surface seeps to the overall flow at Seep 1, Seep 1 flow had to be estimated for 8/30/93. This was done by using an average ratio between the DNR gaged value and the LTV reported value, which was obtained from a standard weir equation.

Appendix 8

Section A8.1

Elevation of Overflow, Seep 1 Pretreatment System

10/28/97 surveyed site

The elevation of the overflow pipe was measured in October of 1997 and 1998. The OSS staff reading at overflow averaged 3.50 ft. (3.52 ft. in 1997, 3.49 ft. in 1998).

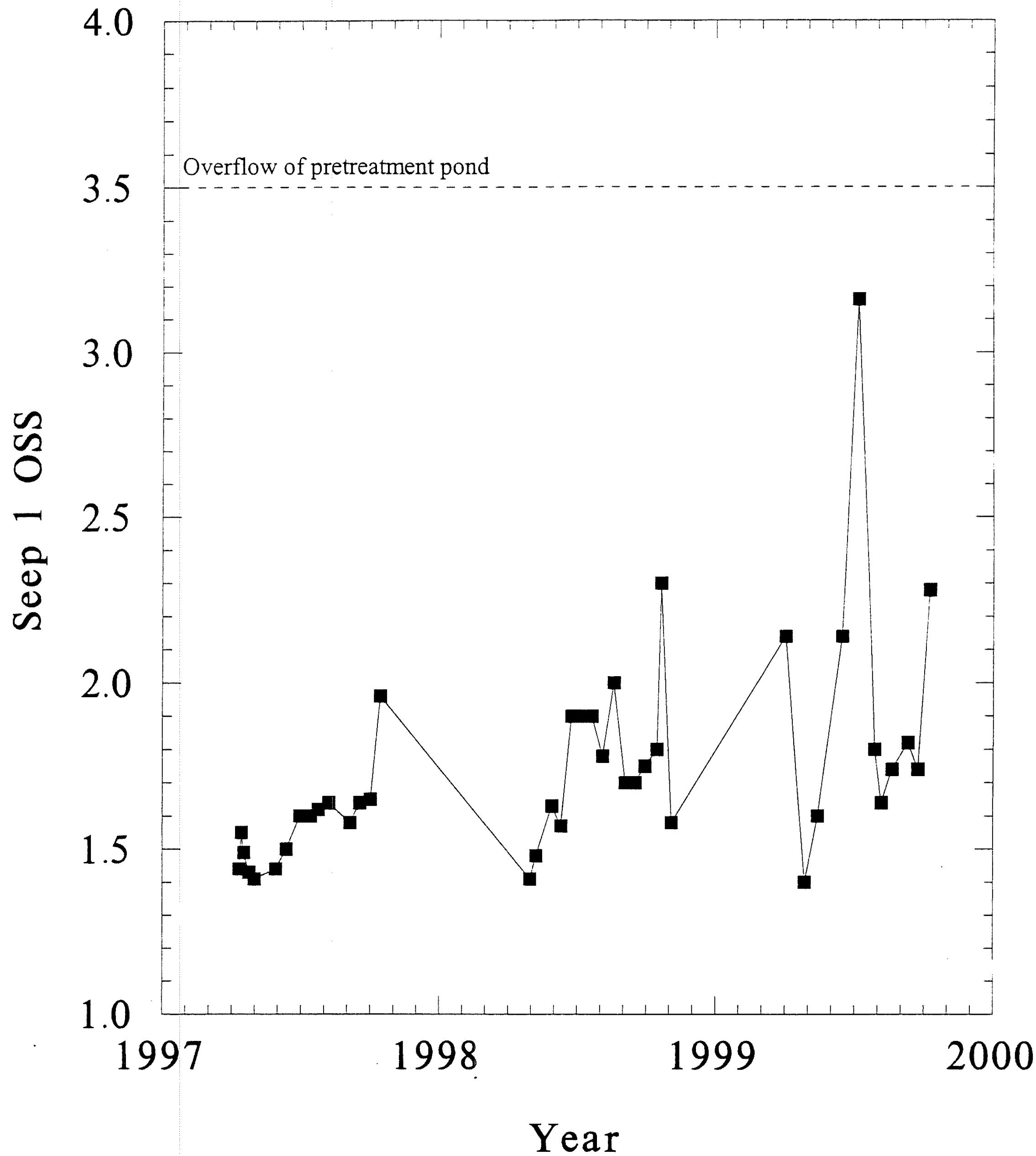


Figure A8.1. Staff gage readings (OSS) vs. time for the Seep 1 pretreatment system, 1997-99.

Section A8.2

Piezometers – Seep 1 pretreatment

Memo

Date: 9/18/00

To: Paul Eger

From: Glenn Melchert

Subject: Piezometers–Seep 1 Pre-treatment

Installation Notes

Piezometers 1 through 7 were installed on 9/16/98. Each pipe was 5 feet long and consisted of ½ inch diameter schedule 80 gray pvc. Piezometers 1- 4 were driven 1 foot into the mineral soil. Piezometers 5, 6 and 7 were driven into the soil exposed between the pretreatment pond and the waste rock stockpile. Piezometers 2d and 3d were installed on 10/26/98 and 10/23/98, respectively. Piezometer 2d was installed 1 foot deeper than #2 and about a foot away. Piezometer 3d was installed in a similar manner. Piezometers 2d and 3d were longer than 5 feet. Each piezometer was open at each end (no screen) and driven into the ground with a hammer. The drive end of each pipe was covered by a steel bolt. Once the proper depth was attained, the bolt was driven out the bottom of the piezometer with a steel rod that was placed inside the pipe and pushed or hammered down about 2 inches. See schematic and Figure 8 in the text for details.

Table 1. Construction details for each piezometer.

Piezometer	Installed	Distance from rebar in NW corner (ft)	Distance from west shore (ft)	Dip (0 degrees is horizontal)
1	9/16/98	83	6	90
2	9/16/98	48	4	90
2d	10/26/98	48	nm	90
3	9/16/98	20	4.5	90
3d	10/23/98	20	nm	90
4	9/16/98	58	20[a]	90
5	9/16/98	37	1 ft landward	8.5
6	9/16/98	36	1.5 ft landward	45
7	9/16/98	58	2.5 ft landward	90

[a] Approximately 3 feet from the limestone berm.

Piezometer data comparing water levels inside the piezometers to the pond level. Positive values for delta h means the water in the piezometer was higher than the pond level. All values are in feet.

Piezometer	9/29/98[d]		10/1/98		10/15/98		10/26/98		12/4/98[c]	
	top of pipe to pond	delta h	top of pipe to pond	delta h	top of pipe to pond	delta h	top of pipe to pond	delta h	top of pipe to pond	delta h
1	.63	+.42	.47	+.16	.44	+.15	.58	+.22	.70	+.09
2	1.08	+.29	1.08	+.07	1.05	+.10	1.16	+.13	1.26	+.05
2d							1.57	Nm	1.66	+.17
3	1.06	+.46	.95	+.12	.93	+.11	1.05	+.14	1.17	+.09
3d										
4	1.13	0	1.16	-.29	1.13	+.03	1.27	+.44[a]		
5	.63	+.63[b]	.60	+.60[b]	.58	+.58[b]	.70	+.70[b]		
6	1.48	+.40	1.45	+.24	1.43	+.19	1.55	+.40		
7	1.92	+.45	1.89	+.09	1.87	+.49	1.99	+.81		
OSS	1.75		1.78		1.80		1.68		1.54	

[a] data appears anomalous.
[b] Water always slowly dripped from this piezometer, so this value is conservative.
[C] These data were collected when the pond and the water in the piezometers was frozen.
[d] These data are suspect because they were collected using a 1/4" dowel as a dip stick inside the piezometer. The dowel likely displaced some water making it appear higher than actual. For the other dates, piezometer water level was measured with a bubble tube, so no displacement occurred.

Table Notes:

1. The distance to water (pond) for piezometers 5, 6, and 7 was measured on 10/1/98 only (these piezometers are on land). Values for other dates were calculated based on the relationship determined on 10/1/98.

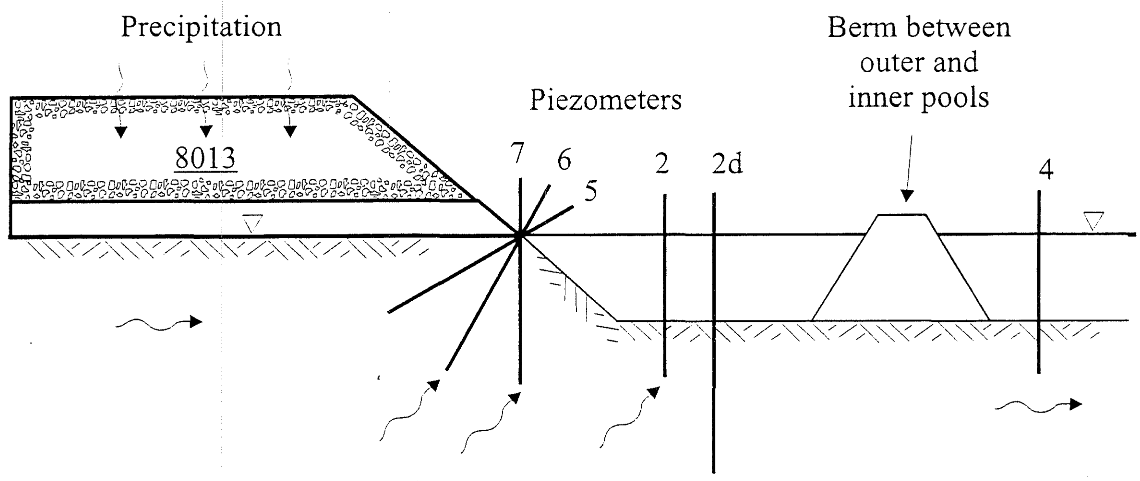
2. On 10/15/98 the piezometers were sampled after measuring water levels. Four hours later, all the piezometers except #4 and #7 had recovered to within 1.5" of original levels.

3. On 10/26/98 the outlet pipe (goes under the road) from the weir was unclogged.

Summary

Limited data from piezometer 4 suggest that most of the time, there is no vertical up welling of groundwater over most of the pond. There is a small upward gradient beneath the portion of the pond adjacent to the rock stockpile (piezometers 1, 2, and 3). The upward gradient is much larger just up slope of the pre-treatment pond (piezometers 5, 6, and 7). This upward gradient causes seeps to occur in this area. This situation also suggests that there may be substantial amounts of groundwater that enters the pre-treatment pool across the interface between the soil and the western edge of the pre-treatment pool.

Cross-section



Top View

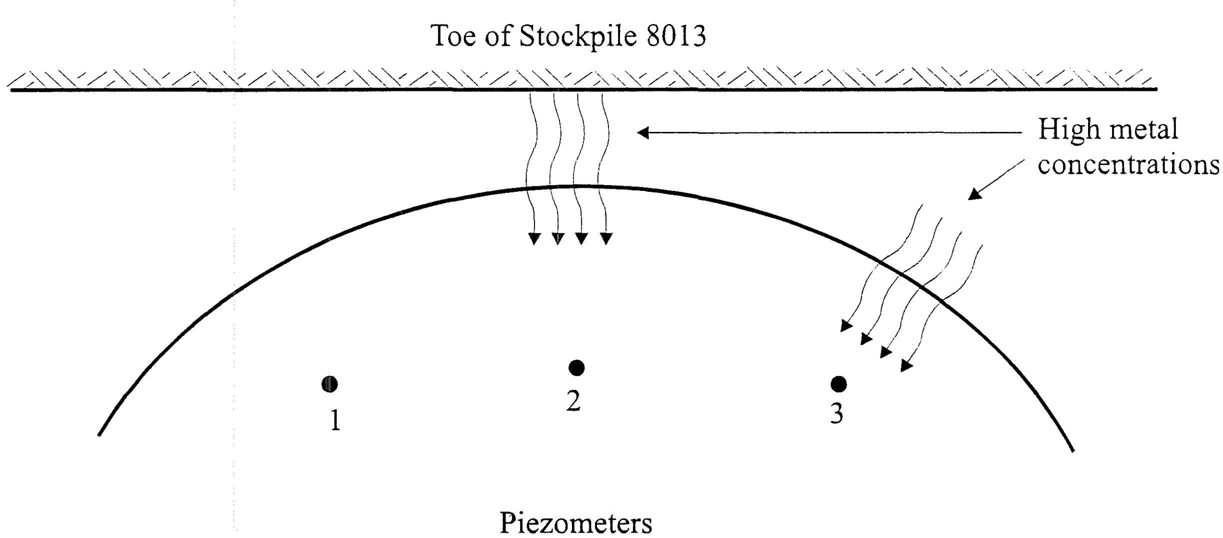


Figure A8.2. Hydrology model of stockpile 8013 and the Seep 1 pretreatment system (schematic).

Table A8.1. Summary of piezometers installation and gradients.

Piezometer	Location	Depth	Approx. Gradient Fall 1998
1	Outer pool	~ 1' below substrate, in mineral	~ 1.2-1.8" upward
2			
3			
4	Middle pool		0
5	Bank, toe of stockpile, ~ 8.5° angle into bank	mineral	~ 6-7" upward
6	Bank, toe of stockpile, ~ 45° angle into bank	mineral	~ 3" upward
7	Bank, toe of stockpile, vertical angle	mineral	~ 6" upward

Table A8.2. Piezometer water quality data, October 1998.

10/16/98

Piezometer	SC	pH	Ni	Cu	Co	Zn
1	2150	6.82	.062	.003	.021	.044
2	3350	6.96	.159	.009	.033	.108
3	1900	6.53	9.8	.06	.099	.138
4	1600	7.13	.155	.005	.027	.031
5	2200	6.56	33	.003	1.81	.043
6	2250	5.14	31	.66	1.61	1.91

Note: all trace metals in mg/L.

Section A8.3

Groundwater Flow at Seep 1, Dunka Mine

Problem: Has construction (August 1992) of the pretreatment pond upstream of the weir affected flow at the weir?

Assumptions:

1. Water table contours approximate topographic contours.
2. The permeability of bedrock, except for fracture zones, is insignificant and flow through fractures is relatively insignificant on a volumetric basis.
3. Groundwater discharge occurs in the vicinity (upstream of the historical weir) of seep 1. This is supported by observations prior to excavation of the pretreatment site that revealed there was no distinct channel between the toe of the stockpile and the weir-only pockets of water here and there. This, along with the fact that the slope in this area is around 3-4% increasing to around 5% under the stockpile toe. Water table elevations in STS well F-14 ranged 0.4 to 0.9 ft. below ground level. This well is located less than 50 ft. north of the drainage swale leading to seep 1.
4. The bedrock feature immediately upstream of the weir (at the site of the under drain) extends 100 ft. or more north and south which would effectively contain nearly all groundwater flow in this area and cause it to move through the weir site with a substantial portion being gaged.
5. The aquifer (overburden) is approximately 7 feet thick. This is average of three nearby wells (9.0, 7.5, 5.5).

Information Known:

From STS Consultants Ltd.; Hydrogeologic Study, 1988; and Supplement to Hydrogeologic Report, 1988.

Seep 1 weir	elev. notch	1451.7 (3/88)
	elev. top	1452.7
	northing	445,495
	easting	2,313,720
Well STS	F-11	2100 ft. WSW of seep 1 weir
Well STS	F-14	5 ft. N. of pretreatment pond (110-130' NW of seep 1 weir)
Well STS	F-15	1000 ft. NW of seep 1 weir

Table 1. Well information collected 11/87 through 10/88.

Well #	Ground Elevation	Average Water Level Below Ground	Well Depth (ft.)	Overburden Thickness (ft.)	Kh[1] (10^{-3}cm/s)	Kh[2] (10^{-3} cm/s)	Screened Interval
F-11	1498.3	1.6 (.4-2.8)	8.3	9	3.8	.67 (.2-1.6)	3.3-8.3
F-14	1456.8	0.6 (.4-1.0)	8.0	7.5	NM	6.1 (1.9-11)	3.0-8.0
F-15	1491.4	2.4(.7-5.5)	5.5	5.5	NM	.61 (.1-1.3)	2.5-5.5

[1] Based on slug test.
[2] Mean value based on grain size. Values in parentheses represent the range of values calculated.
NM Not measured.

Table 2. Grain size data.

Well #	Sample Interval (ft.)	d_{50} (mm)	-200 mesh
F-11	7.5-9	0.4	30%
F-14	5-7	1.0	17%
F-15	2.5-4.5	0.08	48%

Table 3. Soil descriptions.

Well #	Interval	Soil Classification
F-11	0-4.5 4.5-7.0 7-9	SM-ML SP-SM SM
F-14	0-7.5	SW-SM
F-15	0-5.5	SM-ML

Note : STS used the following for their analysis in the "Northern shallow bedrock" region which includes seep 1.

$K = 5 \times 10^{-3}$cm/s
$i = .025$
porosity = .30

Groundwater Gradients (based on surface topography - Dunka Pit Area, Aug. 1, 1964):

- Pretreatment pond area (in a westerly direction, prior to excavation).

$$i = \frac{1465 - 1460}{80''} = .036$$

- F-14 to weir. (Note: topo contour values ~5' greater than surveyed values -- used survey.)

$$i = \frac{1456.2 - 1451.7}{130'} = .035$$

- Pond Perimeter

$$i = \frac{1475 - 1465}{75'} = .133 \quad \text{(northerly)}$$

$$i = \frac{1470 - 1465}{100'} = .05 \quad \text{(westerly)}$$

$$i = \frac{1470 - 1465}{80'} = .065 \quad \text{(southerly)}$$

- Overall flow path (headwater to pond) $\frac{1490 - 1465}{670} = .037 = .037$

- New gradients along pond perimeter after pretreatment pond construction (subtract 4.5' from original $\triangle h$).

$$i = \frac{1475 - 1460.5}{75} = .193 \quad \text{(northerly)}$$

$$i = \frac{1470 - 1460.5}{100} = .095 \quad \text{(westerly)}$$

$$i = \frac{1470 - 1460.5}{80} = .119 \quad \text{(southerly)}$$

Groundwater flow prior to construction of pretreatment pond:

$i = .036$
$K = 6.1 \times 10^{-3}$cm/s
A = 7' thick aquifer x 200' wide valley (based on contours)
$Q = KiA$
$Q = 6.1 \times 10^{-3}$cm/s x .036 x 7' x 200' (60 s/min x .0328ft/cm x 7.481gal/ft^3) = 4.5 gpm

4.5 gpm is consistent with baseflow measured at the weir (limited data 8/93).

If groundwater flow is confined to the "notch" between bedrock knobs (site of under drain), determine gradient necessary to transmit 4.5 gpm. Area of notch = 7' deep (est.) by 10' wide.

$$i = \frac{Q}{KA}$$

$$= \frac{4.5\ gpm}{(6.1\ x\ 10^{-3})(70\ ft^2)} \div 14.723$$

$$i = 0.716$$

This kind of gradient is plausible in the area just upstream of the current weir pool.

Groundwater flow after construction of pretreatment pond:

Based on the presence of seeps and estimated flow paths, groundwater discharge probably occurs along the north, west and south sides of the pretreatment pond. The pond was excavated about 2 ft. deeper than the weir invert elevation (1451.7). The ground elevation at well F-14 is 1456.8' or about 5 feet higher than the weir. Although not surveyed, it appears this elevation carries around most of the perimeter. Since the water table in this area was about 0.5' or less below ground surface (well F-14), the differential head has increased about 4.5' as compared to pre-excavation conditions.

Pretreatment Pond Dimensions (paced)

North side	100'
West (stockpile) side	110'
South side	60'

Calculation of lateral seepage into pretreatment pond. $Q = K \frac{(h_1 - h_2)}{L} A$

West side $Q = 6.1 \times 10^{-3}\text{cm/s}\ (\frac{1470 - 1460.5}{100})(2)(110)(14.723)$
$= 1.9$ gpm

North side $Q = 6.1 \times 10^{-3}\ (\frac{1475 - 1460.5}{75})(2)(100)(14.723)$
$= 3.5$ gpm

South side $Q = 6.1 \times 10^{-3}\ (\frac{1470 - 1460.5}{80})(2)(60)(14.723)$
$=1.3$ gpm

Total = 6.7 gpm

Discussion:

This calculated flow (6.7 gpm) is 50% higher than the 4.5 gpm calculated earlier for pre-existing aquifer flow at seep 1, but given the uncertainty of some of the estimates above and that these two values are in the general range of late summer baseflow (4-5 gpm), they may be about equal. Lateral seepage into the pond may be over estimated if the gradients from the north and south directions (based on topographic contours) are not really that steep. This is likely because water table gradients typically are smaller than surface topography in areas of relatively steep surface slopes. The gradient in the westward direction is believed fairly accurate since the primary recharge area is in that direction which would tend to keep the water table near the surface. There may be errors in the cross-sectional area of the pre-existing flow calculation.

Limited data for the years 1988-1991 (STS 1988) indicate that baseflow ranges around 1-5 gpm. This fairly large fluctuation may be explained by the small recharge area and ground watershed affecting this seep. During periods of drought or low precipitation, groundwater recharge ceases after which baseflow is maintained by the slow dewatering of the aquifer.

If the estimate of lateral seepage into the pond is about equal to or even greater than baseflow, then groundwater discharge due to up swelling from the bottom of the pond is minimal or nonexistent. If hydraulic conductivity or the groundwater gradients are over estimated by as little as a factor of 2, then upwelling could be a significant contributor to flow. The presence of a vertical gradient (positive or negative) could be verified by placing nested piezometers within the pond.

The groundwater flow calculations are believed optimistic because:

1. Hydraulic conductivity was estimated based on grain size analysis (average of 3 different calculations) of well F-14. In well F-7, not listed here, the grain size K and the slug test K match well, but do not match very well in well F-11. The data from F-11 was confounded because the screened interval over which the slug test was done included a sandier zone that was not considered in the grain size analysis. Well F-14 had the highest average K of 3 nearby wells, indicating K could be lower in some areas of the seep 1 watershed.

2. Hydraulic gradients used are probably maximums.

<u>Flow through vertical peat bed</u>

Assume free flow through limestone.
K of peat = 1.7×10^{-1}cm/s (STS)

$$Q = K \frac{\Delta h}{\Delta L} A$$

- Calculate head differential to transmit 5 gpm, 20 and 65 gpm

$$\triangle h\ (5\ \text{gpm}) = \frac{QL}{KA} = \frac{5(1)}{(.17)(24x20')} \times \frac{1}{14.723} = .004\ \text{ft}$$

$\triangle h(20\text{gpm}) = .02$ ft.

$\triangle h(65\ \text{gpm}) = .05$ ft.

Section A8.4

Seep 1 Flow Summary

Seep 1, located at the extreme west side of waste rock stockpile 8013, was first detected in 19976-1977. Flow at this seep typically starts in April and ends in early November, with no flow occurring during the winter.

Data

A 1981 DNR report (Eger et al. 1981) states that periodic measurements were made at Seep 1 in 1976 using a mini current meter, but that since the water depth was often too shallow to use a meter (depth less than 1 inch), it was at those times "necessary to estimate flow using floats as an indicator of flow velocity." Staff gage readings were also taken occasionally, but were deemed unreliable because of erratic results. The values that are presented in the 1986 DNR report were thus calculated by assuming that Seep 1 runoff coefficients were the same as for EM8 and by using a watershed area of 44,390 m^2, which was determined by cut and weigh.

A V-notch weir and a Stevens Type F flow recorder were installed in 1986, so that more reliable flow estimates are available starting with 1986. To calculate flow from 1986, on LTV estimates the daily gage readings from the continuously recording charts, and then used a standard weir equation to convert these values into flow values (reported in CFS). LTV has not actually measured flow to compare with the estimates made from the standard equation. A 1993 DNR analysis of Seep 1 flow indicated that the equation used by LTV underestimates flow by approximately 10%. However, this degree of potential error is still much smaller than for the 1976-1995 data. To arrive at the average flow values that are presented in LTV's NPDES discharge monitoring reports, the daily values are summed up for each month, and then this summed monthly total is divided by the number of days in the month to arrive at an average monthly value.

The Stevens recorder is generally installed in late April or early May, and then removed in late October or early November. After the recorder is removed in the fall, occasional staff gage readings are taken manually on the days when water quality samples are collected, until the seep completely freezes up. Using these point estimates for fall flow is reasonable since flow tends to decline gradually over this period. It is less accurate in the spring when the melting snow pack in the Seep 1 watershed could conceivably pass the system unmeasured.

Ditching

In the original version of the Dunka Closure Report it says that the first ditching activity that influenced the flow rate occurred in 1989. Accurate flow in 1989 was 20 gpm, but fell to 6 gpm in 1990, a decrease that LTV says was due to this ditching activity. Additional ditching in the winter of 1990-1991 "assisted in maintaining flow at 6 gpm during 1991 and 8 gpm during 1992." LTV also states (on page 63) that Seep 1 has a base flow that results from groundwater arising from wetland located south and upgradient of Seep 1, which migrates "through an erosional channel in the original topographic feature." It is also stated that this base flow "may influence water quality," so that, even if all flow through the 8013 was terminated, an appreciable mass load of copper and nickel (and other pollutants) would still arise from this seep.

Though the effects of the ditching on flow volumes at Seep 1 can not be discounted entirely, it appears that the high flow values observed during 1989, indicating that the 1989 flow was overestimated for some reason.

- The total annual flows calculated for three or four years prior to 1989 are very similar to the three or four years following 1989 flow was overestimated for some reason.
- Runoff coefficients calculated for each year since 1986 are consistently about 0.3 (i.e., 30% of the precipitation that falls on the Seep 1 watershed passes through the weir), yet 1989 values are abnormally high, with some of the monthly values actually being over 1.0 (i.e., there was more flow during those months than would have occurred had all of the precipitation falling on the watershed passed through the weir).
- Precipitation during 1989 was relatively normal, even a bit low, so that, unless the effective Seep 1 watershed area was somehow altered, no large surge of precipitation accounts for the abnormally high flow observed for this year.

Treatment Areas

A limestone pretreatment area was constructed during August 4-11, 1992. From this point on, the site referred to in NPDES reports as 043 refers to water samples collected after passing through the pretreatment area. Efforts to quantify flow from the seep itself (i.e., prior to entering the pretreatment area) have been unsuccessful due to the proximity of the pretreatment area to the stockpile toe, and to the relatively diffuse nature of this particular seep.

A wetland treatment area was constructed in 1995 (construction was completed in June). The outfall from this treatment system is now called 043-1.

Winter Flow

In the 1981 DNR report, it is stated that "spring runoff (of the seeps in general) was less than 20% of the total annual flow in 1979 and 1980, the only years for which complete annual records exist," with the value for 1980 being only 2 percent. It is also stated that "there was no flow during the winter."

References

Eger, P. Lapakko K., and Weir, A. 1981. The environmental leaching of stockpiles containing copper-nickel sulfide materials. Minnesota Department of Natural Resources, St. Paul, MN. 62 p.

Section A8.5

Residence Time Estimate, Seep 1 Pretreatment System

Assumptions: total area = 930 m^2
average water depth = 0.3 m

total volume = 279,000 Liters

peak daily flow on July 5, 1999 = 1000 L/min (265 gal/m)

residence ~ $\frac{\text{279,000 Liters}}{\text{1000 Liter /m}}$ ~ 5 hours

2 days later flow dropped to 132 L/min (35 gal/min)

Using the same assumptions: residence time = 35 hours

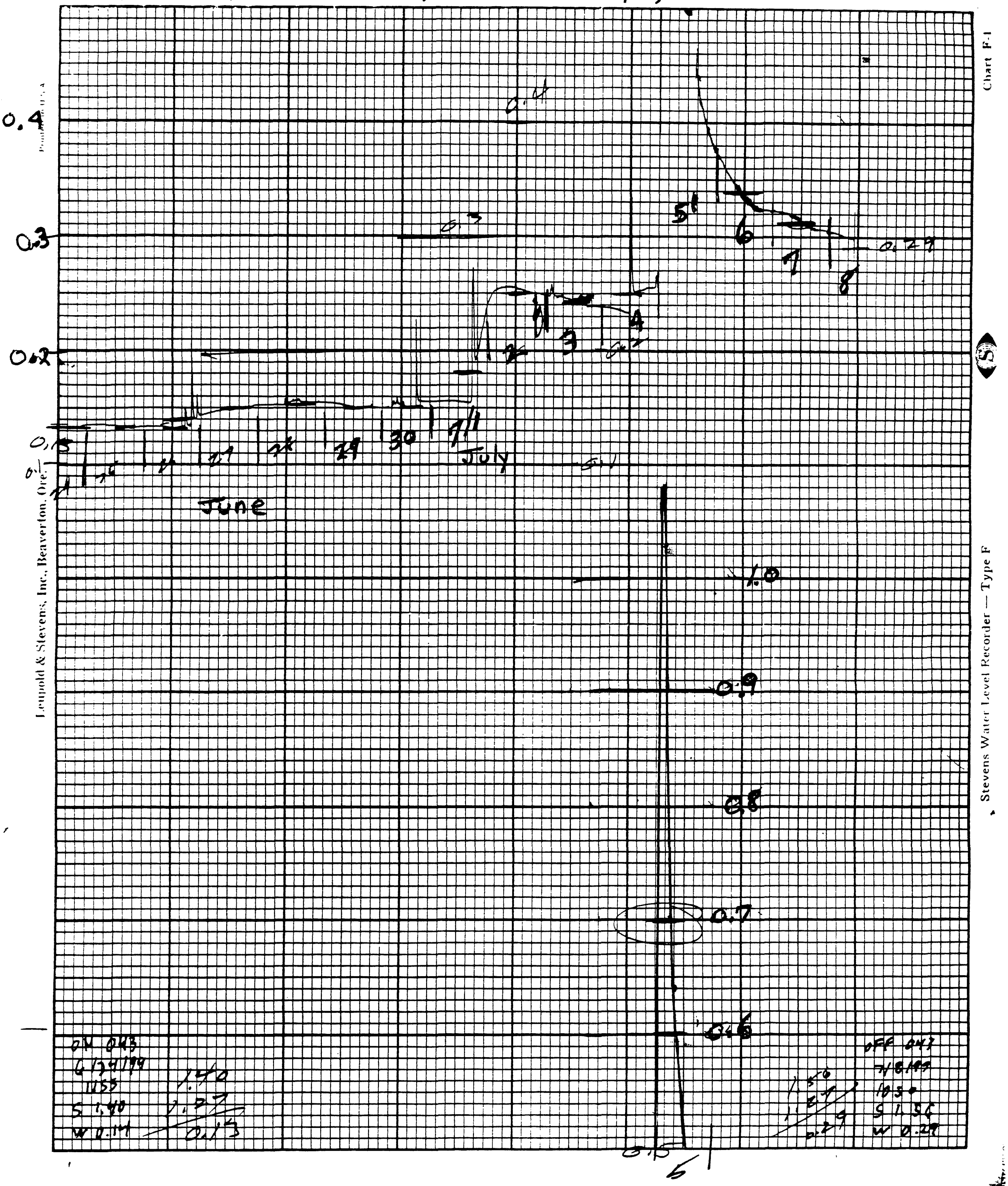
These numbers probably underestimate the total residence time during this period since the pond was flooded. The water depth was about one foot deeper, so the total volume in the pond increased and, therefore, the residence time would also increase.

The high water level prevented adequate contact between the input and the limestone.

Section A8.6
July 1999 Staff Gage Readings and Flow Calculations

In 1999, over the 4th of July rainfall, about 7 inches of rain fell. This section contains a copy of the water level vs time chart and the daily flows calculated by LTV. LTV calculates the flow from the water level with a standard weir equation.

Seep 1 Weir, OSS vs Time, June 24 - July 8, 1999



LTV Mining Company- Dunka

Wetland Flow Monitoring

Month of July, 1999

Location: 043 60 degree V-notch Weir

Date:	Head Feet	CFS	GPM	MGD
07/01/1999	0.18	0.0198	8.90	0.0128
07/02/1999	0.25	0.0451	20.24	0.0291
07/03/1999	0.24	0.0407	18.27	0.0263
07/04/1999	0.25	0.0451	20.24	0.0291
07/05/1999	0.70	0.5916	265.50	0.3823
07/06/1999	0.34	0.0973	43.65	0.0629
07/07/1999	0.31	0.0772	34.65	0.0499
07/08/1999	0.29	0.0654	29.33	0.0422
07/09/1999	0.29	0.0654	29.33	0.0422
07/10/1999	0.28	0.0599	26.87	0.0387
07/11/1999	0.26	0.0497	22.32	0.0321
07/12/1999	0.24	0.0407	18.27	0.0263
07/13/1999	0.23	0.0366	16.43	0.0237
07/14/1999	0.22	0.0328	14.70	0.0212
07/15/1999	0.21	0.0292	13.09	0.0188
07/16/1999	0.23	0.0366	16.43	0.0237
07/17/1999	0.23	0.0366	16.43	0.0237
07/18/1999	0.22	0.0328	14.70	0.0212
07/19/1999	0.20	0.0258	11.58	0.0167
07/20/1999	0.19	0.0227	10.19	0.0147
07/21/1999	0.18	0.0198	8.90	0.0128
07/22/1999	0.17	0.0172	7.72	0.0111
07/23/1999	0.17	0.0172	7.72	0.0111
07/24/1999	0.17	0.0172	7.72	0.0111
07/25/1999	0.16	0.0148	6.63	0.0095
07/26/1999	0.16	0.0148	6.63	0.0095
07/27/1999	0.15	0.0126	5.64	0.0081
07/28/1999	0.15	0.0126	5.64	0.0081
07/29/1999	0.14	0.0106	4.75	0.0068
07/30/1999	0.14	0.0106	4.75	0.0068
07/31/1999	0.13	0.0088	3.95	0.0057
Total				1.04
Average			23.26	0.0335

Appendix 9

Section A9.l

Site Visit by Paul Eger, W1D Wetland and Seep 1 pretreatment system, August 2, 1994

W1D Wetland

I visited the W1D treatment system with Gene Halberg, from LTV, and we first went to the section of the treatment system where they have installed hay bales. They have placed hay bales on two of the berms below the large berm that was built in 1993 to reduce the gradient in the first half of the cell. Three inches of hay were placed on the center of the berm, and then the bales were placed on top of that hay. The first layer of hay was placed to avoid erosion of the material. The bales were placed about one foot apart. There are three rows of hay over one foot apart, and the spacing between each bale is about 6-8 inches. The bales were just placed; they were not staked. They are starting to collapse now, as they absorb water. 'The space between seems a little bit less as the bales start to collapse and fill in the gap. On the first berm, the berm closest to the input, there are three rows of hay bales. Now this was a berm where the water was channelized last year on the far east end, and fairly discrete channel. The hay bales have seemed to spread the water over about one-third of the berm and have dammed water up behind the hay bales. There is a whitish precipitate being produced as the water flows through the hay bales, and there is a strong odor of H_2S in this area. Gene said that after the large rain storms in June, the flow was high. The water actually came over the bales. Gene believes that the bales tended to reduce the erosion in the area, and they have not had to repair the berms this year, since the hay was put in.

In the second, or the next berm where hay bales are placed, there are five hay bales placed the same way as in the first area. They start in on the berm with the five rows. That berm was a little wider with less vegetation. They used all the hay bales. They put in about 300 hay bales in the total system, so there are two berms of hay bales. The pool below the hay bales is quite turbid. What we need to do is take some pH in the areas of precipitation and take a sample of the precipitate and analyze it to see if there are any metals associated with that, or if it is strictly an organic precipitate.

I talked to Gene about their sampling program. They are still running a profile on this site, but they have changed their sampling program of the year. In the first year of operation, which would have been in 1992, a profile sample is taken where the flow is going over the berms. In 1993 it was a mixture of sampling of a flow over the berms and also in the pools. Gene said they would have taken some samples across the width of the pool at three different locations and not found much difference. So, this year they are strictly sampling the pools of water. They are trying to alternate sides of the pool they are sampling on. So, if they sample the east side of berms 3 and 4, then they will sample the left sides of the pool between berms 4 and 5 stagger that as they go through the system to do the profile.

Gene also mentioned that they looked at total versus filtered nickel and didn't see much difference in the samples. The hay bales have been in about six weeks, and there seems to have been an improved performance of the W1D system. In the last four or five cells in 1993 the nickel concentration did not drop from the large glacial till berm to the outlet weir. It was thought that this was due to the channelization of flow that occurred in that portion of the system. The hydraulic gradient is fairly steep in this area, and as a result of high flows, channels developed. The flow went down the east side of the system in 1993 with minimal amount of contact. I suggested that this year they raise the berm prior to the weir, which would lower the hydraulic gradient and install hay bales. LTV did not raise the berm but they have installed hay bales. I have not talked to Dennis Koschak. My guess is that he may not have wanted to raise the berm because vegetation is finally getting established. The northern portion of the system has extremely dense vegetation. This is the area above, north of the large berm with the three pipes that control the water flow from that berm. The cattails are starting to develop seed heads this year, and the vegetation seems to be helping in dispersing flow. Since the hay has been put in, the concentration drops by about 50% as it moves through the hay bales. But there is a very, very large drop in the very last cell, right prior to the weir. [This could be due to the sample location (although nickel does drop substantially at weir).]

We took a look at the pool above the limestone weir, and the water is very turbid, a muddy, brown color. As we stood there watching, we saw bubbles coming out from the bottom of the pond, apparently bringing sediment up with the bubble. This last cell seems to be a little larger than some of the other cells. We do not know what its depth is and about 6-7 bales of hay was added to this last cell. Hay bales were taken to the area; about two inches was peeled off and just flung into the pond. This hay drifted around for a while but then sunk. There seems to be a lot of biological activity in the cell, and it's possible that this is accounting for the large drop in concentration. Concentrations have gone from around .5 mg/L coming in to about 0.8 mg/L as it exists the system.

Now the flow today was very low. We estimated the flow was 20 gallons/min. The water prior to reaching the outlet weir flows through a stand of vegetation. At this flow rate the vegetation seems to be very successful in taking out the turbidity, and the water coming out was quite clear.

We talked a little about the pumping that has been going on at the site. The pump that comes form the input weir, the W1D site, can only pump 28 gallons/min. The bucket engaged to find the pumping rate, and then they record the one and off time, since that pump is turned on and off manually. To find the total, we multiplied 28 times the number of minutes that the system operated.

Gene provided sine data on the most recent sampling through the wetland. There is a very large drop in the concentration in the northern part of the system in the upper parts of the wetland, the nickel concentration drops from about 4.5 to 1.6 mg/L. It is not quite clear why this occurs, although the vegetation is very dense in that area, and at these low flows, it seems like it's a very good distribution or could be a very good distribution of flow in this area.

Two photos were taken of the system. One was taken facing south showing where the hay bales were placed at the outlet weir, standing at the big glacial till berm, while one was taken facing north of the stockpile showing the dense vegetation, and the other was taken south. Additional work needs to be done to investigate the zones of nickel removal, particularly what is occurring in the last pond. It could be that sine there is organic material place din the bottom of the pond, and there is organic material and nutrients being washed out of the hay above that pond. We have created a situation where we get a lot of biological activity, and this is what is responsible for the nickel removal.

Seep 1

Gene gave me some data from the most recent profile that was done in Seep 1. The Seep 1 inflows are the same points that LTV measured last year. They have not incorporated our points into their monitoring program. The limestone in some of the berms appears to have subsided or settled. Last year the limestone was all above water. This year there are several areas where there is limestone below the water. There potentially seems to be less contact between the water and limestone, if the water is actually short circuiting coming through those subsided areas. Above 5-6 bales of hay were added in a manner similar to the last pool at W1D, so the hay was just peeled off and thrown into the last section of the seep treatment area. What it looked like was that all that hay has just floated to the front of the piled cell and have piled up along the berm. In order to get some additional sulfate reduction, we need to have the water flowing through the hay. I suggested to Gene we take the first part of the cell and stack hay bales, almost making it like a walking surface of hay bales in that first portion. That would hopefully give us more contact in the hay and give us more material, increase the reactions that are occurring in the system. The pH at the weir was 6.4, so it has dropped substantially and the nickel is about 8 or 9 mg/L. It seems like we are having less treatment efficiency than in previous years. There is a fair amount of precipitate in the Seep 1 area on the south side, kind of a milky precipitate, similar to what has been observed at that site in previously. Some of the limestone is being coated with this precipitate. In one area the limestone upstream has this whitish precipitate and then downstream has just a brown organic precipitate, possibly some kind of attached algae growing on the limestone. I picked up some rocks and it did not seem like this material was totally coating the limestone surface. So, there should be some availability of the surface.

Section A9.2
Notes From 10/5/95 Survey of the W1D Wetland Treatment System

On 10/5/95, Glenn Melchert and Jon Wagner surveyed the upper portion of the W1D system (i.e. that portion of the system between the culvert and the glacial till berm). The weather was cool and overcast, with some drizzle and air temperatures of about 45° F. The 050 staff gage read 4.40', with about 6" of flow in the weir.

The riprap berm just downstream of the culvert is designated in this report as Berm 1. The next three berms, which are all upstream of the glacial till berm, are designated as Berms 2-4, with Berm 4 being the berm just upstream of the glacial till berm.

Rebar stakes were placed at the (stockpile) end of each of the four berms, and rebar stakes were also placed at the far ends of berms 2 and 3 (we only had six rebar stakes with us). These stakes were placed to provide a reference point from which to measure across the berm. Hopefully these stakes will remain visible when snow covers the wetland, so that peat samples can be collected from appropriate spots. Additional (lathe) stakes were placed at a few sites where it seems that we may want to collect peat samples; the location of these stakes are noted in Table 1.

After placing the rebar stakes, we stretched a 300-ft tape measure across the width of the berms, and noted the total width of each of the four berms. We then noted where flow seemed to be occurring with relation to each of the four berms, and where channelization was present. There had been significant rainfall prior to our visit so that flow was quite high, and it seems likely that the flow paths that we noted are where flow occurs at low flows as well.

We also investigated the water and peat depths at various distances (usually 5, 10 and 15 feet) both upstream and downstream of each berm; the results of these surveys are presented in Table 2. In general, the peat was quite thin on top of the berms (i.e., 1 to 4 inches), with peat depth increasing to depths of 2 or 3 feet on the sides of the berms. However, due to subsidence of the berms it was not always easy to determine where the tops of the berms were located.

Because the power auger that will be used to collect the peat cores in the winter can be easily damaged if it encounters non-peat material, care should be taken to ensure that peat depth at each sampling location is known prior to sample collection, so that we avoid damaging the auger. This will obviously be most important when sampling near the riprap berm.

It should be noted that the wetland seems to extend closer to the 8031 than is shown in the map prepared by LTV; it seemed to get to within about 20 feet of the stockpile toe, with standing water present in this area of the wetland. The following is a short description of what we observed at each of the four berms:

Berm 1 (the riprap berm)

The total width of the berm was 54.0 meters. The top of the riprap was almost entirely under 3 or 4 inches of water, with the exception of a small area in the center of the berm, where there was a rise that extended out of the water. Obviously no peat samples can be collected from the top of this berm.

Upstream of the berm there was a strip of peat about 10 feet wide; any peat samples collected upstream of the berm will be from this strip (i.e. far enough upstream so that rocks won't be encountered, but not so far up that the sample will come from an open water area). See Table 2 for details of where to collect peat samples.

On the upstream side of the berm, the major flow was between 19.0 and 21.0 meters, with the 21.0 to 26.0 interval pretty dry (due to a hummock). From 26.0 to 54.0 meters, most of the upstream area was largely flooded.

On the downstream side, flow was noted between 17.0 and 18.5 meters. We put a stake 10' downstream of the edge of the riprap (at 18.5 meters); peat at this spot was 18" deep. (The riprap is about 18 ft. wide at 18.5 meters.) The downstream side was pretty much dry between 20.5 and 26.0 meters. At 33.2 meters there was a noticeable channel about 10' downstream, with a large delta behind it. There were another two comparable channels at 42.0 and 45.7 meters (with a hummock separating these two channels).

Berm 2

The total width of the berm was 52.3 meters. We stretched the tape measure across the berm along the wooden plank that now serves as a walkway, but which was originally placed to even out the flow across the berm to lessen the likelihood of washouts of the berm. Upstream of this plank (and thus the tape measure), standing water was present across most of the width of the berm. But the downstream side was quite dry from 0.0 to about 20.0 meters, so that one could walk on this peat and not get your boots wet (and if this area was dry during a period of high flow, it certainly remains dry during lower-flow conditions). The plank was acting like a dam, with little visible flow being transmitted over/through the plank except near the far side (i.e. away from the stockpile).

Near the far side there were several obvious flow channels downstream, where it appeared that most of the standing water upstream of the plank was being routed. There was disperse flow between 37.2 and 48.2 meters, with a peak at 48.2 (and about 0.5 meters wide). There was also flow between 40.0 and 41.9 meters, with a peak in the 40.0 to 41.0 interval.

We placed lathe stakes at several sites in these channels that seem good candidates for peat samples; Table 1 identifies the location of these stakes.

Berm 3

Total length of the berm was 53.6 meters. On the line between the stakes, the peat is wet almost from the stockpile edge of the wetland. Flow starts at 3.9 m and continues to 6.2 m, with most between 4.3 and 4.7 m. (This is broad overland flow over the wooden planks.) In fact, the wooden planks again seem to be largely working as planned in this berm, with water damming up on the upstream side of the plank, and with flow fairly evenly distributed across the width of the plank. (Water was observed broadly spread both upstream and downstream of the planks in this area).

The other area where flow is noticeably going over the plank are between 42.3 and 48.3 meters (flow in this area was noticeably stronger than between 4.3 - 4.7 meters). Flow is coming over the plank pretty evenly over this stretch, but downstream the flow path channelizes and meanders; at 10' downstream, the area of most flow is between 44.5 and 46.8 m.

Berm 4

The total length of the berm was 46.6 meters. There was a bit of flow noticeable at 5.5 to 8.0 meters, with most of this at 6.0 meters. There is also minor overplank flow between 12.0 and 12.8 meters, with a white precipitate present on the peat at 12.1 meters. At both of these flows, flow paths are pretty much perpendicular to the berm.

The berm is pretty much dry between 12.8 and 22.3 meters. Flow is again noticeable from 22.3 meters to the (far) edge of the wetland, with three major areas of flow at 27.6, 40.5 and 45.0 meters; the strongest flow was at 27.6 (with rapid flow and a distinct channel), with the other two flows weaker and about 30 cm wide each.

Watershed determination:

An attempt was made to determine which of the surrounding area contributed to flow in the wetland. On the far side (away from the stockpiles), the surrounding ground rises pretty steeply to a broad crest, limiting the amount of contributing watershed area. However, water falling on the side of the ridge facing the wetland obviously enters the system; my estimation is that the width of this area, from wetland edge to halfway across the crest of the ridge, is about 20 feet.

On the side of the wetland facing the stockpile, a ridge exists on the wetland-side of the road which largely prevents flow from the road (and flow coming off the stockpile) from entering most of the wetland. This ridge extends down the length of the wetland until the last cell (just upstream of the original output weir), where it ends. It appears that, in this last cell, flow from the surrounding area is able to enter the system. It was our thought that it may be possible to extend the ridge by 20 feet or so, so that the final cell is isolated from this surface flow. (It would likely require only a few dumptruck loads to accomplish this.)

As we have noticed before, outflow tends to be more than inflow during precipitation events. Partly this is due to rain falling directly on the wetland, but it is also likely due to water entering the last cell from the road/stockpile areas. By preventing this source of (uncounted) input water, and the dilution of the input water that results from it, it would be possible to get a better handle on how the wetland system is actually performing.

At the top end of the wetland, it was apparent that some of the rain that falls on the road area enters the system; Figure 1 identifies the approximate contributing watershed area.

Table 1. Location of lathe stakes that designate potential peat collection sites.

Stake #	Berm	Location along the width of the berm (meters)	Feet upstream of the berm	Feet downstream of the berm
1	2	39.8	~ 0 (in flow channel)	--
2	2	48.2	"	--
3	2	48.0	--	15
4	4	11.6	7	--

Table 2. Peat/water depths near the first four berms of the W1D treatment system.

Berm No.	Distance from the stockpile side of the wetland (meters)	Distance (ft.) upstream [1]	Distance (ft.) downstream [1]	Water depth (in.)	Peat depth (in.)	Comments
1	20.5	10 15	-- --	4 12	2 3	In major flow channel
1	34.0	10 15	-- --	5 5	17 19	In flooded area
1	44.7	-- -- --	10 15 20	1 1 NA	7 24 NA	At this location, riprap extends 7' downstream. A stump was hit 1 ft. deep at 20' downstream
2	16.0	5 -- --	-- 5 10	3 dry dry	30 18 18	Water too deep to go more than 5' upstream
2	33.0	5 -- -- -- --	-- 5 10 15 20	14 dry dry dry 0.5	8 12 15 30 18	Water too deep to go more than 5' upstream
2	39.8	5 -- --	-- 5 10	14 1 1	6 8 20	In flow channel. Water too deep to go 10' up

Berm No.	Distance from the stockpile side of the wetland (meters)	Distance (ft.) upstream [1]	Distance (ft.) downstream [1]	Water depth (in.)	Peat depth (in.)	Comments
2	48.0	5 -- -- --	-- 5 10 15	12 1 4 2	5 8 24 24	In flow channel. Water too deep to go 10' up
3	4.5	0 8 -- --	0 -- 5 10	2 NA NA NA	4 24 5 24	In flow path
3	23.3	5 10 -- --	-- -- 5 10	NA 8 NA 6	1 14 12 24	In flow path
3	44.5	5 10 --	-- -- 5	4 12 6	8 12 18	This is the major flow path of this berm. The peat at 10' up felt gravelly. At 10' down, water is too deep to sample.
4	6.0	5 -- -- -- --	-- 5 10 15 20	1 1 1 2 2	26 2 2 8 8	In flow path.

Table 2. Peat/water depths near the first four berms of the W1D treatment system (continued).

Berm #	Distance from the stockpile side of the wetland (meters)	Distance (ft.) upstream	Distance (ft.) downstream	Water depth (in.)	Peat depth (in.)	Comments
4	12.0	5 10 --	-- -- 5	1 dry 3	48 44 33	
4	25.0	5 10 -- -- -- --	-- -- 5 10 15 20	2 4 2 2 2 4	42 39 1 2 10 36	Lots of flow seen here; meanders downstream.
4	34.0	5 10 -- -- -- --	-- -- 5 10 15 20	4 4 2 4 8 4	24 24 8 2 4 16	This location was chosen arbitrarily. Some rocks were felt in the upstream peat.

Notes: Berm 1 is the riprap berm just downstream from the culvert, and Berm 4 is the Berm just upstream of the glacial till berm. All upstream/downstream distances are measured from a line drawn between the stakes that mark the ends of the berms (usually rebar). The center of the berm is estimated by the crest of the berm. For berms with 4 x 4's, the center corresponds to the location of the 4 x 4.

Table 3. Locations of wells.

Berm	Meters from stockpile side	Feet upstream	Feet downstream
1	24.5	10	--
2	14.9	2	--
2	40.7	2	--
3	23.3	2	--
3	44.5	2	--
4	35.6	--	7

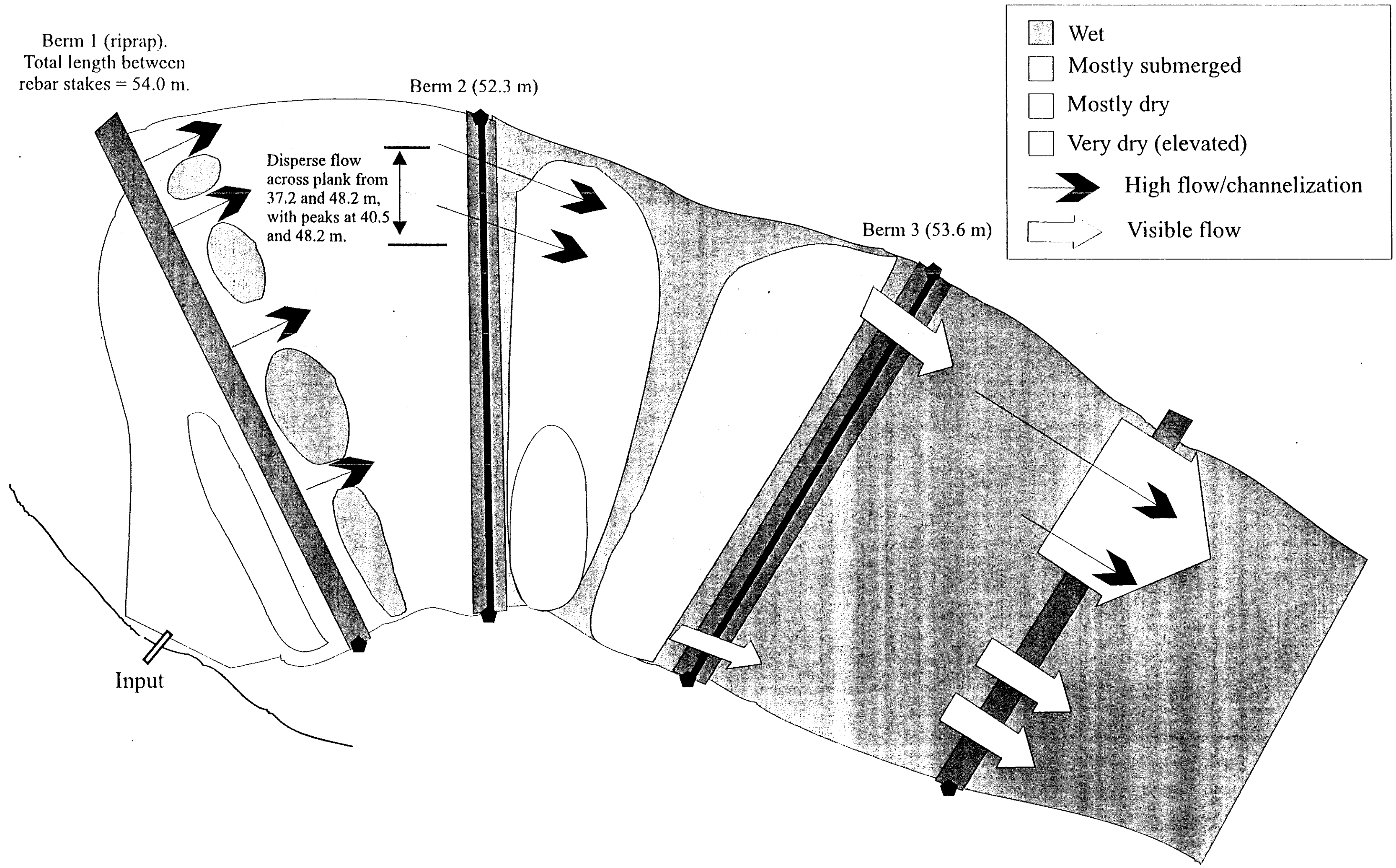


Figure A9.1. W1D wetland treatment system; flow patterns observed on 10/5/95.

Section A9.3
Comments on Seep 1 - Peat/Limestone Treatment System

1. Construction began on Tuesday, August 4, 1992. Construction was completed on Tuesday, August 11, 1992.

2. Construction details:

    a) Limestone berm crests will be one ft. above weir.
    b) Peat height will not be even with the weir (one ft. below limestone crest).
    Note: peat was actually placed at two levels. Peat near the limestone was placed approximately even with the weir, but midway between the limestone berms, the peat was 6-12 inches lower. These peat trenches were typically 3-6 ft. wide.
    c) The area was excavated to approximately 2 ft. below the weir, which amounted to approximately 3-4 ft. excavated near the stockpile.
    d) The outermost limestone "ring" functions as a riprap zone to stabilized the mineral soils. There is no ponding upgradient of this ring. This limestone riprap does not extend above original grade and much of it is about 1 ft. below grade.
    Note: probably all of the seeps here emerge from the boundary between the organic/humic surface layer (up to one ft. thick) and the underlying mineral soils.
    e) The outer ring was completed first, then the inner rings, and finally the limestone underdrain/berm. The backhoe was perched on an unexcavated peninsula near the center of the site to dig and place the outer limestone. The backhoe gradually moved back as the inner rings were excavated and completed. This was preferable over excavating the entire area first and then trying to place the peat and limestone from an operational standpoint, according to Don Markwardt.
    f) The limestone apron and drain is 1 ft. thick. The top of the apron is about 1 ft. below the weir.

3. The only bedrock encountered was the bedrock ridge just upstream of the weir.

4. There was quite a bit of silty to sandy till mixed with the limestone in many places, especially in the two outermost limestone rings. This was because LTV was low on limestone and in order to get as much limestone as possible soil was incorporated in the loads. Limestone at the weir pool and the apron and underdrain was from a new shipment and it appeared relatively free of soil.

5. The limestone was on the order of 4-6 inches in diameter and subrounded. Eighty to ninety percent of the surface of each limestone rock was coated with a limestone powder layer. The coating looked like powdered sugar and was quite thin.

6. The final berm (with the underdrain) is covered with riprap (not limestone). This riprap was placed after the limestone and peat on either side, so there is not a concern for short-circuiting here. The core of the final berm is material that was excavated from the site. It was a clay silt.

7. Peat overlying the limestone apron is 12-16 inches thick.

8. All the peat used consisted of two parts screenings to one part Area 5.

9. The invert of the bypass pipe is two feet above the peat.

10. The working length (normal to flow direction) of the final berm underdrain is 11 ft. maximum. This was controlled by bedrock. The working width (parallel to flow direction) was 17-18 ft. The limestone apron was roughly 20 ft. x 24 ft. The size of the pool between the final berm and the weir had maximum dimensions of 18 ft. by 27 ft. The bottom of this pool was filled with limestone.

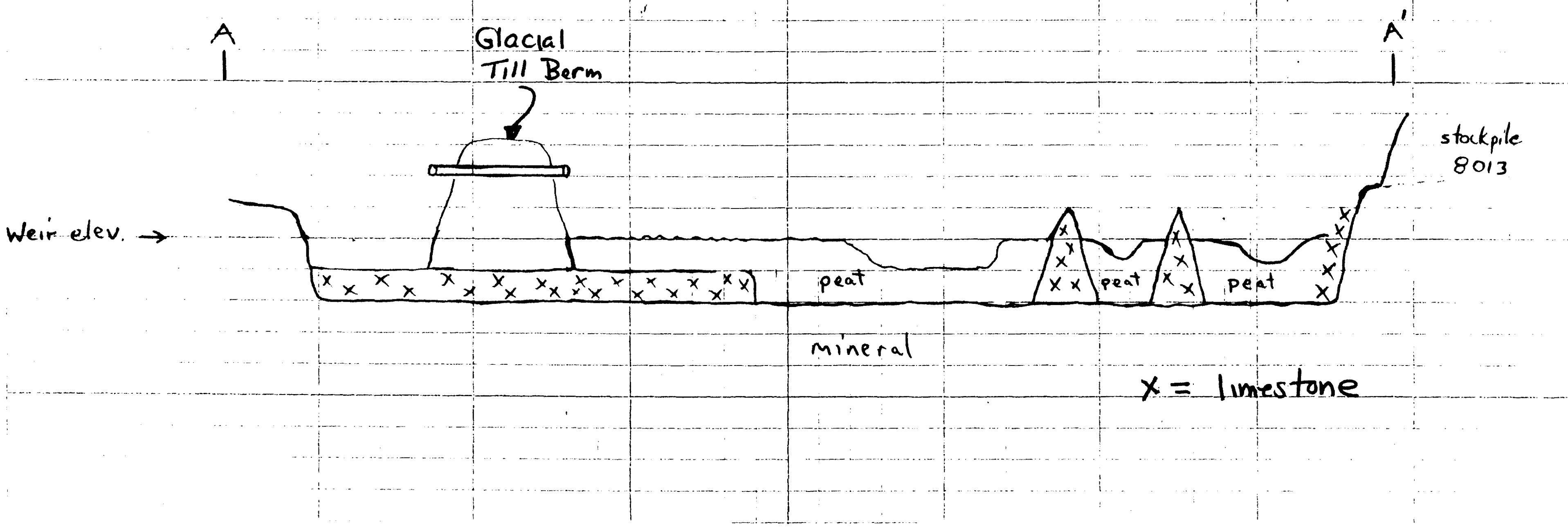
11. The limestone berms are quite small. They are teepee shaped in cross section.

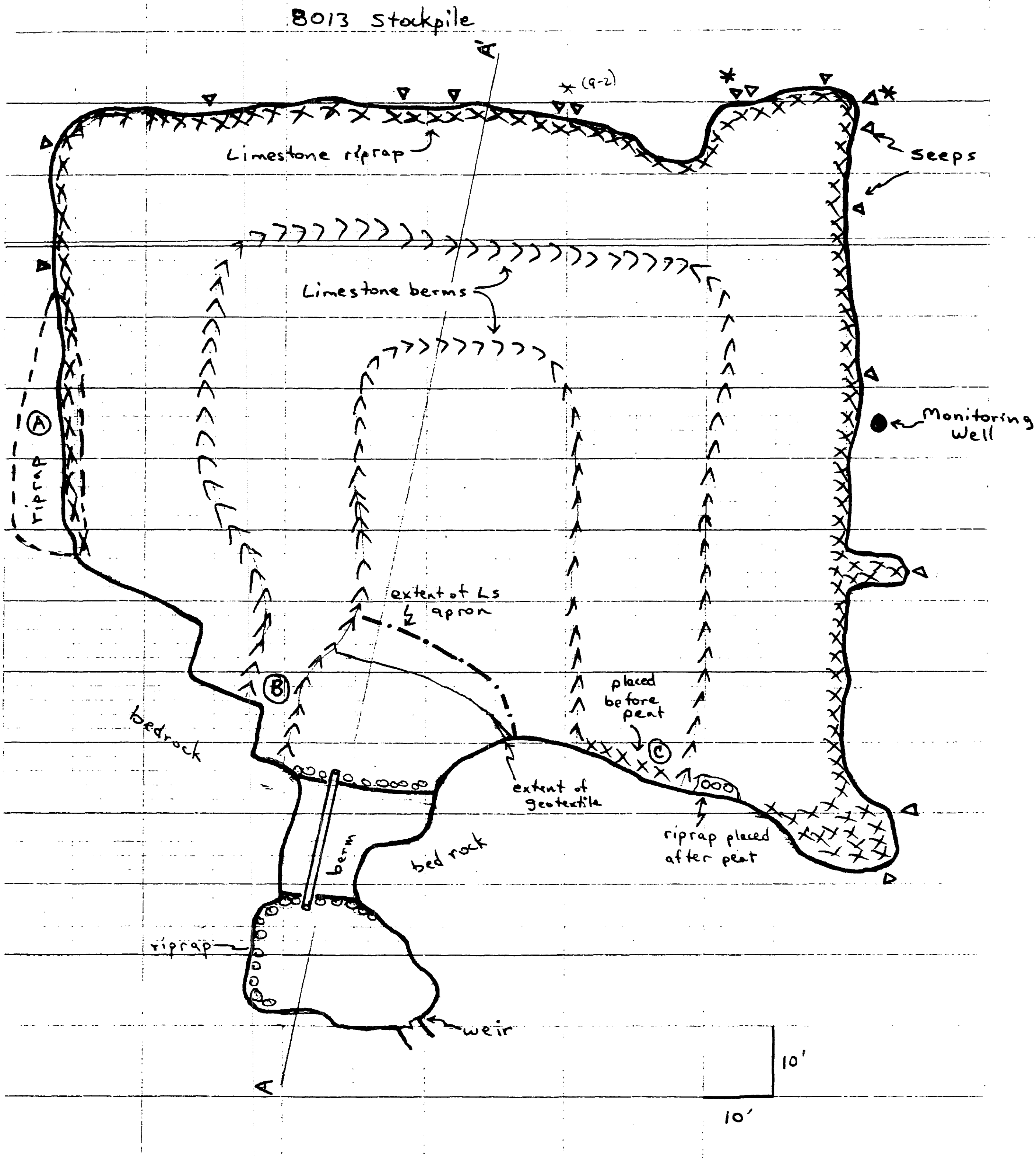
12. See attached figure:

    a) The perimeter of the excavation upstream of the final berm was scaled out, as well as the steep locations. Critical dimensions of the final berm and the limestone apron were also scaled out.
    b) The riprap at the far left (A) was placed after the limestone and peat. The riprap was placed to stabilize the area which was along side the 24 inch culvert from the capping project. There probably are seeps under this riprap.
    c) Seeps observed at 1300 on August 11, 1992 are noted with triangles. Significant rainfall occurred at about 0700 on August 11. The most significant seeps (.5 to 1.0 gpm est) are designated with triangles and *. All the other seeps were primarily wet areas. Except for area A, nearly all of the seeps were found and located.
    d) Site B is an area where the two limestone berms could be interconnected. Limestone does extend between the two berms, probably because they are so close together, but I could not determine how thick the limestone connection might be. This site was covered with peat.
    e) Site C apparently was placed as riprap to stabilize the bank. This material was placed before the peat and may provide for short-circuiting.
    f) Riprap (not limestone) on and around the final berm was placed after the peat was placed.

Seep 1 Cross Section A–A'

8/92



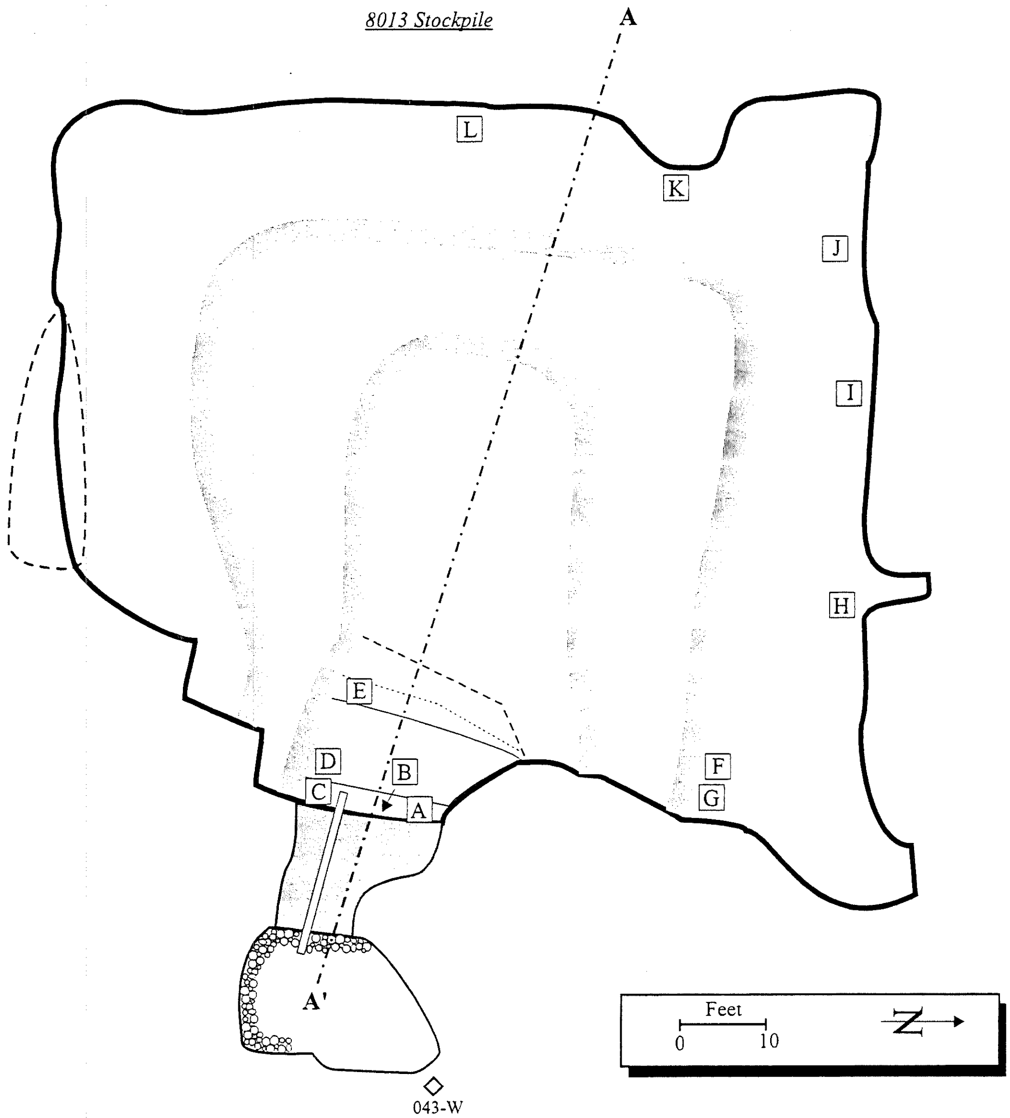

8013 Stockpile
A'
(9-2)
Limestone riprap
seeps
Limestone berms
A
riprap
Monitoring Well
extent of Ls apron
B
placed before peat
C
bedrock
extent of geotextile
berm
bed rock
riprap placed after peat
riprap
weir
A
10'
10'

SEEP 1 (8/11/92)

Section A9.4

Survey of Seep 1 Pretreatment System, July, September 1997

Additional samples were collected from the Seep 1 pretreatment system to determine if concentrations were uniform with depth. Since the seeps are cold (<40° F) and specific conductance is high, it was possible that the seeps would enter the pool and flow to the bottom due to their higher density. Samples were collected at several locations throughout the system. Surface samples were collected about one inch below the surface and bottom samples were collected about one inch above the bottom. The largest difference between surface and bottom concentrations occurred in the outer pool near the toe of the stockpile (Figure A9.1). Difference in water quality decreased as water moved through the system (Tables A9.1 and A9.2).



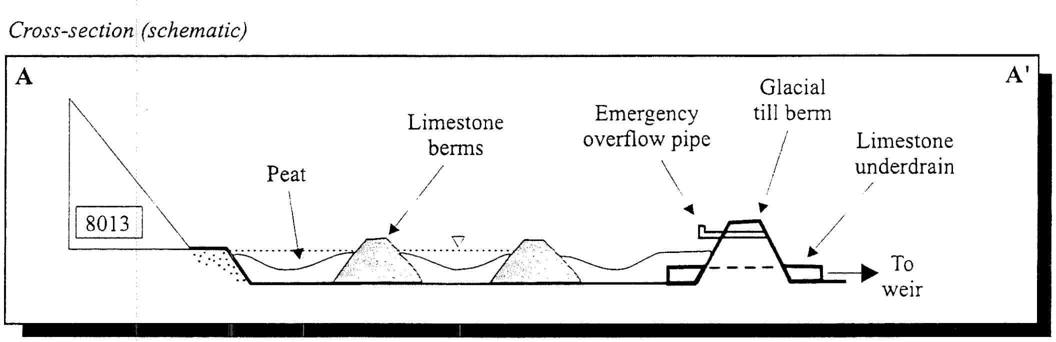
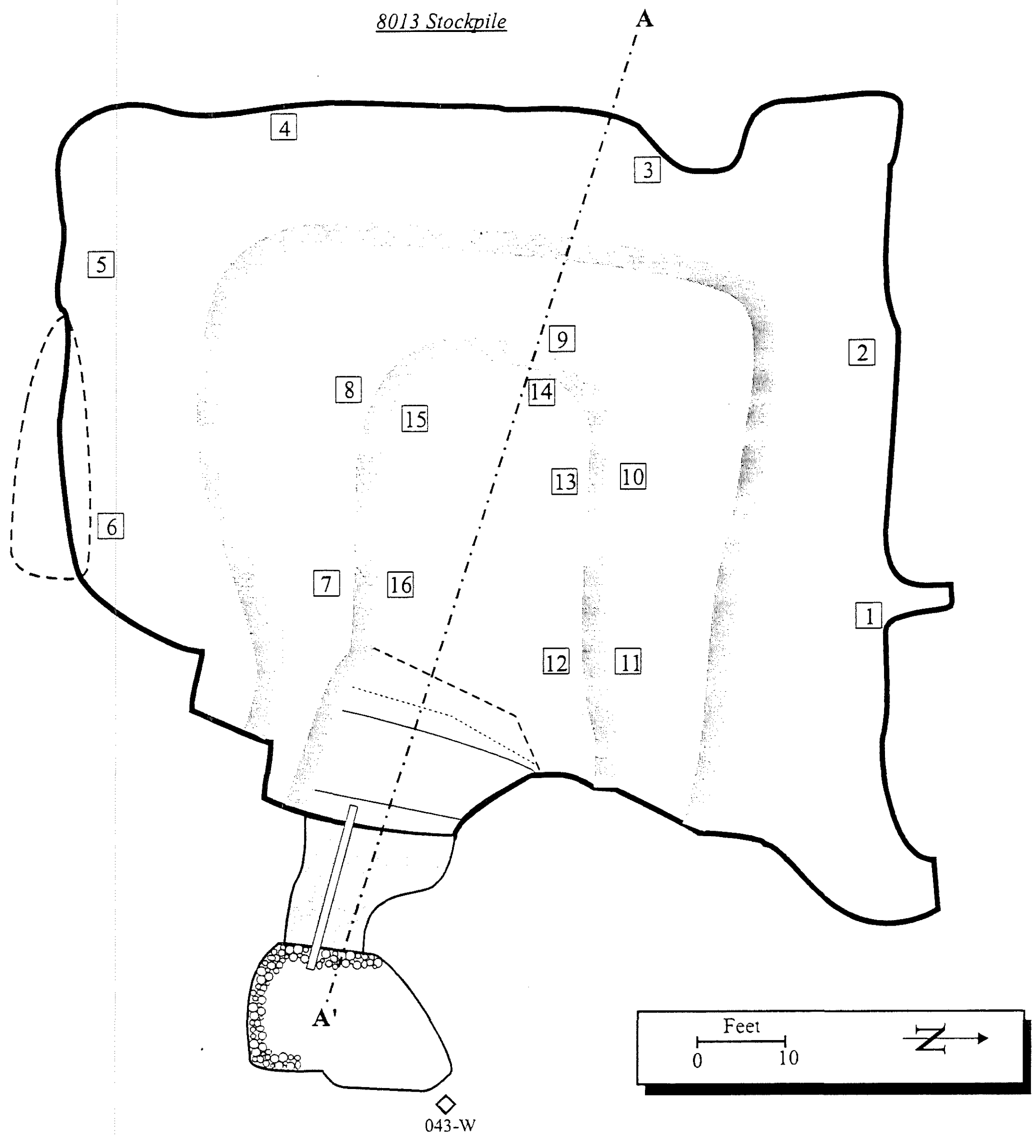


Figure A9.2. Seep 1 pretreatment system, locations of sample sites, 7-24-97.

Table A9.1. Water quality data, Seep 1 pretreatment system, 7-24-97.

Site	Location	Depth	Co (ppm)	Cu (ppm)	Ni (ppm)	Zn (ppm)
L	~ 3 feet from edge of pond	Surface	1.60	3.40	24.00	2.12
K	~ 3 feet from edge of pond	Surface	0.70	1.10	13.90	1.64
K	~ 3 feet from edge of pond	Bottom	1.70	3.60	24.50	2.56
J	~ 3 feet from edge of pond	Surface	0.40	0.70	10.90	1.27
I	~ 3 feet from edge of pond	Surface	0.60	1.10	13.60	1.63
I	~ 3 feet from edge of pond	Deep	1.20	2.40	14.90	2.53
H	~ 3 feet from edge of pond	Surface	1.10	2.10	19.10	2.39
G	At first limestone berm, accumulation of white precipitate	Bottom	1.20	2.20	19.60	2.45
F	At first limestone berm, accumulation of white precipitate	Surface	1.00	1.80	17.20	2.23
E	At upstream edge of hay bates	Surface	0.40	0.50	14.50	1.54
D	~ 2 feet toward pool from site C, visible flow	Surface	0.40	0.30	13.10	1.20
C	Upstream of outlet berm, south side	Surface	0.40	0.50	14.60	1.44
B	Upstream of outlet berm, middle	Surface				
A	Upstream of outlet berm, north side	Surface	0.40	0.40	14.50	1.40

For site locations, see Figures A9.2 and A9.3.



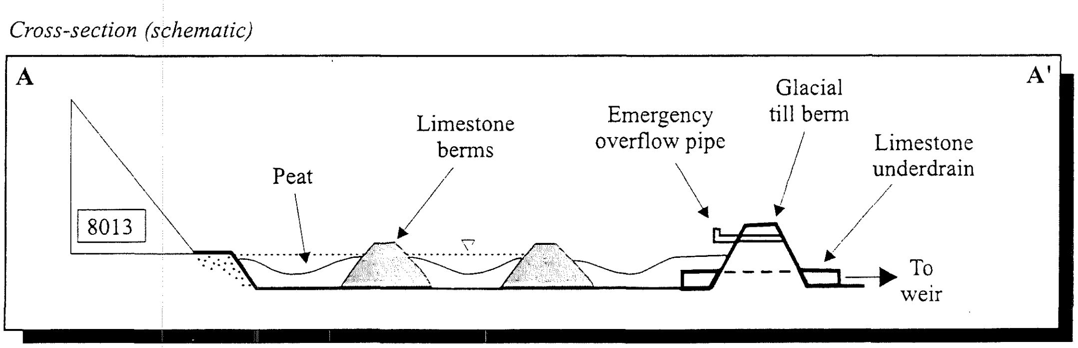


Figure A9.3. Seep 1 pretreatment system, locations of sample sites, 9-4-97.

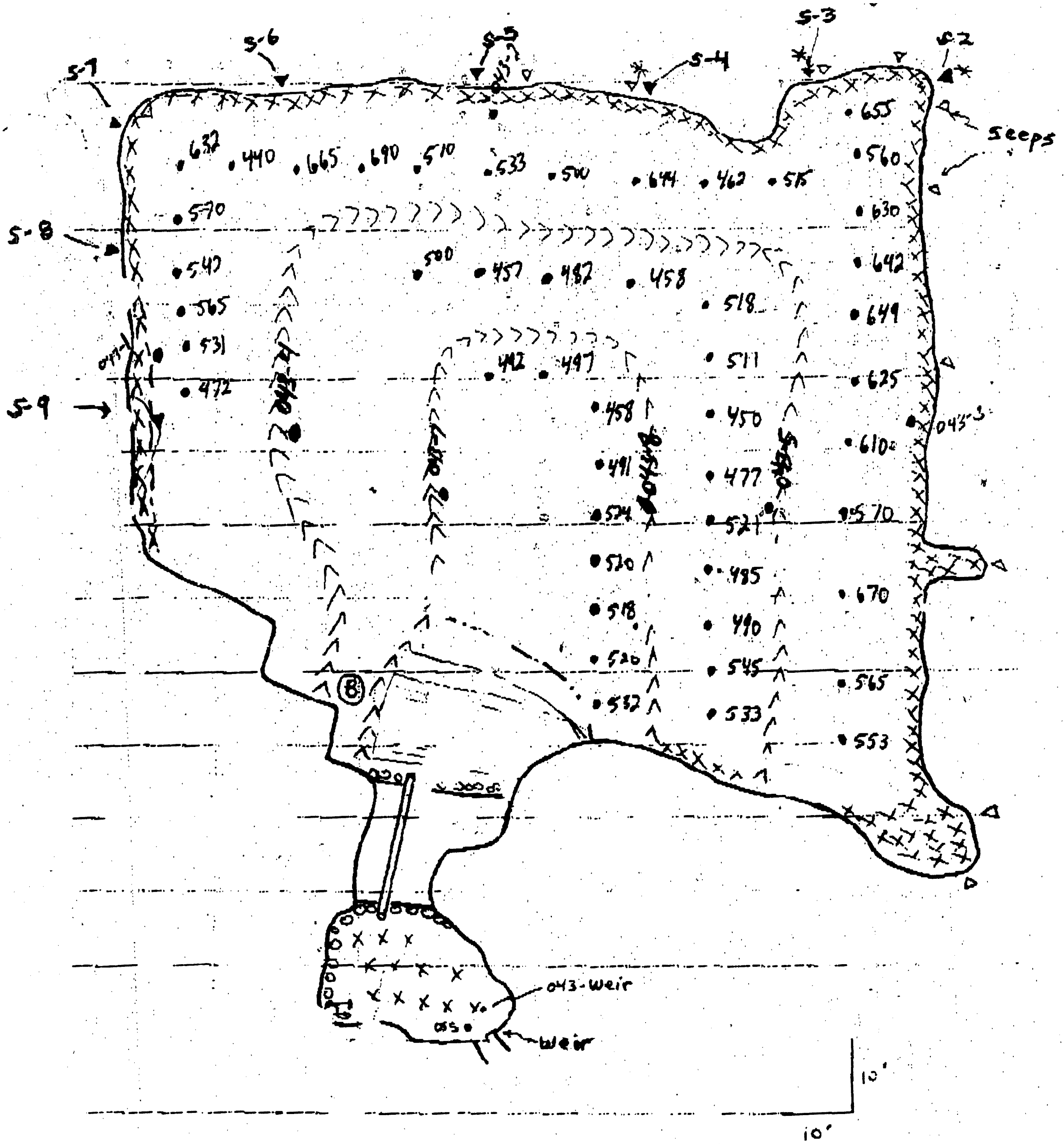
Table A9.2. Water quality data, Seep 1 pretreatment system, 9/4/97.

Site	Location	Depth	Specific Conductance (microsiemens)	pH
1	outer pool	surface	2150	6.04
1a	outer pool	bottom	2450	5.63
2	outer pool	surface	2290	6.01
2a	outer pool	bottom	2490	5.87
3	outer pool	surface	2010	6.33
3a	outer pool	bottom	2575	6.26
4	outer pool	surface	2100	6.88
4a	outer pool	bottom	2400	6.18
5	outer pool	surface	2250	6.67
5a	outer pool	bottom	2410	6.65
6	outer pool	surface	2250	6.50
6a	outer pool	bottom	2500	6.26
7	middle pool	surface	2250	6.74
7a	middle pool	bottom	2150	7.2
8	middle pool	surface	2150	7.19
8a	middle pool	bottom	2150	7.30
9	middle pool	surface	2100	7.38
9a	middle pool	bottom	2100	7.39
10	middle pool	surface	2250	7.29
10a	middle pool	bottom	2150	7.30
11	middle pool	surface	2250	7.32
11a	middle pool	bottom	2200	7.38

Section A9.5

Specific Conductance Survey, October 1997

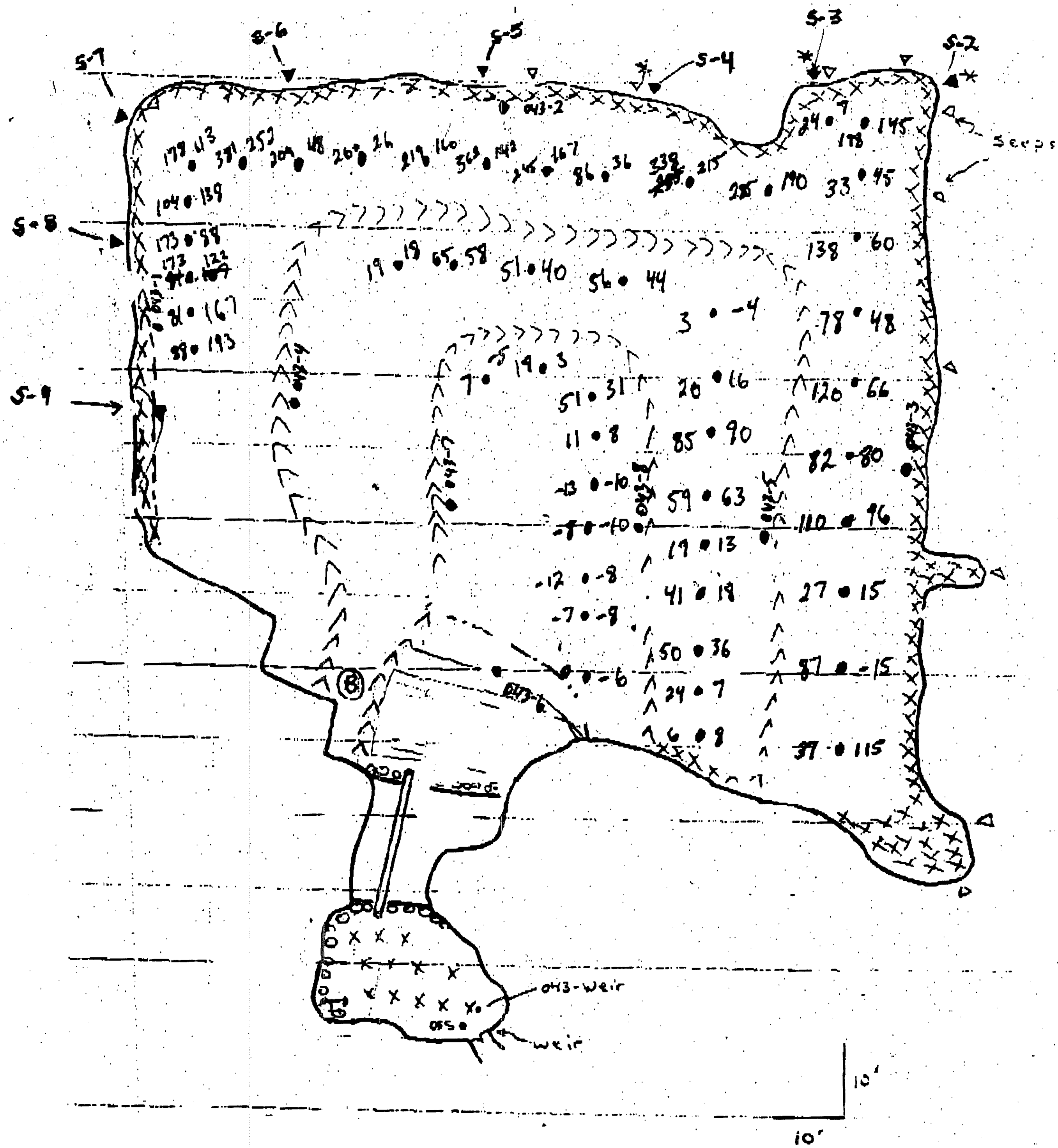
On October 1, 1997, a detailed specific conductance survey was conducted. The relative surface values are presented in Figure A9.4. To get the actual field readings add 1000 to the values shown in the figure. The relative readings for the middle and bottom are shown in Figure A9.5. To get the field reading the surface value at that location must be added to the values in the figure. These readings were most likely made with a YSI conductance meter, and have not been corrected for temperature. They provide relative comparisons, but are not true values.



Notes: (1) Add 1000 to all values; (2) Sample points are approximately 3 steps apart ~ 7 ft.; and (3) slight trickle from S-2 ~ 10 ml/min; all other seeps were dry or slightly damp.

* = substantial seeps	∇ = seep	▼ = monitored seep	x = limestone riprap	○ = local riprap

Figure A9.4. Specific conductance, surface samples, Seep 1 pretreatment system, 10/1/97



Notes: (1) Middle level is on right of sample point, bottom is on left of sample point; (2) surface value was subtracted from middle & bottom values; (3) measurement was taken 1" from bottom.

* = substantial seeps	∇ = seep	∇ = monitored seep	x = limestone riprap	○ = local riprap

Figure A9.5. Specific conductance, middle and bottom samples, 10/1/97.

Appendix 10

Analysis of Precipitate Collected From Seep 1 Pretreatment System

MIDLAND RESEARCH CENTER

A WHOLLY OWNED SUBSIDIARY OF MIDLAND STANDARD INCORPORATED
POST OFFICE BOS 67
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PHONE (218) 885-1951
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April 28, 1998

Mr. Paul Eger
MnDNR-Division of Minerals
500 Lafayette Road
St. Paul, MN 55155-4045

RE: Report on DNR Sample 11066
(Seep; 1 PPT; 10-28-97)

X-ray Diffraction (XRD)

A small portion of the solids were removed from the sample container, filtered, and allowed to dry. A portion of this was placed on a glass slide and an X-ray Diffraction (XRD) pattern was run to identify mineralogy. No heating or other drying of the sample was done before the XRD pattern.

The pattern had few peaks, making identification somewhat uncertain. The pattern in general was broadly domed indicating that much of the phases present were poorly crystalline or amorphous and consequently not identifiable with XRD. A second run was done after drying at 100°C for several days. The peaks were sharpened a bit with several new peaks.

The probable phases are two (or more?) hydrated iron sulfates. These have the following formulas.

Iron sulfate hydrate (XRD 21-930) $Fe_{14}S_{18}O_{75}.nH_2O$ (predominant)

Iron sulfate hydroxide hydrate (XRD 16-935) $Fe(OH)SO_4.5H_2O$

The second phase is also known as fibroferrite.

The second XRD pattern indicates a small amount of probable 10 angstrom sheet silicates/clays. The iron sulfates above are not major components. Clays and aluminosilicates are the probable primary phases. The material has a very low density.

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ST. PAUL

Chemistry Analyses

Chemex Labs, Inc. performed whole rock and trace element analyses (see results). After a long process of filtering and drying about 3/4 of the entire sample, only seven grams of material was produced. After consultation with chemex, they believed that enough material was available to do most, if not all, requested analyses.

The sample contained 2.36% sulfur, and about .05% inorganic C (presumably as CO_2). The sample contained predominantly Al_2O_3 and H_2O. There was 20.95% SiO_2 compared with 36.68% Al_2O_3.

Of the major cations, it contained the most iron (1.85% Fe_2O_3). The sample contained 9.15% moisture (loosely held), with 19.85% water of crystallization.

With regard to other elements of interest, the sample contained anomalous Cu (5400 ppm), Ni (1280 ppm), Zn (440 ppm), U (28.5 ppm), and the rare earths.

Discussion

The chemistry and XRD agree pretty well. There is an excess of alumina. The most aluminous clays, if they contain all the silica, would still leave some alumina left, probably as hydrous aluminum oxide gels. Since the 10 angstrom clay peak is so weak, probably most everything is in the form of hydrous, poorly crystalline gels. The iron sulfates appear to be the most "crystalline" substances. Such gels are probably good candidates for adsorbing all kinds of anomalous metals and cations. Beside the base-metal amounts, I was surprised at the amount of U and rare earth elements. With regard to rock types, these elements tend to be naturally concentrated in felsic rather than mafic or ultramafic rocks.

Aluminum oxides are rather strange in that they tend to be amphoteric. In acid conditions, they behave as a base. In high PH conditions, they behave as acids (they tend to dissolve in strong acids or bases; precipitate in-between).

There probably isn't much material left for them to analyze. If you would like anything else analyzed for, let me know. I still have a quarter of the material left in the refrigerator. That could also be used. Call if you have questions.

Sincerely,

Barry Frey

Barry Frey
Technical Consultant
cc: Dave Antonson DNR-Minerals Hibbing

Chemex Labs, Inc.
Analytical Chemists * Geochemists * Registered Assayers
994 Glendale Ave., Unit 3, Sparks
Nevada, U.S.A. 89431
PHONE: 702-356-5395 FAX: 702-355-0179

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P.O. BOX 67
NASHWAUK, MINNESOTA
55769

A9816614

Comments: ATTN: BARRY FREY

CERTIFICATE A9816614

(AAW) - MIDLAND RESEARCH CENTER

Project: 101.177
P.O. # :

Samples submitted to our lab in Sparks, NV.
This report was printed on 21-APR-98.

SAMPLE PREPARATION

CHEMEX CODE	NUMBER SAMPLES	DESCRIPTION
217	1	Geochem ring entire sample
200	1	Whole rock fusion

ANALYTICAL PROCEDURES

CHEMEX CODE	NUMBER SAMPLES	DESCRIPTION	METHOD	DETECTION LIMIT	UPPER LIMIT
594	1	Al2O3 %: Whole rock	ICP-AES	0.01	100.00
588	1	CaO %: Whole rock	ICP-AES	0.01	100.00
590	1	Cr2O3 %: Whole Rock	ICP-AES	0.01	100.00
586	1	Fe2O3(total) %: Whole rock	ICP-AES	0.01	100.00
821	1	K2O %: Whole rock	ICP-AES	0.01	100.00
593	1	MgO %: Whole rock	ICP-AES	0.01	100.00
596	1	MnO %: Whole rock	ICP-AES	0.01	100.00
599	1	Na2O %: Whole rock	ICP-AES	0.01	100.00
597	1	P2O5 %: Whole rock	ICP-AES	0.01	100.00
592	1	SiO2 %: Whole rock	ICP-AES	0.01	100.00
595	1	TiO2 %: Whole rock	ICP-AES	0.01	100.00
475	1	L.O.I. %: @ 1000 deg.C	FURNACE	0.01	100.00
540	1	Total %	CALCULATION	0.01	105.00
2840	1	Ba ppm: ICP-MS	ICP-MS	1	10000
2841	1	Cs ppm: ICP-MS	ICP-MS	1	10000
2842	1	Hf ppm: ICP-MS	ICP-MS	1	10000
2843	1	La ppm: ICP-MS	ICP-MS	1	10000
2844	1	Nb ppm: ICP-MS	ICP-MS	1	10000
2845	1	Rb ppm: ICP-MS	ICP-MS	1	10000
2846	1	Sr ppm: ICP-MS	ICP-MS	1	10000
2847	1	Ta ppm: ICP-MS	ICP-MS	1	10000
2848	1	Y ppm: ICP-MS	ICP-MS	1	10000
2849	1	Zr ppm: ICP-MS	ICP-MS	1	10000
818	1	Crystalline water	Leco RMC100	0.01	100.0
819	1	Surface moisture	Leco RMC100	0.01	100.0
1380	1	S %: Leco furnace	LECO-IR DETECTOR	0.01	100.0
1381	1	C %: Inorganic	LECO-GASOMETRIC	0.05	100.0

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim or deposit has been determined based on the results of assays of multiple samples of geologic materials collected by the prospective investor or by a qualified person selected by him/her and based on an evaluation of all engineering data which is available concerning any proposed project Statement required by Nevada State Law NRS 519

Chemex Labs, Inc.
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Project : 101.177
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Total Pages : 1
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P.O. Number :
Account : AAW

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SAMPLE	PREP CODE		Al2O3 %	CaO %	Cr2O3 %	Fe2O3 %	K2O %	MgO %	MnO %	Na2O %	P2O5 %	SiO2 %	TiO2 %	LOI %	TOTAL %	Ba ppm
MRC-98-421	217	200	36.68	0.61	< 0.01	1.85	0.17	0.47	0.04	0.46	0.10	20.95	0.09	36.26	97.68	62

CERTIFICATION: Hart Bichler

* ANALYTICAL DATA MAY BE LOW DUE TO A HIGH MOISTURE CONTENT.

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SAMPLE	PREP CODE		Cs ppm	Hf ppm	La ppm	Nb ppm	Rb ppm	Sr ppm	Ta ppm	Y ppm	Zr ppm	+H20 %	-H20 %	S % Total	C % inorg
MRC-98-421	217	200	< 1	< 1	74	< 1	10	35	1	120	7	19.85	9.15	2.36	0.05

CERTIFICATION: Hart Bichler

* ANALYTICAL DATA MAY BE LOW DUE TO A HIGH MOISTURE CONTENT.

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Account : AAW

CERTIFICATE OF ANALYSIS A9816616

SAMPLE	PREP CODE		Rb ppm	Sm ppm	Ag ppm	Sr ppm	Ta ppm	Tb ppm	Tl ppm	Th ppm	Tm ppm	Sn ppm	W ppm	U ppm	V ppm	Yb ppm	Y ppm	Zn ppm	Zr ppm
MRC-98-421	299	297	8.6	11.3	< 1	34.3	< 0.5	2.4	< 0.5	3	1.5	< 1	< 1	28.5	15	10.3	119.5	440	7.5

CERTIFICATION:

Chemex Labs, Inc.

Analytical Chemists * Geochemists * Registered Assayers

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To: MIDLAND RESEARCH CENTER

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55769

Project : 101.177
Comments: ATTN: BARRY FREY

Page Number : 1-A
Total Pages : 1
Certificate Date: 23-APR-98
Invoice No. : I9816616
P.O. Number :
Account : AAW

CERTIFICATE OF ANALYSIS A9816616

SAMPLE	PREP CODE		Ba ppm	Ce ppm	Cs ppm	Co ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Gd ppm	Ga ppm	Hf ppm	Ho ppm	La ppm	Pb ppm	Lu ppm	Nd ppm	Ni ppm	Nb ppm	Pr ppm
MRC-98-421	299	297	60.0	81.5	0.6	61.0	5400	15.3	9.9	3.5	14.9	4	< 1	3.3	74.0	5	1.7	60.5	1280	< 1	16.6

CERTIFICATION: Hart Bichler

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55769

A9816616

Comments: ATTN: BARRY FREY

CERTIFICATE A9816616

(AAW) - MIDLAND RESEARCH CENTER
Project: 101.177
P.O. # :

Samples submitted to our lab in Sparks, NV.
This report was printed on 23-APR-98.

SAMPLE PREPARATION

CHEMEX CODE	NUMBER SAMPLES	DESCRIPTION
299	1	Pulp; prepped on other workorder
297	1	Meta-borate fusion charge

ANALYTICAL PROCEDURES

CHEMEX CODE	NUMBER SAMPLES	DESCRIPTION	METHOD	DETECTION LIMIT	UPPER LIMIT
2855	1	Ba ppm: ICP-MS	ICP-MS	0.5	10000
2501	1	Ce ppm: ICP-MS	ICP-MS	0.5	10000
2858	1	Cs ppm: ICP-MS	ICP-MS	0.1	10000
2859	1	Co ppm: ICP-MS	ICP-MS	0.5	10000
2860	1	Cu ppm: ICP-MS	ICP-MS	5	10000
2502	1	Dy ppm: ICP-MS	ICP-MS	0.1	1000
2503	1	Er ppm: ICP-MS	ICP-MS	0.1	1000
2504	1	Eu ppm: ICP-MS	ICP-MS	0.1	1000
2505	1	Gd ppm: ICP-MS	ICP-MS	0.1	1000
2861	1	Ga ppm: ICP-MS	ICP-MS	1	1000
2842	1	Hf ppm: ICP-MS	ICP-MS	1	10000
2506	1	Ho ppm: IPC-MS	ICP-MS	0.1	1000
2507	1	La ppm: ICP-MS	ICP-MS	0.5	10000
2862	1	Pb ppm: ICP-MS	ICP-MS	5	10000
2508	1	Lu ppm: ICP-MS	ICP-MS	0.1	1000
2509	1	Nd ppm: ICP-MS	ICP-MS	0.5	10000
2863	1	Ni ppm: ICP-MS	ICP-MS	5	10000
2844	1	Nb ppm: ICP-MS	ICP-MS	1	10000
2510	1	Pr ppm: ICP-MS	ICP-MS	0.1	1000
2864	1	Rb ppm: ICP-MS	ICP-MS	0.2	10000
2511	1	Sm ppm: ICP-MS	ICP-MS	0.1	1000
2865	1	Ag ppm: ICP-MS	ICP-MS	1	1000
2867	1	Sr ppm: ICP-MS	ICP-MS	0.1	10000
2868	1	Ta ppm: ICP-MS	ICP-MS	0.5	10000
2512	1	Tb ppm: ICP-MS	ICP-MS	0.1	1000
2869	1	Tl ppm: ICP-MS	ICP-MS	0.5	1000
2550	1	Th ppm: ICP-MS	ICP-MS	1	1000
2513	1	Tm ppm: ICP-MS	ICP-MS	0.1	1000
2870	1	Sn ppm: ICP-MS	ICP-MS	1	10000
2871	1	W ppm: ICP-MS	ICP-MS	1	10000
2549	1	U ppm: ICP-MS	ICP-MS	0.5	1000
2872	1	V ppm: ICP-MS	ICP-MS	5	10000
2514	1	Yb ppm: ICP-MS	ICP-MS	0.1	1000
2873	1	Y ppm: ICP-MS	ICP-MS	0.5	10000
2874	1	Zn ppm: ICP-MS	ICP-MS	5	10000
2875	1	Zr ppm: ICP-MS	ICP-MS	0.5	10000

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim or deposit has been determined based on the results of assays of multiple samples of geologic materials collected by the prospective investor or by a qualified person selected by him/her and based on an evaluation of all engineering data which is available concerning any proposed project Statement required by Nevada State Law NRS 519

Appendix 11

Table A11.1. Annual and monthly precipitation totals (inches) at the Dunka Mine, 1992-99.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	May-Oct Total *	Annual Total *
1992	---	---	---	---	---	1.97	3.94	3.50	3.46	---	---	---	17.30	24.15
	0.63	**1.35**	**0.56**	**1.75**	**3.66**	**3.71**	**3.43**	**4.06**	**4.42**	**0.77**	**1.10**	**1.46**	**20.05**	**26.90**
1993	---	---	---	---	1.94	2.49	6.71	2.60	2.76	0.93	---	---	17.43	25.12
	0.99	**0.28**	**0.39**	**2.63**	**2.42**	**2.83**	**6.92**	**4.61**	**3.65**	**1.52**	**2.08**	**1.32**	**21.95**	**29.64**
1994	---	---	---	---	1.46	8.75	2.66	1.22	---	---	---	---	19.16	26.63
	0.59	**0.27**	**0.80**	**4.28**	**3.09**	**5.83**	**4.53**	**2.67**	**2.76**	**2.31**	**1.12**	**0.41**	**21.19**	**28.66**
1995	---	---	---	---	0.58	0.55	6.45	3.70	3.94	---	---	---	18.49	23.88
	0.72	**0.74**	**0.86**	**1.41**	**1.58**	**0.81**	**6.15**	**4.96**	**3.44**	**3.27**	**0.40**	**1.26**	**20.21**	**25.60**
1996	---	---	---	---	0.58	0.72	6.29	3.76	4.94	1.94	---	---	18.23	30.59
	2.24	**1.86**	**0.36**	**2.08**	**1.51**	**6.62**	**4.08**	**2.00**	**3.68**	**3.90**	**3.39**	**2.43**	**21.79**	**34.15**
1997	---	---	---	---	---	3.76 [A]	1.21	3.23	1.59	2.53	---	---	15.46	22.34
	2.24	**0.25**	**1.51**	**0.78**	**2.54**	**4.36**	**2.26**	**2.52**	**2.35**	**2.00**	**1.68**	**0.42**	**16.03**	**22.91**
1998	---	---	---	---	---	2.26	1.48	---	---	---	---	---	19.16	27.17
	0.75	**1.19**	**1.04**	**1.20**	**3.47**	**4.18**	**3.51**	**3.88**	**3.78**	**4.29**	**2.32**	**1.51**	**23.11**	**31.12**
1999	---	---	---	---	3.29 [B]	3.66	9.49	3.07	3.19 [C]	---	---	---	28.80	35.43
	1.01	**0.68**	**1.77**	**2.41**	**3.41**	**3.30**	**8.95**	**3.71**	**6.80**	**2.37**	**0.34**	**0.42**	**28.54**	**35.17**
Average	---	---	---	---	1.59	3.10	4.78	3.12	3.75	2.30	---	---	19.38	26.91
	1.15	**0.83**	**0.91**	**2.07**	**2.71**	**3.96**	**4.98**	**3.55**	**3.86**	**2.55**	**1.55**	**1.15**	**21.61**	**29.27**

A: 6/9/97 - 6/30/97
B: 5/11/99 - 5/31/99
C: 9/1/99 - 9/23/99 (since 2.62 in. fell on 9/26/99, according to NOAA, the value of 6.80 was used when calculating the May-Oct and annual totals for the top line (Dunka data).

(Continued on next page)

* The column called total uses all Dunka data when available, and then fills in missing months (mostly during winter) to get an annual total.

Note: The **bottom line** shown for each year (the values in **bold**) are results based on climatoligical data obtained from NOAA, which is accesible at the State Climatologist's web site ((http://www.climate.umn.edu). There are several weather stations near the Dunka Mine (including Winton, Embarrass, Ely and Tower), but data isn't always available year-round for all these stations. The web site, after being given a site location, automatically calculated which station had the most relevant data. The **top line** of data for each year is the results from actual measurements at Dunka.

Appendix 12

Section A12.1 - Background

The primary removal mechanism the W1D is assumed to be the removal of metals by association with the organic fraction of the peat. Removal mechanisms are assumed to be the same as those in small wetland test cells (Eger et al., 1994). Peat contains a complex mixture of organic compounds with a series of functional groups. These groups provide a variety of sites for metals to bind. In the test cells, sulfide precipitation was much less important in the overall removal of nickel. These results were based on the changes in water quality observed in the treatment cell. The pH of the drainage decreased as it passed through the cell; the result of the exchange of metal ions in the water for hydrogen ions on the peat. In contrast, there was no statistically significant difference between the input and output sulfate concentration, which implies that the overall rate of sulfate reduction was small.

The minor amount of removal associated with sulfide precipitation is similar to that reported in studies by Wieder for peat wetlands, in which minimal accumulation of sulfur was found (Wieder and Lang 1986). Wieder suggests that although metal sulfides may form, they are later oxidized and converted to other forms. The oxidation of sulfide precipitates may not be a major concern in a constructed wetland if the water level is maintained so that the substrate remains saturated. In compost based wetlands, however, significant amounts of reduced and elemental sulfur have been measured (Hedin et al, 1989). Compost provides a readily decomposable organic substrate, and sulfate reduction rates up to 1,200 mmol/m^3/d have been measured (Reynolds et al., 1991). More typical rates are on the order of several hundred millimoles per cubic meter per day (Eger 1992).

The specific mechanisms of metal removal are important because they affect the overall lifetime of the wetland. Long-term treatment of mine drainage is an important regulatory issue, and the ability of wetlands to provide continued treatment has not been demonstrated. As a result, the Office of Surface Mining has required back-up chemical treatment for wetlands built to control coal mine drainage (O.S.M. 1988). If the removal is primarily due to removal by organics, then the system lifetime is limited by the total amount of removal sites that are available in the top portion of the wetland. If the primary removal mechanism was sulfate reduction, the process would continue as long as there was an organic food source and an input of sulfate. Sulfate reduction would be more likely to offer long-term treatment. Although additional adsorption sites will be generated annually as plants die and decompose, the formation of new sites is slow. To provide a balance between the input of metals and the formation of new removal sites in the study cell, input flow and load had to be reduced by about an order of magnitude.

Another method to increase the treatment life of the wetland is to construct the system so that the surface peat can be replaced. At the W1D site the peat mixture was placed on top of an existing wetland (Frostman et al., 1993). New material can be added when the removal capacity of the mixture is exhausted.

Another factor that limits the removal in natural wetlands is the transport of metals to reaction sites. Metal concentrations generally decreased with depth at both sites. In natural wetlands, flow occurs primarily across the surface, generally within the upper 30 cm (Romanov 1968). This occurs as a result of a minimal vertical hydraulic gradient and a decrease in hydraulic conductivity with depth. However, wetlands can be constructed to encourage vertical flow and provide more contact with the substrate. This type of wetland requires additional engineering design, but the increase in treatment per unit area can be significant (Eger and Melchert 1992).

Appendix A12.2 - Wetland Lifetime

Assumptions:

- Wetland area 7000 m^2 (original W1D wetland only)
- Removal depth of 20 cm
- Maximum concentration of 10,000 mg Ni/Kg dry peat
- Bulk density 0.1 gm dry peat/cm^3.

Basis of Assumptions

- Depth of removal 20 cm for over land flow wetlands
- Metal concentrations in the substrate decrease with depth. In a study of a natural wetland (Eger and Lapakko, 1988), the highest concentrations were in the top 20 cm of the wetland. Metal measurements made every 2 cm in samples collected from wetland test cells (Eger et al, 1974) showed that concentrations generally decreased with depth.
- At the W1D wetland the highest concentrations were in the 0-10 cm layer, although even in the 20-30 cm layer concentrations were 100 to 1,000 times the initial values.

Peat Density: 0.1 gms

Bulk densities for horticultural peats ranged from 0.07 gm/cm^3 for sphagnum to 0.64 gm/cm^3 for well decomposed peat.

Bulk Density

Peat Type	lbs/cu ft	g/cc
Sphagnum	4.5 - 7.0	0.07 - 0.11
Hypnum	5.0 - 10.0	0.08 - 0.16
Reed-sedge (low lime)	10.0 - 15.0	0.16 - 0.24
Reed-sedge (high lime)	10.0 - 18.0	0.16 - 0.29
Decomposed peat	20.0 - 40.0	0.32 - 0.64

Lucas, R.E., Rieske P.E., and Farnham, R.S. Peats for soil improvement and soil mixes. Michigan State University, Cooperative Extension Services, 11 pp.

Maximum nickel concentration = 10,000 mg/Kg.

Measured concentrations in field samples exceeded this value as well as estimated concentrations in laboratory columns (Lapakko, et al, 1986). This should be a reasonable estimate.

Cattail establishment, five years.

Cattails in a wetland in Pennsylvania reached a stable cattail density after six growing seasons (Stark et al, 1994).

- Initial removed capacity of the wetland = 1400 Kg nickel
- = volume of peat x bulk density x nickel removal capacity
- = area of wetland x effective removal depth x bulk density x nickel removal capacity
- = 700 m^2 x $(100\ cm/mm)^2$ x 20 cm x 0.1 gm/cm^3 x 10,000 mg Ni/Kg dry peat x $\frac{1}{10^3 gm/Kg}$
- = 1400 x 10^6 mg Ni x $\frac{1}{10^6\ mg/Kg}$
- = 1400 Kg Nickel

After five years, vegetation is well established and new sites begin to accumulate and increase the removal capacity by 7 Kg Ni/year. (This assumes that new peat accumulates at a rate of 1 mm/year, and has the same removal capacity as the existing substrate). Long term post closure input load to the wetland is assumed to be 10 Kg nickel/year, which is the average of the input for 1997 through 1999.

To solve for the lifetime of the wetland, t 1400 + 7 t = 525 + 10 t where 525 Kg is the amount of initial removal capacity consumed in the first five years.

10 Kg is the average annual input load
7 Kg is the annual increase in removal capacity
so t = 292 years

Appendix 13

Section A13.1

This appendix contains miscellaneous notes and calculations primarily relating to the design, operation, and performance of the W1D wetland. It is a compilation of old files. Although this report focused on the original part of the system constructed in 1992, this appendix also contains some discussion on the extension constructed in 1995.

Observations on the W1D Treatment System

Removal increased in this section in the summer of 1994 after hay bales had been placed on several berms. The bales helped to disperse flow and H_2S was detected. Concentration decreased substantially during this time period, although removal decreased as temperatures began to decrease in the fall.

There was not enough contact time in the hay bale area itself to provide for reaction, but it is possible that organics were washed from the hay into the pool areas downstream where there was enough residence time to allow sulfate reduction to occur.

There was a notable smell of H_2S in the area after the hay had been installed and evidence of biological reactions occurring in the downstream pools.

The hay also stabilized the system with respect to high flows and helped distribute the flow.

Lower part of 1D system beyond glacial till berm is only about one-half the size of the upper system; therefore, expect a lower rate of removal.

Cause of excess channelization in lower part of system; berms are narrower so have a higher average velocity.

Design of W2D/3D system meets requirements based on test cell data. Drop across berm in 2D/3D is less than in 1D, ½ to ¾ ft drop where in W1D, the design called for a foot, in absence of rip rap will scour.

Dye Studies

1993 dye study conducted by NRRI indicated more channelization in lower half of system and less contact time

4 days prior to glacial till berm, 3 days below

NRRI conducted two dye studies at W1D in 1993. Both occurred during periods of relatively low flow.

first started on Aug 16
took about 7 days for the peak to reach outflow

average outflow for this period was 23 gpm (range 15 - 35) using this flow rate the effective volume of the system is V = 232,000 gallons

The key sample points are at the input culvert under the road, the three pipes through the large till berm, and the outflow. It is at these points that all the flow is captured.

Summer Test

Note: There are some strange things in the flow data file. This is particularly noticed in input file. Need to check ppt. Our flow measurements show a downward trend while LTV shows an upward trend. In addition, the staff readings are higher for LTV than they are for the spot readings taken when we bucket gaged. Flow estimates have been made from LTV files and bucket gaging.

Estimated input flow during 7-day period: 30-40 gpm

Estimated outflow: 20-30 gpm

Time of travel was computed by the time to peak concentration

Time from input to till berm:

minimum 93 hours
other times 118-160
about 4 days if assume most of the flow goes through the 2 end pipes. These are the ones with the time of travel of 93-118 hours

from till berm to outflow is on the order of 46-71 hours or 2 to 3 days

If we assume that the most flow goes through the pipe with the shortest travel time, then
flow from the input culvert to the till berm is about 4 days
flow from till berm to outlet weir is about 3 days
total time 7 days

Design Calculations

The final size of the wetland must consider both metal and hydraulic loading and should be the largest area calculated.

Data from the test cells indicated that the minimum residence time was two days.

Residence time (days) = Volume of water (m^3) / Flow (m^3/day)
= Area of wetland x average water depth / flow

Wetland area (m^2) = residence time (days) x flow (m^3/ day) / average water depth (m)

Assuming a water depth of 5 cm, an average flow of 20 gallons per minute and a minimum residence time of two days, the minimum area would be 47,000 ft^2. The required area also needs to be calculated based on the rate of metal removal. Removal rates are calculated on an areal basis by dividing the mass of metal removed by the area and the number of days of operation.

areal removal rate (mg/ m^2/ day) = mass removed (mg)/ wetland area (m^2) / days

Nickel rates in the test cells ranged from 4 mg/ m^2/ day for the majority of the cells to 8 mg/ m^2/ day in the cell where the peat and peat screenings mixture was added. The area of the wetland can be calculated from

area (m^2) = average input mass (mg/ day) / areal rate of removal (mg/m^2/ day)

Using an average flow of 20 gallons per minute, a nickel concentration of 5 mg/L and an areal rate of 8 mg/ m^2/ day, an area of 68,000 ft^2 would be required. Since these calculations are based on average flow conditions, the wetland may not be sufficiently sized to treat higher flows resulting during periods of high rainfall which produces substantially larger input flows.

Actual residence time calculated by NRRI using dye were higher than calculated from the simple model. The actual W1D wetland does not have a uniform water depth or a uniform distribution of flow.

Design of Original W1D Wetland Treatment System

STS consultants designed system based on the 1990-91 flow data.

Problems:

1. This is a period with reported flow lower than long term average.

2. Based on our measurements of flow in 1993, LTV flow estimates were about 15% low. We do not know if this condition existed in 1990 and 1991, but there has been concern about the accuracy of LTV flow records.

   The difference in flow between LTV and DNR was on the order of 5 -15 gpm. At low flows the % error was higher.

   example LTV 11 gpm % difference = 39
   DNR rating curve 18

LTV 65 % difference = 16
rating curve 77

3. Initially the size of the system was too small, even based on the low flow estimates. After comments were submitted, the system was resized, but still the size was based on a 20 gpm average flow.

   A 40 gpm was probably more realistic and better reflected long-term averages.
   A complete analysis of flow had never been completed.

Construction began in March of 1992

System Design

- Nine berms, each about 1 foot high at successively lower elevations, length about 700'
- First berm elevation 1485
- Berms drop by 1 foot intervals down to 1477
- Outlet weir was not installed initially
- Gradient toward end of system
    - 3' drop in 200', 1.5% drop from berm 5 to 8
- initial gradients
    - 2' in about 200' (first 3 berms) from berm 1 to 3
    - 2' in 175 from berm 3 to 5
    - from 8 to 9 1' in 100'

Peat Mixture

LTV area 5 plus Michigan peat screenings in last three cells. Other areas had area 5 peat plus screenings from Minnesota sphagnum

Vegetation

- berms hand seeded with Japanese millet
- open areas seeded with cattail seed

- took heads of cattail and mixed in solution of soap and water; add few bolts and agitated.
- bolts helped break up heads; soap helped to disperse seeds.

total area of peat is 75,000 ft sq

1992

attempted to better distribute flow by

- rip rap on first berm
- installed treated 4 x 4 treated lumber to berms 2, 3, 4

decided peat in last 4 cells was not proper pH
installed pretreatment above weir

Based on field observations, it was determined that some flow bypasses pretreatment system

prior to start of 1993 season peat in last 4 cells was replaced.

at 1481 berm, raised berm (glacial till berm) and added pipes (this is berm 5)

this reduced the gradient, took about 18" of drop out of the system at this elevation?

need elevation of drop structure pipes and large berm

inlet slots at 1481.5
raised berm to 1482

so only lowered water level 6"

<u>Historical Flow at W1D</u>

Prior to 1986, there were no flow records for the W1D site. Flow for these periods was estimated from runoff coefficient for EM-8 watershed.

This method may have been OK prior to pumping of environmental sump and development of EM 8-E.

Best to use data from 86-91 since this was measured at site

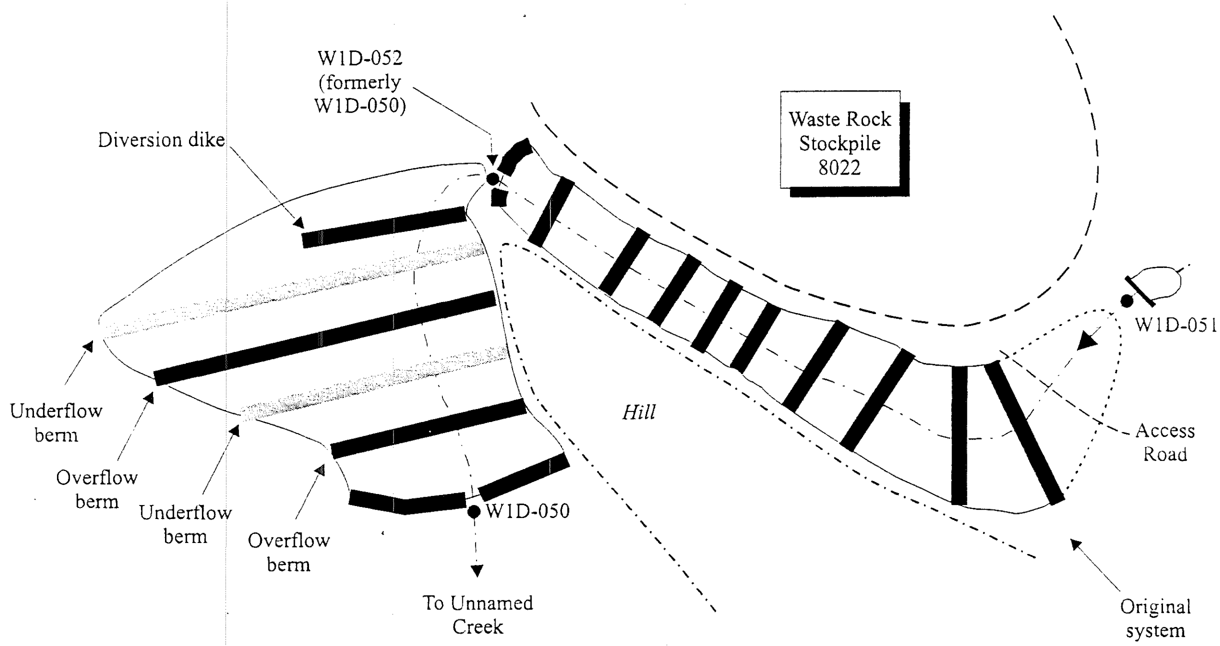


Figure A13.1. W1D treatment system expansion (put on line July 1995).

Average flow for 86-89

total 0.520 L X 10^8

assume an average of 225 days of flow get yearly average of 42 gpm

average flow for 90-91

25 gpm

average flow for the entire period 36 gpm

<u>Notes on W1D Extension - Constructed in 1995</u>

- Berms are spaced 75 ft. apart
- Alternate between under flow and overflow
- About 25 ft. of peat is placed on each side of the berm, this provides an area of around 25 ft. of open water between each set of berms

- New design, rather than have flow over the berms, standpipes will be used to get water flow through berm, plan to use rip rap on top of till berms.

- LTV removed existing peat so berms can be built on mineral soil and minimize settling. In the original system, berms were built directly on peat.

- The estimated hydraulic conductivity for the peat and screenings mixture seems very optimistic. The closure document has some lab data which yields conductivity on the order of 0.1 cm/sec.

- Even with a hydraulic conductivity of this magnitude, only a portion of the flow will flow through the underdrain. The estimates are on the order of .1-1 gpm.

<u>Calculation of flow in underflow berms</u>

It is unlikely that all the flow will be transmitted in the underdrain. Provisions need to be made for flow over the top of these berms.

- First underflow berm
    - length 400 ft., depth of limestone 1.5 ft.
    - cross sectional area: 600 sq. ft.

- Hydraulic head
    - invert elevations for pipes through overflow berms not given, it appears that inverts will be about .5 ft. below the top of the berm. This will give a head of .5 ft.

    - width of berms is about 50 ft.
    - gradient .5 / 50 = .01

- Flow rate

    - assume permeability of .001 cm/sec
    - Q = KAH/L

      $$\frac{.001 \text{ cm/sec} \times 600 \text{ sq. ft.} \times .01 \times 60 \text{ sec/min.}}{30.48 \text{ cm/ft.}}$$

      .012 cu ft/min x 7.48 gal/ cu. ft
      .09 gpm
    - if permeability was increased it could increase flow, but to get substantial flow through underdrain, i.e., 9 pgm, would need permeability of .1 cm/sec.

Section A13.2
Seep 1 Pretreatment System

Flow Reduction, Seep 1

	May - October		
	ppt (in)	Flow	Flow/ppt
Pre-capping 1986-1991	21.2	7.3[a]	.34
Post-capping 1993-1999	19.5	5.1	.26
1993-1998	18	4.6	.25
Projected[b]	21.2	5.4	

[a]1989 flow data omitted since more water was reported at the weir than fell on the watershed.
[b]The lower flow in 1993-1998 is due in part to less precipitation. If it is assumed that the ratio of flow/ppt is constant, the projected flow at 21.2 inches of ram can be estimated by:

$$\frac{\text{Flow}}{\text{ppt}} = .25 = \frac{X}{21.2}$$

$$X = 5.4$$

% reduction in flow after capping

$$\frac{7.3 - 5.4}{7.3} \times 100\% = 26\%$$

if the difference in rainfall is not included the reduction in flow is 37%.

If 1999 is included (it was excluded due to the unusual high rainfall on July, May-October rainfall was 28.8 in.

- without correction for precipitation: 31%
- with correction for precipitation: $.26 = \frac{X}{21.2}$; X = 5.5 % = 25

If we assume a 25% reduction in flow:

- Average mass for 1986-1991 (1989 excluded due to problems with flow data = 124)
  - Nickel = 124
  - Copper = 5.4

- Reduction due to flow (assumes no change in concentration)
  - Nickel = 93 Kg
  - Copper = 4 Kg

- Average mass at weir for 1993-1998
  - Nickel = 38
  - Copper = 0.9

- Annual estimated removal
  - Nickel 93-38 = 55
  - Copper 4-0.9 = 3.1

- Total estimated removal for 1993-1996 (corresponds to peat samples)
  - Nickel = 220 Kg
  - Copper = 12.4 Kg

Nickel is much greater than the removal calculated by using outer pool concentrations (77 Kg) and the metal values in the substrate (30 Kg).

Copper is close to both the outer pool estimates 11.1 Kg and the substrate estimate 9.4 Kg.

This discrepancy suggests that the overall load of nickel has decreased as a result of capping, but not copper. During 1993, the entire copper load could be accounted for from the small surface seepage at the top of the stockpile.

Appendix 14
W1D Pretreatment System

Page

Section A14.1.
W1D Pretreatment System

A pretreatment system was installed at the toe of the 8018 in 1992. The goal was to remove metals before they entered the W1D wetland treatment system. In 1993 the DNR conducted sampling in and around the system and determined that water was bypassing the pretreatment area (DNR data summary, 1993).

In March 1998, substrate samples were collected from the system to examine metal removal. The objective was to determine if the lower loads into the wetland were due to a large metal uptake in the pretreatment system.

Although nickel was elevated in the substrate, the relatively low concentrations, 1000-3000 mg/Kg, and small area did not account for the change in nickel load.

Table A14.1. Description of W1D pretreatment peat samples, March 17, 1998.

Site	Ice Thickness (cm)	Water Depth (cm)	Total Peat depth (cm)	Intervals (cm)	Description	Comments
1	13		100	0-10	Ice chips	Ice to 13 cm, peat frozen to ~ 36 cm; heavy Typha
				10-20	Ice chips	
				20-30	Few ice chips, then McCaully	
				30-60	Peat got moist ~ 50 cm, was dry prior	
				60-100		
2	22		110	0-2	Blk fibrous peat	Heavy Typha
				2-8	Gray silt - discarded	
				8+	Blk peat	
3	10		110	0-10	White fibrous roots	Thick Typha
				10-20	Some fibrous roots	
				20+	Minimal roots	
4	15	24	102	40-50	Occ. 1-2 silty, gray ½" dia. chunks throughout profile. Sand in peat	Medium Typha
5	10		100		Strong odor, hydrogen sulfide	No Typha

Each sample was split into three segments: 0-20, 20-50, 50-100, except at Site 1 where intervals analyzed were 0-10, 10-20, 20-30, 30-60, and 60-100.

Table A14.2. Chemical analyses, 1999 W1D pretreatment peat samples.

Site	Percent moisture	Percent ash	pH	Cu	Ni	Sample
1: 0-10 cm	72	43	6.21	153	1510	11533
10-20 cm	69	68	5.78	86.3	265	11534
20-30 cm	74	67	5.90	45.8	105	11535
30-60 cm	72	62	6.15	78.2	49.7	11536
60-100 cm	51	62	6.21	77.4	53.8	11537
2: 0-20 cm	72	73	6.05	221	428	11538
20-50 cm	73	68	6.23	206	146	11539
50-100 cm	73	64	6.63	95.8	96.0	11540
3: 0-20 cm	75	66	6.50	797	2730	11541
20-50 cm	77	43	6.86	118	148	11542
50-100 cm	72	67	6.92	96.9	126	11543
4: 0-20 cm	75	67	6.15	96.2	304	11544
20-50 cm	73	64	6.52	85.3	96.7	11545
50-100 cm	73	73	6.58	54.5	68.8	11546
5:. 0-20 cm	75	60	7.00	165	1720	11547
20-50 cm	76	64	7.12	266	190	11548
50-100 cm	71	66	7.23	60.0	124	11549
6: 0-20 cm	84	61	6.33	125	1030	11550
20-50 cm	76	68	6.59	51.4	95.4	11551
50-100 cm	73	65	6.92	59.2	96.5	11552

Note: copper and nickel values are mg of metal per kg of dry peat.

July 28, 1992

Mr. Dennis Koschak
LTV Steel Mining Company
P. O. Box 847
Hoyt Lakes, MN 55750

STS Project 94000-D

Re: Seep W-1d Pretreatment System at the Dunka Mine - LTV Steel Mining Company
NPDES Permit No. MN0042579

Dear Mr. Koschak:

On July 24, 1992, the Minnesota Pollution Control Agency (MPCA) approved use of a pretreatment system at Seep W-1d in the inert pad material above the existing peat/wetland treatment system. The pretreatment system will not alter the treatment system or water reporting to monitoring point 051. All water discharged through monitoring point 051 is treated through the peat/wetland treatment system at outfall 050.

Enclosed is a plan and specification which should be used to construct the pretreatment system. Originally, Type I compost was planned to be the organic stratum within the system. The Minnesota Department of Natural Resources (MDNR) has, to date, identified that the only sources for Type I compost are in St. Cloud and the Twin Cities. These materials would not be acceptable due to costs and potential alien contaminants that might be in these urban materials. As such, the plan provided to you identifies peat as the organic treatment media. The peat should have the following properties:

- Two parts Minnesota Sphagnum Inc. peat with one part Area 5 peat or one part Coarse Agri-peat from Aitken, Minnesota with one part Area 5 peat
- pH greater than 5.0
- Von Post greater than 3.0
- Organic content by dry weight greater than 85%
- Hydraulic conductivity minimum 1 meter/day

If you or the MPCA have any questions concerning the plan, please do not hesitate to contact us.

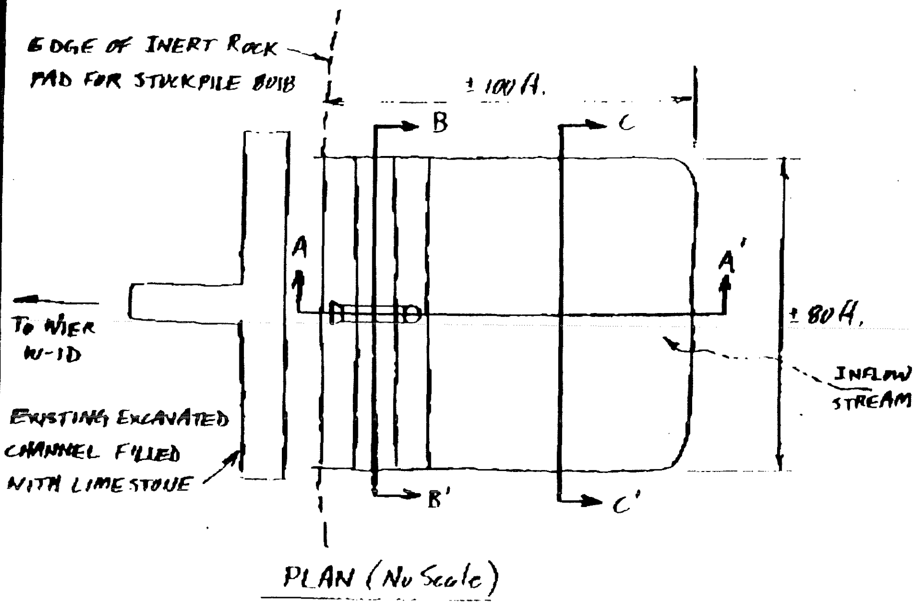
Respectfully,

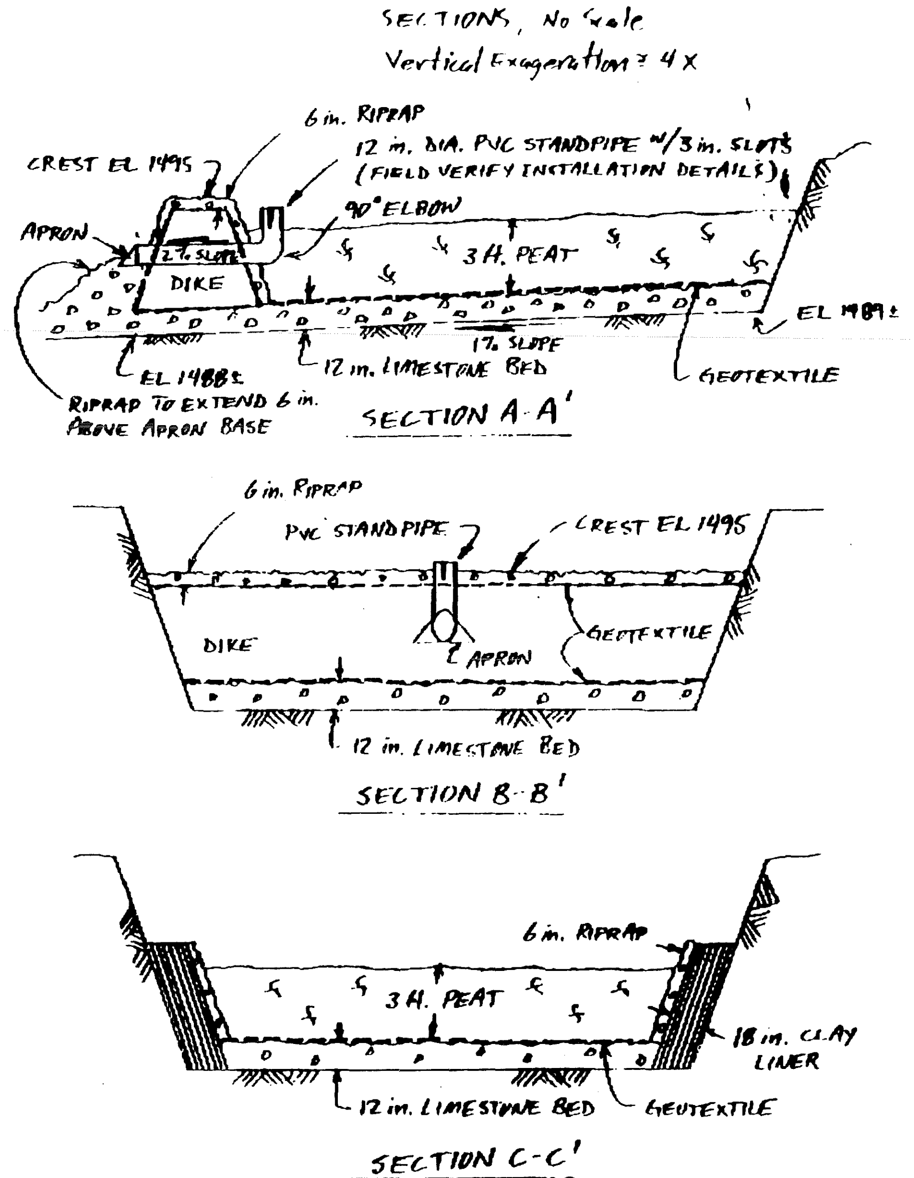
STS CONSULTANTS, LTD.

Theodore M. Frostman
Principal Scientist

Stephan M. Gale, P.E.
Principal Engineer

SMG/dn
Enc.





NOTES

A. Construction Sequence

1. Excavate treatment basin to dimensions shown with 1% minimum slope @ bottom, 1.5H:1.0V sideslopes.
2. Place 18-inch compacted clay liner 2 sides, 9 inch lifts compacted to 95% ASTM D-698.
3. Place 12-inch limestone bed.
4. Place geotextile over limestone bed.
5. Construct dike in 12-inch lifts compacted to 95% ASTM D-698, 1.5H:1.0V sideslopes. Install PVC standpipe, culvert & apron. Field verify installation details.
6. Place geotextile over dike.
7. Place 6-inches riprap over clay liner and dike.
8. Place 3-foot loose organic medium in treatment basin as directed by Owner.
9. Place additional limestone @ toe-of-dike to 6-inches above apron base and mold into existing channel.

B. Materials

1. Limestone bed & riprap material to consist of minus 6-inch to plus 2-inch non-dolomitic crushed limestone.
2. Dike material to consist of minus 1/2-inch glacial till, screened 8018 stockpile material.
3. Organic medium to consist of Peat, Class I Compost or equal as approved by Engineer.
4. Clay liner material to consist of clay borrow from Ely or Aurora site.
5. Geotextile to consist of non-woven needle-punched geotextile conforming to MnDOT 3733 Type 4 physical properties, 12-inch overlaps @ seams.
6. PVC standpipe & culvert to consist of 12-inch diameter PVC pipe with three 3-inch wide vertical slots at top-of liner

OUTFALL 050-W-1D PRE-TREATMENT
DUNKA MINE
LTV STEEL MINING COMPANY

STS Consultants Ltd. Consulting Engineers

STS PROJECT NO. 94000L
STS PROJECT FILE
SCALE NONE
SHEET NO.

Section A14.3.
Field Notes, 8/6/92 and 8/11/92

8/6/92

1. There is roughly an 18" drop from the top of the stockpile pad to the top of the peat.

2. Clearly, most of the Q does not surface in this system.

3. LTV, or someone, should determine whether runoff control structures are necessary just north of point A on the map. I did not check this out, but my recollection is it is likely that significant quantities of runoff and sediment could wash into the peat bed.

4. The peat bed "pond" shows evidence of being 100% saturated at some time in the past. Peat at the downstream side has definitely settled about one ft. based on the perched peat high water mark on the riprap. There is less subsidence indicated on the upstream end.

5. There appears to be a slight slope to the peat bed.

6. At the downstream end, the peat level appears to be 1-2 ft. higher than undisturbed land surface at the collection trench.

7. Seepage at point B, although significant, appears much less than at weir. Weir was bucket gaged at 26.5 gpm.

8/11/92

8. Hoover excavated a ~12 ft x 14 ft pit at point B on figure. Pit was excavated from rock pad and not the peat. At 1430 hours water in pit was turbid with no signs of flow.

9. Noted significant flowage (many gpm) at point C. This was not present on 8/6.

10. Saw a small head drop from pit to the peat. This is due to a small (3") peat berm at the edge of the pit.

11. Riser pipe not installed yet.

12. Pond was full this time. Water level now just below pipe. Saw evidence that water was 1-2" higher and spilled into the pipe. This probably occurred earlier today due to heavy rain this morning.

13. All peat was saturated. Even with water level high, there was still a noticeable gradient across the peat surface for the upstream half of the system.

14. The surface of the downstream half of the system was flat. Near the spill pipe there was a 2-3" thick floating mat of peat. There was 9-12" depth below the mat before peat occurred.

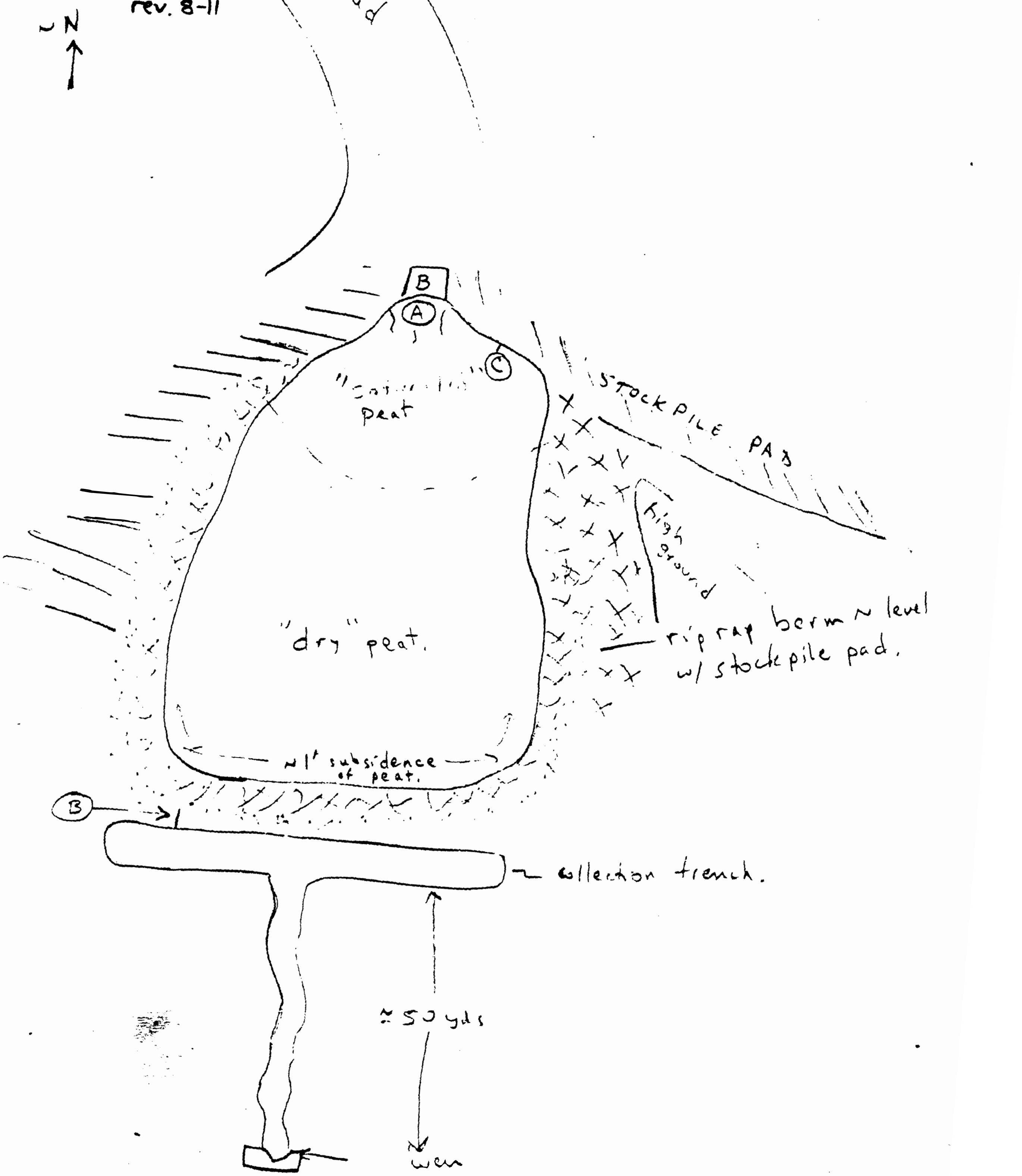
15. Water in the collection trench was ~ 1 ft. deep. There was geotextile in the trench.

16. Minor seepage observed similar to earlier visit.

17. All exposed riprap is local in origin (i.e., not limestone).

W-1D seep. ([illegible]-92)

rev. 8-11



Notes

(A) = zone of very minor trickles of water. Do not see water coming from pad. Could be a zone of upwelling.

(B) = seepage – can be sampled

Section A14.4
Water Quality Sampling

In 1993 samples were collected in and around the W1D pretreatment bed in an attempt to determine treatment efficiency. Since water bypassed the system and most of the water enters as groundwater, it was not possible to easily determine the performance of the system.

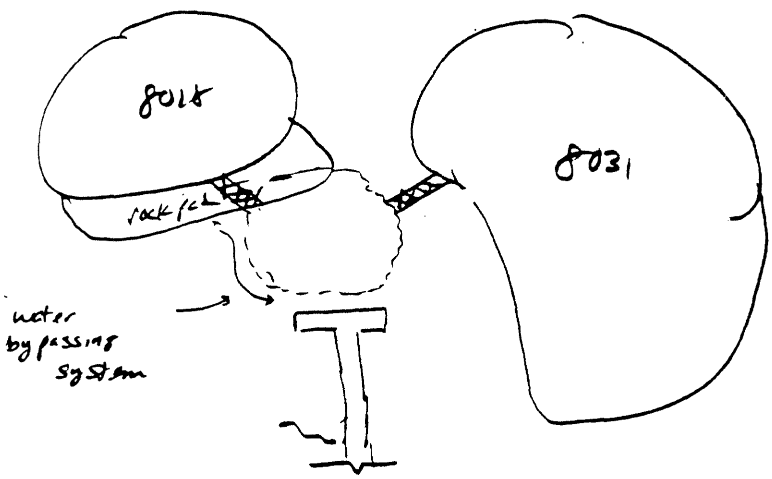
Figure A14.1 provides a schematic of the system. The sampling sites for both 1993-1994 and for a survey in 1998 are shown in Figure A14.2.

Table A14.3 provides a description of the sites sampled on 7/22/94.

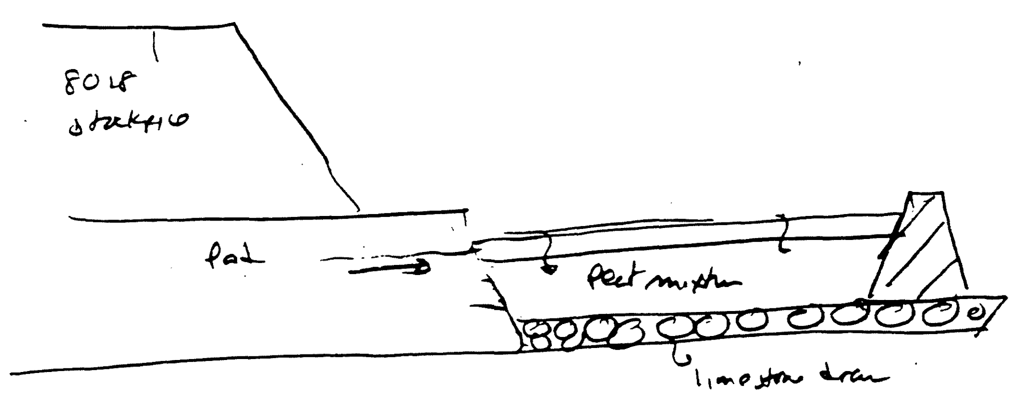
Figure A14.1. W1D pretreatment system, schematic.

W1D Pretreatment

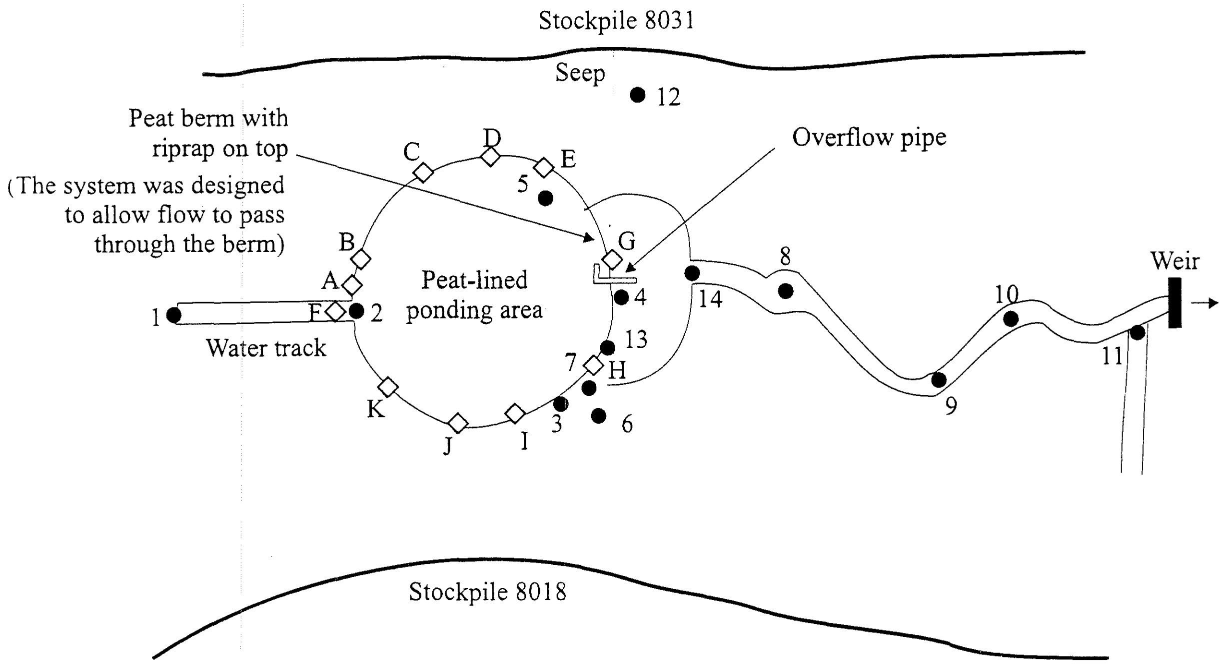
Model



Cross Section thru 8018



22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD



Note The numbered sites (black circles) have been sampled in the past, while the sites with letters (white diamonds) were sampled during the survey conducted at 1530 hours on 9/3/98.

Figure A14.2. Sample locations, W1D pretreatment system.

Table A14.3. Site Descriptions, 1993, 1994.

1. Standing H_2O at beginning at ditch
2. Pond side at limestone
3. Rapid seep coming through pad – 10' west of treatment berm
4. Pool area – next to outflow culvert
5. SE corner of treatment pond
6. Small seep that adjoins #3 above
7. Random site where a small seep appeared to be separated; then joining flow with #3 and #6
8. Random – larger open area
9. Random – sharp bend in stream bend
10. Random – mid-stream
11. Random – appeared as if a flow may be hidden under vegetation
12. Seep – standing H_2O in intermittent seep, next to 8018 stockpile.

Note: Downstream sites are approximately 3-10 yards apart.

Table A14.4. Drainage quality in the area of the W1D pretreatment system, DNR sampling 1993.

Site	Date	pH s.u.	S.C. μS/cm	SO4 mg/L	Cu mg/L	Ni mg/L	Co mg/L	Zn mg/L	Ca mg/L	Mg mg/L	Flow L/s
W1D-3	7/29/93	6.87	2900	2080	0.10	8.08	0.17	0.10	281	344	Med
	8/5/93	7.01	4020	2680	0.14	10.00	0.21	0.14	361	482	
	8/12/93	NA									0.400
	8/17/93										0.309
W1D-6	7/29/93	6.60	2400	1530	0.04	2.62	0.07	0.04	232	269	No
	8/5/93	6.23	1100	585	0.04	1.69	0.08	0.04	85	89	Med
W1D-7	7/29/93	7.16	2900	920	0.05	6.92	0.13	0.08	276	326	No
	8/5/93	7.33	3400	2060	0.05	6.03	0.12	0.07	309	366	Low
	8/12/93	NA									0.021
	8/17/93										0.010
W1D-11	7/29/93	7.13	2800	1910	0.07	5.73	0.07	0.07	278	318	Low
	8/5/93	7.05	3500	2320	0.11	7.96	0.09	0.08	330	410	Med
W1D-12	7/29/93	6.87	3000	1960	0.05	1.96	.012	0.33	304	356	No
	8/5/93	6.49	3520	2380	0.03	2.29	0.09	0.36	342	421	Low
W1D-13	7/29/93	7.18	2950	1870	0.07	6.34	0.12	0.08	285	332	Med
	8/5/93	7.49	3150	2130	0.05	3.84	0.08	0.04	301	326	
	8/12/93	NA									0.164
	8/17/93										0.076

Table A14.4. Drainage quality in the area of the W1D pretreatment system, DNR sampling 1993.

Site	Date	pH s.u.	S.C. μS/cm	SO4 mg/L	Cu mg/L	Ni mg/L	Co mg/L	Zn mg/L	Ca mg/L	Mg mg/L	Flow L/s
W1D-14	7/29/93	6.38	2650	1730	0.07	5.71	0.10	0.07	284	323	Low
	8/5/93	7.27	3500	2400	0.07	6.66	0.12	0.07	323	383	Med

NA - not analyzed.

Note: Metals values are total concentrations.
All flow measurements were taken under relatively low flow conditions. Qualitative flow descriptors for all sites except W1D-14 may be estimated as:

No = no flow
Low = <0.063 L/s (<1 gal/min)
Med = 0.063 to 0.505 L/s (1 to 8 gal/min)

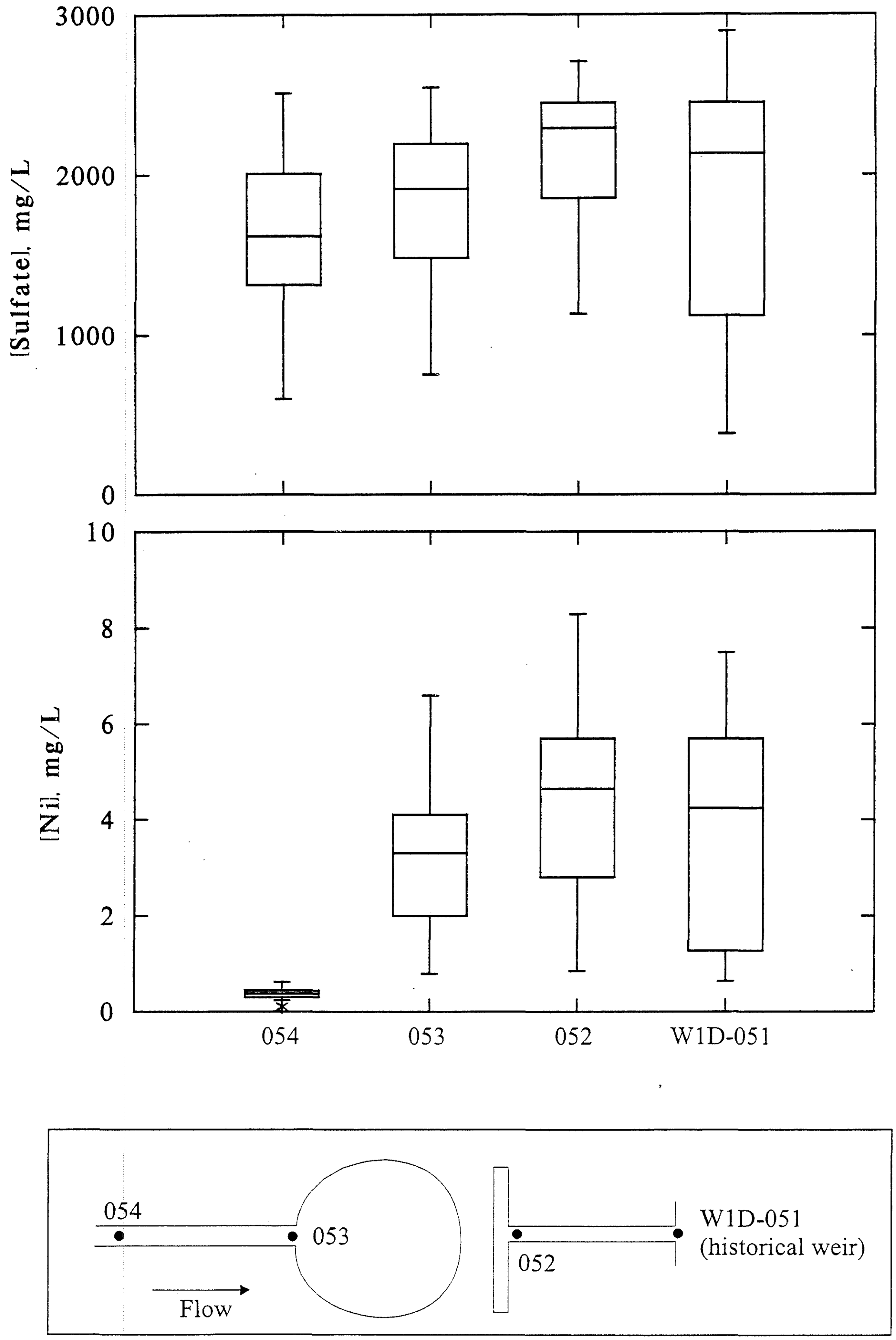


Figure A14.3. Nickel and sulfate box plot, W1D pretreatment, 1993-94.

Figure A14.4. Specific conductance survey of W1D pretreatment system, 7/22/94.

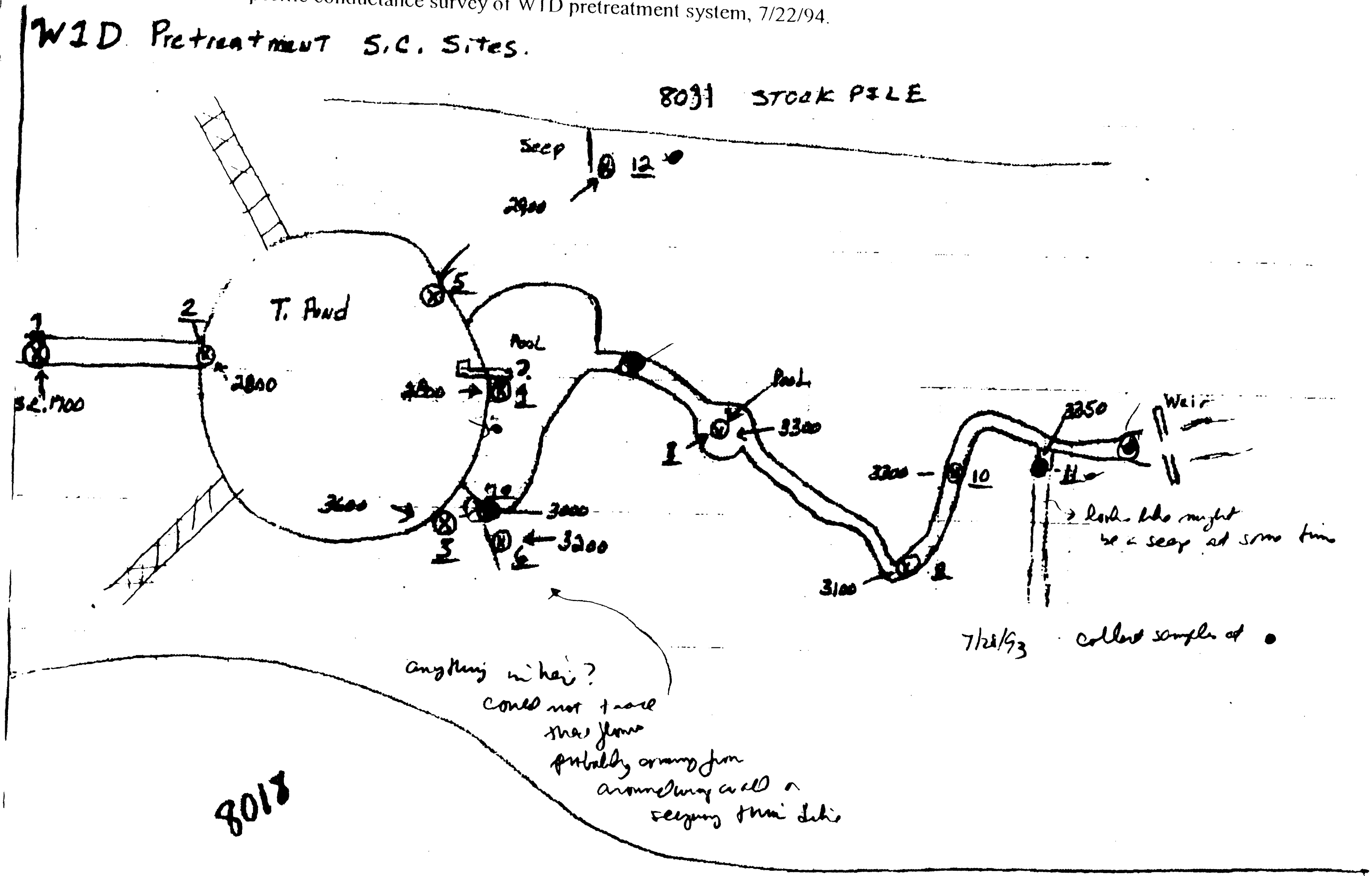


Table A14.5. Flow and water quality in the W1D pretreatment system, 9/3/98.

Site	S.C.	Q (est.)	Ni (ppm)
2	1600	Slight	1.63
A	2000	Slight	-
B	2300	Slight	-
C	1850	-	-
D	1900	-	-
E	1900	-	-
F	1000	-	-
G	1900	-	1.15
H	1900	-	-
I	2000	-	-

Site	S.C.	Q (est.)	Ni (ppm)
J	1950	-	-
K	1900	-	-
3	1800	1 L/min	2.08
6	1800	Slight	-
7	1750	Slight	-
11	1900	None	0.37
13	2000	0.3 L/min	0.12
14	1900	None	0.80
Weir	1900	13.7 L/min	0.11