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FINAL REPORT

Giroux Wash Tailings Impoundment
TDS Mobility Testing

Prepared for:

Nevada Division of Environmental Protection

Prepared by:

Geomega
2995 Baseline Dr.
Boulder, CO 80303

for

BHP Copper - Nevada Mining Company
Robinson Operations

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1.0 Introduction

This report presents the results of a three-phased investigation to evaluate the potential for seepage and TDS mobility from the permitted Giroux Wash Tailings Impoundment at BHP Copper, Robinson Operations. The Giroux Wash Tailings Impoundment is a conventional unlined tailings disposal facility for the disposal of copper flotation tailings, located southwest of the active Robinson Operations mine site. Tailings generated during the milling process are pumped to the impoundment for disposal. Giroux Wash slopes from north to south, and an east-west tailings embankment was constructed to constrain deposition of tailings to the northern portion of Giroux Wash.

A geologic fault trending northwest-southeast underlies the eastern portion of the Impoundment in the vicinity of the embankment. East of the fault, the Impoundment is underlain primarily by volcanic rocks, with a depth to groundwater of approximately 250 feet below ground surface (bgs). West of the fault, the Impoundment is underlain by alluvium, with a depth to groundwater of approximately 800 feet bgs.

The NDEP requested that BHP Copper, Robinson Operations, investigate the potential for vertical seepage through the impoundment base, into underlying alluvium, volcanic detritus, and volcanic bedrock. BHP therefore completed the Phase I and II TDS Mobility Studies, which are summarized herein pursuant to Section 2.5.3. of the February 27, 1997 Work Plan (and recent Consent Agreement between BHP and the NDEP).

Through the preliminary Phase I investigation, and primarily through the Phase II program, BHP examined tailings deposited in the impoundment, the tailings/native alluvium interface, and native alluvium directly beneath impounded tailings. The Phase I and II investigations indicated limited vertical seepage into underlying alluvium has occurred at the time and boring locations observed. The Phase I and Phase II investigation activities were reported to NDEP on January 2, 1997 and March 31, 1997, respectively. As required by Section 2.5.3. of the February 27, 1997 Work Plan, this report also summarizes the Phase I and Phase II investigations.

The Phase III TDS Mobility investigation was completed pursuant to Section 2.5.4. of the February 27, 1997 Work Plan to determine the potential for horizontal seepage downgradient of the embankment. The results from the Phase III investigation are available, and therefore, are included in this report so that it will serve as a convenient and comprehensive final report of all TDS mobility studies.

2.0 Phase I TDS Mobility Testing

BHP initiated the TDS mobility investigation with the preliminary Phase I program. One hollow stem auger boring was angle drilled through the tailings embankment and tailings, terminating in alluvium underlying the tailings. Field measurements of pH and TDS from recovered samples (Table 1) indicated TDS migration is attenuated by native alluvium within approximately 16 feet of the tailings/alluvium interface. However, difficult drilling conditions prevented the hollow-stem auger method from providing satisfactory subsurface samples, and promoted infiltration of tailings water into the augers thus contaminating the samples upon recovery. This limitation prevented a full investigation to be completed under the Phase I program and thus, the Phase II investigation was initiated.

3.0 Phase II TDS Mobility Testing

Three angle borings were installed in December 1996 (TB-1, TB-2 and TB-3). All three borings were collared in the embankment, drilled through the embankment, through tailings and into underlying alluvium (Figure 1). Five vertical borings (B-1 through B-5) were completed both downgradient and upgradient of the embankment, outside the current tailings disposal area, to collect ambient background samples for characterization (Figure 1).

Relatively undisturbed samples were collected during Phase II drilling *via* continuous coring using a roto-sonic drilling rig. This drilling method provided better recovery and no avenue for tailings water contamination of subsurface samples, thus allowing for a more detailed analysis of TDS mobility than the Phase I activities. Samples recovered during the Phase II drilling program were analyzed in the field for paste pH and specific conductivity (SC), and for NDEP Profile I constituents by a State of Nevada certified laboratory.

3.1 *Results of Phase II TDS Mobility Testing*

3.1.1. Background Borings

Five background soil borings (B-1 through B-5) were drilled in Giroux Wash at locations outside of the Tailings Impoundment area (Figure 1). The background borings were drilled and sampled to establish ambient pH, SC profiles, and soil chemistry for areas known to be unaffected by the deposition of tailings.

In general, the soil chemistry of background samples appears to be relatively similar. The measured pH values range between 7.3 and 9.3 while most of the SC values range between 60 and 300 uS/cm. The exception to this is the six to twelve feet depth interval of B-1. Physical and chemical characteristics of background soils in the boreholes are described below.

Background Sample B-1

The first background boring (B-1) was located approximately 50 feet west of the main drainage through Giroux Wash and about 165 feet south of the impoundment embankment (Figure 1). This bore was performed with a hollow-stem auger and sample was collected by a split-spoon sampler on July 9, 1996.

The upper interval of core obtained from B-1 was characterized as dry, unconsolidated, and well-sorted brownish-tan, silty-sand with minor secondary calcite ($CaCO_3$). The sand unit was continuous from the surface to a depth of 11 feet, where a semi-consolidated and resistant gravel layer was encountered. Drilling and sampling continued until the 16.5-foot depth interval at which point the resistance of the gravel layer resulted in auger refusal and precluded further sample recovery. As a result, the B-1 boring was terminated, backfilled with soil cuttings, and re-spudded approximately 10 feet east of the original location. Drilling at the new location was successful in penetrating the gravel layer, and soil sample collection was resumed at the 16- to 18- foot depth interval to a total depth of 20 feet.

SC values ranged from 175 uS/cm in the top two feet of soil (Table 2), where natural surficial leaching processes act to remove soluble soil salts, to 1910 uS/cm at a depth of 12-feet. SC values steadily decline below the 12-foot depth to the 20-foot depth (600 uS/cm) where drilling ended. A pronounced "conductivity spike" was measured in the 10 to 14 feet depth interval, which coincides with the gravel zone.

As with the SC measurements, soil chemistry changed around the 12-foot interval, where high concentrations of chloride (483 mg/kg) and sulfate (5930 mg/kg) were encountered. These concentrations are considerably higher than the other background locations and the chloride concentrations measure in the analysis of the tailings material (average tailings chloride concentration: 12 mg/kg). Since there are also increased concentrations of aluminum and sodium at this depth, it is hypothesized that this "concentration and conductivity spike" reflects a normal build-up of salts (localized hardpan) that has accumulated at the sand-gravel interface.

All samples recovered from boring B-1 were dry, and no evidence of tailings water infiltration at this boring location was observed. The chemistry observed in boring B-1 differs from the tailings chemistry in measured metal concentrations (e.g., copper, iron, magnesium, manganese, and zinc). Metal concentration in B-1 are indicative of the background ranges observed in B-2 and B-3 (described below). Elevated concentrations of major elements chloride, sulfate, and sodium were observed in B-1 soils at a depth of 12 feet bgs, derived from naturally derived salts associated with hardpan.

Background Sample B-2

Background boring B-2 was located approximately half a mile south of the impoundment, approximately 20 feet north of the BHP property fence, which runs east-west across Giroux Wash (Figure 1), and is located approximately 50 feet west of the main drainage in Giroux Wash. This boring was drilled by the hollow-stem auger and sampled using a split-spoon sampler on July 10, 1996.

Soil core in B-2 was dry, unconsolidated, light brown, gravelly sand extending from the ground surface to the total boring depth at 18 feet. An increase in gravel content was observed at a depth of 10- to 12-feet. Unlike boring B-1, this gravel layer did not impede drilling; however, due to the increased grain size and loose nature of the soil, there was no sample recovery from the 14 to 18 feet depth interval. The hole was subsequently abandoned and backfilled with soil cuttings.

Field measurements of SC were relatively uniform along the entire depth of B-2, ranging from 89 uS/cm^2 at a depth of 4-feet, increasing to a maximum of 131 uS/cm^2 at 8-feet, and decreasing to 116 uS/cm^2 at 14-feet (Table 2). As with B-1, the highest SC values recorded in boring B-2 is associated with increasing gravel content at the 8- to 12-feet depth interval, suggesting that similar geochemical mechanisms, such as precipitation of calcite and other hardpan solid phases, may be occurring at the sand-gravel contact.

The soil chemistry in B-2 is relatively uniform, with the exception of calcium (133,000 mg/kg) in the 2- to 4-feet layer, which is more than double that measured at other locations.

Background Sample B-3

An additional background boring was located close to B-1 to determine if the conductivity spike observed in B-1 was a localized phenomenon, or if the spike had horizontal continuity. Background boring B-3 was subsequently located approximately 300 feet south of the impoundment and 50 feet west of the main drainage. The drilling was performed by a hollow-stem auger and sampled with a split-spoon sampler on July 10, 1996.

Background boring B-3 was drilled to a total depth of 24 feet, through coarse, gravely sand at the surface (0- to 2-foot) transitioning to a buff-colored fine to medium sand at 2- to 4-feet, and then to a reddish silt with clay and fine sand from 4- to 24-feet. Occasional secondary calcite was observed in the upper 8 feet. Highly developed "partings" dominated the structure of this soil probably due to the presence of clay minerals.

Measured SC values in B-3 were relatively uniform over the entire depth, ranging from 283 uS/cm at the surface to 244 uS/cm at the 24-feet (bottom of the hole), and are approximately one-half those measured in B-3 (Table 2).

The soil chemistry in B-3 is fairly uniform through its depth except that, like B-2, there is approximately twice as much calcium (102,000 mg/kg) in the 2- to 4-foot layer than other locations.

Data collected from B-2 and B-3 indicate that the concentration and conductivity spike observed in B-1 was a localized phenomenon without significant horizontal continuity. Therefore, the conductivity spike observed in B-1 is not considered relevant for comparing background sample data to impoundment sample data.

Background Sample B-4

Background sample B-4 was located approximately 600 feet west of the tailings impoundment, near the tree-line which marks the edge of the impoundment area and in an area that will be inundated with tailings in the next year (Figure 1). Hence, the surface soil had been removed from this area. Sample was collected from the surface to a depth of 20 feet using the roto-sonic drill rig on Dec. 8, 1996. Since this bore was within the ultimate impoundment foot print, it was filled with bentonite grout when completed.

Soil core from B-4 consisted of a dry, unconsolidated, white gravelly sand. Unlike the previous borings, the sample was relatively uniform throughout its entire depth and lacked a distinct gravel layer.

Field measurements of pH and SC were uniform throughout the boring. The pH ranged between 9.0 and 9.3 while the SC range between 67 and 101 uS/cm.

Background Sample B-5

This twenty foot vertical boring was completed northeast of the tailings impoundment in an area outside the ultimate impoundment footprint. The boring was performed by the roto-sonic drill rig on December 3, 1996.

Unlike the other background samples, soil core in B-5 varies distinctly with depth from the surface. The surface soil is a dark brown sandy soil with visible organic material. Soil recovered from the 5-foot depth was a lighter brown than the surface soil, and contained secondary calcite. Below the 5-foot depth down to a depth of 10-feet, sample consisted of reddish brown sand. Beneath the 10-foot depth, the sample contained powdery fine gray material representing bedrock at this location.

Field measurements of pH and SC were heterogeneous, as were the observed physical characteristics of the sample recovered from B-5. The surface soil had a pH of 7.6 and an SC of 75 uS/cm. The SC increased at the 5-foot depth to 220 uS/cm, likely due to the presence of secondary calcite, while the pH was measured to be 7.3. At the 10-foot level, the pH increased to 8.2 and the SC decreased to 90 uS/cm. In the bedrock (below 10 feet in depth), pH and SC at the 15- and 20-foot depths were 8.4 and 8.5, and 66 and 62 uS/cm respectively.

3.1.2. Impoundment Samples

Three angle borings were drilled by the roto-sonic rig from the top of the embankment to collect samples from both the tailings deposited in the impoundment and the native material, underlying the tailings for assessment of soil and pore water quality underlying Giroux Wash Tailings Impoundment. Drilling was discontinued when measured pH and SC were similar to background measurements collected from native soil samples.

The borings were drilled from the top of the embankment at an angle between 30 and 35 degrees to the horizontal. The bores were drilled from the embankment crest, emerged from the side of the embankment approximately half-way between the crest and the tailings surface; casing was then pushed through the embankment, into open air, and then through the tailings until it met refusal at the tailings/native material interface. The sample within the casing was recovered with the core barrel. These samples consisted mainly of tailings and some of the native material at the interface. To collect sample below the interface, a second casing was advanced as the drilling proceeded. After completion of the bores, the casings were filled with bentonite grout and then removed.

Since these bores were drilled at roughly a 30 degree angle from the horizontal, the bore depth is approximately twice the vertical depth (the sine of 30 degrees is one half). To avoid confusion, this text will refer to vertical depth only. Physical and chemical characteristics of impounded tailings and underlying soils collected from each borehole are described below.

Impoundment Sample TB-1

This 35 degree boring was drilled at a location approximately 1,000 feet from the east end of the tailings impoundment embankment on December 7, 1996. This boring was closest to the point where tailings are discharged into the impoundment.

The vertical bore depth of TB-1 was 53 feet, of which 25 feet were through the embankment, 8 feet were through tailings, and 20 were into the substrate. Sample recovered from TB-1 consisted of 7 vertical feet of wet black tailings, underlain by one vertical foot of wet black tailings mixed with gravel and coarse sand. Below this level, five vertical feet of wet gravelly sand were recovered. Sample recovered from beneath the wet gravelly sand consisted of a fairly uniform gravelly sandy loam which was slightly damp.

Field measurements of SC were taken on each sample as it was collected to determine the depth at which to cease drilling. Drilling was ceased after collection of several successive samples the SC measurements which resembled those of the background samples. On-site field measurements for pH were attempted but were abandoned as the meter malfunctioned due to the extreme cold. After collection, field measurements of SC were confirmed in the field laboratory located in a BHP warehouse. Measurements of pH were also made at that time.

Eight soil samples were collected from TB-1 and submitted to a Nevada certified analytical laboratory for NDEP Profile I Analysis for Solids. The following table summarizes select field and laboratory chemical analyses of sample recovered from TB-1:

Soil Chemistry from TB-1

(Depth = vertical depth below surface of tailings, depth units are feet, SC units are umhos, pH in standard units, concentrations are in mg/kg, DL = detection limit)

Depth	SC	pH	SO4	Ag	Cu	Fe	Mn	Mo	Ni
5 (wet tails)	1580	8.7	3720	49	1160	130,000	676	164	34
7 (wet tails)	1024	8.5	407	DL	29	13,700	336	8	7
9 (wet gravel)	198	8.5	257	DL	7	9,530	305	3	9
13 (damp loam)	.189	8.6	278	DL	5	17,700	371	2	9
15 (damp loam)	189	8.6	.243	DL	7	13,700	255	2	8
21 (damp loam)	164	8.6	280	DL	14	9,410	191	2	8
25 (damp loam)	152	8.6	177	DL	20	7,400	153	2	7
28 (damp loam)	145	8.6	176	DL	10	6,330	155	2	10

Impoundment Sample TB-2

This angle boring was located near the middle of the tailings impoundment, directly above the deepest tailings deposit. The boring was sampled to a total vertical depth of 63 feet; 22 feet through the embankment, 12 feet through the tailings, and 52 feet into the substrate. The boring was completed on December 6, 1996.

The sample recovered from TB-2 consisted of 11 feet of black tailings, one foot of wet tailings and sand, 3 feet of damp sand, and 16 feet of very slightly damp gravelly sandy clay loam. The tailings/native material interface is at a location 12 vertical feet below the surface of the tailings.

Six soil samples were collected from TB-2 and submitted to a Nevada certified analytical laboratory for NDEP Profile I Analysis for Solids. The following table summarizes select field and laboratory chemical analyses of sample recovered from TB-2:

Soil Chemistry from TB-2

(Depth = vertical depth below surface of tailings, depth units are feet, SC units are umhos, pH in standard units, concentrations are in mg/kg, DL = detection limit)

Depth	SC	pH	SO4	Ag	Cu	Fe	Mn	Mo	Ni
9 (damp tails)	720	7.4	412	DL	12	18,600	324	4	8
14 (damp sand)	280	8.7	243	DL	5	12,300	376	DL	5
17 (damp loam)	123	8.7	293	DL	10	12,200	324	2	9
21 (damp loam)	112	8.6	323	DL	23	15,000	382	3	12
28 (damp loam)	156	8.6	489	DL	15	10,700	284	2	9
36 (damp loam)	203	8.6	809	DL	13	10,500	255	2	10

Below the tailings interface, the soil chemistry was similar to background conditions (Table 3 and Figures 2 through 5). The exception to this was the sample from the 36-foot vertical depth which contained elevated levels of calcium, chloride, and sulfate, approximately twice the levels observed at other locations in the bore.

Impoundment Sample TB-3

This angle bore was located approximately 1,000 feet from the west edge of the impoundment embankment and was completed on December 5, 1996. Samples were collected from 53 vertical feet of material; 22 feet through the embankment, 11 feet through the tailings, and 20 feet through the substrate,

The sample recovered from TB-3 consisted of 9 feet of black tailings, two feet of mixed tailings and sand, and 20 feet of very slightly damp gravelly sandy clay loam. The tailings/native material interface is at a location 11 vertical feet below the surface of the tailings.

Nine soil samples were collected from TB-3 and submitted to a Nevada certified analytical laboratory for NDEP Profile I Analysis for Solids. The following table summarizes select field and laboratory chemical analyses of sample recovered from TB-3:

Soil Chemistry from TB-3

(Depth = vertical depth below surface of tailings, depth units are feet, SC units are umhos, pH in standard units, concentrations are in mg/kg, DL = detection limit)

Depth	SC	pH	SO4	Ag	Cu	Fe	Mn	Mo	Ni
0 (wet tails)	530	7.8	994	1	781	107,000	724	112	28
2 (wet tails)	655	7.8	1110	DL	687	105,000	665	105	29
5 (wet tails)	690	7.8	753	DL	676	113,000	729	103	28
7 (damp tails)	303	8.3	880	1	261	50,200	450	31	18
9 (dry mix)	270	8.3	459	DL	11	6,850	195	2	8
11 (wet mix)	383	8.7	335	DL	12	6,320	171	DL	12
14 (damp loam)	152	8.7	362	DL	36	11,100	275	3	14
17 (damp loam)	128	9.0	373	DL	30	12,500	305	DL	10
19 (damp loam)	128	9.1	270	DL	22	8,210	343	DL	9

The results of NDEP Profile I analyses demonstrate two intervals of soil chemistry discontinuities (Figures 2 through 5). The first discontinuity occurred between the 5- and 7-foot samples corresponding to the location of the tailings interface. Across this interval copper decreased from 676 to 261 mg/kg, iron from 113,000 to 50,200 mg/kg, and molybdenum from 103 to 31 mg/kg. Sulfate concentrations were similar across this distance. The second chemical discontinuity occurred between the 7- and 9-foot samples where sulfate decreased from 880 to 459 mg/kg, copper from 261 to 11 mg/kg, iron from 50,200 to 6,850 mg/kg, and molybdenum from 31 to 2 mg/kg. The location of this second break coincides with the mid-point of the wet soil.

3.1.3. Interstitial Water Samples

The 23 soil samples collected from the angle borings (TB-1, TB-2 and TB-3) that were submitted for NDEP Profile I Soils Analysis, were centrifuged in order to collect pore fluids for NDEP Profile I Water Analysis. Of the 23 samples, only three yielded an adequate fluid volume (e.g. more than 10 ml)

for chemical analysis. These samples were the 7-foot sample from TB-1 (13.5 ml) and the 0- and 5-foot samples from TB-3 (250 and 50 ml respectively). For these samples, the TDS ranged from 2550 to 3040 mg/L, sulfate from 1460 to 2100 mg/L, and manganese from 0.37 to 0.55 mg/L (Table 4).

Samples with volumes less than 250 ml were diluted with distilled water to 250 ml in order to obtain enough volume to perform the analyses. Analytical results reported here account for the dilution by re-scaling the reported analyte concentrations (i.e. for the 50 ml to 250 ml dilution, reported analyte concentrations are multiplied by 5 to account for this dilution). Fluid volumes sufficient for analysis could not be recovered from below the tailings/native material interface. Adjusted analyte concentrations are presented in Table 4.

3.2 Conclusions: Phase II TDS Mobility Testing

Based on the field and laboratory data generated from the Phase II borings and sample analysis, tailings solution infiltration into native materials below the impoundment is limited to a zone less than three vertical feet below the tailings/native material interface at the tailings borehole locations. In addition, wetting of the native material by water in the impoundment has not been observed at depths more than five feet below the tailings interface. Both of these observations are best represented by boring, TB-3. maybe

The gravimetric water content of the tailings ranges between 5 and 19 percent (total porosity of the tailings is 30 percent) while the water content in the substrate ranges between 6 and 15 percent (average total porosity of the soils 25 percent) (see Table 5 and Figure 6). In-situ moisture contents measured in Giroux Wash soils prior to construction of the tailings impoundment ranged between 4 and 15 percent (WESTEC, 1993). Hence, it appears that neither the tailings, nor the substrate soils, are near saturation, which limits tailings solution infiltration into the native material underlying the impoundment.

4.0 Phase III TDS Mobility Testing

Three vertical hollow-stem auger borings (P31, P32, P33; Figure 1) were drilled downgradient of the embankment. Split spoon samples were collected at 5-feet intervals for observation of physical characteristics

(Appendix I), and field analysis of paste pH and specific conductivity (Table 6). Split spoon samples representative of subsurface conditions and lithologies encountered during drilling were selected for laboratory analysis of 1) natural moisture content, and 2) grain size distribution (Tables 7 and 8, respectively).

A proposed total depth for each Phase III boring was established at 75 feet, based on subsurface conditions documented during drilling of two monitoring wells (WCC-G1 and WCC-G3) downgradient of the embankment. As shown on the boring log for WCC-G1 (Appendix I), a layer of fine to very coarse sand and gravel was encountered from 42 to 50 feet below ground. Similarly, in WCC-G3 (Appendix I) an interval of fine to medium sand and gravel was encountered from 44 to 68 feet below ground. Below approximately 50 feet in WCC-G1 and 70 feet in WCC-G3, the boring logs suggest that the volcanic and alluvial material is fine-grained and cementaceous.

If horizontal seepage occurs, it will likely be preferentially conducted in the shallow, gravel and sand located within a depth of 75 feet below the embankment base. At the time of the investigation, no evidence of seepage was encountered by the Phase III borings (P31, P32, P33).

4.1 Drilling Locations

The borehole locations for P31 and P32 were selected at locations downgradient of where tailings deposition was thickest at the time of drilling, and hydraulic heads would be greatest. These locations are shown in Figure 1. Boring P31 did not encounter volcanics, as it was located west of the Giroux Wash fault. Thus, boring P33 was drilled near the eastern extent of the embankment (Figure 1), downgradient of tailings deposition.

Note, the Tailings impoundment is in the initial stage of filling, and tailings have not been distributed along the entire length of the embankment. Therefore, boring P33, drilled specifically to encounter volcanics, is located downgradient of the current eastern distal edge of tailings deposition (Figure 1).

Borings P31 and P32 were drilled downgradient of the central portion of tailings deposition, and thus are downgradient of thick tailings deposits. Horizontal seepage, if it occurs, will be controlled by the hydraulic head associated with area of thickest tailings deposition.

A drainage blanket and associated underdrainage system was installed on the embankment, and extends downgradient of the embankment to intercept potential seepage and increase stability. The Phase III borings were drilled 5 to 20 feet downgradient (south) of the existing drainage system boundary.

The Phase III borings were drilled over a two day progression, starting with P31, moving to P32 and finally P33. Boring P31 was left open for approximately 24 hours after drilling, while borings P32 and P33 were drilled. As well, boring P32 was left open for approximately 6 hours while P33 was drilled. Boring P33, the last boring drilled, was left open for approximately 3 hours prior to abandonment. The borings were checked periodically for water production, and remained dry until abandonment. Groundwater was not encountered in any Phase III boring, and the boreholes were abandoned by re-filling with a 50% mixture of bentonite and cuttings.

4.2 Description of Borings

The Phase III borings P31 and P32 encountered gravel-rich alluvium similar to WCC-G1 and WCC-G3. However, the alluvial matrix material observed in borings P31 and P32 was less-coarse than that recorded for the wells. Boring P33 encountered a thin veneer of alluvium, with underlying gradationally-weathered volcanic tuff. Boring logs for P31, P32 and P33 are provided in Appendix I, and summaries of drilling results are provided in the following sections.

4.2.1. Boring P31

Boring P31 was drilled east of the central Giroux Wash drainage (Figure 1). This boring encountered alluvium (gravel with variable silt and sand matrix) (See boring log in Appendix I). At a depth range between 40 and 48 feet, gravel content decreased, with silty sand dominating this interval. At 48 feet, gravels were re-encountered and remained consistent to 75 feet. The alluvial matrix changed with depth in P31: silt-rich from 0 to 30 feet; silty-sand to 50 feet; silt rich to 65 feet; silty-sand to sand from 65 to 75 feet. Saturated conditions were not encountered during drilling of P31, nor was a

notably permeable horizon encountered. Therefore, drilling was terminated at 75 feet in depth.

The sediments encountered in P31 appear capable of conducting horizontal seepage if such were to occur. However, the boring was dry throughout its depth. Boring P31 was left open for 24 hours after drilling. The boring was checked for water production several times during this period using a "popper" type depth sounder. No water was observed in the boring to a depth of 75 feet. Due to low cohesion of sands, the boring collapsed from the original depth of 75 feet up to approximately 60 feet below ground approximately 14 hours after drilling. No water was observed prior to abandonment of the borehole. The borehole was abandoned by refilling with a 50% mixture of cuttings and bentonite chips to seal the borehole and prevent infiltration through the disturbed material.

4.2.2. Boring P32

Boring P32 was drilled west of the central Giroux Wash drainage (Figure 1). This boring encountered alluvium, similar to P31, but consisted overall of more fine-grained material. Alluvial gravels were encountered within specific horizons in boring P32, whereas P31 showed more continuous gravel layers. The alluvial strata in P32 varied with depth between 0 to 40 feet from silty-sand to sandy-clay, and also varied in gravel content and size. Within the depth range of approximately 40 to 60 feet, gravels were abundant. Gravel content diminished between 60 to 65 feet. Between 65 and 75 feet in depth, a clayey to silty sand was encountered, containing a minor amount of gravel, and in certain horizons common coarse sand layers. Saturated conditions were not encountered during drilling of P32, nor was a notably permeable horizon encountered. Therefore, the decision was made to stop drilling at 75 feet in depth.

Similar to P31, the sediments encountered in P32 also appear capable of conducting horizontal seepage if such were to occur. However, the boring was dry throughout its depth. Boring P32 was left open for 6 hours after drilling. The boring was checked for water production several times during this period. No water was observed in the boring. The borehole was abandoned by refilling with a 50% mixture of cuttings and bentonite chips to seal the borehole and prevent infiltration through the disturbed material.

4.2.3. Boring P33

Boring P33 was drilled downgradient of the eastern section of the embankment in order to encounter volcanic material (Figure 1). This boring encountered a thin veneer of alluvium and then penetrated into gradationally weathered volcanic rock. This boring was clearly located east of the Giroux Wash fault which juxtaposes a thick alluvial sequence to the west against volcanics to the east.

The volcanic tuff penetrated by P33 graded with depth from saprolite through weathered rock, to auger refusal. Split spoon refusal prevented collection of volcanic saprolite and rock samples in P33; cuttings were observed during drilling. The saprolite and volcanic tuff were dry. As the volcanic tuff becomes less weathered with depth, the potential for conducting seepage is severely diminished.

The current eastern limit of tailings disposal does not extend far beyond the apparent location of the fault as evidenced by boring P32 encountering alluvium (west of the fault). Therefore, a limited depth of tailings exists on the eastern side of the fault, which overlies volcanics. This currently limits hydraulic head that drives potential vertical and horizontal seepage, and further diminishes the existing potential for seepage to be occurring from the impoundment through the volcanics.

Boring P33 was left open for 3 hours after drilling. The boring was checked for water production twice during this period. No water was observed in the boring. The borehole was abandoned by refilling with a 50% mixture of cuttings and bentonite chips to seal the borehole and prevent infiltration through the disturbed material.

4.3 Field Analyses of pH and Specific Conductivity

Field measurements of paste pH and specific conductivity (SC) were conducted on split spoon soil samples to identify pH and/or SC spikes from high ionic strength tailings seepage within a specific horizon. Measured pH and SC were fairly consistent within each boring, decreasing slightly with depth (Table 6). No pH or SC spikes were observed in any sampled horizon, strongly suggesting no horizontal tailings water seepage is occurring.

4.4 Laboratory Analyses of Moisture Content & Grain Size Distribution

Laboratory analyses of moisture content (Table 7) and grain size distribution (Table 8) were conducted on split spoon samples from borings P31 and P32. Samples selected for these analyses were representative of the major lithologies encountered with depth in each boring. Laboratory analyses were not conducted on P33 samples. Split spoon refusal in P33 prevented sample collection for laboratory analysis of moisture content. Boring P33 encountered gradationally weathered volcanic tuff, where drill cuttings do not represent grain size of the rock material.

Natural moisture content of the alluvium sampled in borings P31 and P32 were consistently low, ranging from 1.07% to 6.25% (Table 7). Average porosity measured in the subsurface alluvium is 25% (taken from site characterization work performed by WESTEC (1993) to support siting and design of the impoundment). These results indicate that the alluvium sampled in borings P31 and P32 is unsaturated, thus indicating no evidence of seepage from the impoundment.

Grain size distribution in samples collected from borings P31 and P32 indicate that overall, the alluvial sequence penetrated by these borings is comprised predominantly of sand, with minor gravel, and common to minor silt/clay. This data is supported by field observations of split spoon samples collected from each boring. Alluvium encountered by boring P31 is a fining upward sequence (Figure 7). Note for P31 that a higher weight percentage of the material is retained by the coarser sieves as samples increase in depth. Boring P32 encountered a fining-downward sequence (Figure 8), where a greater percentage of coarse-grained material was retained at shallower depths.

Grain size distribution indicates that boring P31 is generally more coarse-grained than P32, which is supported by field observations. Comparing Figure 7 and Figure 8 (boring P31 and P32, respectively), a higher percentage of fine-grained sediments (e.g. 200 mesh) comprises the samples from P32 (20% to 50%), than for P31 (2% to 12%). Coarse to fine sand comprises the majority of alluvial samples collected from borings P31 and P32, with varying amounts of gravel, silt and clay. These data suggest that the alluvial sequence underlying the embankment is relatively permeable. Therefore, if horizontal seepage was occurring from the impoundment, the

borings P31 and P32 encountering conductive sediments would have intercepted tailings water. However, the borings were dry, as discussed above, and there appears to be no seepage occurring from the impoundment.

4.5 Conclusions: Phase III TDS Mobility Testing

Phase III borings P31, P32 and P33 provided a detailed sampling and analysis of the subsurface alluvium underlying the downgradient edge of the impoundment. Textural observations of the subsurface horizons encountered in these borings were compared to boring logs prepared for monitoring wells WCC-G1 and WCC-G3 (referenced previously for determining drilling depth).

The alluvial system underlying the impoundment shows extensive variability in material texture, color, and grain size distribution (characteristic of alluvial systems). Each of the three borings drilled for the Phase III TDS mobility testing (P31, P32 and P33) differed from each other, and each differed from WCC-G1 and WCC-G3. Figure 9 is a schematic block diagram of the impoundment and downgradient area, illustrating the Phase III borings, monitoring wells, and alluvial system sedimentology. Subsurface horizons that appear more permeable than adjacent horizons within each boring (based upon visual characteristics) are shown in green. There does not appear to be overall continuity of the apparent, relatively permeable zones (Figure 9). As well, no continuous fine-grained aquitard horizon was encountered in the Phase III borings, which would lead to horizontally directed seepage through the native alluvium.

Unsaturated conditions were encountered in the Phase III borings (based on visual observation, and moisture content results in Table 7). While grain size distribution varied considerably with depth and between borings (Table 8), no notably coarse grained horizons were encountered that would provide a direct preferential flow path for seepage. Measured pH and specific conductivity did not indicate the presence of tailings solution in the sediment horizons sampled. Therefore, the Phase III TDS Mobility Testing program indicates that horizontal seepage is not occurring beyond the embankment of the Giroux Wash Tailings Impoundment.

5.0 Conclusions

Current tailings disposal in the Giroux Wash Impoundment primarily overlies alluvium, with a limited extent of tailings disposal along the eastern section of the embankment overlying volcanics. The alluvial sediments underlying the impoundment consist of fluvial and colluvial deposits, with stratified (and probably lenticular) sediment sequences that vary in grain size distribution.

TDS Mobility testing indicated that vertical seepage of tailings water is currently limited to less than five feet below the tailings/native material interface during the first year of operation, with solute transport limited to less than three feet below the interface at present. The Phase III testing program indicated that horizontal seepage is not occurring downgradient of the embankment. Therefore, the Giroux Wash Tailings Impoundment currently provides sufficient and substantial retention of tailings solution. The conclusions from the TDS mobility study, and routine groundwater monitoring downgradient of the embankment indicate that waters of the State are not being impacted by the impoundment.

Tables

Table 1. Phase I TDS Mobility Investigation. Field Analyses of Phase pH and TDS		
Vertical Depth Below Tailings (feet)	**pH**	**TDS (mg/L)**
2	9.66	444
6	8.97	527
8	8.88	541
10	9.05	713
12	9.07	444
14	8.85	1162
16	8.56	538
21	8.64	147

Table 2. Specific Conductivity Profiles of Background Samples (depth units in feet, specific conductivity units in uS/cm^2)

Depth	B-1	B-2	B-3	B-4	B-5
0-2	175	107	---	---	70
2-4	194	89	283	68	---
4-6	710	105	252	74	220
6-8	749	131	206	---	---
8-10	1850	120	262	66	90
10-12	1910	120	270	---	---
12-14	867	116	255	95	---
14-16	---	---	271	99	66
16-18	523	---	261	---	---
18-20	600	---	264	95	62
20-22	---	---	221	---	---
22-24	---	---	244	---	---

Table 3. Background Soil Chemistry*
*composited from 6 background soil analyses not including the conductivity spike in B-1
(units are mg/kg)

Analyte	Concentration
chloride	<10
sulfate	307
aluminum	6,960
calcium	78,080
copper	8
iron	7,746
magnesium	2,486
manganese	245
molybdenum	<1.8
potassium	1,507
silver	1.3
sodium	242
zinc	36

Table 4. Interstitial Water Chemistry of Tailings
(units are mg/L and standard units for pH)

Analyte	TB-3 (0-ft.)	TB-3 (5-ft.)	TB-1 (7-ft.)
pH	7.51	6.65	6.31
TDS	3040	2940	2550
alkalinity	65	46	93
calcium	674	670	443
chloride	36	47	41
fluoride	1.2	1.5	<0.1
potassium	18	28	<0.76
magnesium	45	36	87
sodium	36	42	40
nitrate	<0.05	<0.05	<0.05
sulfate	2100	1970	1465
silver	<0.003	<0.003	<0.003
aluminum	0.055	0.11	<0.021
arsenic	<0.001	<0.001	<0.001
barium	0.013	0.03	0.11
cadmium	<0.002	<0.002	<0.002
chromium	0.006	<0.005	<0.005
copper	0.003	0.005	<0.003
iron	<0.024	<0.024	<0.024
mercury	<0.0004	<0.0004	<0.0004
manganese	0.55	0.44	0.37
nickel	<0.017	<0.017	<0.017
lead	0.003	0.015	0.004
selenium	<0.003	<0.003	<0.003
thallium	<0.001	<0.001	<0.001
zinc	0.016	0.021	0.012

Table 5. Gravimetric Water Contents of Impoundment Samples (Depth = vertical depth below surface of tailings, depth units are feet, WC = gravimetric water content, tailings interface underlined)

TB-1		TB-2		TB-3	
Depth	WC	Depth	WC	Depth	WC
5	0.13	9	0.08	0	0.15
7	0.15	14	0.09	2	0.13
9	0.16	17	0.09	5	0.13
13	0.15	21	0.11	7	0.09
15	0.15	28	0.11	9	0.05
21	0.11	36	0.12	11	0.19
25	0.08			14	0.14
28	0.06			17	0.13
				19	0.09

Table 6
BHP - Robinson Operations. Giroux Wash Tailings Impoundment.
Phase III TDS Mobility Drilling
Paste pH and Specific Conductivity (SC) Results

Date Drilled: May 21-22, 1997

Driller: Webber Environmental
Project Manager: Bill Newcomb

	P31		P32		P33	
Depth (ft)	pH	SC (umhos/cm)	pH	SC (umhos/cm)	pH	SC (umhos/cm)
5	NM	NM	NM	NM	8.83	250
10	8.6	433	8.3	385	8.15	256
15	8.6	463	8.3	230	8.56	227
20	8.3	481	8.4	180	8.92	242
25	8.2	441	8.1	383	8.75	250
30	8.2	394	7.3	390	Auger Refusal	
35	8.1	387	7.9	223		
40	8.1	381	7.9	222		
45	7.9	368	7.9	234		
50	8.1	369	8.0	215		
55	8.1	366	7.9	214		
60	7.9	363	7.9	219		
65	7.8	390	8.1	218		
70	8.1	362	8.0	211		
75	8.2	386	7.9	211		
Boring Terminated						

Table 7: Phase III TDS Mobility Testing. Moisture Content Results		
Boring	**Depth (feet)**	**% Moisture Content**
P31	20	1.35
P31	35	1.07
P31	45	2.84
P31	60	3.15
P31	65	2.05
P31	70	2.05
P32	15	3.3
P32	30	6.25
P32	45	2.21
P32	60	4.37
P32	70	5.73
P32	75	2.97

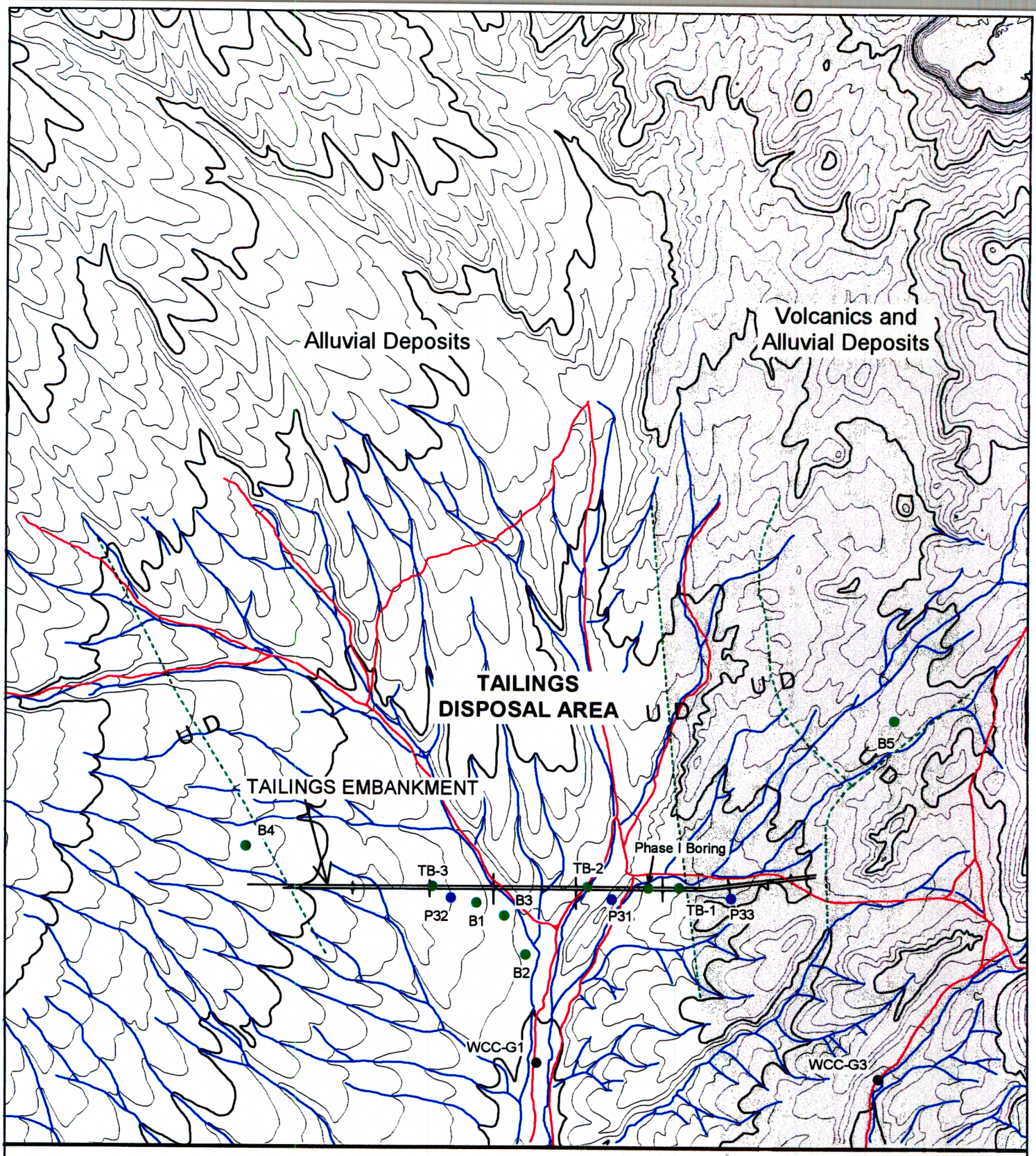
Table 8. Phase III TDS Mobility Testing. Grain Size Distribution as % by Weight Retained in Sieve.
Note: if 25% passed 100 mesh (0.150 mm), sample was sieved to 200 mesh.

P31		Gravel	Sand					Silt or Clay	Silt or Clay
			Coarse	Coarse- Med.	Medium	Med.-Fine	Fine		
			10 mesh	20 mesh	48 mesh	65 mesh	100 mesh	200 mesh	< 200 mesh
Boring	Depth (feet)	1/4"	1.688 mm	0.841 mm	0.297 mm	0.210 mm	0.150 mm	0.075 mm	< 0.075 mm
P31	20	4.9	8.5	26.0	34.9	8.5	6.7	NM	NM
P31	35	13.5	12.4	10.9	37.1	10.7	7.0	NM	NM
P31	45	14.2	19.3	15.8	23.5	8.3	9.9	NM	NM
P31	60	11.0	8.1	11.2	43.1	19.9	3.2	NM	NM
P31	65	47.6	16.7	11.2	5.4	4.6	4.3	NM	NM
P31	70	22.8	18.8	12.7	25.1	8.0	5.6	NM	NM

Table 8 - Continued.

P32		Gravel	Sand					Silt or Clay	Silt or Clay
			Coarse	Coarse- Med.	Medium	Med.-Fine	Fine		
			10 mesh	20 mesh	48 mesh	65 mesh	100 mesh	200 mesh	< 200 mesh
Boring	Depth (feet)	1/4"	1.688 mm	0.841 mm	0.297 mm	0.210 mm	0.150 mm	0.075 mm	< 0.075 mm
P32	15	29.1	25	9.7	4.1	1.1	1.2	3.7	26.2
P32	30	15.5	11.2	5.6	5.2	1.2	3.7	14.5	43.1
P32	45	23.7	18.9	11.1	13.2	5.3	2.4	5.8	19.6
P32	60	17.1	15.6	7	10	4.8	6.4	8.1	31.1
P32	70	26.9	12.3	7.1	9.1	5.2	4.2	4.7	30.4
P32	75	6.6	7.1	6.3	10.2	4.5	5.3	8.3	51.8

Figures



Phase I/Phase II Borings
Phase III Borings
Monitoring Wells
Volcanics

Projected Faults
Road
Drainage
Contour: 100 ft. Interval
Contour: 20 ft. Interval

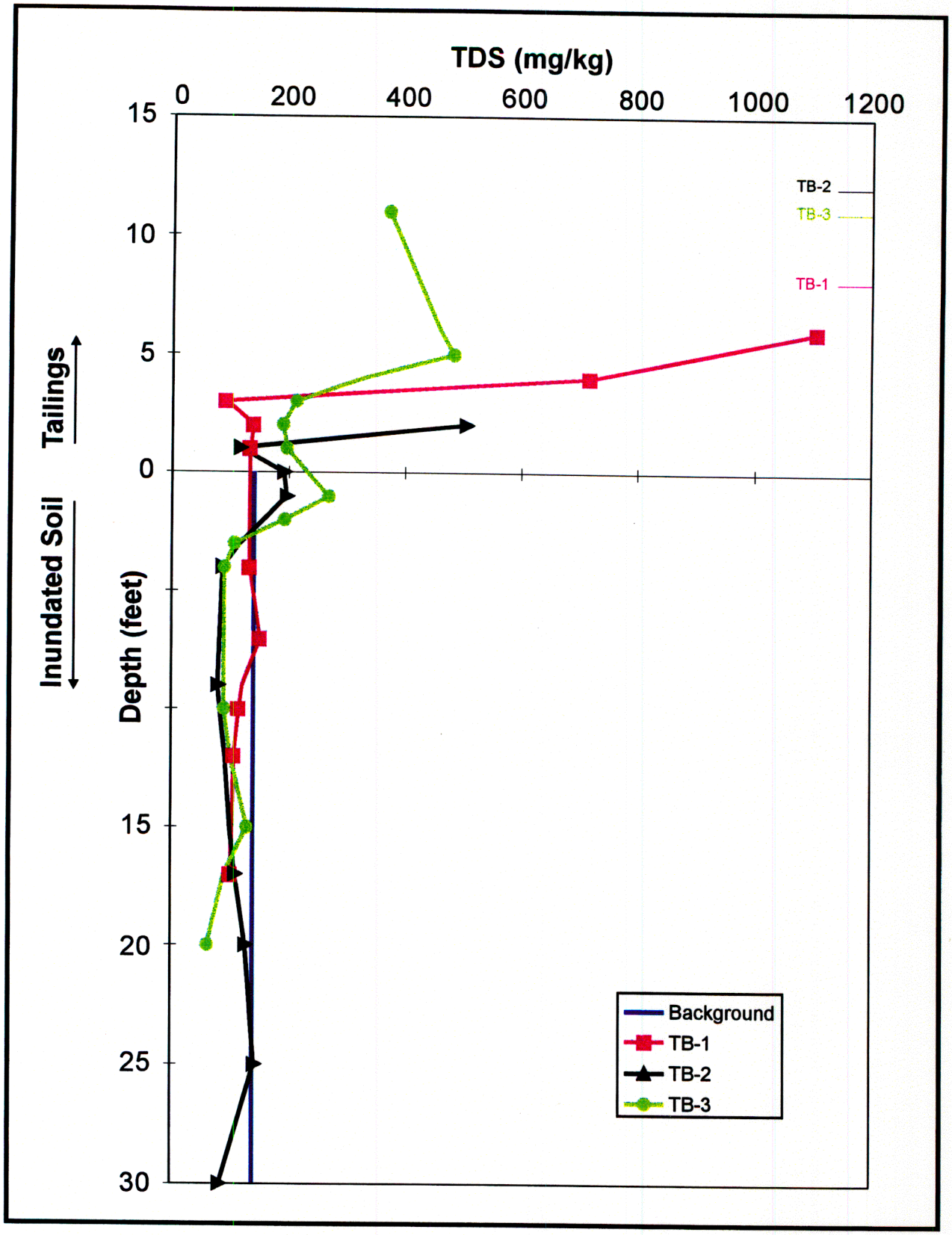
B = vertical
TB = ⊥

N

0 0.5 1 Miles

Generation Date: 6/13/97	Figure 1. Giroux Wash Tailings Impoundment Boring Locations.	Geomega

\\bdk\d:\Projects\bhp\bhptapes\cpad.apr: Figure 1 Layout



Generation Date: 1/31/97	Figure 2. Giroux Wash TDS vs. Depth through Tailings and Pre-Inundation Surface.	Geomega

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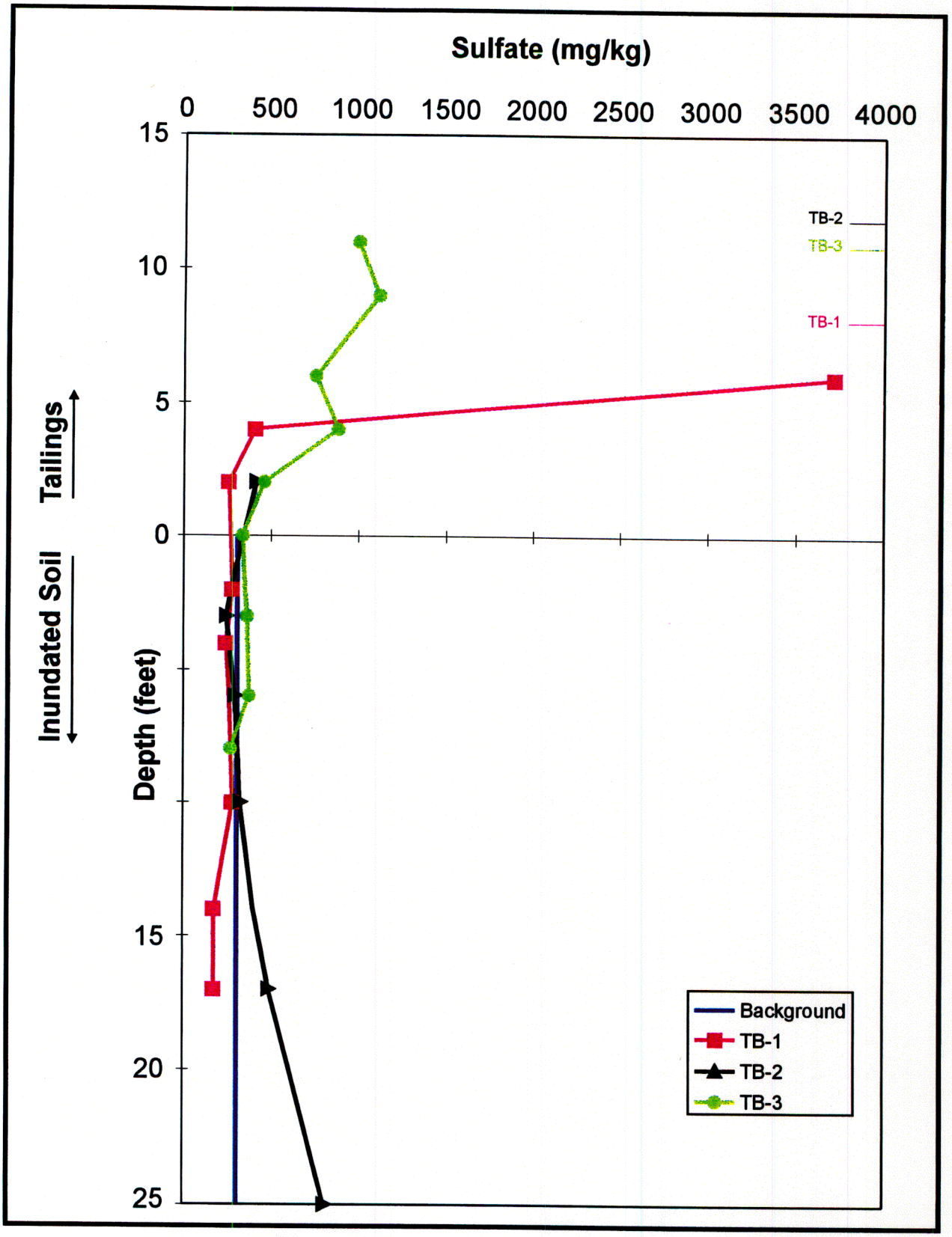

Generation Date: 1/31/97	Figure 3. Giroux Wash Sulfate vs. Depth through Tailings and Pre-Inundation Surface.	Geomega

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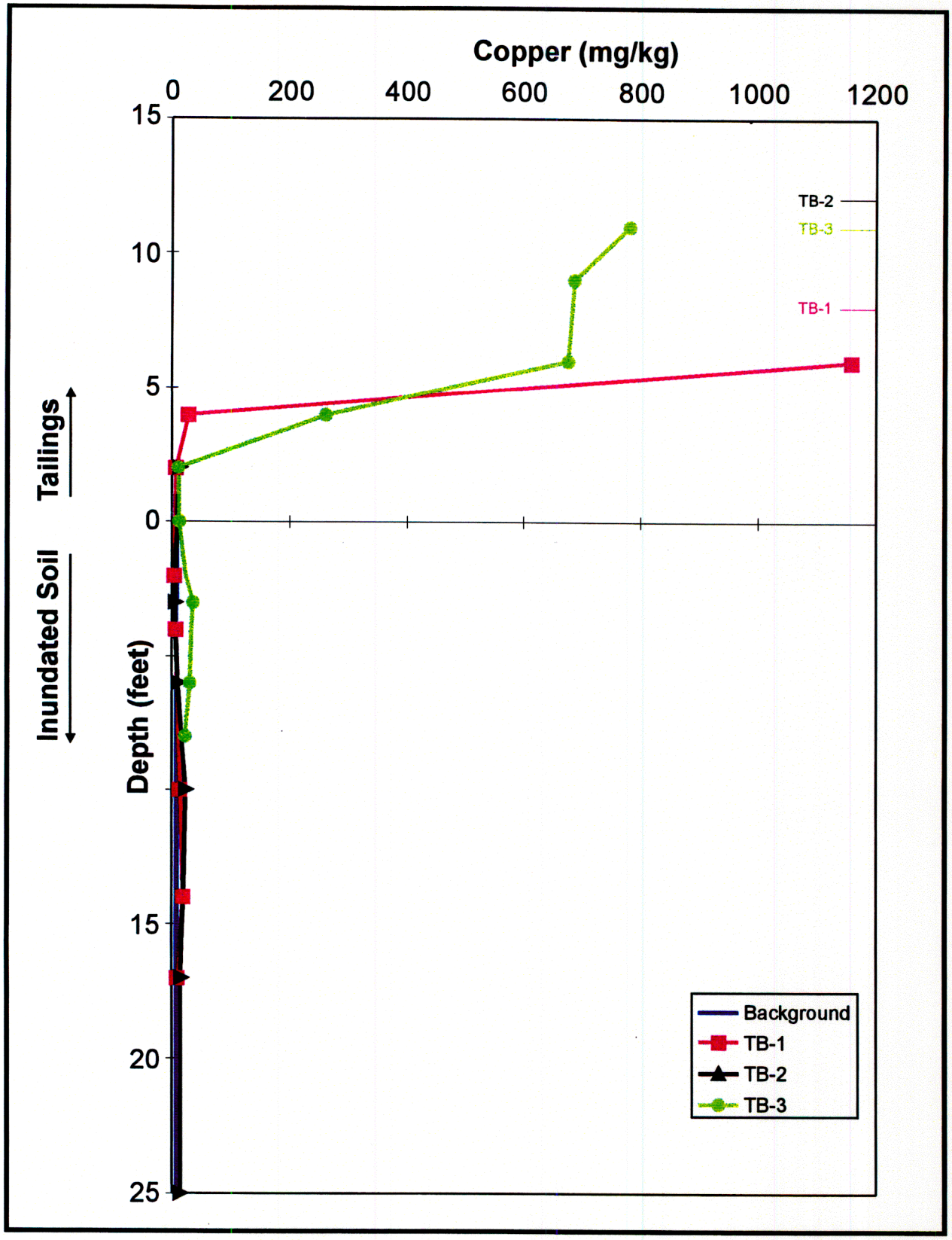

Generation Date: 1/31/97	Figure 4. Giroux Wash Copper vs. Depth through Tailings and Pre-Inundation Surface.	Geomega

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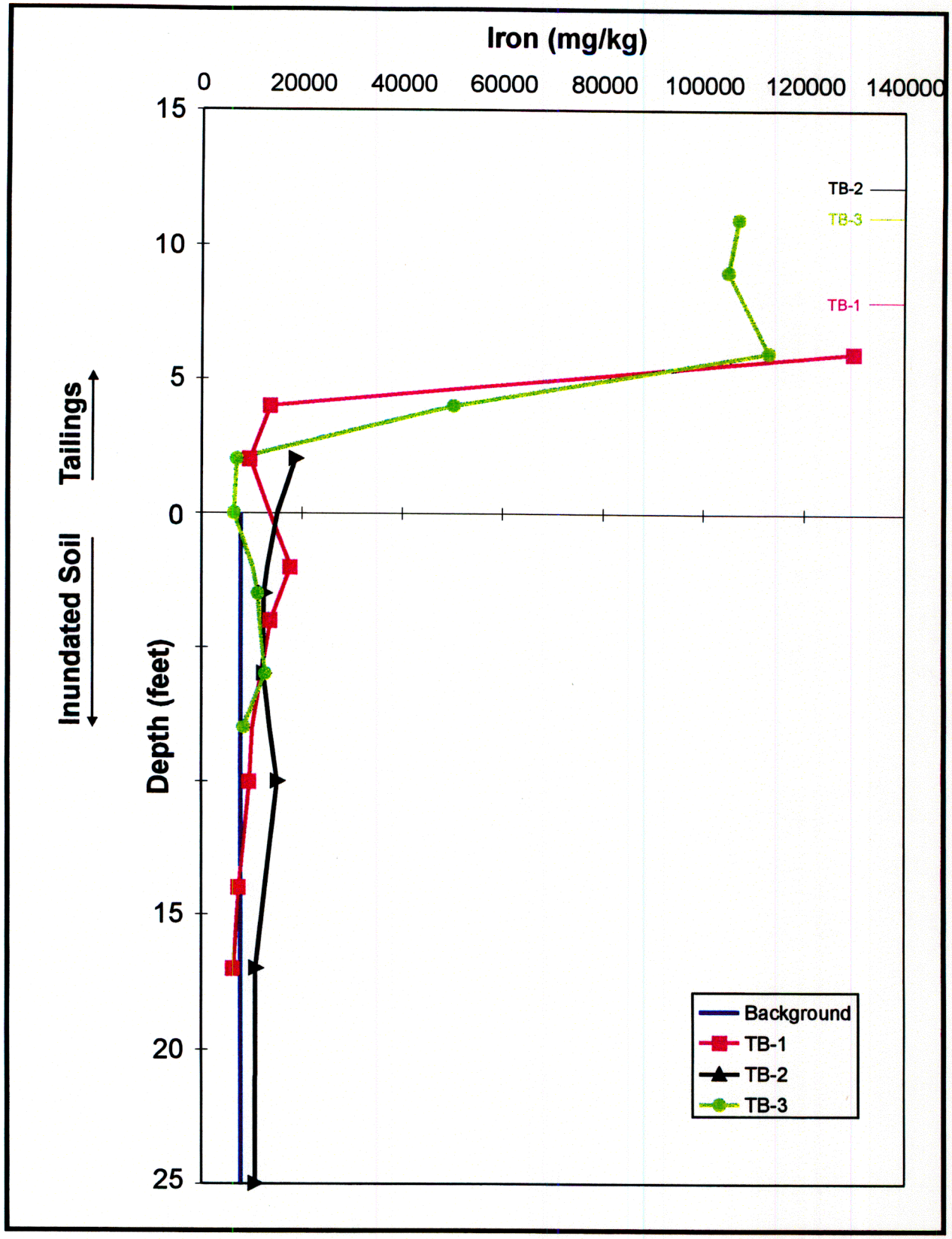

Generation Date: 1/31/97	Figure 5. Giroux Wash Iron vs. Depth through Tailings and Pre-Inundation Surface.	Geomega

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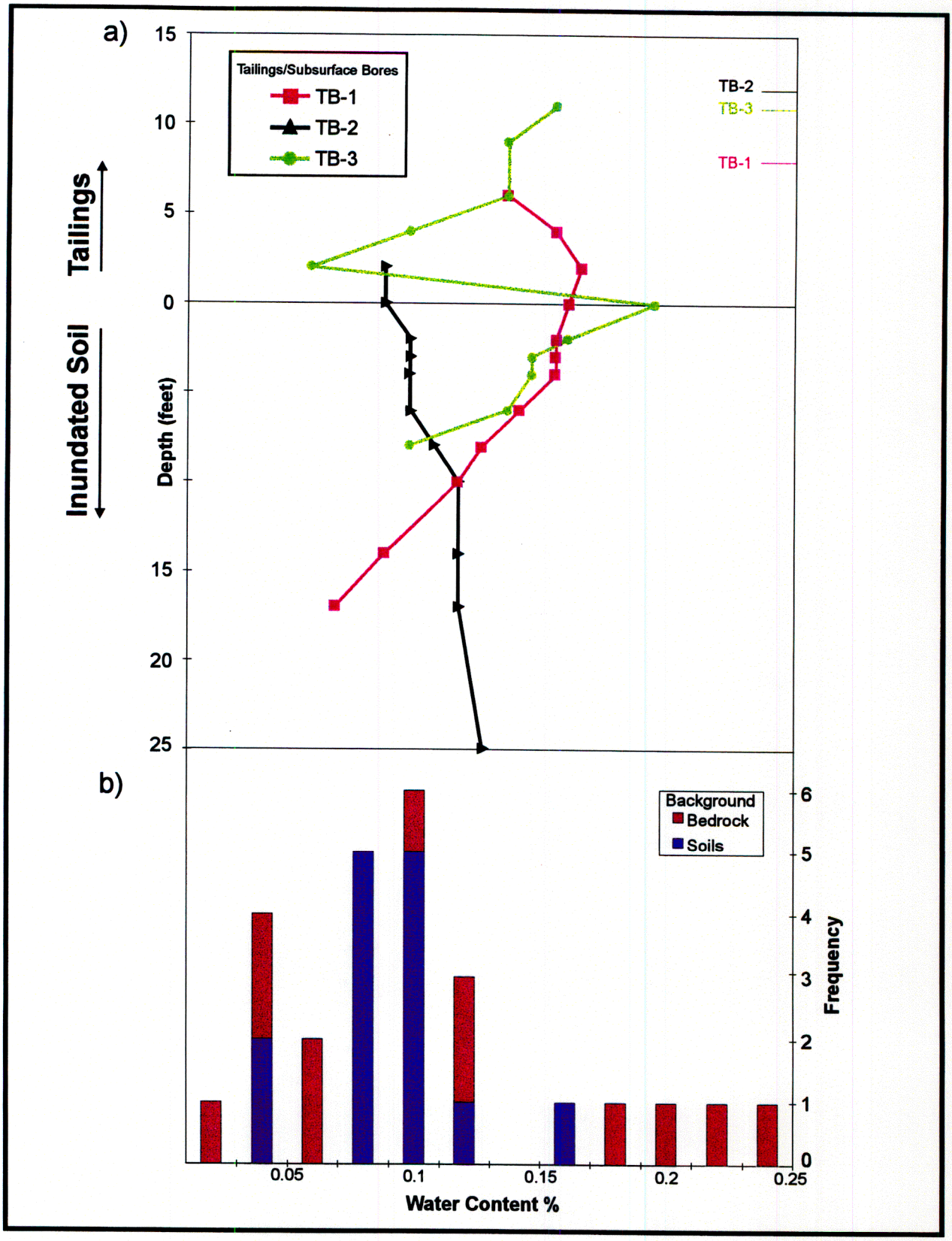

Generation Date: 1/31/97	Figure 6: a) Giroux Wash Water Content vs. Depth through Tailings and Pre-Inundation Surface. b) Background Soil and Bedrock Moisture Contents.	Geomega

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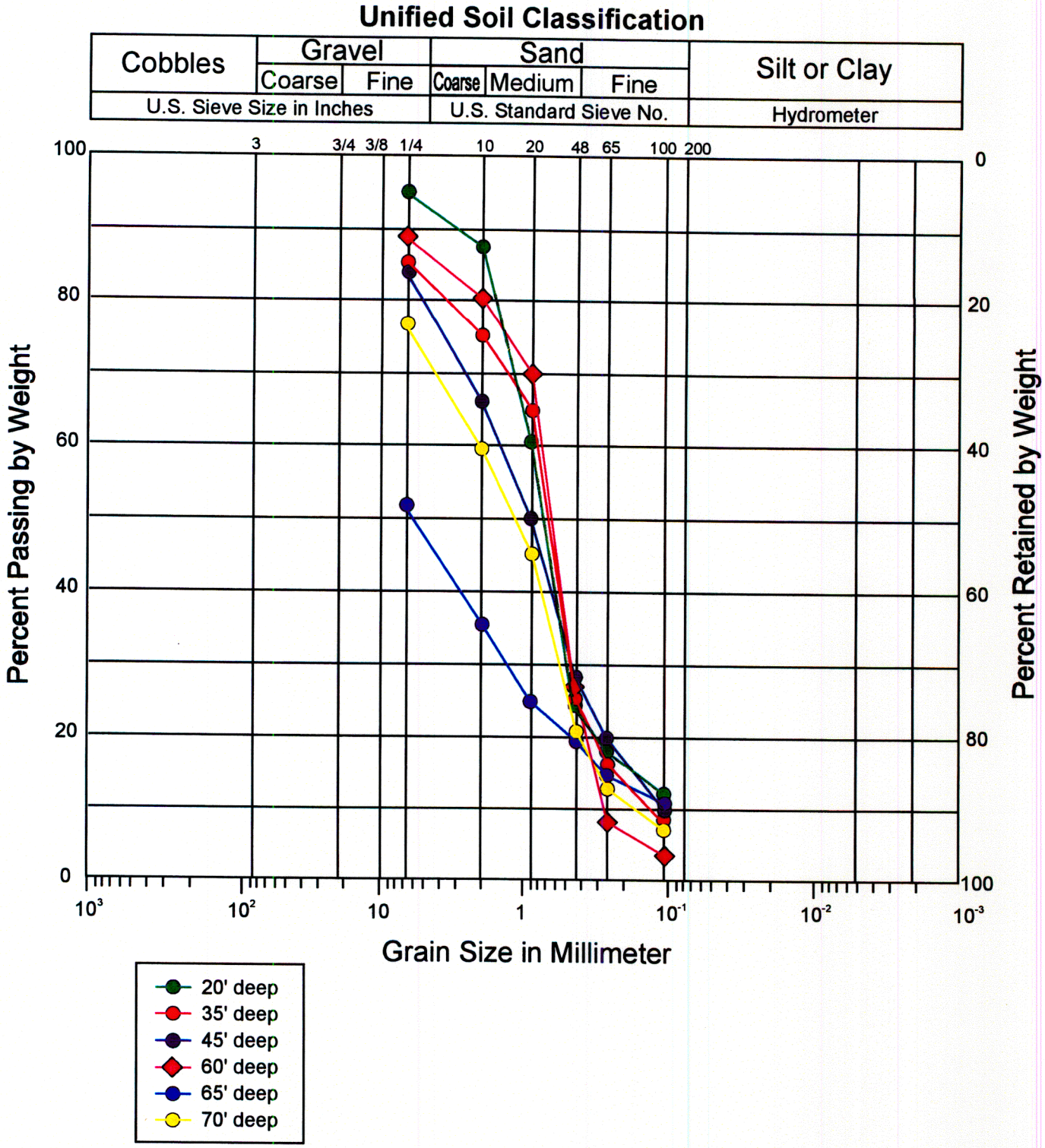

Generation Date: 6/11/97	Figure 7. Grain Size Distribution of P31.	Geomega

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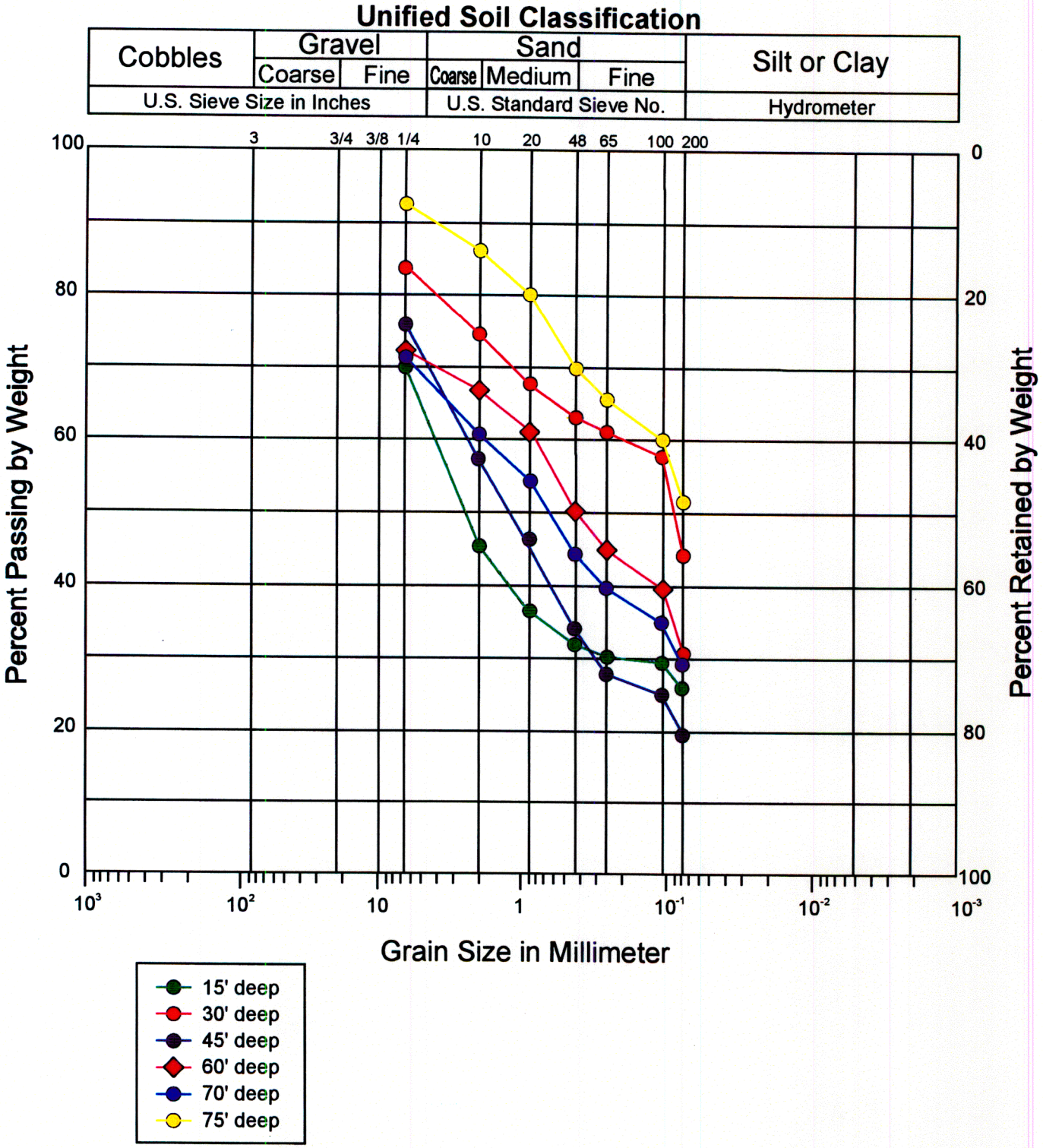

Generation Date: 6/11/97	Figure 8. Grain Size Distribution of P32.	Geomega

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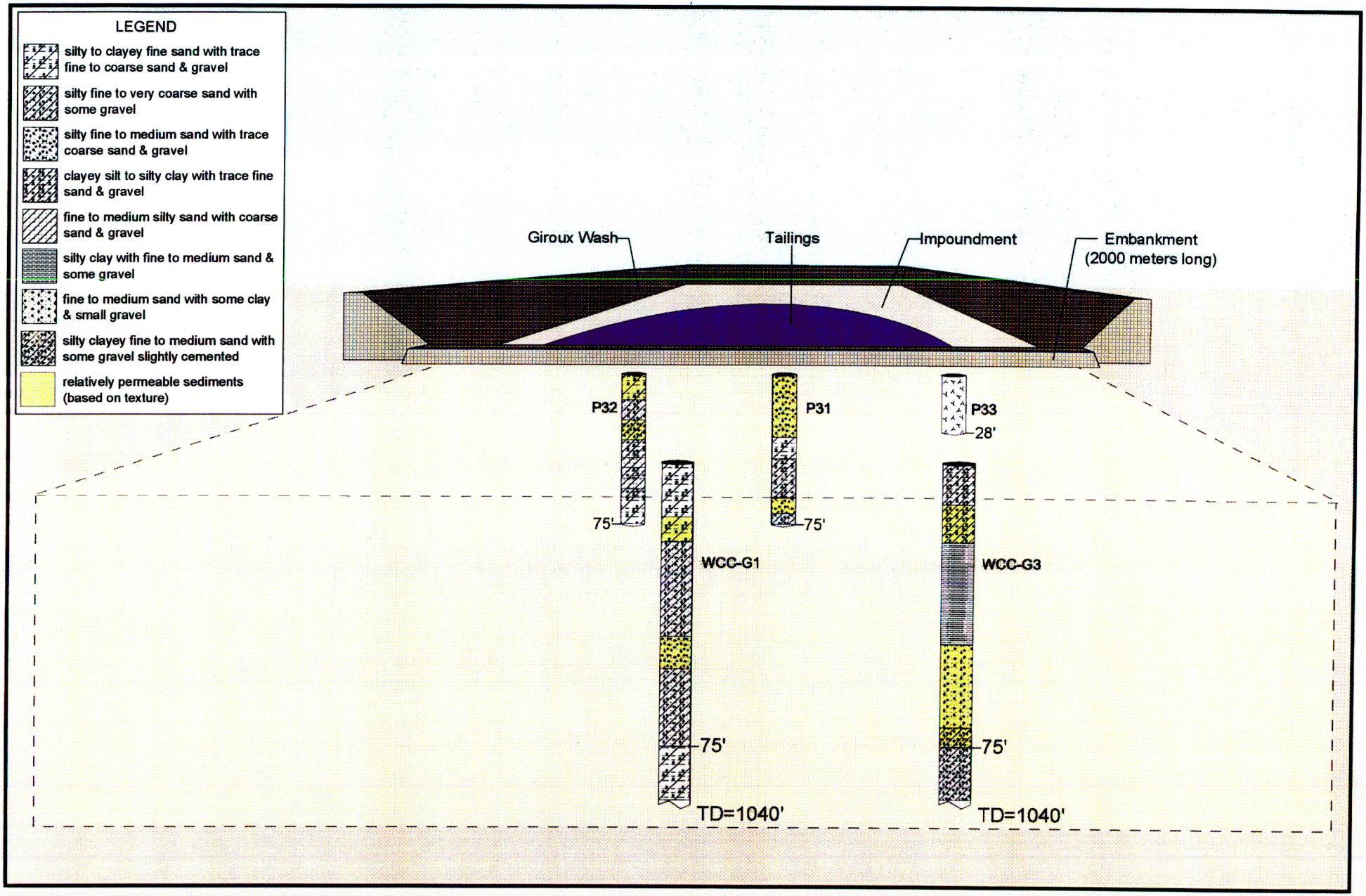

Generation Date: 6/6/97

Figure 9. Selected Cross-Section of Giroux Wash Tailings Inpoundment (View to North). Relatively Permeable Zones (Based on Texture) are Colored Green. Drawing Not to Scale.

Geomega

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APPENDIX I

Boring Logs
WCC-G1, WCC-G3, P31, P332 and P33

Woodward-Clyde Consultants PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G1

BORING LOCATION T.15N, R61E, S25 COORD. N88,426.5, E87,635.3		ELEVATION AND DATUM GROUND=8592.87'	
DRILLING AGENCY LANG EXPLORATORY DRILLING	DRILLER BRYON/MARK/BENJIE	DATE STARTED/DATE FINISHED 06-23-91 TO 06-26-91	
DRILLING EQUIPMENT DRILLTECH DH-1		COMPLETION DEPTH 1040'	SAMPLER
DRILLING METHOD REVERSE CIRCULATION AIR ROTARY	DRILL BIT 6 1/8" TRI-CONE	NO. OF SAMPLES / DIST.	UNDISTURBED
SIZE AND TYPE OF CASING 2" STEEL		WATER ELEV. FIRST 860'	COMPL. 770' / 24 HRS. 768'
TYPE OF PERFORATION 0.020" STAINLESS STEEL WIRE-WRAP	FROM 982 TO 1002 FT	LOGGED BY P. BROOKS/D. ROYBAL	CHECKED BY SWR/SFR
SIZE AND TYPE OF PACK #6-12 VALLEY GRAVEL	FROM 813 TO 1027 FT		
TYPE OF SEAL BENTONITE	FROM 785 TO 813 FT		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Piezometer Data	SAMPLES: Type No.	SAMPLES: Blows, ft.	SAMPLES: Penetr. Resist. (Blows/6 in.)	REMARKS (Drill Rate, Fluid loss, Odor, etc.)
0	DRY, LIGHT BROWN SILTY TO CLAYEY, VERY FINE SAND WITH TRACE FINE TO COARSE SAND AND GRAVEL TO 20mm DIAMETER (SM/SC)								1335 HRS.
10									
20	MOIST, LIGHT BROWN SILTY FINE TO VERY COARSE SAND WITH SOME SANDSTONE, LIMESTONE AND WELDED TUFF GRAVELS TO 20mm (SM)								1345 GRAVELS ARE SUBROUNDED TO SUBANGULAR
30	MOIST, LIGHT YELLOWISH BROWN SILTY FINE TO MEDIUM SAND WITH TRACE COARSE SAND AND GRAVEL TO 20mm DIA.(SM)								HARDER DRILLING @ 42 FEET
40	MOIST, LIGHT-GRAY FINE TO VERY COARSE SAND WITH SOME GRAVEL TO 25mm DIA. (SP)								1440 GRAVEL INCLUDES: LIMESTONE, CHERT, WELDED TUFF, AND SANDSTONE (RARE) -DRILLING EASIER
50	MOIST, LIGHT YELLOWISH BROWN SILTY FINE SAND WITH TRACE COARSE SAND AND GRAVEL TO 20mm DIAMETER (SM)								
60									1500
70	MOIST, LIGHT YELLOWISH BROWN SILTY FINE TO MEDIUM SAND WITH SOME COARSE SAND AND GRAVELS TO 20mm DIAMETER (SM)								SOME DIFFICULTY PULLING THE ROD-HOLE CAVING IN
80									1520
90									
100									1540
110	MOIST, LIGHT YELLOWISH BROWN FINE TO VERY COARSE SAND WITH SOME GRAVELS TO 20mm DIA. (SP)								
120	MOIST, LIGHT YELLOWISH BROWN SILTY FINE TO MEDIUM SAND WITH SOME COARSE SAND AND GRAVEL TO 20mm DIA. (SM)								1600
130	MOIST, LIGHT YELLOWISH BROWN FINE TO VERY COARSE SAND WITH SOME GRAVELS TO 20mm DIAMETER (SP)								1620
140									

GRAB AND CHIP SAMPLE @ 10 FT. INTERVALS

PROJECT NO. 9053348N-T3100

Woodward-Clyde Consultants PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G1

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Piezometer Data	SAMPLES: Type No.	SAMPLES: Blows/ft.	SAMPLES: Penetr. Resist. (Blows/6 in.)	REMARKS (Drill Rate, Fluid loss, Odor, etc.)
140	MOIST, LIGHT YELLOWISH BROWN SILTY FINE TO MEDIUM SAND WITH TRACE COARSE SAND AND GRAVEL TO 20mm DIAMETER (SM)								GRAVELS INCLUDE: LIMESTONE, CHERT, WELDED TUFF, AND SANDSTONE (RARE) SUBROUNDED TO SUBANGULAR
150									
160	MOIST, LIGHT YELLOWISH BROWN VERY FINE TO COARSE SAND WITH SOME GRAVELS TO 20mm DIAMETER (SP)								
170									
180	SAME AS ABOVE								
190									
200	MOIST, LIGHT YELLOWISH BROWN VERY FINE TO MEDIUM SAND WITH TRACE COARSE SAND AND GRAVEL TO 15mm DIAMETER (SP)								
210									
220	MOIST, LIGHT YELLOWISH BROWN VERY FINE TO MEDIUM SAND WITH SOME COARSE TO VERY COARSE SAND AND GRAVEL TO 20mm DIAMETER (SP)								INCREASE IN GRAVEL CONTENT AT 214 FT.
230									
240	SAME AS ABOVE								
250									
260	SAME AS ABOVE								
270									
280	MOIST, LIGHT YELLOWISH BROWN VERY FINE TO MEDIUM SAND WITH SOME COARSE TO VERY COARSE SAND AND TRACE GRAVEL TO 15mm DIAMETER (SP)								PARTIAL LOSS OF CIRCULATION
290									
300	MOIST, LIGHT YELLOWISH BROWN VERY FINE TO MEDIUM SAND WITH SOME COARSE TO VERY COARSE SAND AND GRAVEL TO 20mm DIAMETER (SP)								
310									

GRAB AND CHIP SAMPLE @ 10 FT. INTERVALS

1620 HRS.
1640
1705
1730
1755
1820
1845
1905
1925

PROJECT NO. 9053348N-T3100

SHEET 2 OF 7

Woodward-Clyde Consultants PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G1

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Piezometer Data	SAMPLES	REMARKS (Drill Rate, Fluid loss, Odor, etc.)
10	MOIST, LIGHT YELLOWISH BROWN VERY FINE TO MEDIUM SAND WITH SOME COARSE TO VERY COARSE SAND AND GRAVEL TO 20mm DIAMETER (SP)					GRAB AND CHIP SAMPLE @ 10 FT. INTERVALS	1945 HRS
20	MOIST, LIGHT YELLOWISH BROWN FINE TO MEDIUM SAND WITH TRACE COARSE TO VERY COARSE SAND AND GRAVEL TO 15mm DIAMETER (SP)						2005
30							
40							2025
350	MOIST, LIGHT YELLOWISH BROWN VERY FINE TO MEDIUM SAND WITH SOME COARSE TO VERY COARSE SAND AND GRAVEL TO 15mm DIA. (SP)						DIFFICULTY IN PULLING DRILL ROD CAVING AND BRIDGING AT ~355'.
360							
370	SAME AS ABOVE						2055
380	MOIST, LIGHT YELLOWISH BROWN VERY FINE TO MEDIUM SAND WITH TRACE COARSE SAND AND GRAVEL TO 15mm DIAMETER (SP)						DIFFICULTY IN PULLING DRILL ROD FROM 380' – MORE CAVING.
390							2120
400							
410	MOIST, LIGHT YELOWISH BROWN SILTY VERY FINE TO MEDIUM SAND WITH TRACE COARSE SAND (SM)						2140 2210
420							
430	TRACE COARSE TO VERY COARSE SAND						RETURN HOSE PLUGGED; CLEAN OUT 2140 – 2210 HRS. 2230
440	MOIST, LIGHT YELLOWISH BROWN FINE TO MEDIUM SAND WITH TRACE COARSE TO VERY COARSE SAND (SW)						2245
450							
460							2315
470	SAME AS ABOVE						
480							

PROJECT NO. 9053348N-T3100

SHEET 3 OF 7

Woodward-Clyde Consultants PROJECT NAME MAGMA COPPER HOLE NO. WCC-G1

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Piezometer Data	SAMPLES: Type	SAMPLES: Recov.	SAMPLES: Penetr. Resist. (Blows/6 in.)	REMARKS (Drill Rate, Fluid loss, Odor, etc.)
480	MOIST, LIGHT YELLOWISH BROWN FINE TO MEDIUM SAND WITH TRACE COARSE TO VERY COARSE SAND (SW)								
490	MOIST, LIGHT YELLOWISH BROWN FINE TO MEDIUM SAND WITH TRACE TO SOME COARSE TO VERY COARSE SAND AND GRAVEL (SP)								
500	MOIST, LIGHT YELLOWISH BROWN FINE TO MEDIUM SAND WITH TRACE COARSE TO VERY COARSE SAND (SW)								
510									
520	MOIST, LIGHT YELLOWISH BROWN FINE TO MEDIUM SAND WITH TRACE TO SOME COARSE TO VERY COARSE SAND AND GRAVELS TO 15mm DIA. (SP)								
530									
540	LIGHT BROWN TO TAN FINE TO MEDIUM SILTY SAND WITH SOME SMALL GRAVEL AND COARSE SAND. SLIGHTLY CEMENTED TO CEMENTED (SM)								
550									
560	SAME AS ABOVE								
570	LIGHT BROWN TO TAN FINE TO MEDIUM SILTY SAND WITH SOME COARSE SAND AND SMALL GRAVEL SLIGHTLY CEMENTED TO CEMENTED (MOIST TO DAMP) (SM)								
580									
590	GRAVELLY FINE TO MEDIUM SAND (SP)								
600	LIGHT BROWN TO TAN SILTY FINE TO MEDIUM SAND WITH SOME COARSE TO VERY COARSE SAND AND GRAVEL TO 20mm DIA. SLIGHTLY CEMENTED TO CEMENTED (SM)								
610									
620									
630									
640	LIGHT BROWN GRAVELLY FINE TO VERY COARSE SAND WITH SOME SILT (SP)								
650									

GRAB AND CHIP SAMPLE @ 10 FT. INTERVALS

NOTE: BRIDGED OFF TRIP OUT @ 0040 HRS. BOTTOM OF BRIDGE @ 360'.
0100 HRS. WORKING ON RIG. HYD. VALVE. & CHANGING HYD. PUMP COMPLETE REPAIRS @ 0520 HRS.

DRILL PIPE BACK AT BOTTOM @ 0730 HRS.

570' – SWITCHED TO WATER TO KEEP HOLE CLEAN.
HOLE BRIDGED OFF AT 570' – 0840 HRS.

1130 HRS. – BACK IN HOLE.

GRAVEL INCLUDES: SANDSTONE, CHERT, LIMESTONE, WELDED TUFF, QUARTZIDE, & SHALE.

1320' – 1340 REPAIR RETURN HOSE CONNECTION

QUARTZIDE GRAVEL HAS TRACE PYRITE; SIMILAR TO THAT ENCOUNTERED IN WCC-5M

PROJECT NO. 9053348N-T3100

Woodward-Clyde Consultants PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G1

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Piezometer Data	SAMPLES: Type No.	SAMPLES: Blows/6"	SAMPLES: Penetr. Resist. (Blows/6 in.)	REMARKS (Drill Rate, Fluid loss, Odor, etc.)
50	LIGHT BROWN GRAVELLY FINE TO VERY COARSE SAND WITH SOME SILT (SP)								1525 HRS.
60									
670	SAME AS ABOVE								1545
680	LIGHT BROWN SILTY FINE TO VERY COARSE SAND WITH SOME GRAVEL TO 25mm DIA. (SM)								DRILLING HARDER @ 685'
690									1615
700	SAME AS ABOVE								
710									1645
720	SAME AS ABOVE								
730									1715
740	LIGHT BROWN SLIGHTLY CEMENTED SILTY FINE TO MEDIUM SAND WITH SOME COARSE TO VERY COARSE SAND AND SOME TRACE SMALL GRAVEL (SM)							GRAB AND CHIP SAMPLE @ 10 FT. INTERVALS	INCREASE IN FINES IN RETURN FLUID
750									1745
760									
770									1820
780	LIGHT BROWN SLIGHTLY CEMENTED SILTY FINE TO MEDIUM SAND WITH SOME COARSE TO VERY COARSE SAND AND SMALL GRAVEL (SM)								INCREASE IN GRAVEL CONTENT; STILL LOTS OF FINES IN RETURN FLUID.
790									1855
800	LIGHT BROWN SLIGHTLY CEMENTED SILTY FINE TO MEDIUM SAND WITH SOME COARSE TO VERY COARSE SAND AND TRACE SMALL GRAVEL (SM)								DECREASE IN GRAVEL CONTENT.
810									1925
820									

PROJECT NO. 9053348N-T3100

SHEET 5 OF 7

Woodward-Clyde Consultants PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G1

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Piezometer Data	SAMPLES: Type No.	SAMPLES: Recov. ft.	SAMPLES: Penetrn. Resist. (Blows/6 in.)	REMARKS (Drill Rate, Fluid loss, Odor, etc.)
20	LIGHT BROWN FINE TO VERY COARSE SAND WITH TRACE TO SOME SMALL GRAVEL (SP)								DECREASE IN FINES
30	LIGHT BROWN SILTY FINE TO VERY COARSE SAND WITH TRACE TO SOME SMALL GRAVEL (SM)								
40									
850									
860	LIGHT BROWN SILTY FINE TO VERY COARSE SAND WITH SOME SMALL GRAVEL (SM)								
870									
880	SAME AS ABOVE								YIELD ~6gpm AT 880'
890									
900									YIELD ~10gpm AT 900'
910	INCREASE IN FINES BETWEEN 900 - 930								
920									YIELD ~15gpm AT 920'
930	LIGHT BROWN SLIGHTLY CEMENTED SILTY FINE TO VERY COARSE SAND WITH SOME SMALL GRAVEL (SM)								
940									YIELD ~20gpm AT 940'
950									
960	SAME AS ABOVE								YIELD ~30gpm AT 960'
970									
980									YIELD ~30gpm AT 980'
990									

GRAB AND CHIP SAMPLE @ 10 FT. INTERVALS

1925 HRS.
2000
2030
2100
2250
2325
0005 6-25-91

PROJECT NO. 9053348N-T3100

SHEET 6 OF 7

Woodward-Clyde Consultants PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G1

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Piezometer Data	SAMPLES: Type No.	SAMPLES: Blows/6 in.	SAMPLES: Penetro-Rator (Blows/6 in.)	REMARKS (Drill Rate, Fluid loss, Odor, etc.)	
990	LIGHT BROWN SILTY FINE TO MEDIUM SAND WITH SOME COARSE TO VERY COARSE SAND AND SMALL GRAVEL (SM)							GRAB AND CHIP SAMPLE @ 10 FT. INTERVALS	INCREASE IN FINES AT 990'.	0040 HRS.
000	LIGHT BROWN SILTY FINE TO COARSE SAND WITH SOME VERY COARSE SAND AND SMALL GRAVEL (SM)								YIELD ~35gpm @ 1000'	
010										
020									YIELD ~40gpm @ 1020'	0120
030	SAME AS ABOVE								YIELD ~40gpm @ 1040'	0150
040	BOH @ 1040'									

9053348N-T3100

SHEET 7 OF 7

Woodward-Clyde Consultants PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G3

BORING LOCATION	T16N, R82E, S30 COORD. N 88,231.4 E 92,058.1	ELEVATION AND DATUM	GROUND = 6714.19'
DRILLING AGENCY	LANG EXPLORATORY DRILLING	DRILLER	BRYON\MARK\BENJIE
DATE STARTED/DATE FINISHED	6/27/91 TO 6/28/91	DRILLING EQUIPMENT	DRILLTECH DH1
COMPLETION DEPTH	1005'	SAMPLER	CUTTINGS
DRILLING METHOD	REVERSE CIRCULATION AIR ROTARY	DRILL BIT	6-3/8" HAMMER
NO. OF SAMPLES	DIST.	UNDISTURBED	
SIZE AND TYPE OF CASING	2" STEEL	WATER ELEV.	FIRST 505'
COMPL.	24 HRS. 290'	TYPE OF PERFORATION	0.020" STAINLESS STEEL WIRE-WRAP FROM 500 TO 520 FT
LOGGED BY	P. BROOKS/D. ROYBAL	CHECKED BY	SWR/SFR
SIZE AND TYPE OF PACK	#6-12 VALLEY SAND FROM 469 TO 552 FT		
TYPE OF SEAL	BENTONITE FROM 444 TO 469 FT		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Piezometer Data	SAMPLES: Type	SAMPLES: Blows	SAMPLES: Recovery	REMARKS (Drill Rate, Fluid loss, Odor, etc.)
0	LIGHT BROWN TO TAN, CLAYEY SILT TO SILTY CLAY, WITH TRACE TO SOME FINE SAND, AND TRACE SMALL GRAVEL, DRY (ML-CL)								0230 HRS. START DRILLING 8" HOLE TO SET SURFACE CASING
10	LIGHT BROWN TO TAN, FINE TO MEDIUM SILTY SAND, SOME COARSE SAND AND FINE GRAVEL, MOIST TO DAMP (SM) ALLUVIUM								
20	LIGHT BROWN TO GRAY, SILTY CLAY WITH SOME FINE TO MEDIUM SAND, SOME SMALL GRAVEL (CL) VOLCANIC TUFF								HOLE DRILLED USING 6-3/8" HAMMER WITH WATER — 0245 HRS.
									0345
	LIGHT BROWN TO GRAY, FINE TO MEDIUM SAND, SOME CLAY, SOME SMALL GRAVEL TO 15mm, SLIGHTLY CEMENTED (SP)								0410
									EASY DRILLING
70	LIGHT GRAY TO TAN, FINE TO MEDIUM SAND, SILTY, SLIGHTLY CLAYEY, SOME COARSE SAND, SOME SMALL GRAVEL, SLIGHTLY CEMENTED (SM-SP)								0430
80	SAME AS ABOVE BECOMING MORE CEMENTED								0445
	LIGHT GRAY TO TAN, FINE TO MEDIUM CEMENTED TO SLIGHTLY CEMENTED SAND, SILTY, WITH SOME COARSE SAND, TRACE TO SOME SMALL GRAVEL, (SM-SP)								0455
130	SAME AS ABOVE								0505
140									

GRAB AND CHIP SAMPLES @ 10 FT. INTERVALS

PROJECT NO. 9053348N-T3100 SHEET 1 OF 6

Woodward-Clyde Consultants

PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G3

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Penetrometer Data	SAMPLES: Type No.	SAMPLES: Recov. %	SAMPLES: Penetr. Resist. (Blows/6 in.)	REMARKS (Drill Rate, Fluid Loss, Odor, etc.)	
140	LIGHT GRAY TO GRAY, FINE TO MEDIUM CEMENTED TO SLIGHTLY CEMENTED, SAND, SILTY, WITH SOME COARSE SAND AND SMALL GRAVEL (SM-SP)								VERY EASY DRILLING	0505 HRS.
150										
160	LIGHT BROWN TO TAN, FINE TO MEDIUM, SLIGHTLY CEMENTED TO CEMENTED SAND, SILTY, SOME COARSE SAND AND SMALL GRAVEL (SM-SP)									0515
170										
180	SAME AS ABOVE								REPAIR HYD. HOSE ~ 5MIN	0530
190	LIGHT GRAY TO TAN, FINE TO MEDIUM CEMENTED SAND SILTY, SOME COARSE SAND AND SMALL GRAVEL (SM-SP)									
200										0545
210	SAME AS ABOVE								EASY DRILLING	
220										05.
230	GRAY TO DARK GRAY, FINE TO COARSE SLIGHTLY SILTY SAND, SOME SMALL GRAVEL CEMENTED (SM-SP)									
240	SAME AS ABOVE									0605
250										
260	GRAY TO LIGHT GRAY, FINE TO COARSE SLIGHTLY SILTY SAND SOME SMALL GRAVEL, SLIGHTLY CEMENTED TO CEMENTED (SM-SP)								EASY DRILLING	0615
270										
280	SAME AS ABOVE									0630
290	BROWN TO RED BROWN, FINE TO COARSE SILTY SAND WITH TRACE RED SILTY CLAY AND SOME SMALL GRAVEL, CEMENTED (SM)									
300	SAME AS ABOVE									0637
310	GRAY TO LIGHT GRAY FINE TO COARSE SAND SLIGHTLY SILTY, TRACE RED SILTY CLAY, SLIGHTLY CEMENTED (SP)									
320										0650

GRAB AND CHIP SAMPLES @ 10 FT. INTERVALS

PROJECT NO. 9053348N-T3100

SHEET 2 OF 6

Woodward-Clyde Consultants

PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G3

DEPTH (FEET)	DESCRIPTION	REMARKS (Drill Rate, Fluid loss, Odor, etc.)
320	LIGHT GRAY, FINE TO COARSE SAND SLIGHTLY SILTY, SLIGHTLY CEMENTED TO CEMENTED, SOME BROWN SAND (SP)	0650 HRS.
330		
340	SAME AS ABOVE SOME SMALL GRAVEL	0702
350	SAME AS ABOVE	
360	LIGHT GRAY, FINE TO COARSE SAND, SLIGHTLY SILTY, SLIGHTLY CEMENTED TO CEMENTED, OCCASIONAL SMALL GRAVEL	0714
370		
380	BROWN GRAY SHALE, SILTY, SLIGHTLY SANDY, CLAYEY	0730
390	LIGHT BROWN TO TAN LIMESTONE, THIN CLAY LENSES, TRACE IRON STAINS SLIGHTLY FRACTURED	BEDROCK @~375'-385'
400	TAN TO LIGHT BROWN LIMESTONE, WITH THIN GRAY SILTY CLAY LENSES, SOME IRON STAINS, SLIGHTLY FRACTURED TO FRACTURED, SOME CALCITE LENSES	0'
410		
420	SAME AS ABOVE LESS CLAY LENSES	0810
430	LIGHT BROWN TO TAN LIMESTONE WITH THIN CALCITE LENSES, OCCASIONAL GRAY SILTY CLAY LENS, SOME IRON STAINS, SLIGHTLY FRACTURED	
440		0835
450	SAME AS ABOVE	
460	TAN TO LIGHT BROWN LIMESTONE WITH THIN WHITE CALCITE LENS, SOME IRON STAINS, SOME GRAY SILTY CLAY	
470		
480	SAME AS ABOVE	
490	BROWN GRAY TO GRAY SHALEY CLAY, SILTY, SLIGHTLY SANDY TRACE SMALL GRAVEL (CL) ARCTURAS FORMATION	
500		

GRAPHIC LOG: LITHOLOGY; Piezometer Installation; Water Content; Piezometer Data

SAMPLES: Type No.; Blows/6"; Penetrn. Resist. (Heavy/6 in.)

GRAB AND CHIP SAMPLES @ 10 FT. INTERVALS

PROJECT NO. 9053348N-T3100

SHEET 3 OF 6

Woodward-Clyde Consultants PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G3

Depth	DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Piezometer Data	SAMPLES: Type etc.	SAMPLES: Recov. %	SAMPLES: Penetr. Resist. (Blows/6 in.)	REMARKS (Drill Rate, Fluid loss, Odor, etc.)	
	BROWN GRAY TO GRAY, SHALEY CLAY, SILTY SLIGHTLY SANDY (CL)									
	BROWN GRAY LIMESTONE, FRACTURED, SOME SHALE, SANDY, GRAVEL								WATER DETECTED @ ~505' YEILD ~5 GPM	
510	BROWN GRAY, SHALEY CLAY, SILTY, SLIGHTLY SANDY, SOME GRAVEL (CL)									
520										
530	GRAY, SHALEY CLAY TO SHALE, SILTY, SLIGHTLY SANDY BECOMING GRAY GREEN @~535' (CL)									
540	SAME AS ABOVE									1201 HRS.
	SAME AS ABOVE									1245
	SAME AS ABOVE									137[illegible]
600	LIGHT GRAY TO GRAY, SHALEY SANDY CLAY WITH COARSE SAND SIZE FRAGMENTS OF RED JASPER AND LIGHT GREEN CHERT									1400
610	TAN AND LIGHT GREENISH GRAY, SHALEY SANDY CLAY									
620									YIELD ~3 GPM @ 625'	1430
630	BROWN, SHALEY SANDY CLAY WITH TRACE GREENISH GRAY SANDY CLAY AND LIGHT YELLOWISH BROWN LIMESTONE (CL)								YIELD ~3 GPM @ 645'	150[illegible]
	LIGHT BROWN, CLAYEY, FINE SAND WITH TRACE YELLOWISH BROWN LIMESTONE AND COARSE SAND SIZE RED JASPER AND LIGHT GREEN CHERT (SC)									153[illegible]
									1600 HRS. STOPPED FOR INSURANCE REASONS 1720 HRS. TRIP BACK INTO HOLE STARTED AGAIN	190[illegible]
650	LIGHT BROWN TO LIGHT GRAY LIMESTONE									191[illegible]

GRAB AND CHIP SAMPLES @ 10 FT. INTERVALS

Woodward-Clyde Consultants PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G3

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Piezometer Data	SAMPLES: Type No.	SAMPLES: Recov. %	SAMPLES: Penetr. Resist. (Blows/6 in.)	REMARKS (Drill Rate, Fluid loss, Odor, etc.)	
680	LIGHT BROWN TO LIGHT GRAY LIMESTONE									1915 HRS.
	LIGHT REDDISH BROWN, CLAYEY FINE SAND TO CEMENTED FINE SANDSTONE, SOME LIGHT GRAY SANDY LIMESTONE TO SLIGHTLY CEMENTED LIGHT GRAY FINE SANDSTONE							GRAB AND CHIP SAMPLES @ 10 FT. INTERVALS	NO CHANGE IN WATER PRODUCTION	
690										
700										1940
710										
	LIGHT BROWN TO LIGHT GRAY SLIGHTLY CEMENTED FINE SANDSTONE									
720	REDDISH BROWN CLAYEY FINE SAND WITH SOME LIGHT GRAY CLAYEY FINE SAND (SC)									2000
730										
	REDDISH BROWN TO LIGHT GRAY SLIGHTLY CEMENTED FINE SANDSTONE								HARDER DRILLING	
740	LIGHT OLIVE GRAY TO LIGHT YELLOWISH BROWN SANDY LIMESTONE								FRAGMENTS TO 15mm	2025
750										
760										2050
	REDDISH BROWN SLIGHTLY CEMENTED CLAYEY SANDSTONE								YIELD 2-3 GPM @ 765'	
	LIGHT BROWN SLIGHTLY CEMENTED TO CEMENTED FINE SANDSTONE								INCREASE IN FINES	
780	LIGHT OLIVE GRAY LIMESTONE WITH TRACE GRAY LIMESTONE, YELLOWISH BROWN LIMESTONE, WHITE CALCITE AND BROWN CHERT								YIELD ~3 GPM @ 785'	211
790										
800										2145
810										
	LIGHT BROWN SLIGHTLY CEMENTED CLAYEY FINE SANDSTONE								INCREASE IN FINES	
820	LIGHT GRAY CEMENTED FINE SANDSTONE									2215
	LIGHT OLIVE GRAY LIMESTONE WITH TRACE YELLOWISH BROWN AND GRAY LIMESTONE, WHITE CALCITE								YIELD ~5 GPM @ 825'	
830									FRAGMENTS TO 15mm	
840										224
	REDDISH BROWN SLIGHTLY CEMENTED CLAYEY FINE SANDSTONE								YIELD ~6 GPM @ 845'	
850	LIGHT OLIVE GRAY LIMESTONE WITH TRACE GRAY LIMESTONE, WHITE CALCITE AND BROWN CHERT									
860	BROWN SLIGHTLY CEMENTED TO CEMENTED FINE SANDSTONE, SOME BROWN CLAYEY FINE SANDSTONE								INCREASE IN FINES	232

PROJECT NO. 9053348N-T3100 SHEET 5 OF 6

Woodward-Clyde Consultants PROJECT NAME MAGMA-ROBINSON HOLE NO. WCC-G3

DESCRIPTION	GRAPHIC LOG: LITHOLOGY	GRAPHIC LOG: Piezometer Installation	Water Content	Piezometer Data	SAMPLES: Type & No.	SAMPLES: Recov. ft	SAMPLES: Penetr. Resist. (Blows/6 in)	REMARKS (Drill Rate, Fluid loss, Odor, etc.)	
BROWN SLIGHTLY CEMENTED TO CEMENTED FINE SANDSTONE, SOME BROWN CLAYEY FINE SANDSTONE							GRAB AND CHIP SAMPLES @ 10 FT. INTERVALS	YIELD 5 GPM @ 865' FRAGMENTS TO 15mm	2320 HRS.
BROWN CEMENTED FINE SANDSTONE								DRILLING SLOWER FRAGMENTS TO 20mm BUT MOST <10mm	2345
								YIELD ~4 GPM @ 905'	0030 6-28-9
LIGHT OLIVE GRAY CEMENTED FINE SANDSTONE									
LIGHT OLIVE GRAY LIMESTONE WITH TRACE GRAY LIMESTONE, WHITE CALCITE AND BROWN CHERT									0115
SAME AS ABOVE									0150
BROWN CEMENTED FINE TO MEDIUM SANDSTONE									
LIGHT GRAY TO OLIVE, LIMESTONE WITH WHITE CALCITE, SOME CHERT								YIELD ~5 GPM @ 965'	0225
								SLOW DRILLING	
SAME AS ABOVE									0315
BROWN CEMENTED FINE TO MEDIUM SANDSTONE, SOME BROWN CLAY									0350
BOTTOM OF HOLE 1005'. @ 0400 HRS. 6/28/91								YIELD ~5 GPM @ 1005'	

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SOIL BORING COMPLETION LOG

BORING ID	Boring P31
TOTAL DEPTH	75'
DRILLING CO.	Webber Environmental
DRILLER	-----
DATES DRILLED	05/21/97

PROJECT INFORMATION

CLIENT	BHP, Nevada
LOCATION	Robinson Project
MANAGER	Bill Newcomb
LOGGED BY	Bill Newcomb

DEPTH	SOIL TYPE	SOIL DESCRIPTION	SPT	pH	S.C.	NOTES
0		Alluvium 1: road-compacted.	NM	NM	NM	
10		Alluvium 2: light brown material with silt and silty sand and gravels (>1"). sandy layer of residual rhyolite at 30'.	22-22-13	8.6	433	
			12-15-22	8.6	463	
20			20-31-50/6"	8.3	481	MC and GS sample at 20'.
			25-50/5"	8.2	481	
30			41-50/5"	8.2	394	
		Alluvium 3: brown silty sand matrix.	22-50/5"	8.1	387	MC and GS sample at 35'.
40			41-50/6"	8.1	381	
		Mixed Sand: light brown, silty fine to medium sand grading into small gravels.	31-50/3"	7.9	368	MC and GS sample at 45'.
50		Alluvium 4: mixed clast gravel with brown silty clay matrix.	NM 50/5"	8.1	369	
			50/5"	8.1	366	
60			50/5"	7.9	363	MC and GS sample at 60'.
		Sand and gravels: brown to gray, dry sands and gravels. gravels <0.5".	12-50/6"	7.8	390	MC and GS sample at 65'.
70		Alluvium 5: brown alluvium with sandy-silty matrix. hard drilling.	50/5"	8.1	362	MC ang GS sample at 70'.
			50/3"	8.2	386	
80						

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SOIL BORING COMPLETION LOG

BORING ID	Boring P32
TOTAL DEPTH	75'
DRILLING CO.	Webber Environmental
DRILLER	-----
DATES DRILLED	05/21/97

PROJECT INFORMATION

CLIENT	BHP, Nevada
LOCATION	Robinson Project
MANAGER	Bill Newcomb
LOGGED BY	Bill Newcomb

DEPTH	SOIL TYPE	SOIL DESCRIPTION	SPT	pH	S.C.	NOTES
0		Alluvium 2: light brown alluvial gravels with silty sand matrix.	NM	NM	NM	
10			50/6"	8.3	385	
		Alluvium 4: light brown silty sandy clay with alluvial gravels.	12-16-23	8.3	230	MC and GS sample at 15'.
20			20-31-36	8.4	180	
			27-31-50/2"	8.1	383	
30			31-24-27	7.3	390	MC and GS sample at 30'.
		Alluvium 5: light brown alluvial gravels with clayey silt to fine sand matrix. Variable clast size grading to gravel at 45'.	17-50/6"	7.9	223	
40			50/6"	7.9	222	
			50/5"	7.9	234	MC and GS sample at 45'.
50		Alluvium 4: mixed clast gravel with brown silty clay matrix.	25-14-24	8.0	215	
			50/6"	7.9	214	
60		Alluvium 5: reddish-brown clayey silt to clayey fine sand and minor gravel.	17-30-31	7.9	219	MC and GS sample at 60'.
			17-30-50	8.1	218	
70			16-27-32	8.0	211	MC and GS sample at 70'.
			50/6"	7.9	211	MC and GS sample at 75'.
80						

Geomega

SOIL BORING COMPLETION LOG

BORING ID	Boring P33
TOTAL DEPTH	28'
DRILLING CO.	Webber Environmental
DRILLER	-----
DATES DRILLED	05/22/97

PROJECT INFORMATION

CLIENT	BHP, Nevada
LOCATION	Robinson Project
MANAGER	Bill Newcomb
LOGGED BY	Bill Newcomb

DEPTH	SOIL TYPE	SOIL DESCRIPTION	SPT	pH	S.C.	NOTES
0		VOLCANICS: spoon refusal. observed cuttings. gray-brown silty fine sand,residual weathered volcanic rock. clasts of unweathered volcanic rock at 25'.				
5			NM			
10			NM	8.83	250	
15			NM	8.15	256	
20			NM	8.56	227	
25			NM	8.92	242	
30			NM	8.75	250	