DEVELOPMENT OF THE ZONE 2 WASTE DUMP

Submitted to the Yukon Territory Water Board

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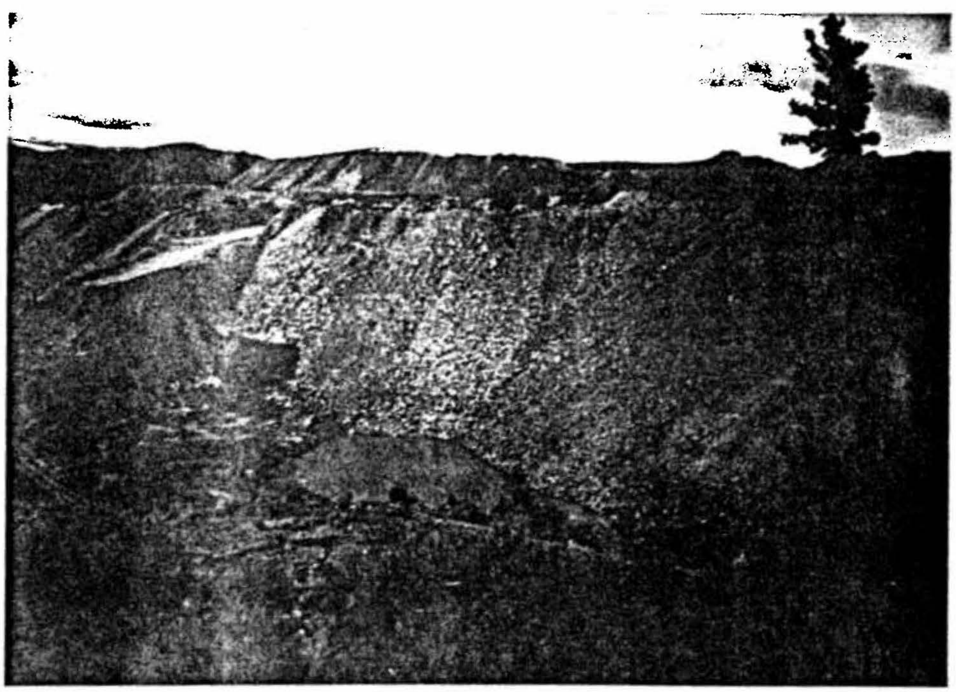
by

CURRAGH RESOURCES, INC.
117 Industrial Road
Whitehorse, Yukon



Zone 2 pit and dump, 9/87

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1. PART ONE: SUMMARY

This report contains Curragh Resources Inc.'s plans for the use of the Zone 2 area of the Faro pit as a waste dump and an evaluation of the environmental impacts of this plan.

The Zone 2 pit is an old pit which has been abandonned for several years. Water enters the pit through seeps and via a ditch system which collects water from the upper benches of the main pit and from the toe of waste dumps adjacent to Zone 2. The water in this ditch is neutral but contains elevated zinc levels. Water seeping through patches of oxidized ore left in the pit wall is acid with extremely high zinc levels. It is not feasible to mine this acid-generating material as most of the pit has been backfilled with waste rock. In the past, water has on occasion filled the pit and overflowed into the North Fork of Rose Creek. Pit water is neutral but contains levels of zinc exceeding Curragh's effluent standards. Pit water is currently being pumped to the tailings pond.

The engineering plans for the use of Zone 2 as a waste dump are presented in Part Two. These include a map showing the current and ultimate limits of the dump and a schedule of waste rock deposition. Measures being implemented to reduce water flow through the area and to collect contaminated water are described.

Part Three consists of an assessment of environmental impacts, both short and long term. Historic and recent data on water quality and flow through the area are presented and discussed. It is recognized that overflow from the pit has the potential to raise levels of zinc in the North Fork of Rose Creek. The installation of a collection drain and sump to pump water to the tailings pond ensure that no overflow will occur during the life of the Faro mine. The waste rock being deposited in the pit is non acid-generating and thus will not result in further contamination of the water. Plans for dealing with potential contamination at abandonment are discussed at a conceptual level. The abandonment plan for this area will form part of the Faro pit abandonment plan required by Curragh's water licence by March 31, 1988. No viable options for abandonment are being limited by the backfilling of the Zone 2 pit.

The engineering plans and water quality data were submitted to Dr. A MacG Robertson of Steffen, Robertson and Kirsten (B.C.) Inc., Consulting Engineers for review. Dr. Robertson was asked to consider the environmental impact during the life of the mine and to advise Curragh as to whether or not abandonment options for the area would be limited by the implementation of the plans. Plans were revised to incorporate the recommendations presented in this review. The letter report from Dr. Robertson is included as an appendix.

2. PART TWO: ENGINEERING PLANS

2.1. INTRODUCTION

This report's purpose is to provide details of the backfilling of the former Zone 2 pit . This area serves as the next major waste dump site and represents approximately eight million tonnes of dump capacity or 18 % of the dump capacity required through mine life. This dump area is of major importance as its proximity to the mine workings (Figure 1) significantly lowers haul truck cycle times compared to other dumping options.

The Zone 2 pit lies directly in front of the area to be developed. Failure to backfill the Zone Two pit would pre-empt use of this dump area. Alternate dump sites could be used, but at a greater haulage cost per tonne. Consideration would have to be given to moving the power line (Figure 1), developing dumps across the North Fork of Rose Creek or developing existing dumps to higher levels.

2.2. SUMMARY

The development of the Zone 2 dump will be done in three stages.

The first stage of the project requires lining of the Faro Creek Diversion, construction of an access ramp to the 3710 foot elevation[1] North Fork Rose Creek bottom, diversion of part of the ditch system currently draining to Zone 2 and dewatering of the remainder of the Zone 2 pit.

The second stage of development calls for the construction of an internal drain that will collect water from the backfilled pit and direct it through a drain pipe to a sump. The diversion of surface flow away from Zone 2 will be extended and upgraded to abandonment standards during this stage. A piezometer will be installed through waste rock to the pit bottom to provide a sampling point and to measure the rate at which the water level rises.

The final stage will be the development of the waste dump itself to the ultimate design limits (Figure 2).

[1] Elevations in this report are Faro mine datum, which is 109 feet lower than U.T.M.

FARO PIT SITE PLAN

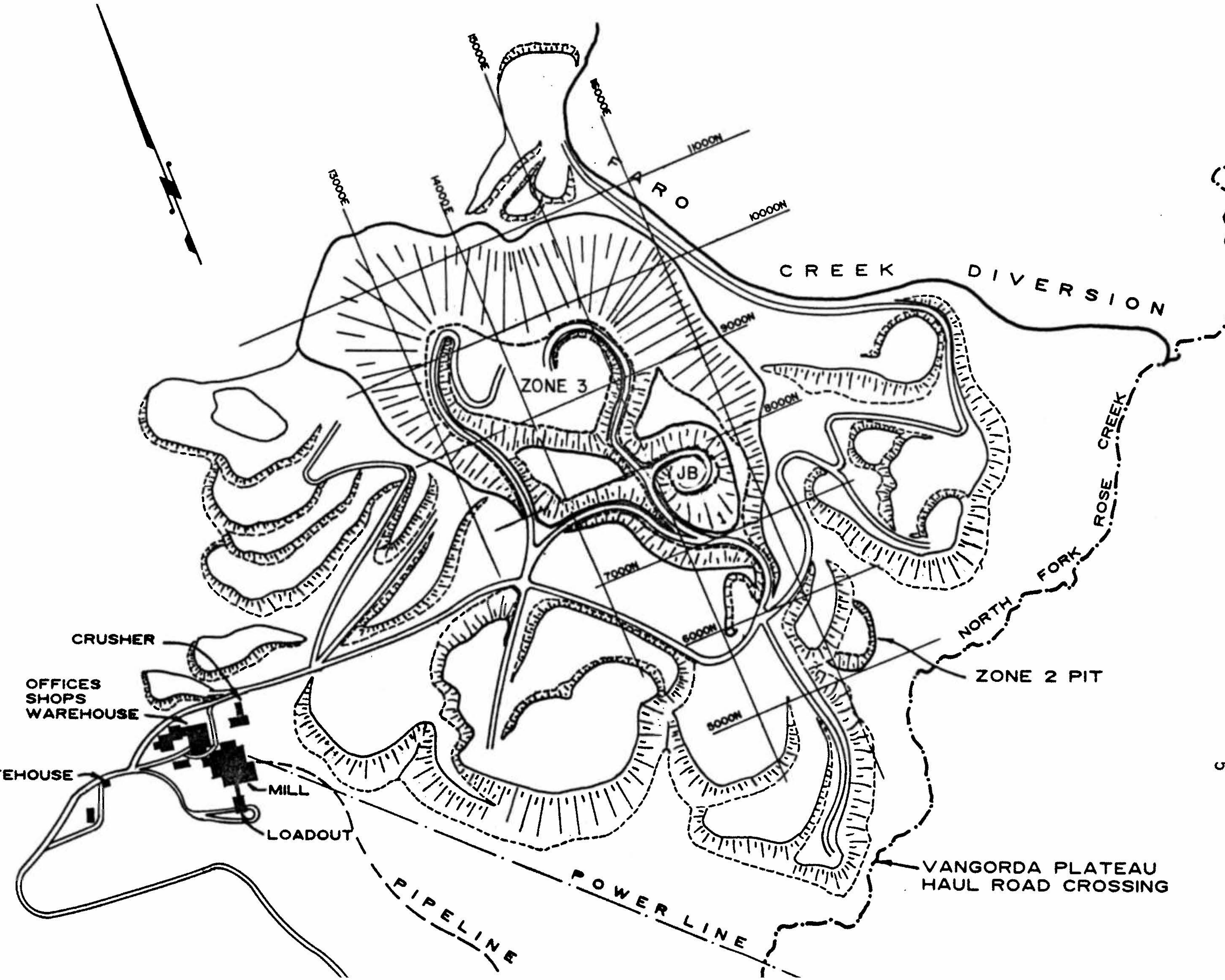
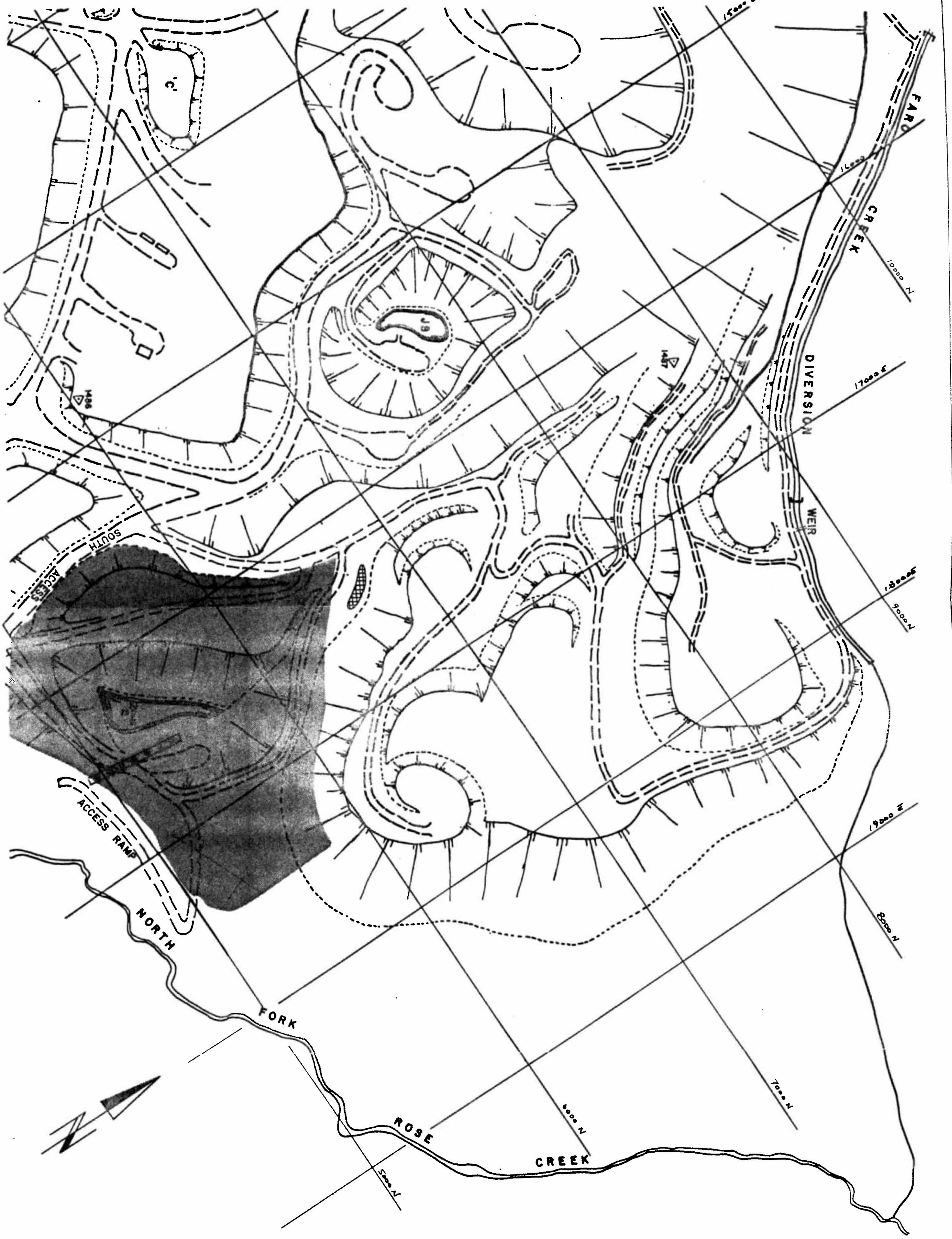


Fig. 1



LEGEND

- FARO DIVERSION LINER
- INTERNAL ROCK DRAIN
- SEEP AREA
- AREA TO BE COVERED BY ZONE 2 WASTE DUMP
- CURRENT DUMPS
  - CREST
  - TOE

CURRAGH RESOURCES INC.

ZONE 2 WASTE DUMP

SCALE 1:6000 1987·12·08

Fig. 2

2.3. PROJECT TIMING

The time frame for completion of the three stages of the project is outlined in Table 1. Time to completion is approximately three years.

TABLE 1: PROJECT SCHEDULE

PROJECT DESCRIPTION	START DATE	FINISH DATE
STAGE 1		
DEWATER ZONE 2	JUN 12/87	NOV 15/87
DIVERT PART OF INFLOW TO ZONE 2	NOV 15/87	DEC 1/87
CONSTRUCT RAMP TO ZONE 2	AUG 21/87	OCT 30/87
INSTALL LINER IN FARO CREEK DIV.	OCT 1/87	OCT 15/87
STAGE 2		
CONSTRUCT INTERNAL DRAIN	OCT 21/87	DEC 30/87
UPGRADE ZONE 2 INFLOW DIVERSION	SPRING/SUMMER 1988	
INSTALL PIEZOMETER	EARLY 1988	
STAGE 3		
FILL ZONE 2 TO DUMP LIMIT	JAN/1988	DEC/1989

2.4. STAGE ONE DEVELOPMENT

Stage one of the project encompasses all the necessary details prior to beginning backfilling the Zone Two pit.

2.4.1. Construction of the Zone Two Access Ramp

Construction of an access ramp to the 3710 foot elevation (Figure 2) requires approximately 34,000 loose m^3 of material cut from the existing crest of the Zone 2 waste dump as well as approximately 23,000 loose m^3 of additional fill. This material is non sulphide-bearing rock, calc-silicate transitional to phyllite. Ramp design is constrained by the dump limit on the west to a 21 m width. With berm allowance, this restricts the ramp to single truck hauling. The ramp grade is -10% and follows on top of the old perimeter access into the Zone 2 pit. The ramp will provide access to the discharge point of the internal drain as well as accessing a source of gravel for the pit operation.

2.4.2. Liner Installation in the Faro Creek Diversion

Lining the Faro Creek Diversion has two major benefits. First, the reduction of water inflow to the existing mine workings will help to stabilize the north east wall as well as reduce mine dewatering costs. Second, the inflow of water to the Zone Two pit is expected to be reduced. The anticipated life requirement of the liner is five years, although the manufacturer suggests that the liner will last up to 20 years if properly installed. Ditches lined with similar material were installed in 1982 and are standing up well.

Installation of the liner has been completed. Approximately 690 m of the diversion were lined (Figure 2). First the ditch walls and base were sloped and graded to protect the liner from puncture or tearing. This was achieved by using a Cat 235 backhoe to dress the sides and bottom of the ditch.

Each liner measures 9 m by 30 m. Starting at the downstream point, crews of four stretched the liner into position and anchored the leading edge in a shallow trench running across the stream. This trench was backfilled to provide a seal. The sides of the liner were anchored using 13 mm diameter rebar pins 0.6 m long, every 1.5 m along both sides. Each liner was overlapped approximately 3 m and a 5 cm layer of calc silicate rock, crushed to minus 5 cm, was placed in the bottom to provide an anchor.

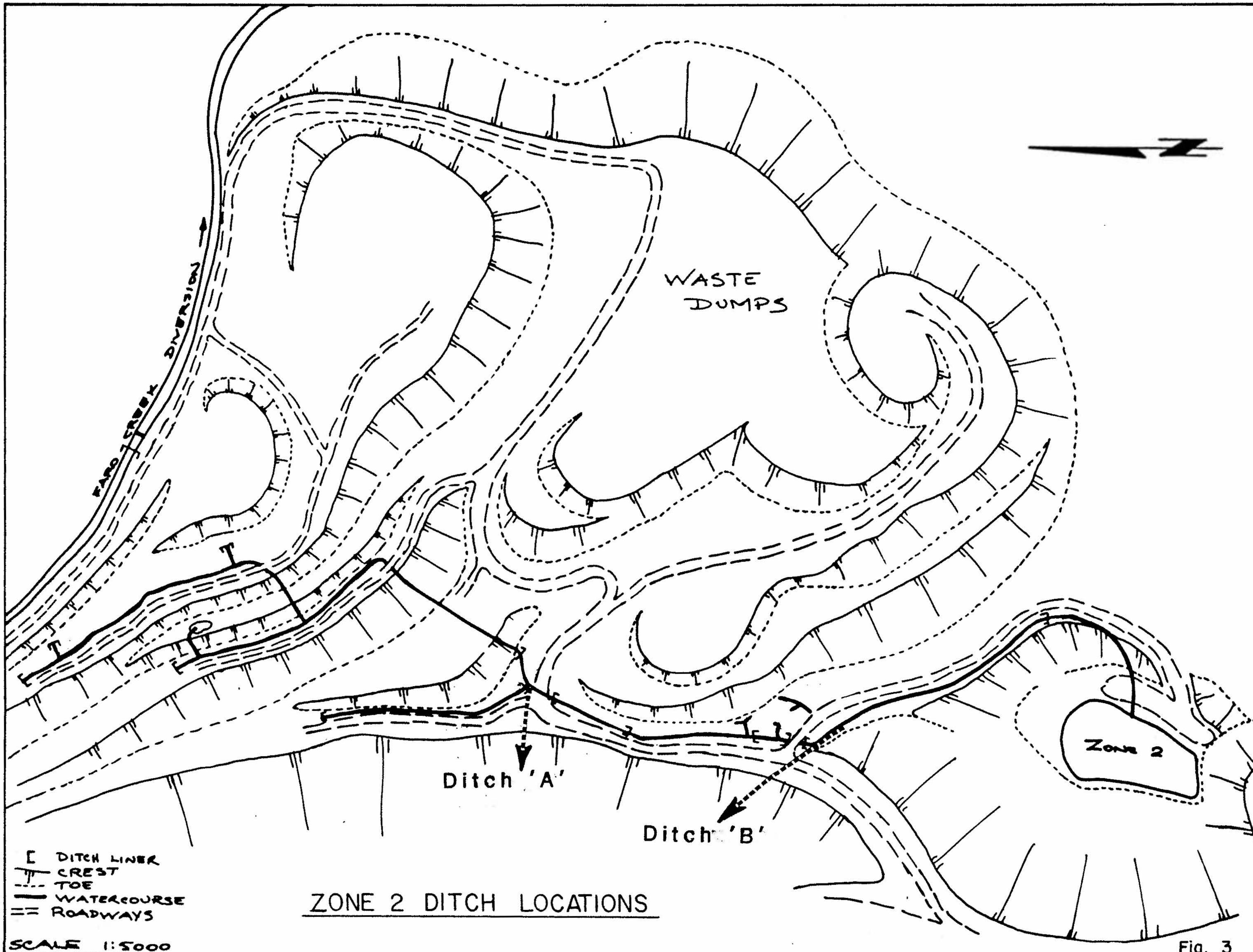
2.4.3. Zone Two Dewatering

Dewatering the Zone Two pit began in June, 1987 using a Flygt BS 2400 submersible pump with high head capacity. A second pump of the same description was installed in August. Water joined pit water from the JB pit in-line and was pumped to the tailings pond. Dewatering was completed November 15, but the pump installation will remain in place through the spring of 1988.

2.4.4. Diversion of Surface Flow

The surface inflow to Zone 2 from the lined ditch north of the pit will be intercepted and diverted into the JB pit, where an active sump is in place and is capable of handling the increased flow. Flow from the upper part of the ditch was intercepted during Stage One.

The diversion ditch (Ditch A, Figure 3) constructed during this stage is located at the 4030 foot bench in the main pit. It consists of an open, unlined ditch and it diverts all flow from the lined ditch system upstream of this point directly to the JB pit.



ZONE 2 DITCH LOCATIONS

Fig. 3

2.5. STAGE TWO DEVELOPMENT

2.5.1. Internal Rock Drain

An internal rock drain is being constructed to allow collection of water from the pit below the level at which it would naturally overflow (Figure 4). The drain will be buried within the backfilled portion of the Zone 2 workings but at an elevation approximately 3 m (10 feet) lower than the known natural drainage discharge point of 3812 feet. A drainage channel approximately 120 m (400 feet) long by 4.3 m (14 feet) wide by 6.1 m (20 feet) deep will be filled to 2.4 m (8 feet) with coarse calc silicate riprap and will daylight the Zone 2 workings to the north side of the valley. This channel will be backfilled to the 3950 foot elevation.

A heavy wall 41 cm diameter H.D.P.E. pipe will collect the water from a point approximately 40 m (130 feet) from within the backfilled channel or ditch and direct it to the face of the dump where it can be collected in a sump and pumped back to the tailings pond. An impervious dyke of compacted till will be used to dam the water and force it through the drain pipe. A second pipe near the top of the dyke will act as an overflow. By installing a valve on the lower pipe, the 3 m (10 feet) between the two pipes will provide live storage capacity within the backfilled pit.

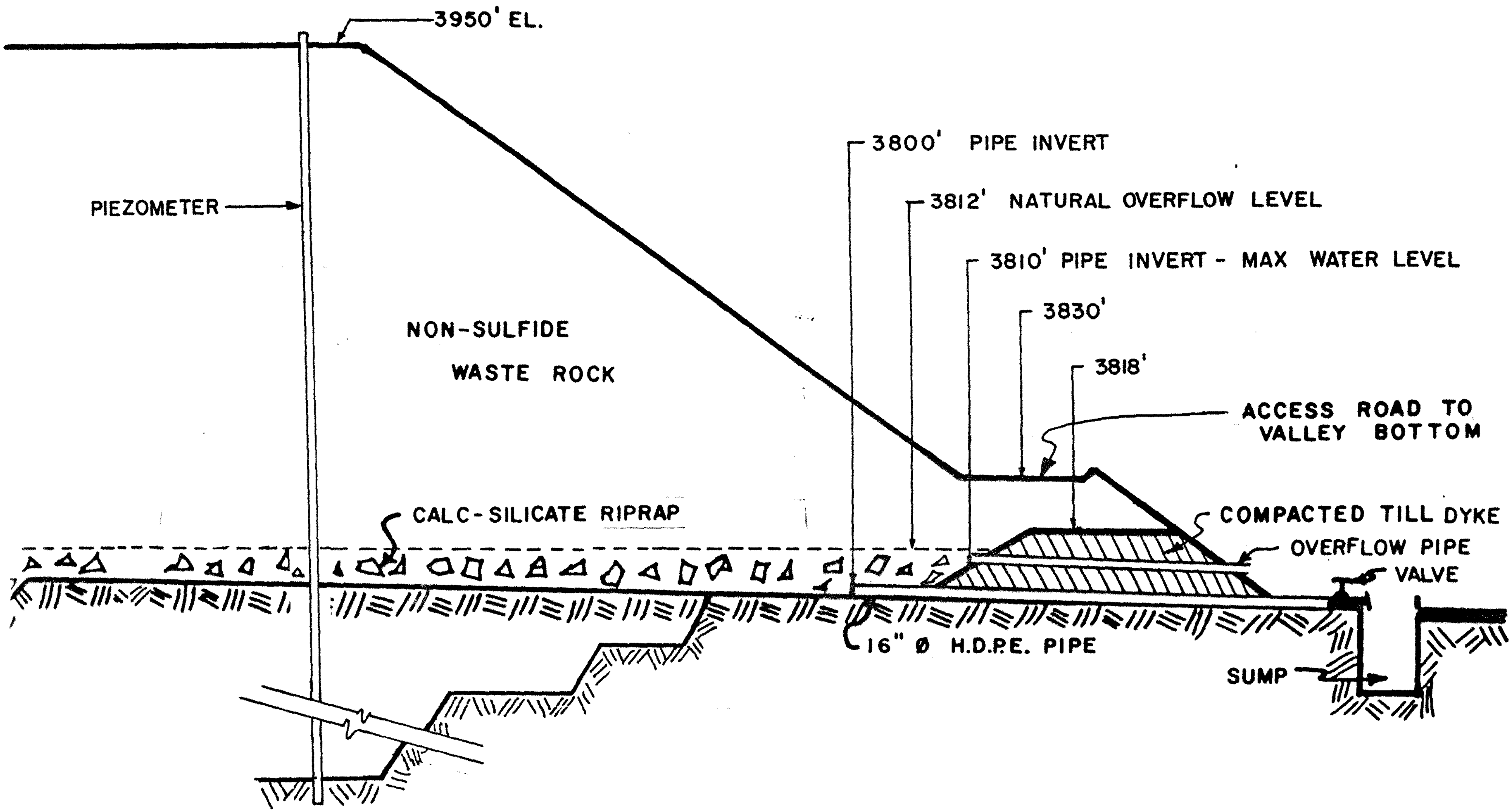
Using a 25% swell factor, the voids within the dump provide approximately 106,000 m^3 of reservoir capacity between the two pipes.

2.5.2. Extension of Surface Inflow Diversion

In late spring or summer, 1988, a permanent diversion ditch will be constructed to reduce surface and shallow subsurface flow to Zone 2 (Ditch B, Figure 3). This will consist of:

1) A structure to collect seeps from the area identified as the major source of surface flow to the Zone 2 pit (see Part Three). Designs have not been finalized for this structure. However, it will consist of a ditch deep enough to collect shallow subsurface flow, will be well-lined and designed to collect diffuse seepage along its length.
2) A ditch to divert this accumulated seepage to the JB pit.

Part of the Zone 2 pit will be left uncovered until this ditch has been completed so that the pit may be dewatered following



LONGITUDINAL SECTION THROUGH INTERNAL ROCK DRAIN.

freshet of 1988.

This diversion will be constructed as an abandonment measure and detailed plans will form part of the Faro pit abandonment plan. The limits of the Zone 2 dump will not extend over this high seepage area (Figure 2). There are no other year-round seeps that will be buried.

2.5.3. Piezometer Installation

A standpipe piezometer will be installed at the low point of the backfilled Zone 2 pit in order to measure the rise in water level and to provide an access point for water sampling. This information will assist in assessing the effectiveness of the diversion ditch described above.

2.6. STAGE THREE DEVELOPMENT

Stage Three incorporates the full development of the Zone 2 dump. Approximately 8 million tonnes of fill are scheduled for this area. This is a principal dump area through the fourth quarter of 1989. Table 2 presents the dump schedule by quarter, with waste rock types.

TABLE 2: ZONE TWO DUMP SCHEDULE

PERIOD	TONNES	PERCENTAGES OF WASTE ROCK TYPES*
1ST QTR/88	2,226,000	100% BIOTITE SCHIST
2ND QTR/88	2,144,000	100% BIOTITE SCHIST
3RD QTR/88	455,000	80% BIOTITE SCHIST; 20% CALC-SIL
4TH QTR/88	808,000	100% BIOTITE SCHIST
1ST QTR/89	577,000	100% BIOTITE SCHIST
2ND QTR/89	287,000	100% BIOTITE SCHIST
3RD QTR/89	202,000	100% BIOTITE SCHIST
4TH QTR/89	1,263,000	98% BIOTITE SCHIST; 2% CALC-SIL
TOTAL	7,962,000	98.5% BIOTITE SCHIST; 1.5% CALC-SIL

*Calculated as percentages of total non-sulphide waste rock for each bench/phase combination to be mined in each quarter. Percentages are approximate as some waste will go to other dumps.

3. PART 3: ENVIRONMENTAL IMPACT

3.1. SUMMARY

There will continue to be no discharge of contaminated water from the Zone 2 area to the North Fork of Rose Creek while the Faro mine is operating. Any seepage from the backfilled pit will be pumped to the tailings pond. The waste rock to be deposited in the Zone 2 dump is non acid generating and thus will not contribute to any longterm problems. Viable abandonment options will not be eliminated by the implementation of this plan. Water quality data for the Zone 2 area are presented and abandonment plans are discussed.

3.2. ACID GENERATION POTENTIAL OF WASTE ROCK TO BE DEPOSITED IN ZONE 2

As precipitation to the new Zone 2 waste dump will drain into the backfilled pit, the dump will be used for non sulphide wastes only. As indicated in Table 2, approximately 98.5% of the waste rock to be deposited in the dump will be biotite schist (rock type 1DO, biotite-muscovite-andalusite schist, described in Jennings and Jilson (1986) as schist of the Mt. Mye formation). The remaining 1.5% will be calc-silicate (types 3DO, calc-silicate and 3Dbxa, calc-silicate breccia, described as calc-silicate of the Vangorda formation in Jennings and Jilson (1986)). Table 3 presents results of acid generation potential testing of waste rock of these types. One sample of pyritic massive sulphide (rock type 2E) is included for comparative purposes.

The samples were taken in the spring of 1987. Samples labelled with a letter name were rocks taken from the working face of the pit. This set of samples was submitted first, and the results indicated a high degree of variability. The remaining samples were then sent for analysis. These were chosen randomly from a computer listing of drill holes/footage of each rock type. Within the selected footage, samples were chosen by a geologist to be representative of the rock type. Sample size was 2 to 3 kg. Samples were sent to CHEMEX Labs Ltd. in North Vancouver for analysis following methods outlined in "Field and Laboratory Methods Applicable to Overburdens and Minesoils" (Environmental Protection Agency 1978).

Table 3 indicates that both the biotite schist and and calc-silicate are net acid consumers. Material with an effective neutralization of less than -5 $CaCO_3$ equivalent (tons/1000 tons

TABLE 3: ACID GENERATION
POTENTIAL OF ZONE 2 WASTE ROCK TYPES

ROCK TYPE	SAMPLE (hole and footage)		% S	MAXIMUM POTENTIAL ACIDITY(1)	PASTE pH	NEUTRALIZATION POTENTIAL(2)	EFFECTIVE NEUTRALIZATION(3)
BIOTITE SCHIST							
1DO	77-09	210	0.035	1.09	9.1	82.5	81.41
1DO	80-08	300	0.087	2.72	8.7	36.8	34.08
1DO	80-02	320	0.124	3.88	8.3	31.9	28.02
1DO	80-02	280	0.215	6.72	8.7	94.8	88.08
1DO	81-10	240	0.246	7.69	8.2	91.7	84.01
1DO	76-13	340	0.280	8.75	7.9	29.8	21.05
1DO	77-16	340	0.296	9.25	8.2	42.5	33.25
1DO	84F-24	240	0.354	11.10	8.2	34.4	23.30
1DO	76-08	340	0.359	11.20	8.8	36.7	25.50
1DO	80-08	220	0.381	11.90	7.4	67.9	56.00
1DO	76-03	400	0.538	16.80	8.3	132.0	115.20
1DO	B		1.140	35.60	7.5	10.4	-25.20
Mean values			0.34	10.56	8.3	57.62	47.06
CALC-SILICATE							
3DO	D		0.423	13.20	8.9	212.7	199.50
3Dbxa	82F-06	180	0.026	0.81	9.3	98.1	97.29
3Dbxa	76-04	250	0.048	1.50	9.1	76.2	74.70
3Dbxa	82F-06	160	0.066	2.06	9.3	55.2	53.14
3Dbxa	76-04	280	0.067	2.09	8.8	87.4	85.31
3Dbxa	80-04	280	0.070	2.19	9.1	57.9	55.71
3Dbxa	77-01	280	0.111	3.47	8.9	99.3	95.83
3Dbxa	80-03	100	0.121	3.78	9.2	79.3	75.52
3Dbxa	80-03	140	0.628	19.60	9.0	63.3	43.70
3Dbxa	E		0.789	24.70	8.5	17.9	-6.80
3Dbxa	82F-01	270	0.791	24.70	9.2	95.0	70.30
Mean values			0.29	8.92	9.0	85.66	76.75
MASSIVE SULPHIDE							
2E	A		30.900	965.60	5.9	2.8	-962.81

(1) $CaCO_3$ Equivalent (tons/1000 tons rock). Calculated from % S.
(2) $CaCO_3$ Equivalent (tons/1000 tons rock).
(3) $CaCO_3$ Equivalent (tons/1000 tons rock). Difference between neutralization potential and maximum potential acidity.

rock) is defined as potentially toxic (Environmental Protection Agency 1978). However, recent work has indicated that samples with much higher effective neutralization values generate acid under certain conditions (Ferguson and Erickson 1987), due to relative rates of acid production and consumption.

The sulphides and the carbonates are patchily distributed within the schist and the calc-silicate, resulting in high variability among samples. One sample of each type was a net acid generator. This would indicate that there exists some potential for acid generation in small pockets within a dump constructed of either waste rock type. However, as most samples were clearly net consumers of acid, significant acid mine drainage should not occur. Therefore, water quality in the Zone 2 pit should not be adversely affected by drainage through the proposed dump.

3.3. IMPACT ON WATER QUALITY

If water accumulates in the Zone 2 pit to an elevation of 3812 feet, it seeps through permeable material in the bank at this level and flows to the North Fork of Rose Creek. This seepage from Zone 2 has on occasion resulted in elevated levels of zinc in the North Fork. Table 4 presents data from two periods of overflow. Regular samples were not taken upstream of the seepage, but the one value on record, extractable zinc of 0.005 mg/L on Nov. 2, 1983, indicates that background levels were low.

Zinc levels from 1980 to 1984 in the North Fork are presented in Figure 5. It is suspected that there has been some zinc addition via the Faro Creek diversion (from water pumped to it from the Faro swamp) throughout the life of the mine. However, the sharp rise in zinc concentration during the 1983/84 overflow period indicates that seepage from Zone 2 can have a far greater influence on North Fork water quality.

It is difficult to interpret the historic data, as there are few records of seep flows or rates at which water rose in the pit. Although the seepage flow from Zone 2 in 1983/84 was sufficient to have a marked effect on the North Fork, records of water levels in the Zone 2 pit indicate that the level did not rise substantially between October, 1984 and April, 1985. Water rose only from the 3790.1 to the 3791.4 foot elevation between August 15 and December 9, 1985. Differences could be related to the configuration of the drainage ditch system, which was installed between 1982 and 1984 and has been extended and lined since. The surface and groundwater inflow rates are unknown. It would appear, however, that when inflow is relatively low, the water level in the pit rises only very slowly. This would suggest that there is an outflow of groundwater from the pit sufficient to nearly balance inflow under some conditions. Much of this

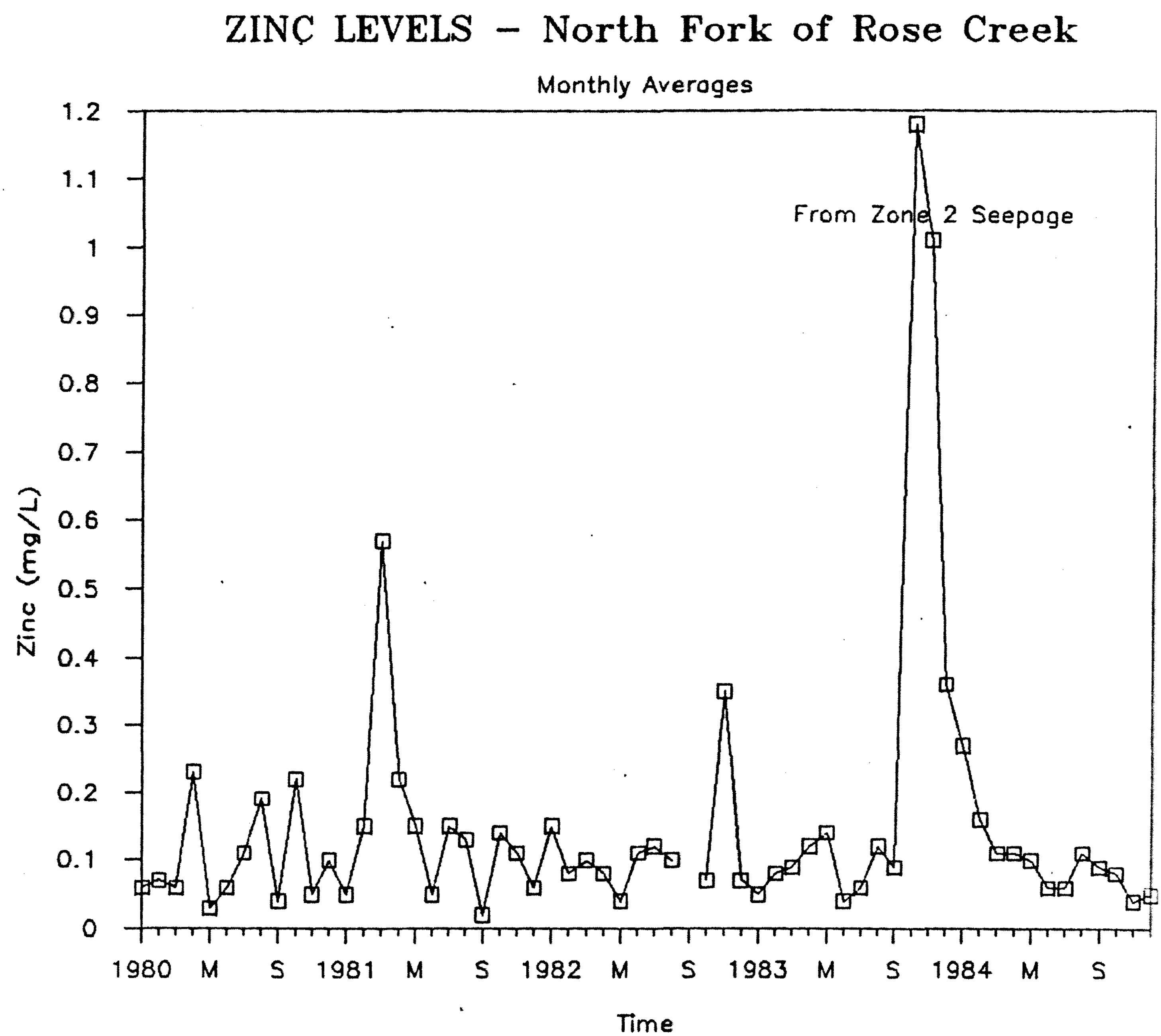

ZINÇ LEVELS – North Fork of Rose Creek
Monthly Averages
Zinc (mg/L)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
From Zone 2 Seepage
1980
M
S
1981
M
S
1982
M
S
1983
M
S
1984
M
S
Time

Fig. 5

TABLE 4: ZINC CONCENTRATIONS IN ZONE 2 SEEPAGE AND THE NORTH FORK OF ROSE CREEK DURING PERIODS OF OVERFLOW OF THE ZONE 2 PIT

Date	Zn (ext) mg/L Average of daily samples		Comments
	Zone 2 Seepage	North Fork (X2)	
1983-84			
Late Oct.			Overflow began
Nov 1-7	9.26	1.21	
Nov 8-14	9.26	1.05	Liming started
Nov 14-20	6.48	0.84	
Nov 21-27	5.09	1.17	
Nov 28-Dec 4	5.41	0.77	Pumping to Zone
Dec 5-11	6.18	0.40	3 pit started
Dec 12-18	6.86	0.33	
Dec 19-26	6.51	0.33	
Dec 27-Jan 2	7.15	0.38	
Jan 3-9	7.76	0.35	
Jan 10-16	7.48	0.25	
Jan 17-23	8.00	0.19	
Jan 24-31	7.34	0.17	Seepage stopped as
February			water level dropped
1986			
Sept 6-10	-	.18	Overflow noticed Sept 6, pumping
Sept 11-17	-	.23	started immediately

TABLE 5: ZONE 2 PIT WATER QUALITY, LATE AUGUST, 1987 (DATA FROM WATER RESOURCES DIVISION, NORTHERN AFFAIRS, WHITEHORSE)

Extractable Metals (ICP scan), expressed as mg/L							
Al	.13	Co	.172	Na	11.2	Si	4.7
As	<.05	Cr	<.005	Ni	.16	Sn	<.01
B	<.001	Cu	.025	P	.1	Sr	.74
Ba	.053	Fe	4.08	Pb	.04	Ti	<.002
Be	<.001	Mg	47.2	Sb	<.05	V	<.005
Ca	133.	Mn	2.55	Se	<.05	Zn	21.4
Cd	.026	Mo	<.005				

groundwater would flow in the direction of the main Faro pit, which is currently approximately 100 m deeper than the Zone 2 pit.

Results from analysis of Zone 2 water quality by the Water Resources Division of Northern Affairs (Table 5), taken in August, 1987, indicate that zinc is the only parameter of concern. The pit water is neutral, with high calcium and magnesium levels.

Water enters the pit through:
1) Precipitation to the exposed and backfilled portion of the pit.
2) Surface and groundwater flow from the Zone 2 watershed to the northeast of the pit.
3) Surface flow diverted to this watershed from the upper benches of the main pit.

Possible sources of zinc in this water are:
1) Zinc leached from the waste dumps northeast of Zone 2.
2) Zinc leached from the waste dumps filling 80 % of the Zone 2 pit.
3) Zinc leached from sulphide materials remaining in the Zone 2 pit (both in the backfilled and in the exposed sections).
4) Zinc leached from sulphide materials remaining in the upper benches of the main pit (Zone 3) and carried to Zone 2 in the diverted water.

As outlined in the engineering plans (Part Two), action is being taken now to reduce inflow of zinc-contaminated water to Zone 2 by:
1) reducing flow in the ditch system through the lining of the Faro Creek diversion.
2) diverting as much as possible of the surface inflow to the JB Pit (and eventually to the tailings pond).

These measures will eliminate the flow from the upper benches of the main pit and reduce the flow from the waste dumps.

The impact on the North Fork of Rose Creek at abandonment of the minesite can be minimized by reducing seepage from the pit and/or reducing zinc concentration in the seepage. However, the design of an effective abandonment plan for this area requires a fuller understanding of the sources of water and zinc. Curragh is taking steps to acquire this information:
1) To quantify the sources of zinc loading to the pit, a series of seep surveys has been initiated (described below).
2) In order to better understand the process by which zinc enters the water, testing for the presence of the acid-generating bacteria *Thiobacillus ferrooxidans* is being conducted in cooperation with Environment Canada. Results will be available by late December.

3) A piezometer will be installed at the low point of the pit in order to measure the rate at which water rises in the pit and to provide access for sampling for zinc concentration in the pit water.

3.4. SEEP SURVEY, SEPTEMBER, 1987

3.4.1. Introduction

In order to gain a better understanding of the chemical properties and flow characteristics of surface inflows to the Zone 2 area, all inflows to the pit and to the lined ditch which drains into the Zone 2 pit were sampled during late September, 1987. This study formed part of a seep survey which included the Faro pit, waste dumps and receiving waters, carried out as part of the Faro pit abandonment plan development. Additional seep surveys will be conducted in 1988. These will include one further comprehensive survey (sampling all dump and major pit seeps) during high runoff and a series of surveys of key seeps at different seasons.

3.4.2. Methods

Samples were collected from Sept 24 to Sept 29, 1987. Key site locations are marked on Figure 6.

All inflows to the ditch system collecting seeps from part of the northeast wall of the main pit and from the waste dumps above Zone 2 pit, and draining to the Zone 2 pit, were sampled; major dry seeps were numbered and described so that they may be located during future seep surveys. Water from the Zone 2 pit was sampled.

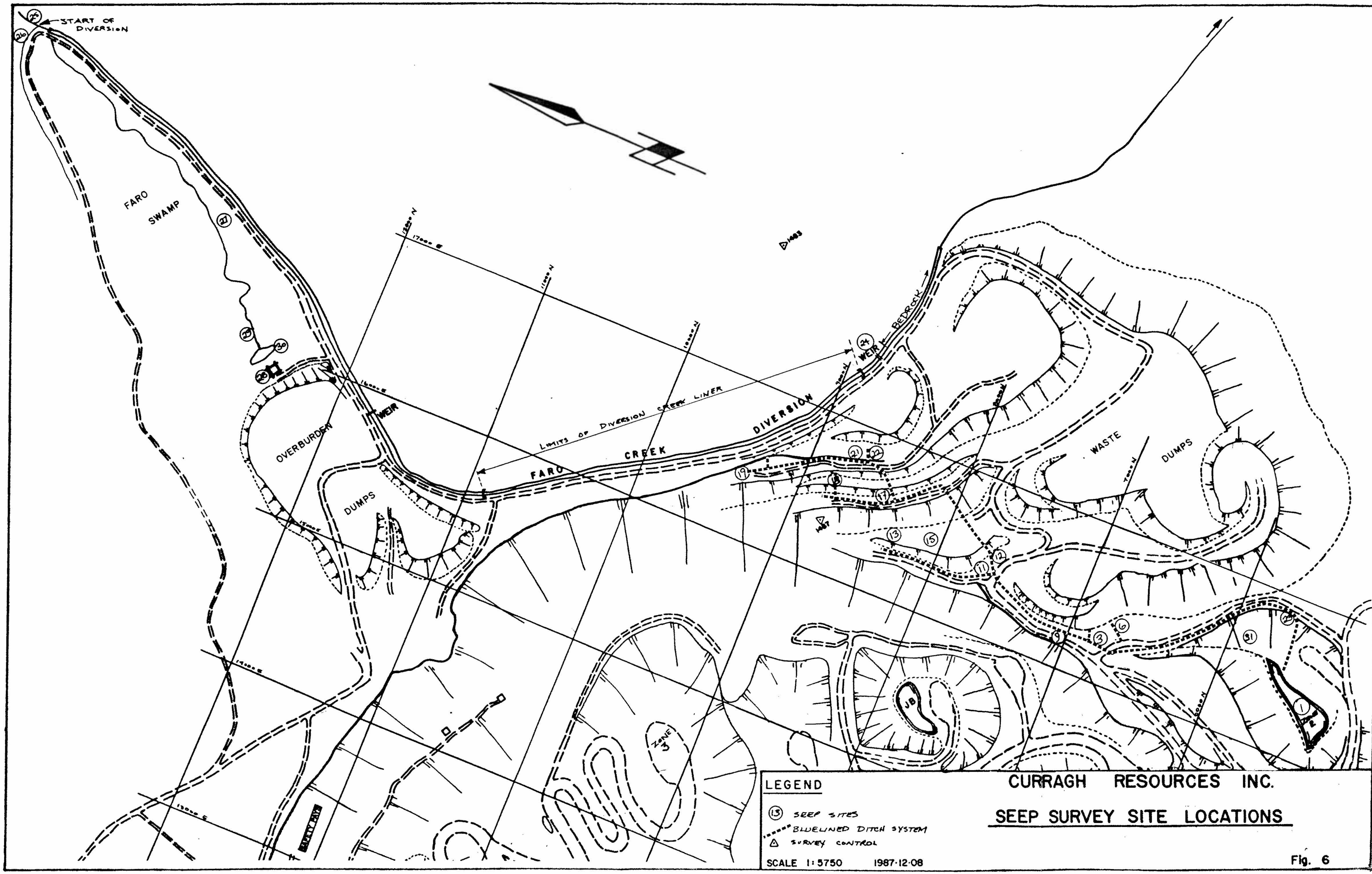
Faro Creek (a possible source of flow to Zone 2) was sampled above the diversion and at a point about 2 km downstream of the point of diversion. Flows were measured at three locations in the diversion ditch.

At each sample site, field measurements were conducted as follows:

1. pH and temperature, using a Beckman 21 pH meter. The meter was recalibrated several times a day using standard solutions.

2. Conductivity, using Hanna HI8033 Conductivity meter, calibrated daily with 0.01 M KCl solution.

3. Flow, where possible, using one of three methods:


START OF DIVERSION
FARO SWAMP
OVERBURDEN DUMPS
WEIR
LIMITS OF DIVERSION CREEK LINER
FARO CREEK DIVERSION
BEDROCK
WASTE DUMPS
ZONE 3
JB
LEGEND
13 SEEP SITES
BLUELINED DITCH SYSTEM
SURVEY CONTROL
SCALE 1:5750
1987-12-08
CURRAGH RESOURCES INC.
SEEP SURVEY SITE LOCATIONS
Fig. 6

a. Marsh McBirney Portable Water Current meter. Depth and velocity readings were taken every 0.1 m and the cumulative discharge was calculated.

In order to estimate the degree of certainty attached to these measurements, five trials were conducted at about 1 m intervals in an area of the Faro diversion ditch with a substrate composed of fairly uniform cobbles (90 m below the point of diversion). The mean flow was 163.2 L/s, with a standard error of 6.16 L/s. The resulting 95% confidence limits are plus and minus 10% of the mean (ie there is 95% certainty that the true value is no more than 10% greater than or less than the reported value).

b. Bucket: flow into a bucket (10 L, 5 gallon or 45 gallon drum) was timed to measure flows through pipes, culverts and liner whenever possible.

In each instance, 3 trials were done and an average taken. Flows measured by this method were more precise than metered flows, as in almost all cases, the three trials were identical.

c. Visual estimation, when no other method was possible. In several locations it was felt that a reliable estimate could not be made and no flow value was recorded.

Estimated flows would be the least accurate. Very small flows were recorded in the field as 0.1 L/s or less than this quantity. The latter were translated into 0.05 L/s for the purposes of estimating metal and sulphate loads.

Photographs were taken at most sites.

Acid-washed, 250 mL bottles were rinsed, filled, and preserved with 1 mL nitric acid for laboratory analysis for total zinc and copper. Although Curragh's water licence requires water samples to be analysed for extractable metals, total metals were chosen so that loadings could be calculated. Samples for total sulphate analysis were taken in 250 mL bottles. Bottles were delivered to Bondar-Clegg & Co. Ltd.'s laboratory in Whitehorse on September 30, 1987 and water analyses were conducted following the standard methods specified by Curragh's water licence.

3.4.3. Results

3.4.3.1. Flow and Water Quality Results

Results of laboratory and field testing are listed in Table 6. Zinc, copper and sulphate loads were calculated as the product of concentration and flow. It should be remembered that the accuracy of these values is limited by the approximate nature of flow values, particularly those arrived at by "estimation" (see Section 3.2.2.1). Flow measurements are shown on Figure 7 and Figures 8 and 9 show total zinc concentrations and zinc loads respectively.

3.4.3.2. Description of Seeps

3.4.3.2.1. Zone 2 Pit

Inflows to the Zone 2 pit were: 1) seeps collected in the lined ditch and directed to Zone 2, and 2) a seep area on the north wall of the pit. The water was being pumped out of the pit at the time of sampling. Pumped water joined JB pit water in-line and flowed to the tailings pond.

SITES:

1- Zone 2 pit water. Neutral, low copper, 20 mg/L zinc, 450 mg/L SO4.

31- Seep area on north face of Zone 2 pit wall. Water emerged from high on the pit wall. There were several damp areas and patches with dark red stains and erosion indicating seasonal seepage. Flow estimated to be about .1 L/s. Acid (pH 3), 9 mg/L copper, 94 mg/L zinc, 860 mg/L SO4.

2- Outlet of blue line ditch to Zone 2. Water was neutral, 4 mg/L zinc, 200 mg/L SO4, low copper, flow of 9.4 L/s.

3.4.3.2.2. Blue line ditch

This lined ditch system intercepts seeps in the upper benches of the main pit and seeps from waste dumps north of Zone 2. The liner, which was installed in 1986, does not intercept side channels well, as they tend to erode the point of entry and run under the liner. Most of the flow in the ditch at the time of sampling entered the ditch either through seeps from the Faro Creek diversion ditch or through seeps emerging from the waste dump north of Zone 2.

The only acid seep to the ditch was from the Zone 3 pit wall. This seep was very similar to the seep in the Zone 2 pit wall,

TABLE 6: ZONE 2 SEEP SURVEY DATA, SEPTEMBER, 1987

Site	Name	Date	Time	Cu mg/L	Zn mg/L	SO4 mg/L	pH units	Cond. umhos/cm	Temp deg.C	Flow L/s	Method of Flow	Zn Load mg/s	Cu Load mg/s	SO4 Load mg/s
	ZONE 2													
1	Zone 2 pit water	Sep 24	1400	0.028	20.100	444.0	7.06		2.4	pond				
2	Ditch at outlet to pit	Sep 24	1400	0.076	4.000	202	7.27	602	2.4	9.40	meter	37.6	0.71	1899
31	Seep to Zone 2 pit	Sep 29	1700	9.300	93.500	860	3.06	1910	5.5	0.10	estimate	9.4	0.93	86
	LINED DITCH													
3	Ditch at road	Sep 24	1530	0.145	2.650	93	7.54	380	2.1	8.40	meter	22.3	1.22	781
4	Seep from dumps to ditch	Sep 24	1540	0.002	1.150	139	7.71	475	1.9	0.40	meter	0.5	0.00	56
5	Seep from dumps to ditch	Sep 24	1550	0.048	5.860	315	7.49	725	1.8	0.70	bucket	4.1	0.03	221
6	Seep from dumps to ditch	Sep 24	1600	0.040	5.600	278	7.00	762	1.7	3.50	meter	19.6	0.14	973
7	Seep from dumps to ditch	Sep 24	1630	0.011	2.610	139	7.06	503	2.4	1.40	meter & est	3.7	0.02	195
8	Seep from dumps to ditch	Sep 24	1640	0.013	2.550	134	6.91	477	2.8	0.48	meter & est	1.2	0.01	64
9	Ditch	Sep 24	1650	0.215	2.790	63	7.20	225	2.9	2.90	meter	8.1	0.62	183
10	Ditch	Sep 25	0900	0.235	2.860	64	7.14	159	6.9	4.00	bucket	11.4	0.94	256
11	Ditch	Sep 25	0930	8.980	99.000	1290	3.30	1580		0.10	bucket	9.9	0.90	129
12	Ditch	Sep 25	1000	0.018	0.515	32	6.70	121		3.70	bucket	1.9	0.07	118
13	Dry seep to ditch									0.000		0.0	0.00	0
14	Seep from pit to ditch	Sep 25	1400	0.022	0.600	101	8.32	290		0.05	estimate	0.0	0.00	5
15	Dry seep to ditch									0.000		0.0	0.00	0
16	Ditch	Sep 25	1500	0.007	0.295	30	8.23	185		3.30	bucket	1.0	0.02	99
17	Ditch	Sep 25	1530	0.005	1.260	42	8.05	125		0.14	bucket	0.2	0.00	6
18	Seep to pipe to ditch	Sep 25	1620	0.005	1.730	40	7.80	158		0.14	bucket	0.2	0.00	6
19	Top of ditch system	Sep 25	1630	0.003	0.070	13	8.10	90	4.6					
20	Ditch below lined patch	Sep 25	1640	0.004	0.108	14	8.20	76	4.6			0.0	0.00	0
21	Ditch	Sep 25	1650	0.011	0.315	25	8.20	93	4.2	1.50	meter & est	0.5	0.02	38
22	Ditch	Sep 25	1700	0.009	0.420	30	8.10	157	4.2					
23	End of lined ditch	Sep 26	0930	0.084	3.920	180	7.43	563	2.2	9.20	meter	36.1	0.77	1656
	FARO CREEK													
24	Faro diversion at weir	Sep 26	1030	0.009	0.285	14	7.80	41	2.0	81.40	meter	23.2	0.73	1140
25	Faro Creek	Sep 26	1200	-0.002	-0.002	8	7.82	27	2.8					
26	West Ditch to Faro Creek	Sep 26	1210	0.004	0.024	9	7.75	52	2.8	4.90	meter	0.1	0.02	44

- denotes less than

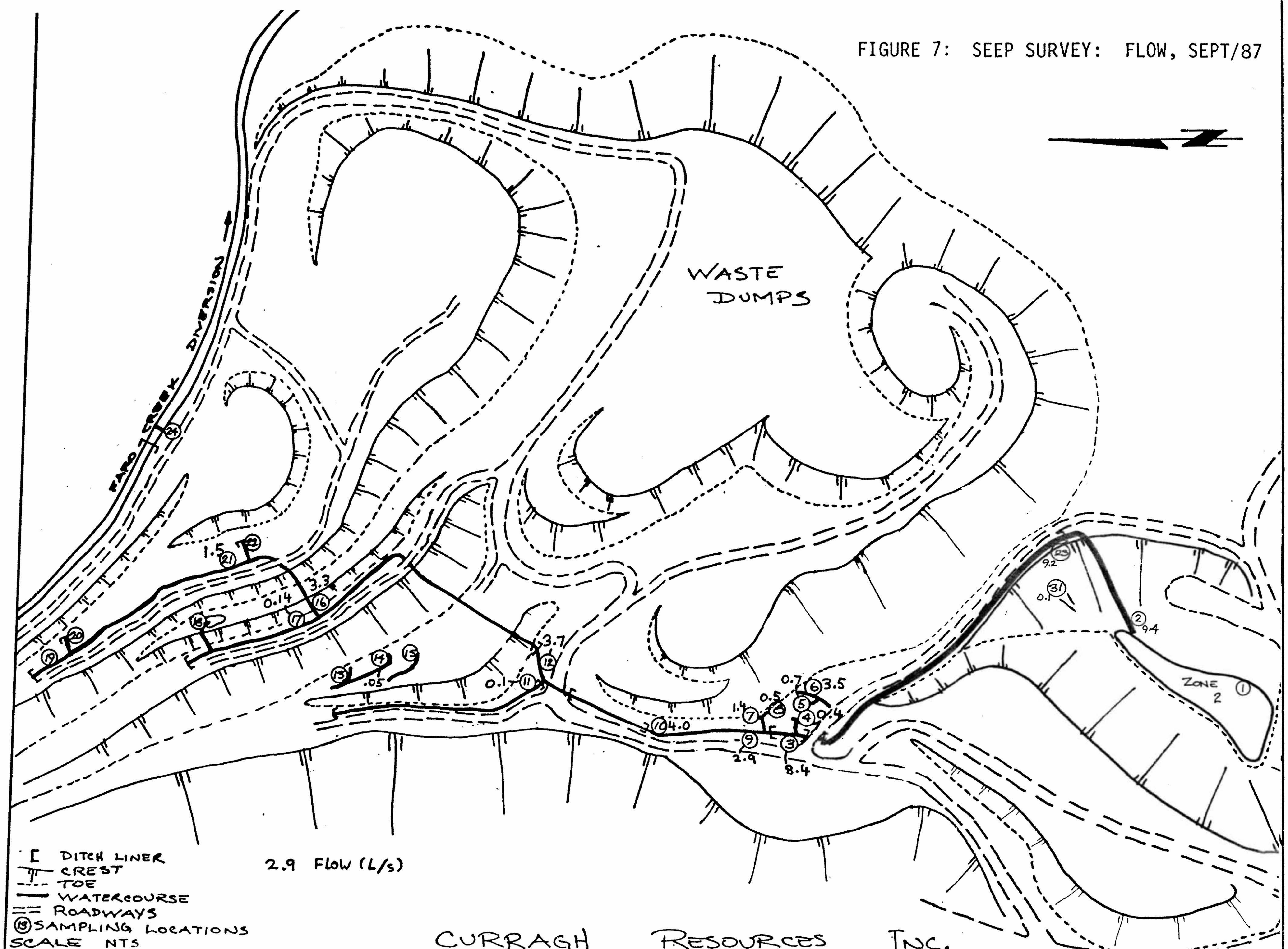


FIGURE 7: SEEP SURVEY: FLOW, SEPT/87

FIGURE 8: SEEP SURVEY: ZINC CONCENTRATION, SEPT/87

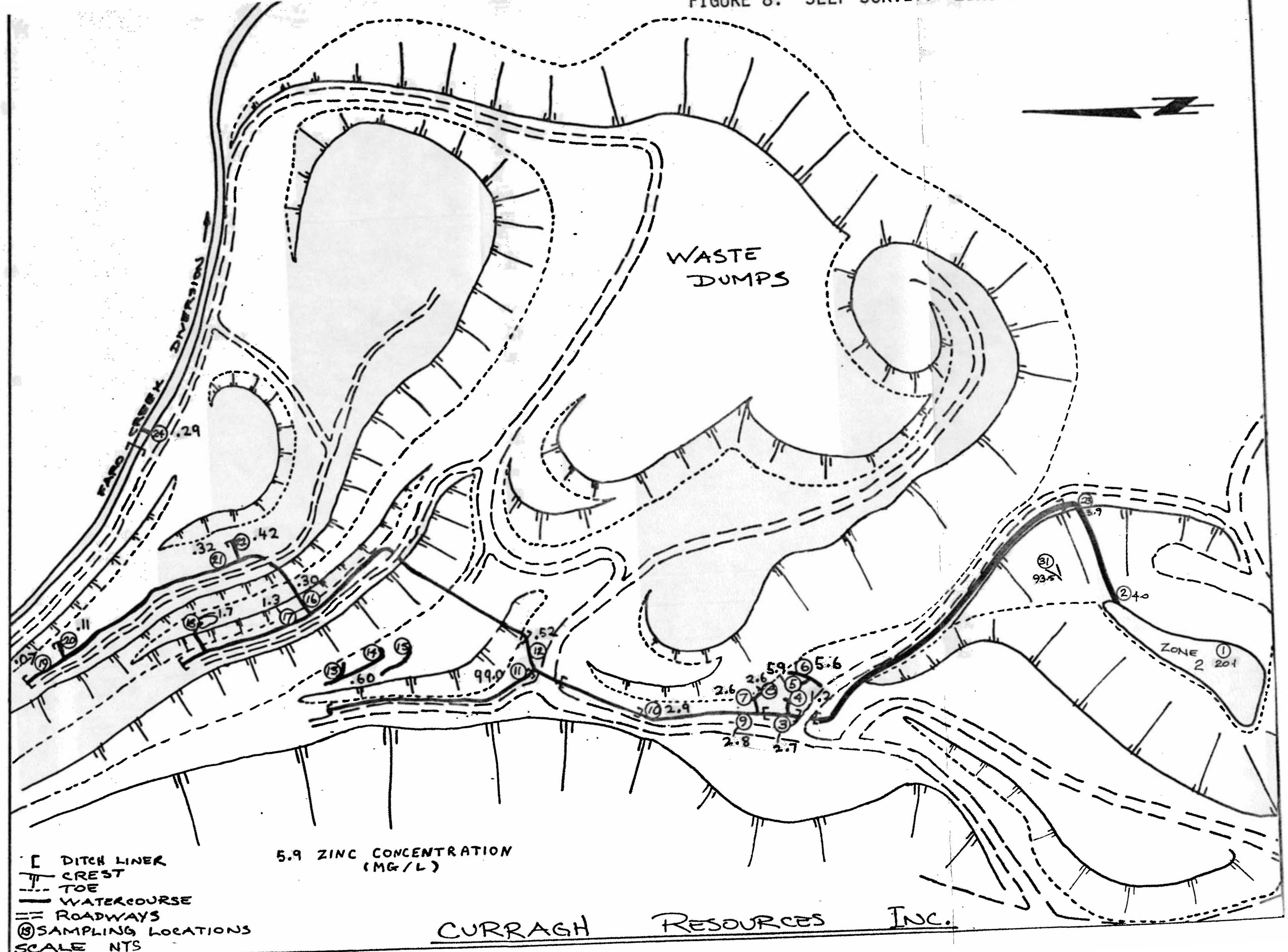
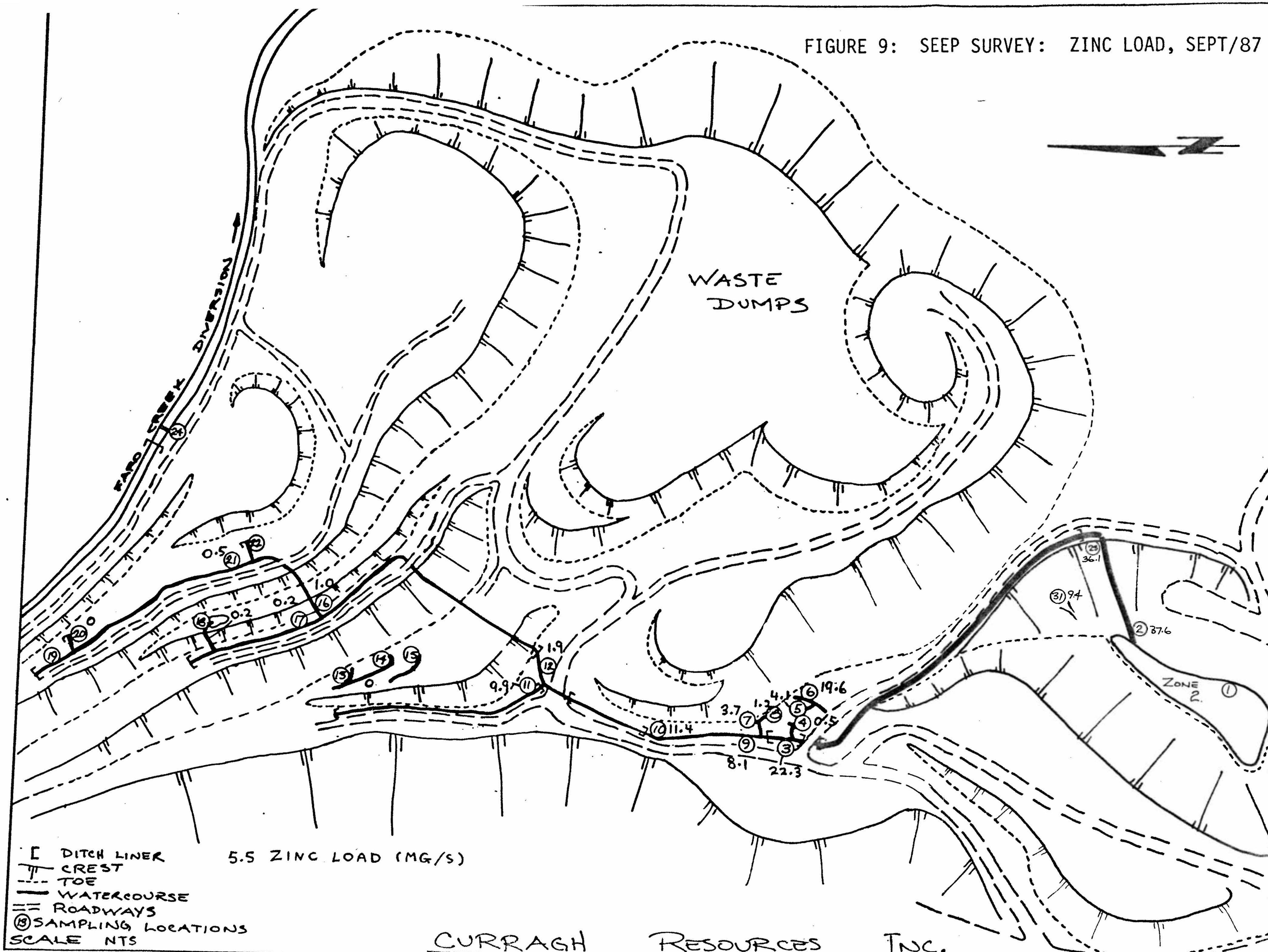


FIGURE 9: SEEP SURVEY: ZINC LOAD, SEPT/87



with very low pH, high zinc and copper. The zinc remained in solution but the copper was apparently removed from solution as the water was neutralized in the ditch. Major sources of zinc were the neutral seeps with high zinc from the old waste dumps northeast of Zone 2.

SITES:

23- End of liner (above east wall of Zone 2). Water quality similar and flow very similar to site 2.

3- Ditch at road crossing north of Zone 2 pit. Sample taken upstream of the seeps from the waste dumps at the road crossing (Seeps 4 ,5 and 6). Flow was almost as great as at the outlet, indicating that water downstream of this point was leaking out and running underground to Zone 2. Copper slightly elevated from the acid seep (seep 11) and zinc lower than at the outlet.

4, 5, 6- Seeps from the old waste dumps above Zone 2. The seeps ranged from about 1 to 6 mg/L zinc and accounted for much of the zinc and sulphate loads entering Zone 2 pit from this ditch system. They were neutral and low in copper. Much of the flow from all three was observed to be running under the liner and probably seeping through the pit wall to Zone 2 (partly as Seep 31).

7 and 8 - These two seeps flowed from the toe of the dump to the ditch. They were neutral, low in copper and about 2.5 mg/L zinc. There were many very small seeps and damp areas all along this section. This is reflected in the difference in flows in the ditch between Sites 9 and 3 (a threefold increase).

9- This sample was from a short unlined section of the ditch. Water neutral, zinc 2.8 mg/L and copper just above the effluent limit of .2 mg/L. The main source of contamination above this point was Seep 11.

10- Lined section of the ditch about 50 m upstream of site 9. Flow was greater here than at site 9: some flow appeared to go into the toe of the dump between 10 and 9. Water quality similar to site 9.

11- This branch of the ditch collects seeps from a bench in the main pit. Flow was small in this ditch, but the water acid (pH 3.3) and very high in zinc (99 mg/L), copper (9 mg/L) and sulphate (1290 mg/L). The water flowing out of this ditch seeps from sulphide material in the pit wall above this bench. It emerges from the bottom of the wall in several locations and stains and gullies indicate that there is surface runoff down the wall at high flow. The top of the ditch was dry at the time of sampling.

13, 14 and 15- The quality of the water before it seeps through the pit wall to Seep 11 is represented by Seep 14. This water was high pH (8.3), low copper, and zinc just over the effluent standard of .5 mg/L. Seeps 13 and 15 (now dry) on the same bench would also run through this sulphide material to seep 11.

12- Ditch above seep 11. Water slightly acid (pH 6.7), low in copper and sulphate and fairly low in zinc (.5 mg/L).

Seeps 16 through 22- The seeps in the upper part of this lined drainage system were alkaline (pH around 8), very low in copper and fairly low in zinc. Most of the flow entered in the top section of the ditch, one bench below the Faro Creek diversion ditch.

3.4.3.2.3. Faro Creek

Faro Creek is diverted around the pit into the North Fork of Rose Creek (see Figure 6). The point of diversion is upstream of a swampy area. The first kilometer of the diversion runs along this swamp, separated by a berm with a road on it. Seepage from this part of the diversion would flow into the swamp, along the original Faro Creek channel and then seep through into the northeast wall of the Zone 3 pit.

The second kilometer of the diversion runs along the rim of the Zone 3 pit and seepage would flow to this pit and to the lined ditch to Zone 2.

The next 100 to 150 m of the diversion is at the top of the Zone 2 watershed and is partially in bedrock. Seepage from this section would flow to Zone 2.

The remainder of the diversion descends steeply into the North Fork valley.

FLOW DATA:

Flows in the Faro Creek diversion (measured with the stream velocity meter) before the liner was installed:

- In uniform part of stream channel, 90 m from point of diversion (mean of 5 trials):	163.2 L/s
- Upper weir - 1075 m from point of diversion:	106.3 L/s
- Lower weir - 2200 m from point of diversion:	81.4 L/s

- Loss of 56.9 L/s in first km of diversion (This may be an overestimate of the amount of water lost, as the top flow measurement was done in a cobble-substrate stream channel while the lower two were in smooth cross-sections on the weir crests.)

- Loss of 24.9 L/s in the second km of diversion.

SITES:

25- Faro Creek above diversion. Boulder substrate, flow could not be measured. Background water quality: pH 7.8, copper and zinc below the limit of detection, and sulphate concentration 8 mg/L.

26- Interceptor ditch from west, joins Faro Diversion at point of diversion. Flow 5 L/s, a small fraction of the creek's flow. Water was uncontaminated, similar in quality to Faro Creek, with slightly higher sulphate and zinc levels.

24- Faro Diversion at lower weir (2.2 km downstream of the point of diversion.) This is just above the section where the channel cuts into bedrock. Zinc concentration of about .3 mg/L came mainly from water pumped to the diversion ditch from the Faro swamp (pumping has since ceased).

3.4.4. Discussion

3.4.4.1. Water Quality

Most seeps in the Zone 2 drainage area do not have the characteristically low pH found in mines with acid drainage problems. Water which seeps from the dumps and through most pit wall areas is neutral to slightly alkaline. This was found to be the case not only in the Zone 2 area, but throughout the Faro pit and dumps (data available from the Whitehorse office of Curragh Resources Inc). Only two seeps (sites 11 and 31) were acid. The source of this acid mine drainage is pockets of ore left in the pit wall.

Copper levels are generally low--elevated only in the acid seeps. As the water from seep 11 mixes with the water in the ditch it is buffered and copper levels decrease. The copper load of the trickle of water at seep 11 is .94 mg/s, while the copper load of the entire ditch at its outlet to Zone 2 is only .71 mg/s (Table 6). The pit water in Zone 2 is well buffered and copper concentration is extremely low.

Zinc, however, remains in solution at high pH levels. The zinc load in the lined ditch system (Figure 9) is approximately cumulative, taking into account the uncertainty involved in these measurements and the loading from unmeasured seeps to and from the ditch.

The concentration of zinc in the Zone 2 pit water is five times higher than that of the water flowing in through the lined ditch (20 mg/L in the pit water and 4 mg/L at the outlet of the ditch).

Thus the zinc load of the remainder of the inflow to the pit must be five times the load from the ditch, or about 190 mg/s. It is probable that this additional zinc is picked up by seeps hidden by the waste dumps covering 80% of the Zone 2 ultimate pit. It would only require a flow of about 2 L/s of water with as high a concentration of zinc as was measured in the one visible seep (seep 31) to achieve this load.

As Figure 10 indicates, There are many pockets of acid-generating rock remaining in the pit wall (rock types 2A, 2C, 2D and 2E). Those in the northeast wall would be in the path of surface and subsurface flow from the area of high seepage (from site 9 to the point where seep 6 enters the ditch, Figure 6). Another source of zinc load to the pit water may be the old waste dumps in the Zone 2 pit. There are no records of rock types in these dumps.

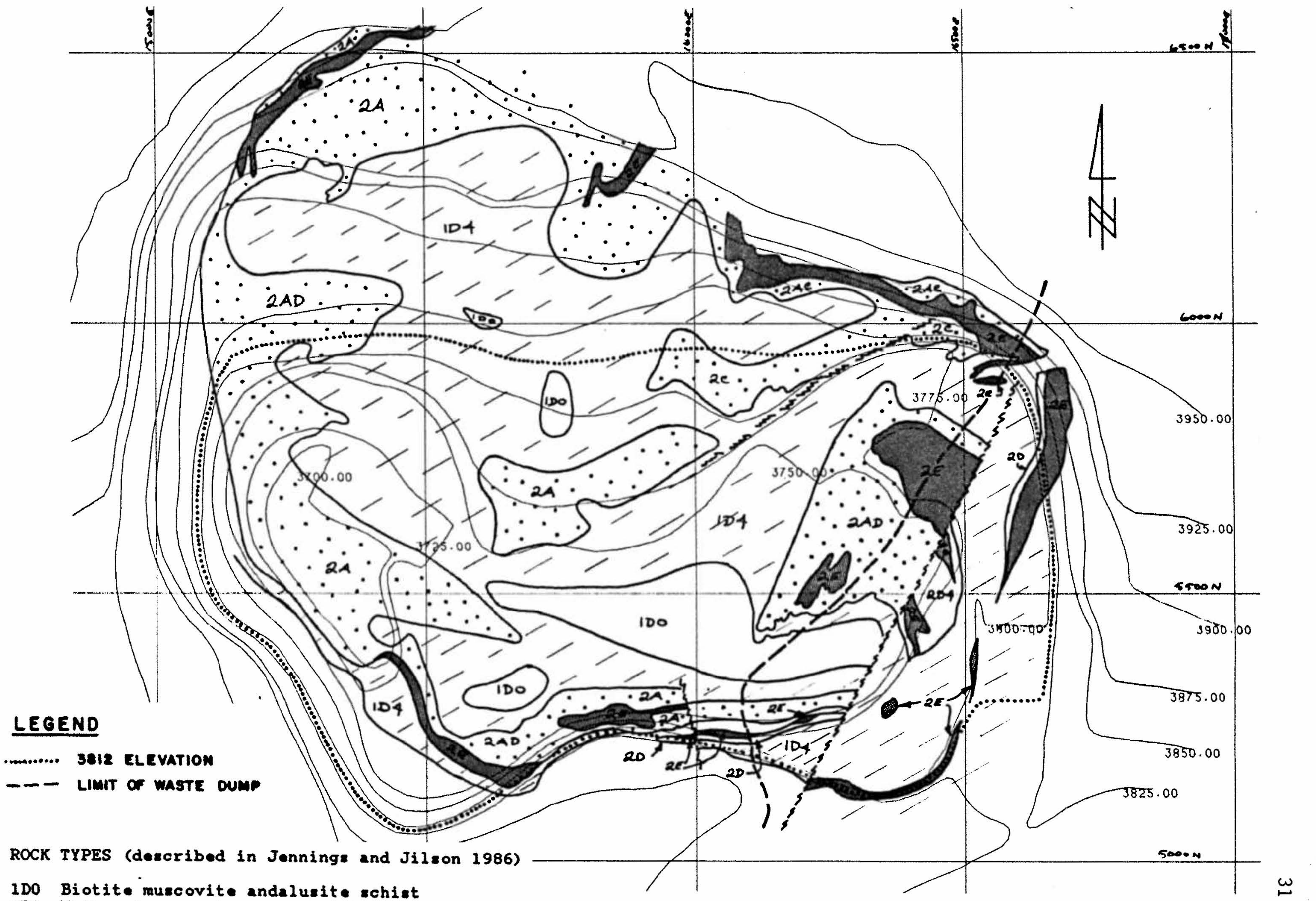
Seeps 14 and 11 provide good evidence that acid generation can raise the zinc concentration of water flowing along a short pathway through pockets of sulphide material. Water flowing across one bench, sampled as seep 14 to contain only 0.6 mg/L zinc, entered the pit wall and flowed down one bench (6 m) to emerge with 99 mg/L zinc (Figure 8). It is suspected that the source of seep 31 (zinc concentration 94 mg/L) was leakage from the ditch directly above it (zinc concentration 4 mg/L).

The ditch at site 10 was buffered to pH 7.14 shortly after the addition of the extremely acid seep 11. It is possible that the elevated zinc levels in the many neutral to alkaline seeps from pit wall rock and waste dumps observed in this survey and in the seep survey of the rest of the Faro pit and dumps enters the water through the same process of acid generation. The oxidation of sulphide minerals leads to ferric hydroxide precipitation and sulphuric acid production. Zinc and copper is leached from the rock by small quantities of acid water which is buffered as it joins other water within the dump. The copper precipitates but the zinc remains in solution.

Sulphide mineral oxidation proceeds through chemical and biological pathways (Knapp 1987). If the sulphide-oxidizing bacteria *Thiobacillus ferrooxidans* are present, the rate of oxidation is many times more rapid. Samples have been taken of neutral and acid seeps and of pit water to test for the presence of *T. ferrooxidans*.

3.4.4.2. Flow

Figure 11 shows the pit and waste dump outlines superimposed on the original topography of the area. The drainage basin for the Zone 2 pit is drawn on this.



ROCK TYPES (described in Jennings and Jilson 1986)

1DO	Biotite muscovite andalusite schist
1D4	White mica envelope: muscovite schist
2A	Ribbon-banded graphitic quartzite
2C	Semi-massive pyritic sulphide
2D	High grade pyritic quartzite
2E	Massive pyritic sulphide

ZONE 2 GEOLOGY MAP

The Faro Creek diversion ditch is at the top of the watershed. The watershed for groundwater flow would extend north of this. Leakage from the Faro diversion in this section would contribute directly to the inflow to Zone 2. Leakage from the ditch to the northwest of the drainage basin would contribute indirectly to Zone 2 via the lined ditch system.

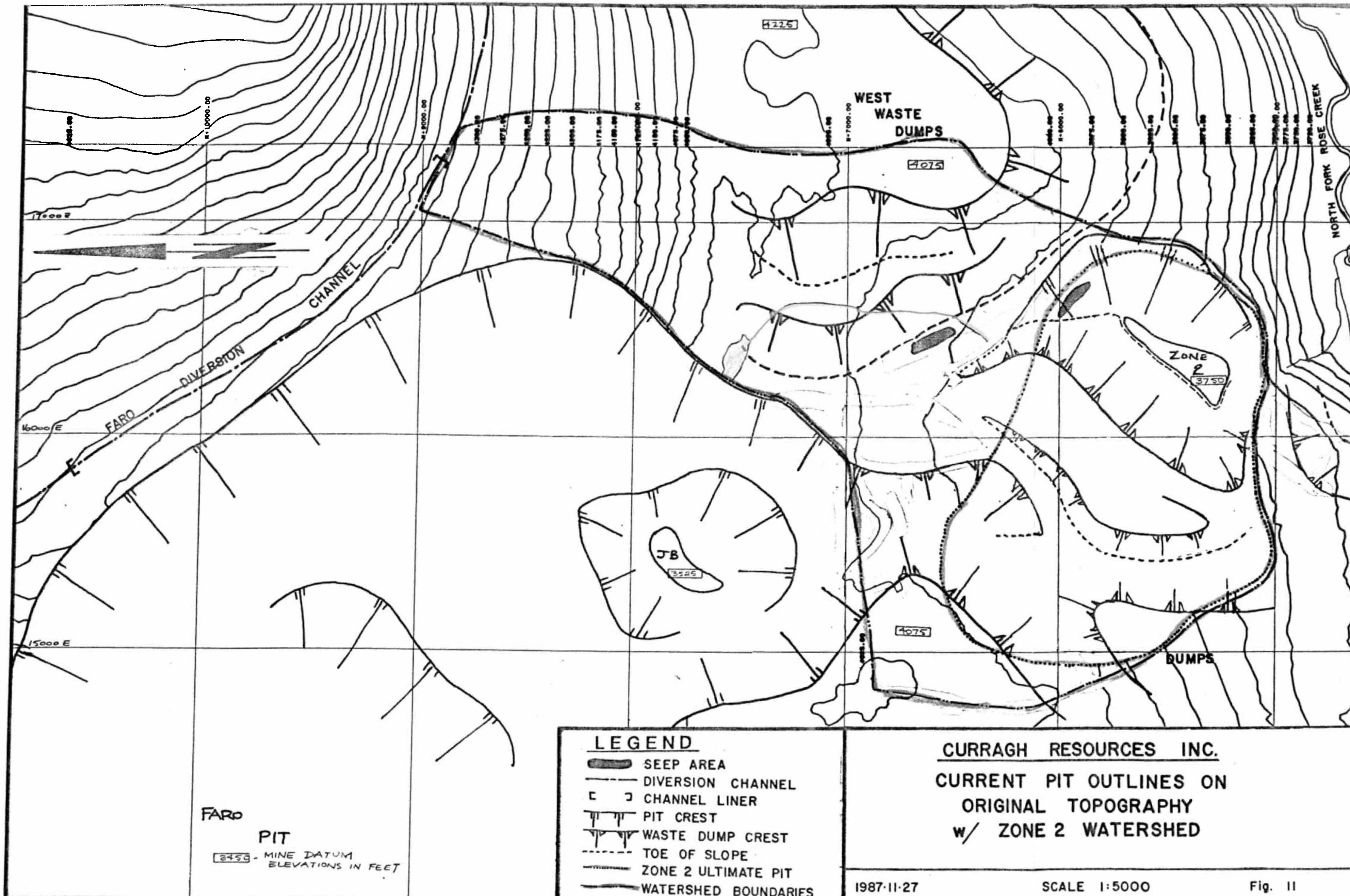
The remainder of the Zone 2 watershed is the ultimate pit and the area to its west. Precipitation to this area would enter the pit under the waste rock covering most of the Zone 2 pit. There were no seeps or signs of dry seeps visible on this side of the pit.

The small lake and its outflow channel indicated north of the Zone 2 pit are completely covered by the west waste dumps. This channel was apparently ditched in the early 1970's to act as a diversion during the mining of Zone 2. It emerges from the dump in the area of seepage observed during this survey. Flow from the part of the drainage basin north and east of the Zone 2 pit would collect in this channel and pond in a flat area partially covered in waste rock. Water emerged from the toe of this section of the dump and from the uncovered part of the bog in small, diffuse seeps (between sites 9 and 3) and in defined channels (seeps 7, 8, 4, 5 and 6).

It is suspected that seeps in this zone originate from this covered stream. Since the total flow from these seeps is far greater than would be expected from precipitation to the watershed area as defined by the original contours, the source of much of this flow must be groundwater, probably emerging in the lake. The total flow from these seeps (calculated as the increase between sites 9 and 3 plus the flows of seeps 4, 5 and 6) was about 10 L/s during the time of this survey. The mean rate of flow from precipitation to the watershed for these seeps would be only 2.9 L/s, averaged over the year, based on a mean annual precipitation for the Anvil weather station (1951-1980) of 367.7 mm (Environment Canada 1981) and a watershed area of 24.8 ha (calculated by digitizing the watershed of the seeps from Figure 11). At least 50% of this 2.9 L/s would be lost through evaporation (Dr. A MacG Robertson, pers. comm.). This flow rate would, of course, vary greatly over the year, probably being below average in the autumn.

3.4.4.3. Conclusions

The diversion of the lined ditch system (Ditch A, Figure 3) and the installation of a surface and shallow subsurface seep collection ditch at the major seepage area (Ditch B, Figure 3) will eliminate much of the water currently flowing to Zone 2. Water currently being diverted from the main pit to Zone 2 will no longer enter the Zone 2 watershed. Water from the seepage


WEST
WASTE
DUMPS
4225
4075
NORTH FORK ROSE CREEK
17000 E
16000 E
15000 E
N 10000.00
N 9000.00
N 7000.00
N 6000.00
FARO DIVERSION CHANNEL
ZONE 2
3750
JB
3525
4075
DUMPS
FARO
PIT
3450 - MINE DATUM ELEVATIONS IN FEET
LEGEND
SEEP AREA
DIVERSION CHANNEL
CHANNEL LINER
PIT CREST
WASTE DUMP CREST
TOE OF SLOPE
ZONE 2 ULTIMATE PIT
WATERSHED BOUNDARIES
CURRAGH RESOURCES INC.
CURRENT PIT OUTLINES ON
ORIGINAL TOPOGRAPHY
w/ ZONE 2 WATERSHED
1987-11-27
SCALE 1:5000
Fig. 11

zone at the toe of the west waste dumps will be intercepted to as great a depth as is feasible and diverted away from Zone 2.

Figure 12 is a scheme of surface flow and seeps contributed to Zone 2 during the survey by water that will be diverted away from Zone 2 by the proposed ditches. At that time, this flow contributed to the pit at least 13 L/s of water. This does not include the shallow subsurface flow which will also be diverted. The component of this surface flow entering the pit through seeps along the northeast wall is estimated to be 4 L/s. The zinc load carried by this flow would depend on the type of rock the hidden seeps flow through. Given the prevalence of acid-generating material in this section of the pit wall (Figure 10), it is probable that some of these hidden seeps contained very high zinc loads. As indicated above, only 2 L/s of seeps equivalent in quality to seep 31 would result in the measured pit water concentration.

The elimination or reduction of this flow has the following related consequences:

1. Cut off a major source of water to the acid-generating material remaining in the north and east walls of the Zone 2 pit, thereby greatly reducing zinc loading to the pit. Zinc concentration in water still flowing through this material will probably remain high.

2. Reduce the total inflow to the pit, thus the rate of overflow from the pit, thus the zinc load in the overflow. It is difficult to predict how this reduction of inflow will affect the zinc concentration in the pit water. However, the measurement that has significance to downstream water quality (and thereby to the abandonment objective) is zinc load, not concentration.

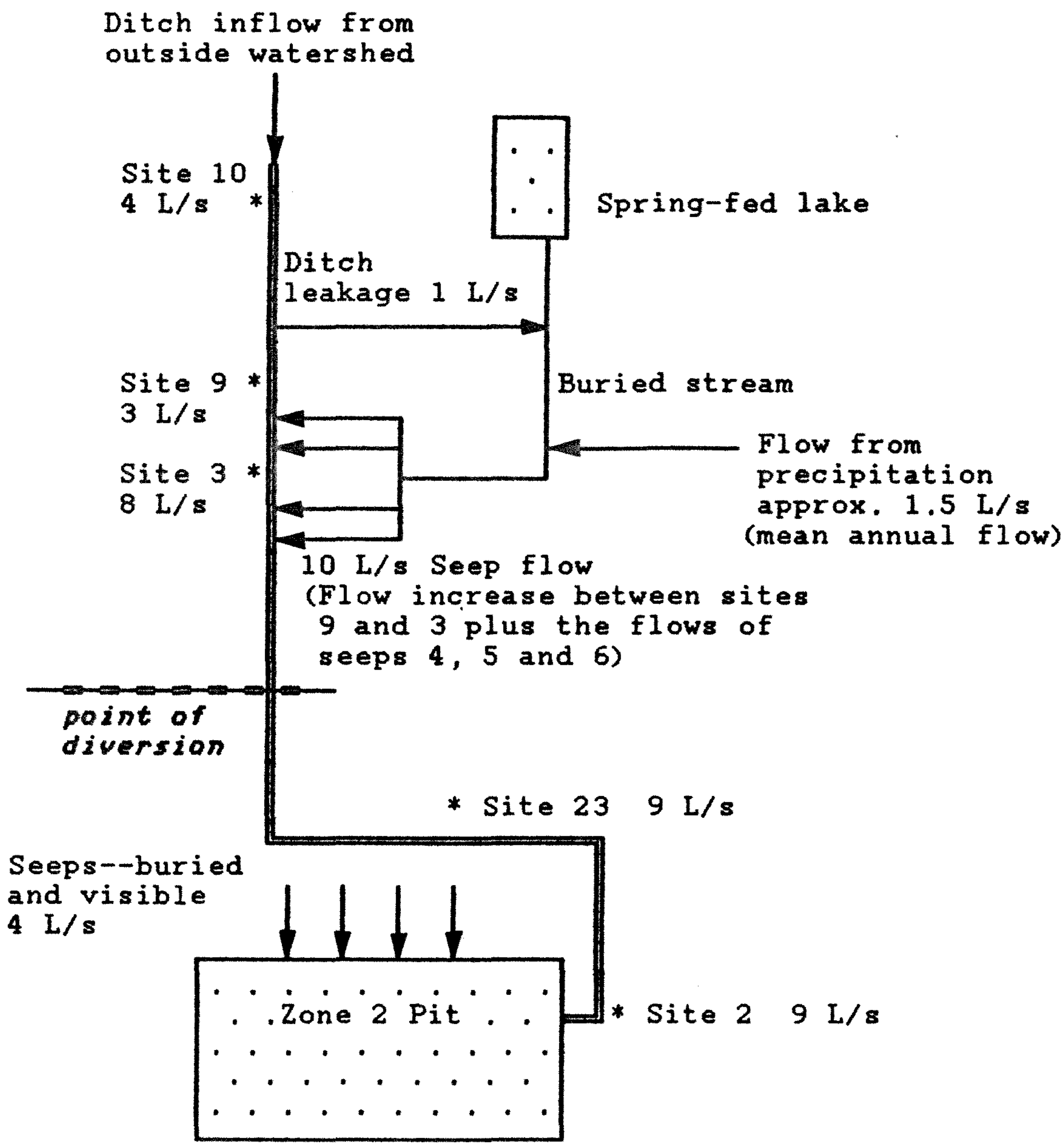
3.5. IMPACT ON NORTH FORK WATER QUALITY DURING OPERATION

As any seepage from Zone 2 will be collected via the rock/pipe drain and pumped to the tailings pond, there will be no impact on North Fork water quality.

The installation of a piezometer in the pit will allow monitoring of the water level in the pit. Should it not be possible to pump on a continuous basis, water can be stored in the reservoir above the level of the collection drain. The installation of an overflow pipe (directing water to a sump) below the level of natural overflow ensures that seepage to the North Fork will not occur.

FIGURE 12: FLOW CONTRIBUTION TO ZONE 2
OF WATER THAT WILL BE DIVERTED

Estimates for late September, 1987



3.6. CONSIDERATIONS FOR ABANDONMENT

Plans for abandonment of Zone 2 will be included in the Faro pit and area abandonment plan required in Part D of Curragh's water licence. Curragh is not required to present an abandonment plan at this time.

This proposed extension of the Zone 2 waste dump will not affect the development of the Faro pit abandonment plan. A possible outlet of the flooded Faro pit at abandonment is the current low point of the pit rim to the west of the Zone 2 dump, along the south access road (see Figure 2). The Zone 2 dump will not be extended along the west face so as not to impinge further on this corridor.

Since it is recognized that longterm impact of drainage from Zone 2 is of concern to the Water Board, some discussion of the direction the development of the abandonment plan is taking is in order.

ABANDONMENT OBJECTIVE:

It will not be possible to treat or redirect outflow from the backfilled Zone 2 pit on a permanent basis and it may not be possible to completely eliminate seepage from the pit. Therefore abandonment plans focus on reducing the zinc load carried by this outflow.

CONCLUSIONS REGARDING THIS OBJECTIVE:

1) Results from the seep survey indicate that zinc concentrations can increase from very low levels to close to 100 mg/L when water flows through acid-generating material left in the pit walls. As Figure 10 indicates, the acid-generating rock remaining in Zone 2 is widely dispersed throughout the walls, much of it above proposed water level. Since it is not practicable to remove or submerge this material, water should be prevented from passing through it to the greatest possible extent.

2) It was concluded from a comparison of flow expected from the watershed size and flow observed emerging from the west waste dumps that much of the water must first surface under the dumps. A substantial portion of the zinc load entering through surface flow to the Zone 2 pit in September apparently was leached from the west waste dumps by a stream that probably originates from springs covered by waste rock. This water cannot be diverted before leaching occurs. However, it is feasible to collect this water and divert it

to the tailings impoundment while the mine is operating and to the main Faro pit at abandonment.

ACHIEVEMENT OF THIS OBJECTIVE:

The reduction of flow through the sulphide material in the Zone 2 pit wall and the diversion of the seeps emerging from the west waste dumps will both be accomplished through diversion of the lined ditch and construction of the seep cutoff drain. These measures are expected to significantly reduce zinc loading to the Zone 2 pit.

EVALUATION:

The reduction of flow to the backfilled Zone 2 pit will be evaluated for its acceptability as an abandonment measure. During the operation of the mine, overflow will be collected and pumped to the tailings pond. The overflow will be monitored for zinc load (and other possible contaminants) and, if the effluent is not of acceptable quality, further means of reducing zinc loading to the Zone 2 pit will be considered. An acceptable zinc load cannot be set at this time as it is related to the extent of zinc loading to Rose Creek from the abandonned Faro pit and tailings impoundments. This will be discussed further in the Faro pit abandonment plan.

One measure which might further reduce zinc loading is the redirection of water entering through precipitation to the backfilled Zone 2 pit. The mean annual flow expected from this area (29.2 ha) would be 1.6 L/s, based on a 50 % loss through evaporation. A low-permeability, contoured surface to the rock waste cover may collect sufficient runoff to further reduce zinc loading. However, this measure would have to be carefully evaluated as covering dumps is expensive and has not yet been demonstrated to be effective in reducing acid mine drainage in dumps at other minesites (Bell, 1987).

As discussed by Dr. Robertson in his evaluation of the engineering plans (Appendix), the development of the Zone 2 waste dump will not make the abandonment problem worse. It is true that the abandonment options are limited by the backfilling of the pit, but the options so limited are not practical:

--Eighty percent of the Zone 2 pit has already been filled by free dumping. Acid-generating rock remains, widely dispersed, in the pit walls. Mining the remaining sulphides cannot remove the rock that has already been covered.

--While much of the sulphide materials can be starved of oxygen through covering with water, some of the acid-generating rock is too high to submerge.

--Grouting would be expensive and ineffective as a permanent measure of reducing flow since it would require extensive grouting of mineralized zones of undetermined shape near a free face through a deep waste rock cover. It is considered that the drilling accuracy and the groutability near the free face would not be adequate to subtantially reduce acid mine drainage.

--Placing a phyllite seal on the bottom of the exposed section of the pit would have little effect, as the relatively small quantity of acid generating rock located in this section would be submerged and unreactive with or without a phyllite seal.

The only realistic approach is to reduce the zinc load carried by Zone 2 water by 1) limiting flow through known sources of leachable zinc, and 2) reducing discharge.

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APPENDIX

OPTIONS FOR ABANDONMENT OF ZONE 2 PIT

LETTER REPORT TO CURRAGH RESOURCES

NOVEMBER 5, 1987

Dr. A MacG Robertson, P.Eng.

Steffen Robertson and Kirsten (B.C.) Inc.
Consulting Engineers

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STEFFEN, ROBERTSON AND KIRSTEN (B.C.) INC.
Suite 801, The Burrard Building
1030 West Georgia Street
Vancouver, B.C., Canada V6E 2Y3
Tel. (604) 681-4196 Telex 04-352578

5th November, 1987.

Curragh Resources Inc.
117 Industrial Rd.,
Whitehorse, Yukon. Y1A 2T8

Att. Ms Joan Eamer

Dear Sirs

RE: OPTIONS FOR ABANDONMENT OF ZONE 2 PIT

Introduction

The Faro mine is considering the development of Zone Two as a waste dump area. An engineering report 'DEVELOPMENT OF THE ZONE TWO WASTE DUMP', dated September 1987 has been developed by the mine describing the proposed dump development. The proposed development has a considerable economic impact on the cost of mining in the Faro pit.

In evaluating the suitability of this development Curragh wishes to consider the implications of such development on the long term reclamation and abandonment of the Faro mine. This brief letter report summarizes the observations made and conclusions reached by ourselves during a review of the proposed development and an evaluation of its implications to long term reclamation and abandonment.

Reclamation and Abandonment Issues

The water contained in the Zone Two pit has metal concentrations which exceed the discharge quality concentrations defined in Curragh's Water License. Current dewatering is therefore to the tailings pond where it is treated prior to discharge. Water flows into the Zone Two pit will continue after the proposed waste dump development. This will cause the water level in the pit to rise to approximately the 3812 elevation level at which natural discharge is reported by the mine personnel to occur.

A seep survey has been started by Curragh to determine the quantities and qualities of surface water movement through and about the the Faro waste dumps. This survey was initiated in June 87, and expanded in September 87. All the results of this survey are not yet available and it will require repetitions of the survey and sampling throughout the year to clearly define the sources and routs of contaminated surface flows. A discussion of the current survey program and results is provided in a separate letter. From the available results it is apparent that a number of seeps occur from the southeast dumps which have zinc concentrations (5 to 6 ppm) which exceed the permissible discharge standards (0.5 ppm). These seeps are collected and drain into the Zone Two pit. The greater portion of the original Zone Two pit has been backfilled with waste. It is therefore not possible to identify all seepage sources into the Zone Two pit. The zinc concentration in the pit water is currently about 20 ppm.

The seepage into the Zone Two pit appears to be substantially from seepage losses from the Faro Creek diversion ditch. This ditch has now been lined and it is anticipated that this will result in a very large reduction in the inflows into the Zone Two pit. Zone Two pit inflows and therefore pit discharges in the long term (after appropriate abandonment preparation of the faro creek diversion) is expected to be a small proportion of the current flows.

Based on the available information it is concluded that seepage into the pit includes sources which have not and will not be determined from a surface seep survey; that such seepage will continue after abandonment; that the quality of this seepage water will continue to exceed discharge standards unless additional reclamation measures are implemented. The nature of the additional reclamation measures required to ensure that the quality of seepage from the Faro waste dumps will achieve abandonment plan objectives has not been determined and it is understood that this will form part of the overall Faro mine reclamation and abandonment plan.

Assessment of the suitability of the proposed Zone Two waste dump development is therefore aimed at evaluating if the proposed development can or will improve the long term contaminated drainage. Further, to establish if the proposed development will make the implementation of the ultimate abandonment program more difficult.

Assessment of Zone Two Dump Scheme

The primary concern of the Zone Two dump scheme is the potential long term effect on Acid Mine Drainage (AMD). AMD seepage results from two sources; acid generation/leaching of the waste rock and acid generation/leaching of the pit wall rocks.

Two zones of acid generating wall rock have been identified in the unfilled area of the Zone Two pit. These are areas of mineralized rock in the base of the southern portion of the pit and higher up in the east wall. It has been suggested that these zones be covered with phyllite waste which will be compacted to form a low permeability cover.

i) Base zone. This zone will be under water which will effectively exclude oxygen and prevent appreciable acid generation. A cover would serve little purpose.

ii) East wall zone. This zone is located above the ultimate water table and will continue to oxidize and produce acid seepage. Construction of a phyllite cover would reduce the acid generation but is unlikely to prevent it completely. Oxygen entry and seepage from above will still continue. The seep survey has demonstrated that metal loadings from this source of seepage is small compared with the total loading reaching the Zone Two pit. Thus the placement of this phyllite cover would have only a marginal effect on the metal concentrations in the Zone Two seepage. In view of the high cost of placing such a cover it is not considered cost effective.

It has been suggested that the mineralized rock be mined from the two identified zones. The distribution of mineralized material in the pit wall has not been determined. It is not known how much mining or how far back mining would have to be done to remove all such material from the walls. Further mining may expose yet further stringers of mineralization in the pit walls. Thus the success and cost of such an alternative is unknown. The cost of the appropriate mineralization definition drilling and subsequent mining will be large. In view of the small incremental improvement in the seepage water quality, mining of these mineralized zones is not considered cost effective.

Construction of the waste dumps, as proposed, do not appear to add to the difficulty of reclaiming the Faro mine waste dumps in general. Expansion of the total area under waste dumps may add to the overall cost of reclamation by whatever methods are finally selected. The potential for collecting AMD by ditching along the the toe of the dumps remains.

Collection and Treatment of AMD

Until an overall abandonment plan is developed and successfully implemented it will be necessary to collect and treat drainage from the Zone Two pit. By installing a collector drain, as proposed, at a substantial depth below the discharge elevation of 3812 the seepage can be collected before it breaks through to the North Fork of Rose Creek valley. A collector layout as illustrated in Figure 1 is recommended. This arrangement allows the water in the pit to be maintained at least 10 ft. (3 m) below the mine observed discharge level. The level of the water in the pump sump will serve as a piezometer indicating the water levels in the pit.

The potential for seepage through the pit wall to the valley can only be judged against previous experience or by performing a field investigation into the fracturing and permeability of this pit wall. In view of the previous field experience (breakout only above El. 3813 ft.) it is considered that significant seepage is unlikely. However should such seepage be experienced then an alternative collection and dewatering method, such as a drilled in dewatering well, could be used to control the level of the water in the pit.

Water draining to the pump sump should be pumped to the tailings pond for treatment prior to discharge.

Diversion of Surface Flows Away from Zone Two Pit

To reduce the amount of water flowing to the Zone Two pit, consideration should be given to diverting surface flows to alternative locations from where it can be pumped to the tailings impoundment for treatment and discharge. The cost effectiveness of such diversion depends on the costs and long term reclamation concerns at the alternative locations.

We welcome the opportunity of answering any questions you may have relating to this review.

Yours Truly,

STEFFEN, ROBERTSON & KIRSTEN (BC) INC.

Dr. A MacG Robertson P. Eng.
President

cc. Jack Bowers, Faro Mine

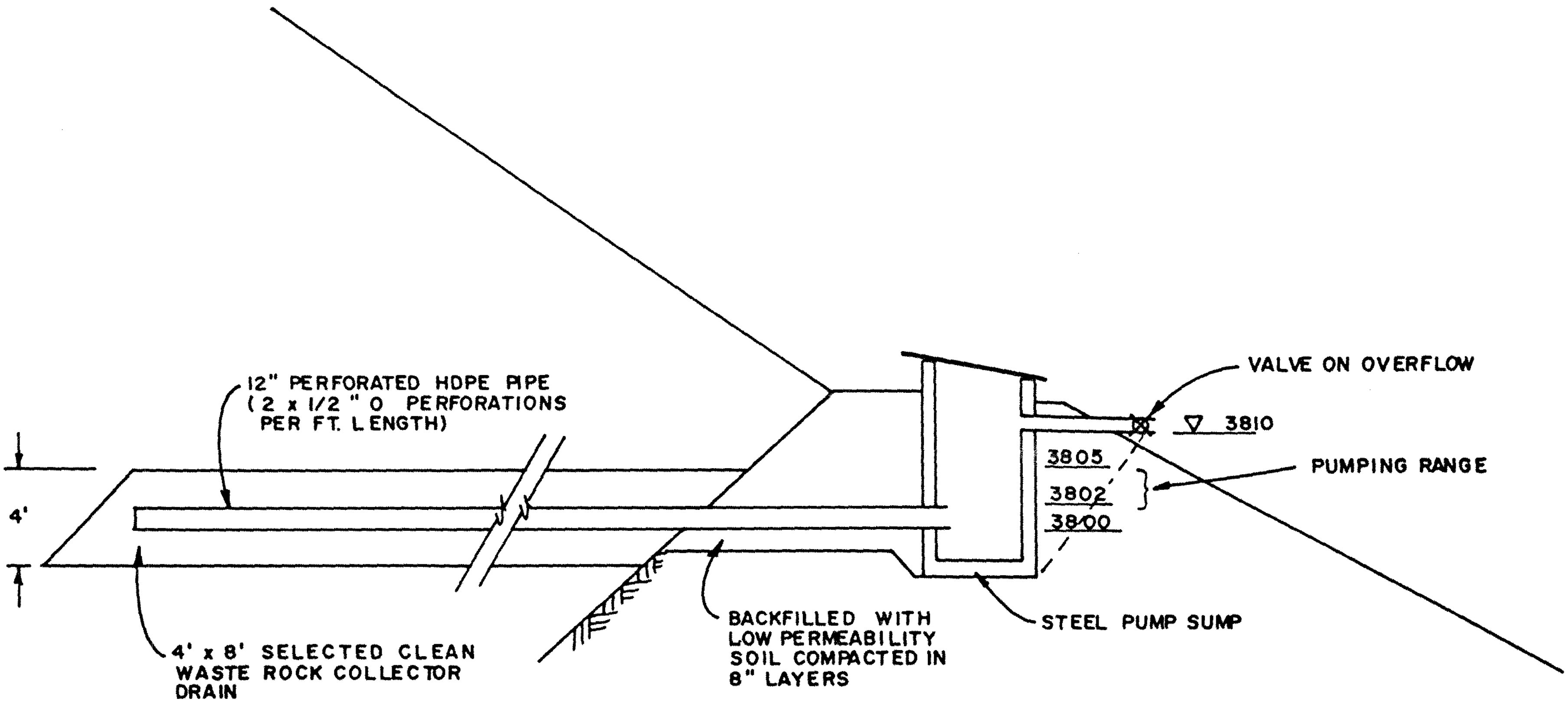

FIGURE 1 SECTION THROUGH ZONE TWO DEWATERING COLLECTOR