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ABSTRACT

In a survey of soils below the Rum Jungle uranium mine tailings dam, parameters measured were pH, moisture content, particle distribution, total Cu, water-extractable Cu, Ca and SO_4 and acid-extractable Ra. The cation profile had a marked discontinuity at the soil/tailings interface. This was attributed to a complex hydrogeology and to the presence of a reduction zone in the soil immediately below the tailings. The tailings acted as an aquaclude to a water table which fluctuated with the monsoonal season. The reduction zone acted as a cation trap, preventing cation transport. The radium concentration dropped to levels acceptable to public health within a few centimetres of the soil/tailings interface.

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COPPER; DAMS; GROUNDWATER; LAND RECLAMATION; NORTHERN TERRITORY; PH VALUE; RADIONUCLIDE MIGRATION; RADIUM; RADIUM 226; REMEDIAL ACTION; RUM JUNGLE; SOILS; TAILINGS;

EDITORIAL NOTE

From 27 April 1987, the Australian Atomic Energy Commission (AAEC) is replaced by Australian Nuclear Science and Technology Organisation (ANSTO). Serial numbers for reports with an issue date after April 1987 have the prefix ANSTO with no change of the symbol (E, M, S or C) or numbering sequence.

CONTENTS

1. INTRODUCTION

The Rum Jungle uranium mine is located in the monsoonal north of the Northern Territory, 64 km south of Darwin. Operations commenced in 1953 and ceased in 1971. A rehabilitation program for the mine site was started in 1982. Part of this program included the removal and burial of 465 000 tonnes of tailings 'contained' in an area known as the Old Tailings Dam. This part of the rehabilitation work was completed by September 1984. Prior to removal, the tailings dam and subsoil were sampled in May 1984 with a view to establishing the amount of material to be removed, providing information on the way the tailings had settled and examining how far soluble material had been transported from the tailings to the subsoil.

2. EXPERIMENTAL

2.1 The Site

There is no official record of the method of disposal of effluent from the Rum Jungle treatment plant and the following paragraphs are based on various reports, letters, site evidence, site inspections made in 1969-70, 1973-74 and 1984, and discussions about disposal methods with plant operators in 1969 when the mine was still operating.

The Old Tailings Dam is shown in **figure 1**. It is approximately rectangular with its longitudinal axis lying east-west. The site occupies approximately 32 hectares and is located immediately north of the treatment plant.

The original area was fairly flat and was drained by a slope of 1 in 100 to the northwest to form a small creek now known as Old Tailings Creek.

The original soil profile was derived from the weathering of a lens of Buldiva Creek Sandstone. The profile would have consisted of an organically rich dark A horizon, a blanched B horizon, in this case an orange to yellow material, and finally the parent red sandstone at depth. Dolomite is found at depth and rises to the surface north, south and west of the area.

A one metre high wall of Buldiva Creek Sandstone was located on the southern boundary of the site and may have been constructed prior to disposal of the tailings to protect the treatment plant. Apart from this wall, there appears to have been no other preparation of the site before the area received the tailings. In 1969 the site contained a large number of standing dead trees and in the 1984 survey the original leaf litter and top soil were found at the tailings/soil interface at most of the sampling sites.

Discharge of tailings at a pH of 1.5-2 and as a 55 per cent slurry commenced in 1954. Site evidence suggests that the slurry was simply discharged into the general area of the dam with no attempt being made to retain the effluent. The slurry would tend to settle out but the supernatant would drain first into Old Tailings Creek and then into the East Branch of the Finniss River. As the area filled up, the solids started to be washed into the creek and river system. Accordingly a perimeter wall was built around the area. The upstream walls were constructed of Buldiva Creek Sandstone, and the downstream and internal walls were built of tailings with a Buldiva Creek Sandstone covering.

With continuing discharge of tailings together with the annual monsoonal rains, the downstream wall was continually breached until all that remained in 1969 was the occasional hillock and fence post. By 1984, even these features were difficult to discern.

A series of internal walls was built towards the eastern end of the dam. It was established that these walls were built on top of existing tailings and were constructed of tailings with a Buldiva Creek Sandstone covering. The walls formed a series of impoundments which were equipped with culverts and overflows. The purpose of the impoundments is unknown. They would have allowed settling of the tailings and discharge of clear supernatant, and permitted recovery of dissolved copper in the supernatant by the cementation process. Site evidence suggests that the walls were mechanically breached at a later date. From 1961, the fresh tailings were directed to the open cuts, first Dyson's and subsequently White's. The Old Tailings Dam site was abandoned to the elements with no control of the run-off from the annual monsoonal rainfall of around 1500 mm which falls between December and April.

The original depth of tailings in 1961 is unknown. **Figure 2** shows the profiles for three transects based on coring and trenching in 1983-84. The average depth is around 1.2-1.5 m with a maximum depth of 3 m at the eastern end and zero at the western end. An erosion rate of 1 cm y^{-1} has been estimated [Davy 1975].

Erosion was a non-uniform process and the drainage tended to channel and cut through the tailings until the original soil surface was exposed. Where sheet erosion occurred, it tended to erode in layers with the surfaces of the layers sealed by a hardened clay cap with an iron oxide flash.

Inspection of the tailings profile in open trenches, showed that the tailings settled into well-defined layers of a coarse material, which will be called a silt, and a fine material with the texture of a plastic clay. In some cases these layers would be up to 200 mm thick but in other areas each layer would only be a few millimetres thick and form a laminate. The clay layers appeared to be thicker towards the western end of the dam. This suggests that differential settling as a function of distance occurred, with discharge predominantly at the eastern end of the dam. A noticeable feature was the almost universal occurrence of a clay layer at the tailings/soil interface. This may have been due to the initial use of a fixed discharge point so that the silt tended to settle out in the vicinity of the discharge point while the clay was transported into the main part of the dam.

There were indications that the clay was relatively impervious and reduced transport of water and hence soluble salts into the subsoil. In 1984, an exploratory trench was dug by the excavating contractor through the central portion of the dam. The trench drained into the creek system. As the trench dried out, a blue and white incrustation developed at the silt layers on the walls of the trench, but was noticeably absent in the clay layers. This indicated that the water could transport laterally through the silt layers but not vertically through the clay layers.

2.2 Sampling

A set of samples was collected by a two-person sampling team during the first two weeks of May 1984. Samples were collected from 15 sites on the tailings dam proper, and at two sites immediately downstream of the dam. The area had been surveyed previously and tied to the Australian Grid. Most of the survey pegs were still in place and it was possible to locate the sampling sites to this survey with reasonable accuracy. The locations of each site are shown in **figure 1**.

The sites were selected on the basis of

(i) providing a reasonably detailed study of the complete area,

(ii) locating the site to the survey pegs,

(iii) collecting samples from undisturbed locations,

(iv) avoiding local dam walls, streams or erosion channels, and

(v) being accessible to a back-hoe where possible.

The excavating contractor had dug the exploratory trench two weeks prior to the arrival of the sampling party. This trench drained into the main drainage channel of the dam and probably accelerated the drainage. Sites 1-3 were located in the sides of this trench. Sites 4-8, 10 and 12-15 were excavated by back-hoe. The water table was penetrated during the excavation of sites 8, 10 and 12-15. The water table was observed to drop at these sites by about 200 mm during the sampling period of two weeks. Sites 9, 11, 16 and 17 were excavated manually with a shovel.

A variety of samples was collected. Prior to sampling, the face of the trench was cleaned, identified and photographed. The tailings were observed to form discrete layers of coarse and fine material. These discrete layers were sampled by trowel as approximately 500 g lots across a 10 mm section. A core was also taken by hammering 350 mm long by 50 mm diameter sections of PVC tubing into the tailings and excavating around the tube to extract it without disturbing the core.

Other discrete trowel samples were taken of both the tailings and the soil at the soil/tailings interface. A limited number of core samples across the tailings/soil interface were also collected by hammering 500 mm long, 100 mm diameter PVC tubes into the material and excavating around the tube to remove the tube without disturbing the core.

Soil samples were collected by trowel at irregular intervals below the tailings/soil interface. The samples were selected on the basis of visible changes in the soil profile and the ultimate depth to which it was possible to sample. Core samples of the soil below the tailings were taken also by hammering 400 mm long,

50 mm diameter steel tubes into the soil and excavating from around the tube to remove the tube without disturbing the core.

2.3 Analysis

All the samples were sent to Sydney for analysis. The soil samples were photographed, air-dried, examined under a microscope and sieved into < 2 mm and > 2 mm fractions. The < 2 mm fractions were sub-sampled by riffling. The sub-sample was oven dried at 110°C for 24 hours and then analysed for copper and radium.

The acid-extractable metals were determined using hot, concentrated acid as the leachant. Acid extraction was preferred to total dissolution, it being assumed that the metals of interest would have moved from the tailings into the soil and would be acid-soluble.

Analysis of the acid-extract for radium was carried out by a radon emanation method using liquid scintillation. In view of the large number of samples and the urgent need for the results, the following simplified procedure was adopted with incomplete in-growth of radon and short counting times (hours).

A 10 g sample of the oven-dried material was leached with 80 mL of concentrated HCl at 100°C for two hours. The residue was filtered cold and the solution made up to 100 mL. A 5 mL aliquot of this solution was adjusted to pH 1-2 with NaOH, made up to 10 mL and purged with N_2 to remove radon. A 10 mL aliquot of scintillant solution (5 g of 2,5,diphenyloxalate in 1 l. of toluene) was added. The vial was sealed, allowed to stand for 14 days and then counted for 50 minutes with a Packard liquid scintillation counter.

The limit of detection for the procedure used was 0.037 Bq g^{-1} (1 pCi g^{-1}). The dissolved copper concentration was determined by atomic absorption spectroscopy (AAS) and the dissolved SO_4 was determined by anion-exchange chromatography.

3. RESULTS

Appendix A is a record of the complete tailings and soil profiles and sampling locations within the profiles. **Appendix B** is a record of the visual and microscopic observations of the sub-soil samples during the various stages of sampling and sample preparation.

The results of analysis of each sample for pH, moisture content, particle distribution, total copper, water-extractable Cu, Ca and SO_4, and acid-extractable Ra, grouped for each profile as a function of depth, are listed in **table 1**. **Table 2** lists the pH, Cu, SO_4 and Ra concentrations in the water samples.

The ^{226}Ra profiles for the first 500 mm below the interface at each site are shown in **figure 3** and the copper profiles in **figure 4**. The diagrams are log-linear with the concentration on a log scale and the depth on a linear scale. The diagrams are arranged in schematic order to represent the position in the tailings dam.

The sulphate profiles are shown in **figure 5**. These diagrams are linear and some of the sites have different scales to accommodate the range of values. The diagrams are in the same schematic arrangement employed for the radium results.

4. DISCUSSION

4.1 Ground Water

The ground water regime plays an important role in the transport of materials in the soil below the tailings dam. The ground water was intersected in a number of the pits. The level in the pits was observed to drop during the two weeks of the survey. The interpreted profile for the water table at the time of sampling is included in **figure 2**.

In 1973, a series of six shallow 100 mm diameter bores was drilled across the western end of the tailings dam, the positions are marked in **figure 1** as bores 2, 3, 4 and 5 in a north-easterly direction. Bore 6 could not be found on this field trip. Bore 1 was located near the eastern wall of the dam. Davy [1975, chap. 6] reported the standing water levels for these bores for the 1973-74 wet season; the results are shown in **figure 6** together with the standing water levels in the neighbouring open-cuts.

The observations show that the ground water table fluctuates in sympathy with the seasons. At the end of the dry season (November) it drops to 58 m (Australian height datum (AHD)) irrespective of ground

surface. At the peak of the wet season (March) the ground water table rises to the surface and for some bores has a positive pressure within the bore. The maximum rise in height was 4.5 m at bore 6 which was on the edge of the tailings area. The maximum pressure was 1 m of water at bore 3.

The positive pressure is interpreted as being caused by the tailings forming an aquaclude upgradient of the bores. The inability of the ground water underneath the tailings to rise to the surface would have generated an approximately westerly ground water flow at the soil/tailings interface and had the effect of washing dissolved material off the interface.

The source of the ground water may be interpreted from the results of the 1973-74 wet season survey. These bores were sampled throughout that wet season and chemical analysis revealed a characteristic heavy metal fingerprint. The manganese levels are listed in **table 3** together with the results for White's open cut. The results indicate that during the dry season the ground water underneath the tailings has a substantial component derived from White's open cut. With the onset of the wet season, the ground water originating from White's open cut is either overlain or pushed aside by an unpolluted source. The origin of this unpolluted source is unknown. This flow pattern is maintained throughout the wet season and into the dry season. Towards the end of the dry season and with a lowering of the water table, the bores start to pick up the chemical fingerprint of White's open cut again.

This qualitative picture was supported with the analysis of the water samples collected in May 1984. These samples represented samples taken at the end of a wet season, **table 2**. Bores 2-5 had a high pH and low copper and radium concentrations compared with the waters sampled from the trenches or from Old Tailings Creek. This indicated that these bore waters were from a relatively unpolluted source.

The waters from the trenches had a low pH and high copper and radium concentrations. There was very poor correlation between the three parameters measured, suggesting that the concentrations of the three species were independent of each other and that the solutions represented washing of the local volume from which they were sampled. There were no correlations for the sulphate concentration either with location or with other species present.

4.2 The Tailings

An earlier survey of the Rum Jungle site was restricted to an investigation of the tailings material. The results are listed in **table 4**. Although the sampling sites were not tied to an identifiable grid and, therefore, cannot be directly compared with the current results, these earlier results do provide information on the distribution of heavy metals in the tailings. Inspection of the radium results indicates that the radium concentration is always greater than 3.7 Bq g^{-1} except in some bottom samples. It was assumed that for those samples in which the radium concentration was less than 3.7 Bq g^{-1} the material was more likely to be contaminated soil than tailings and these results were not included in the following calculations.

The average metal concentrations in the tailings were

Cu	6	mg g^{-1}
Pb	1	mg g^{-1}
Zn	0.05	mg g^{-1}
U	0.47	mg g^{-1}
Ra	26	Bq g^{-1}

There was a wide fluctuation in the values with no correlation between the various metal profiles (**table 4**). Comparisons of the average Cu and Ra values found in the tailings and the values found at the tailings/soil interface show that there is a marked discontinuity at the interface (**tables 1** and **4**, **figures 3** and **4**). The metal concentrations dropped by an order of magnitude across the interface and by a further order of magnitude within the first 5 cm of the soil. Background levels of radium in the vicinity of uranium prospects which do not show surface expression are around 0.03 Bq g^{-1}.

4.3 The Subsoil

4.3.1 Radium in the subsoil

A feature of the radium profiles was the very rapid drop in radium concentration with depth. This was particularly marked towards the eastern end of the dam for sites 1, 2 and 4-7 where the radium level rapidly dropped to the limiting value for detection of 0.03 Bq g^{-1}. These sites were in the unsaturated zone and probably remained unsaturated throughout the year.

In contrast, the radium profiles in sites 8 and 10-15 either did not drop as sharply as observed in the eastern sites and/or did not reach the limiting value for detection. The water table was penetrated at these sites and the level was observed to drop by about 200 mm during the week of sampling. Site 9 was unusual in that it was immediately downstream of a retaining wall and was not truly representative of the tailings area.

4.3.2 Copper in the subsoil

The copper gradients in the subsoil (**figure 4**) are similar to the radium gradients. This indicates that the dispersing mechanism for the copper is similar to that for the radium.

4.3.3 Sulphate in the subsoil

In contrast, the sulphate gradients in the subsoil (**figure 5**) are different to those for the metals. At most sites the sulphate concentration is independent of depth. At the eastern end of the dam the sulphate concentration is around 1 mg g^{-1} (sites 1, 4 and 5) and drops to around 0.2 mg g^{-1} towards the western end of the dam so there is a sulphate concentration gradient down the hydraulic gradient of the subsoil. Thus the sulphate appears to be moving independently of the cations.

The results indicate that solubilised cations are held either by the tailings or the immediate subsoil at the interface while solubilised sulphate is allowed to transport through the tailings and subsoil.

4.3.4 Radium transport

The general picture of radium transport is blurred to some extent by tailings penetration of the subsoil. However the general qualitative indications are that radium is not transported to any significant extent into the unsaturated subsoil, and the saturated transport is very small.

Of particular importance is the effect of the tailings on the water quality of the river system into which they drain. Sampling of the East Finniss river system has been carried out in a sporadic manner over the past 25 years. The radium analyses for the main sampling sites are correlated in **table 5**. The position of the sampling sites is shown in the sketch map of the area (**figure 7**).

Site TAW 12 is at a road bridge 1 km above the junction of Old Tailings Creek with the East Finniss River. Site GS 815097 is a stream gauging station 5 km downstream of the junction and site X17 is at a railway bridge 2.5 km downstream of the junction. No major streams enter the East Finniss River between site X17 and GS 815097. Site TAW 27 is located on Old Tailings Creek just upstream of the junction with the East Finniss River. Site OT1 is a stream gauging station installed in 1984 at the base of the Old Tailings Dam. Site OT2 was a sample taken from the stream running alongside the tailings area.

In the early and mid-sixties, it was mining practice to store acidic plant effluent produced during the dry season in a holding dam upstream of TAW 12 and release the effluent during the wet season. Thus the radium values reported for site X17 during this period are a complex sum of various radium sources. This practice ceased in 1969 and the treatment plant was closed in 1971. By 1973 the radium level in the East Finniss River upstream of the junction with Old Tailings Creek was around 0.06 Bq L^{-1} compared with around 0.02 Bq L^{-1} upstream of the mine site and 0.3 Bq L^{-1} at GS 815097 downstream of the mine site. The high radium values in Old Tailings Creek at TAW 27 indicate that by 1973, around 90 per cent of the radium originated from Old Tailings Creek. Stream flow in the area is very susceptible to local weather and would account for the occasional wide fluctuation about a fairly narrow mean value.

The Old Tailings Dam contained an estimated 640 000 tonnes of tailings at the end of use in 1961. During rehabilitation in 1984, 465 000 tonnes of tailings was transferred to Dyson's open cut together with 44 000 tonnes of subsoil. Thus approximately 175 000 tonnes or 27 per cent of the original material has been lost during the period 1961 to 1984, corresponding to an erosion rate of 7600 tonnes per year or 1.2 cm y^{-1}. With an average radium concentration of 26 Bq g^{-1}, the annual radium loss was 200 GBq.

4.3.5 The tailings/soil interface

The cation profiles were exceptionally sharp and indicative of minimal transport from the tailings into the subsoil. Although the hydrogeology of the system may be a significant contributor to the nature of the cation profiles, it is considered that there is a significant chemical component as well. Pyrite was visually observed in the immediate subsoil below the tailings in a number of the trenches, but was not observed in the tailings material. Organic matter was also found at the tailings interface. The production of pyrite in the soils must be attributed to a strongly reducing and anaerobic environment, possibly catalysed by the presence of reducing bacteria such as *sulphurlobus*. The majority of metals, including all the heavy metals, will be reduced to insoluble metal sulphides under these strongly reducing conditions. Hence this reducing

environment is acting as a cation trap, preventing any transport into the subsoil. In this particular case the effect is quite marked and indicates that the presence of reducing environments should be included in computer programs designed to model cation transport from tailings dams.

4.4 Clean-up Standards

Rehabilitation of a tailings area should take into account that uranium mill tailings present a substantial hazard to the general public for several hundred thousand years and that the hazard will continue long after present regulating/monitoring institutions cease. Therefore, all efforts should be made to ensure that the rehabilitation is correct the first time and that repeat programs are unnecessary.

For the purpose of setting clean-up standards, the United States Environmental Protection Agency [USEPA 1983] applied the linear hypothesis, namely that the health risk is directly proportional to the radiation dose, that there is no dose threshold and that the dose-risk relationship may be determined directly from the observations made at higher doses. It was considered by USEPA that although the major radiation hazard from tailings is from alpha radiation, the application of the linear hypothesis is unlikely to lead to overestimates of risk, and may lead to underestimates.

Uranium mill tailings can affect humans through four principal pathways:

- inhalation of radon-222,
- gamma radiation,
- inhalation of aerosol particulate, or
- waterborne transport.

Radon-222 is the decay product of radium-226. It is a radiochemical inert gas with a half-life of 3.8 days and decays by alpha emission. Breathing radon-222 exposes the lung to alpha radiation both from radon-222 decay, and from the short half-life alpha decay products, polonium-218, polonium-214, polonium-210 and the beta decay product lead-210. These products will be trapped in the lung as particulate. Gamma radiation arises from lead-214, bismuth-214 and thallium-210. Aerosol particulate allows transport of the alpha emitters thorium-230 and radium-226, and waterborne transport of radium-226.

Taking these four pathways into account, a clean-up level at Rum Jungle following removal of the tailings should be such as to reduce the risk to public health from these four pathways. The USEPA recommended a radon-222 emission standard of 0.74 Bq m^{-2} s^{-1} (20 pCi m^{-2} s^{-1}). It should be noted that the radon emission rate in the vicinity of the unmined Koongarra uranium ore body, NT was usually above this level, sometimes by an order of magnitude [Davy *et al.* 1978]. The recommended radium-226 level in top soils was 0.185 Bq g^{-1} (5 pCi g^{-1}) averaged over the top 15 cm of soil; for subsoils the recommended level was 0.55 Bq g^{-1} (15 pCi g^{-1}) averaged over any 15 cm layer.

The field results indicate that at most sites the radium level meets the USEPA criteria for radium levels in soils within the first 15 cm. Removal of the tailings, followed by a surface scrape and top dressing with a radiation-clean topsoil will reduce the radiation hazard to levels acceptable for public health.

5. CONCLUSIONS

A field trip to sample the subsoil below the Rum Jungle uranium mine tailings was undertaken successfully. The soils were sampled by trenching and coring, and ground waters were sampled when the water table was penetrated.

A number of soil parameters were measured including Cu, Ra and SO_4 concentrations. The cation profiles showed a marked discontinuity at the tailings/soil interface with the metal concentration dropping very rapidly with depth to detection limit levels.

The discontinuity was attributed to two sources; the hydrogeology and a reduction zone immediately below the tailings.

The hydrogeology was complex. The tailings were considered to act as an aquaclude to rising ground waters while the ground water source varied with season. In the dry season, the water table dropped and the ground water was sourced from White's open cut. With the onset of the wet season the White's open cut-sourced water was replaced by an uncontaminated source and the water table would rise up to the interface where it would be contained under a hydrostatic head by the low permeability tailings.

The reduction zone was located at the soil/tailings interface and was identified by the production of finely disseminated pyrite in the soil zone. This reduction zone acted as an efficient heavy metal chemical trap, preventing cation transport into the subsoil.

It was concluded that the reduction zone played an important role in the prevention of cation transport and should be included in computer programs designed to model the transport of cations away from tailings dams.

The marked discontinuity in the radium profile at the soil/tailings interface indicated that removal of the tailings, scraping the soil/tailings surface and dressing the resulting surface with clean top soil would reduce the radium concentration to levels acceptable for public health.

6. REFERENCES

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TABLE 1
ANALYTICAL RESULTS FOR SUBSOILS

Sample Number	Depth Below Interface (mm)	pH	Moisture (%)	Fraction (% > 2 mm)	Total Cu ($\mu g\ g^{-1}$)	Extractable			
						Cu ($\mu g\ g^{-1}$)	Ca ($\mu g\ g^{-1}$)	SO_4 ($\mu g\ g^{-1}$)	Ra ($Bq\ g^{-1}$)
1.7	0	4.14	-	0.26	1560	244	77	787	0.56
1.8	60	4.16	9.78	0.87	1020	248	89	825	0.063
1.9	160	4.31	10.63	1.27	1700	283	129	978	<0.037
1.10	300	4.16	11.13	1.05	580	169	167	964	<0.037
2.5	0	4.83	-	0.40	3280	17	68	546	0.45
2.6	90	4.83	11.44	2.03	1130	27	45	926	0.058
2.7	360	4.93	16.51	7.49	600	14	38	573	<0.037
2.8	440	4.97	17.97	15.06	260	1.5	34	505	0.081
2.9	710	4.75	19.55	10.10	110	1.2	38	515	<0.037
2.10	840	4.65	19.31	35.50	300	11.5	42	541	<0.037
3.7	0	4.63	-	1.31	670	16	70	566	1.2
3.8	280	4.94	19.28	2.06	270	4.4	53	817	0.087
3.9	530	5.18	17.33	5.13	20	<0.3	42	314	<0.037
3.10	700	5.08	24.14	5.93	20	<0.3	42	325	<0.037
4.7	0	5.60	-	4.06	1620	0.7	144	1089	4.0
4.8	60	6.28	11.67	1.05	730	1.7	124	1330	0.71
4.9	140	6.40	11.62	4.24	370	0.5	44	432	0.061
4.10	270	6.11	13.46	5.06	190	<0.3	129	764	<0.037
4.11	410	5.84	14.98	7.45	10	<0.3	104	739	<0.037
4.12	510	6.27	16.78	10.38	20	<0.3	104	696	<0.037
4.13	640	6.11	15.79	14.40	10	<0.3	80	469	0.037
4.14	870	5.94	12.59	58.42	20	<0.3	57	388	0.053
5.9	0	5.03	-	1.78	1250	<0.3	244	1662	2.0
5.10	40	5.01	9.38	2.62	30	<0.3	87	1168	0.36
5.11	170	5.35	9.41	4.78	10	<0.3	184	1137	0.062
5.12	250	6.29	12.22	5.25	20	<0.3	202	1022	0.058
5.13	400	5.42	15.51	13.92	30	<0.3	271	1987	0.056
5.14	500	4.97	15.56	19.74	20	<0.3	306	2210	0.038
5.15	700	5.60	15.61	39.58	20	<0.3	342	2621	<0.037
6.8	0	5.12	-	0.63	420	1.77	325	1368	3.7
6.9	40	5.37	10.20	1.17	10	<0.3	134	1173	0.23
6.10	140	5.96	9.72	1.24	10	<0.3	79	575	0.13
6.11	240	6.14	10.17	1.37	10	<0.3	59	354	<0.037
6.12	390	5.78	11.71	3.47	10	<0.3	82	563	<0.037
6.13	720	5.45	14.37	5.46	20	<0.3	25	200	0.054
6.14	870	5.51	16.88	8.00	20	<0.3	19	101	<0.037

(Continued)

TABLE 1 (cont'd)

Sample Number	Depth Below Interface (mm)	pH	Moisture (%)	Fraction (% > 2 mm)	Total Cu ($\mu g\ g^{-1}$)	Extractable			
						Cu ($\mu g\ g^{-1}$)	Ca ($\mu g\ g^{-1}$)	SO_4 ($\mu g\ g^{-1}$)	Ra ($Bq\ g^{-1}$)
7.5	0	4.27	-	4.18	730	39	27	214	0.18
7.6	40	4.26	6.25	6.05	220	19	20	152	<0.037
7.7	280	4.35	7.49	5.47	90	6.8	18	148	<0.037
7.8	490	5.94	14.92	29.13	20	<0.3	18	123	<0.037
7.9	660	5.57	15.54	44.64	20	<0.3	22	148	0.042
7.10	840	5.66	17.09	23.72	20	<0.3	22	167	<0.037
8.8	0	4.20	14.51	0.42	660	18	45	401	4.2
8.9	50	4.17	15.64	1.95	320	18	33	328	1.7
8.10	80	4.06	15.23	8.23	170	12	28	264	0.60
8.11	160	4.06	14.78	7.29	60	4	24	226	0.20
8.12	300	4.17	15.54	11.40	30	0.4	38	298	0.15
8.13	400	4.84	17.09	22.92	20	<0.3	48	243	0.12
9.4	0	5.59	-	4.40	1280	2.3	57	351	1.8
9.5	30	5.88	12.66	6.22	470	1.4	23	195	0.072
9.6	140	5.63	12.58	7.08	220	1.4	34	205	<0.037
9.7	280	5.10	13.24	14.00	140	<0.3	34	184	<0.037
9.8	480	5.60	17.50	21.82	140	<0.3	40	292	<0.037
10.10	0	5.11	-	32.87	830	1.5	80	668	2.3
10.11	50	4.86	13.91	26.19	400	3.9	62	670	0.46
10.12	150	5.22	12.56	65.10	310	2.1	63	669	0.39
10.13	300	6.24	14.56	73.76	280	<0.3	40	523	0.44
11.4	0	3.96	-	1.78	580	15	84	491	10.0
11.5	30	3.86	17.44	0.62	270	3	42	296	1.5
11.6	70	3.66	15.78	0.73	70	1	56	279	0.19
11.7	140	3.59	14.70	3.96	50	3	58	269	0.10
11.8	240	3.95	14.27	5.40	30	1	47	287	0.10
11.9	340	3.95	14.30	2.25	20	0.7	44	277	0.14
11.10	440	3.97	15.64	5.47	50	3	55	323	0.16
11.11	740	3.88	14.88	2.52	40	3	53	258	0.074
12.8	0	4.23	-	2.47	180	3	60	867	2.0
12.9	50	4.33	15.25	6.16	80	0.7	28	428	0.92
12.10	130	3.86	17.13	2.21	60	2	29	374	0.12
12.11	170	3.73	16.10	5.44	50	4	18	265	<0.037
12.12	330	3.43	15.05	22.72	15	8	25	331	0.065

(Continued)

TABLE 1 (cont'd)

Sample Number	Depth Below Interface (mm)	pH	Moisture (%)	Fraction (% > 2 mm)	Total Cu ($\mu g\ g^{-1}$)	Extractable			
						Cu ($\mu g\ g^{-1}$)	Ca ($\mu g\ g^{-1}$)	SO_4 ($\mu g\ g^{-1}$)	Ra ($Bq\ g^{-1}$)
13.5	0	4.35	-	6.05	1460	11	48	668	2.9
13.6	50	4.50	14.56	7.38	760	3	34	527	0.76
13.7	120	4.40	14.48	13.05	350	1	36	522	0.44
13.8	240	4.22	17.86	16.88	180	0.9	43	577	0.19
13.9	500	4.02	16.80	24.19	300	8	44	602	0.16
13.10	630	4.03	14.64	71.60	230	7	44	634	0.11
13.11	800	4.00	11.58	85.93	260	5	49	587	0.15
14.7	0	4.30	-	2.71	230	5	449	4397	0.91
14.8	50	4.82	13.67	3.72	310	2	207	1721	0.048
14.9	140	3.16	13.54	12.88	110	1	91	657	<0.037
14.10	180	5.41	16.10	11.91	120	<0.3	67	584	<0.037
14.11	280	4.32	17.71	14.34	100	0.4	43	251	<0.037
14.12	410	5.43	16.78	24.03	70	<0.3	27	209	<0.037
14.13	570	5.13	19.11	44.88	50	<0.3	41	335	<0.037
15.4	0	4.33	-	0.55	480	5	61	372	1.0
15.5	20	4.44	14.39	3.15	100	0.3	31	219	<0.037
15.6	120	2.77	13.22	6.67	90	1	82	237	<0.037
15.7	220	4.38	15.69	9.75	80	<0.3	77	420	<0.037
15.8	280	4.62	17.28	6.41	60	0.3	82	473	0.056
15.9	420	5.37	16.63	19.91	10	<0.3	78	399	0.037
16.1	0	4.28	0.67	9.21	850	58	55	420	1.9
16.2	60	4.61	7.15	3.68	1140	39	20	301	0.30
16.3	100	4.46	9.34	4.54	960	32	21	329	0.20
16.4	200	4.35	11.62	8.81	940	41	43	469	0.14
16.5	300	4.49	11.80	12.79	990	34	67	658	0.10
16.6	400	4.52	12.13	22.38	950	20	84	741	0.16
16.7	470	4.64	11.57	12.52	640	9	91	696	0.072
17.1	0	6.97	3.52	11.08	670	0.4	42	337	-
17.2	60	7.28	9.81	10.12	350	<0.3	51	441	-
17.3	130	7.25	8.98	23.84	390	0.3	44	356	0.20
17.4	200	7.33	6.19	58.17	390	0.3	40	325	0.13
17.5	270	7.65	8.90	17.82	119	<0.3	40	320	0.084
17.6	350	7.83	10.58	18.90	330	0.3	32	239	0.042
17.7	450	7.90	8.78	46.76	130	<0.3	33	373	-

TABLE 2
WATER ANALYSES

Sample	pH	Cu (mg L^{-1})	SO_4 (mg L^{-1})	Ra (Bq L^{-1})
Bore 2	5.87	2.61	971	0.2
Bore 3	7.34	<0.3	268	0.03
Bore 4	7.25	0.8	716	0.07
Bore 5	7.35	<0.3	408	0.02
Site 8	4.06	125	938	0.94
Site 9	5.66	1.9	875	0.77
Site 10	4.94	7.5	496	5.70
Site 11	4.11	25	771	0.85
Site 12	2.83	39	887	0.74
Site 13	4.11	4.6	500	2.4
Site 14	4.15	24	1242	1.8
Site 15	6.07	9	703	0.55
OTC 1	6.67	13	343	0.15
OTC 2	5.67	0.4	28	0.10

OTC 1 = Old Tailings Creek gauging station
OTC 2 = Old Tailings Creek near Site 11

TABLE 3
Mn CONCENTRATIONS IN GROUND WATERS

Date	Bore					
	6	2	3	4	5	1
	(mg L^{-1})					
26.10.73	3	30	75	18	1.5	
18.12.73				33		
22.3.74						121.9
30.4.74	22	0.2	<0.1	<0.1	<0.1	
7.5.74	18	<0.2	<0.1	<0.1	<0.1	
14.5.74	18	<0.1	<0.1	<0.1	<0.1	
21.5.74	16	<0.1	<0.1	<0.1	0.2	
28.5.74	16	0.2	<0.1	<0.1	<0.1	
4.6.74	14	<0.1	<0.1	0.6	0.3	
25.6.74	11	0.6	0.5	<0.1	0.1	
16.7.74	10	2.3	0.3	0.1	0.1	
24.3.74	White's open cut			220 mg L^{-1}		

TABLE 4
COLLATED DRILL HOLE DATA
TAILINGS AREA 1978 (samples collected 1970)

Sample No.	Hole	Depth*	pH	Cu (ppm)	Pb (ppm)	Zn (ppm)	U (ppm)	^{226}Ra ($pCi\ g^{-1}$)
2.1.1	1	0-6"	3.7	2,110	1095	40	60	250
2.1.2		4'	4.4	19,500	421	30	440	726
2.1.3		6'	4.65	7,980	780	56	740	1,478
2.2.1	2	0-6"	3.7	8040	376	28	290	601
2.2.2		5'	3.9	3,510	590	33	380	642
2.2.3		8'	5.1	60	10	5	14	18
2.3.1	3	Surface	3.75	2,300	575	31	140	605
2.3.2		6"		8,560	443	40	720	1.196
2.3.3		1'		15,000	3,070	39	680	839
2.3.4		20"	4.45	8,500	940	39	780	771
2.3.5		2'		3,410	26	16	240	57
2.3.6		3'	4.5	1,380	10	6	40	19
2.4.1	4	Surface		2,740	860	25	290	215
2.4.2		6"	4.3	1,520	850	61	310	1,078
2.4.3		6"-1'		4,680	645	27	660	1,442
2.4.4		18"		9,800	800	50	1,200	1,590
2.4.5		30"	5.8	4,850	710	78	1,100	2,143
2.4.6		3'		2,210	735	66	1,350	1,981
2.4.7		3'6"		450	52	9	80	74
2.4.8		4'6"	5.8	60	10	10	46	17
2.5.1	5	Surface		1,850	280	25	250	394
2.5.2		6"	4.3	1,720	430	29	210	528
2.5.3		1'		1,900	575	27	760	827
2.5.4		18"		3,660	585	26	740	754
2.5.5		2'		12,900	338	29	640	554
2.5.6		3'	4.6	8,150	404	36	1,250	552
2.5.7		3'9"		6,150	421	40	580	613
2.5.8		4'6"		6,450	348	37	540	693
2.5.9		5'		5,300	379	38	560	706
2.5.10		5'6"		5,350	401	40	600	627
2.5.11		5'9"	3.7	780	128	14	155	282

* For historical reasons imperial units have been retained.

(Continued)

TABLE 4 (cont'd)

Sample No.	Hole	Depth*	pH	Cu (ppm)	Pb (ppm)	Zn (ppm)	U (ppm)	^{226}Ra ($pCi\ g^{-1}$)
2.6.1	6	Surface		4,260	600	32	500	552
2.6.2		0-6"	4.1	2,930	940	40	350	1,364
2.6.3		1'		1,170	1,195	46	290	1,560
2.6.4		18"		4,220	900	38	900	2,325
2.6.5		2'6"	6.45	3,820	98	37	740	1,362
2.6.6		3'6"		3,940	820	41	960	2,189
2.6.7		4'6"		3,680	600	31	820	1,455
2.6.8		5'		4,340	840	45	840	1,631
2.6.9		5'6"	6.65	385	80	11	44	51
2.7.1	7	Surface		4,100	7,000	40	155	216
2.7.2		0-6"	3.95	1,940	2,590	28	110	822
2.7.3		1'		1,430	1,320	31	160	856
2.7.4		18"	3.8	1,120	433	28	105	415
2.7.5		2'6"		2,330	1,045	40	440	1,457
2.7.6		3'		5,450	1,185	29	740	1,344
2.7.7		3'6"	4.4	510	35	8	85	40
2.8.1	8	Surface		10,350	530	46	420	253
2.8.2		6"	3.9	2,390	780	29	160	512
2.8.3		1'		1,210	600	27	185	723
2.8.4		18"		2,820	860	26	400	733
2.8.5		2'		7,800	470	30	420	668
2.8.6		2'6"	7.0	12,150	400	34	520	540
2.8.7		3'		2,690	330	22	270	685
2.8.8		3'6"		215	30	5	22	35
2.8.9		4'		35	35	6	10	10
2.8.10		5'	5.5	45	25	8	10	13
2.9.1	9	Surface		5,900	850	34	300	271
2.9.2		0-6"	3.7	1,340	1,150	26	130	476
2.9.3		1'		880	740	22	115	540
2.9.4		18"		8,650	620	27	460	597
2.9.5		2'		16,200	350	30	470	518
2.9.6		2'6"		10,750	590	37	520	523
2.9.7		3'	4.4	8,650	380	30	410	570
2.9.8		3'6"		8,500	500	39	330	301
2.9.9		4'		7,800	430	29	400	635
2.9.10		4'6"		4,560	470	34	800	1,042
2.9.11		5'		340	40	5	28	33
2.9.12		5'6"	6.1	150	30	4	24	14

(Continued)

TABLE 4 (cont'd)

Sample No.	Hole	Depth*	pH	Cu (ppm)	Pb (ppm)	Zn (ppm)	U (ppm)	^{226}Ra ($pCi\ g^{-1}$)
2.10.1	10	Surface		26,550	840	170	700	267
2.10.2		0-6"	3.3	4,120	3,210	39	170	399
2.10.3		1'		5,150	990	51	300	365
2.10.4		18"		4,510	760	32	195	572
2.10.5		2'		5,600	620	24	520	659
2.10.6		2'6"	4.3	6,000	510	26	520	201
2.10.7		3'		12,450	370	32	760	532
2.10.8		3'6"		8,450	410	42	1,150	519
2.10.9		4'		12,450	450	31	1,000	661
2.10.10		4'6"	4.1	1,210	160	8	200	51
2.11.1	11	Surface		29,050	980	200	310	145
2.11.2		0-6"	4.05	2,240	1,890	82	110	107
2.11.3		1'		2,170	3,310	80	95	248
2.11.4		18"		2,320	1,760	60	140	508
2.11.5		2'		16,000	1,300	138	410	316
2.11.6		2'6"	4.45	10,750	1,260	86	320	282
2.11.7		3'		7,150	1,780	130	270	279
2.11.8		3'6"		5,150	890	44	230	360
2.11.9		4'		2,560	850	33	720	963
2.11.10		4'6"		2,930	940	40	660	1,446
2.11.11		4'9"		1,700	220	13	540	126
2.11.12		5'	4.5	550	40	6	115	22
2.12.1	12	Surface		18,600	930	188	390	172
2.12.2		0-6"	3.85	4,060	1,350	82	135	275
2.12.3		1'		3,470	1,600	85	110	238
2.12.4		18"		2,140	2,390	74	85	221
2.12.5		2'		4,770	2,040	65	125	326
2.12.6		2'6"	4.3	6,000	1,110	68	210	239
2.12.7		3'		8,350	1,130	60	290	221
2.12.8		3'6"		7,000	1,350	81	210	295
2.12.9		4'		2,910	870	48	920	423
2.12.10		5'	5.2	2,910	210	29	140	129
Drainage from end of Tailings Dump								66
Dump Drainage 0-9"								21
Dump Drainage Bank								32
East Finniss River Bed								18

TABLE 5
Ra CONCENTRATIONS IN EAST FINNISS RIVER AND TRIBUTARIES (Bq L^{-1})

Date	East Finniss River			Old Tailings Creek		
	TAW 12	GS 815097	X17	TAW 27	G.S.	Near Site 11
4.7.62			8.3			
10.5.63			0.81			
5.9.63			0.89			
3.2.64			0.63			
13.2.64			13.0			
20.8.64			0.93			
18.12.64			0.44			
5.3.65			15.0			
19.10.73	0.005					
26.10.73						
28.10.73			0.22			
7.11.73		0.27				
8.11.73		0.20				
9.11.73		0.32				
10.11.73		0.27				
5.2.74	0.023			0.091		
12.2.74	0.094			0.44		
19.2.74	0.027			0.72		
30.4.74	0.11			0.23		
22.12.80		0.29				
30.12.80		0.040				
9.1.81		0.040				
19.1.81		0.040				
28.1.81		0.25				
10.12.82		0.41				
16.12.82		0.64				
1.1.83		0.28				
14.1.83		0.47				
25.1.83		0.43				
1.2.83		0.59				
7.2.83		0.27				
11.2.83		0.29				
19.2.83		0.38				
22.2.83		0.61				
25.2.83		0.23				
15.3.83		7.4				
21.3.83		0.11				
28.3.83		0.10				
1.4.83		0.11				
18.11.83		0.29				
21.11.83		0.34				
24.11.83		<0.01				
25.11.83		0.26				
8.1.84		0.42				
9.1.84		0.35				
10.1.84		0.37				
11.1.84		0.34				
12.1.84		0.35				
13.1.84		0.36				
15.1.84		0.25				
16.1.84		0.22				
7.5.84					0.15	0.10

Average value in East Finniss River above pollution line = 0.018 Bq L^{-1}

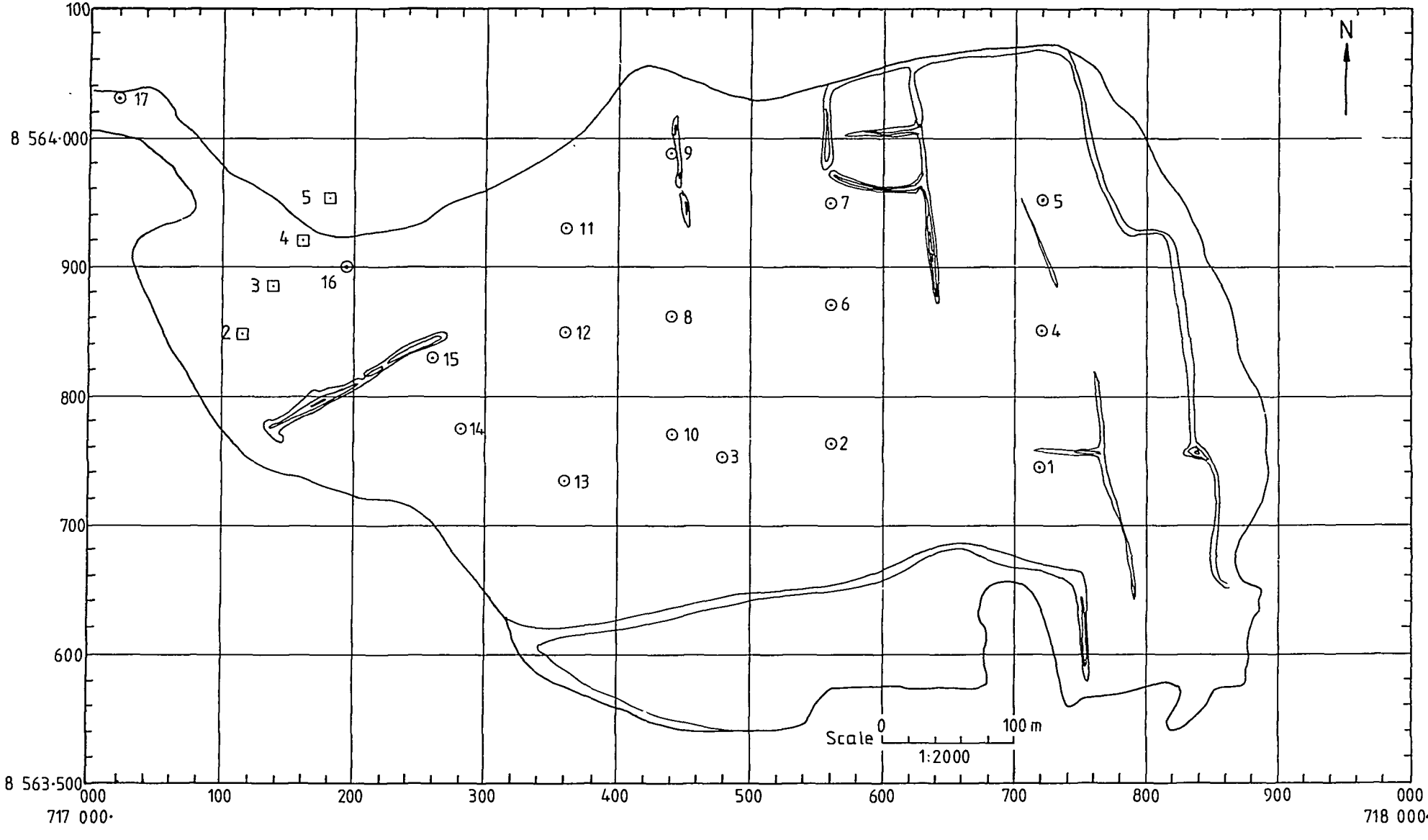


Figure 1 The Rum Jungle Tailings Dam

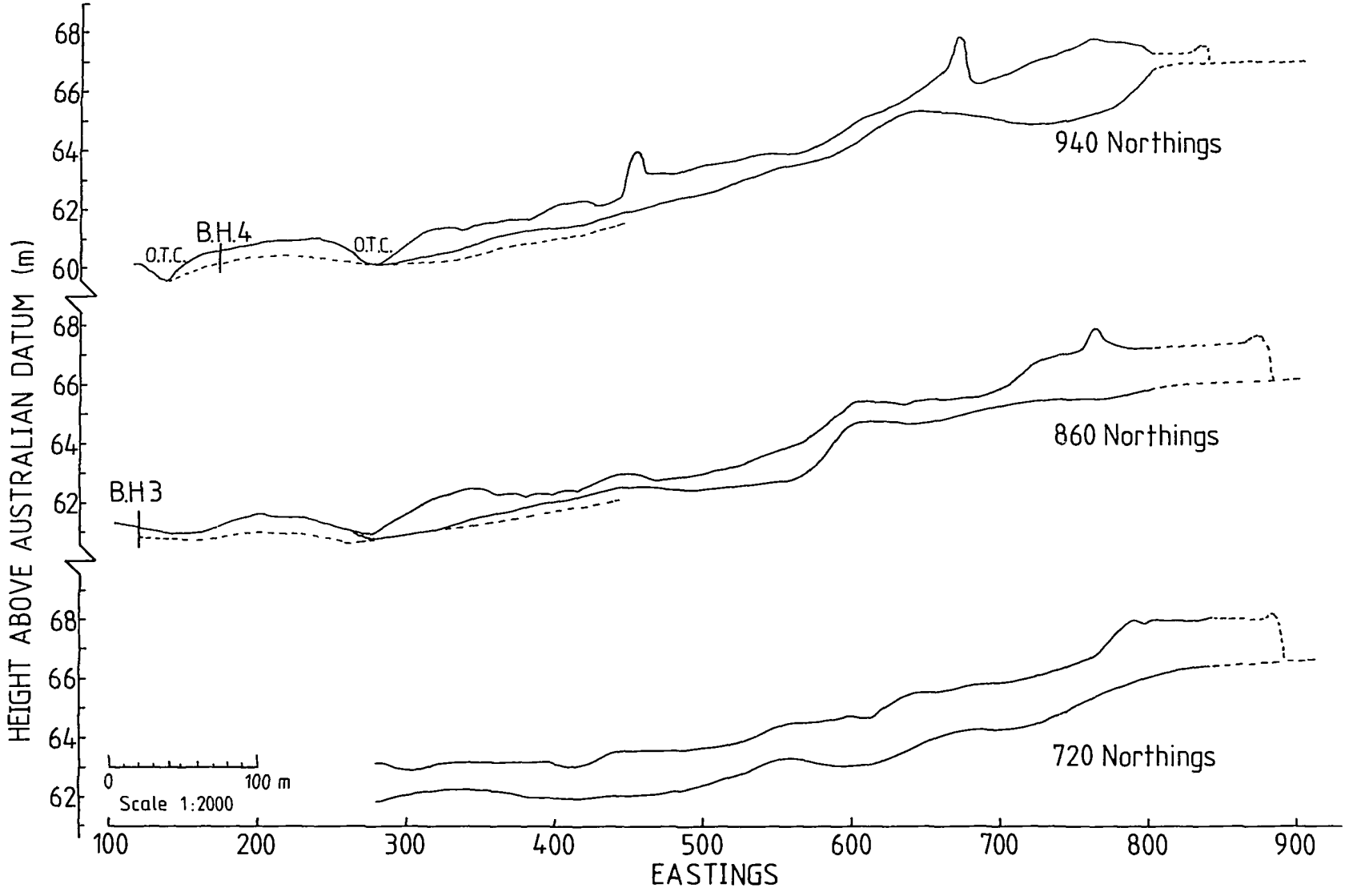


Figure 2 Tailings and ground water profiles

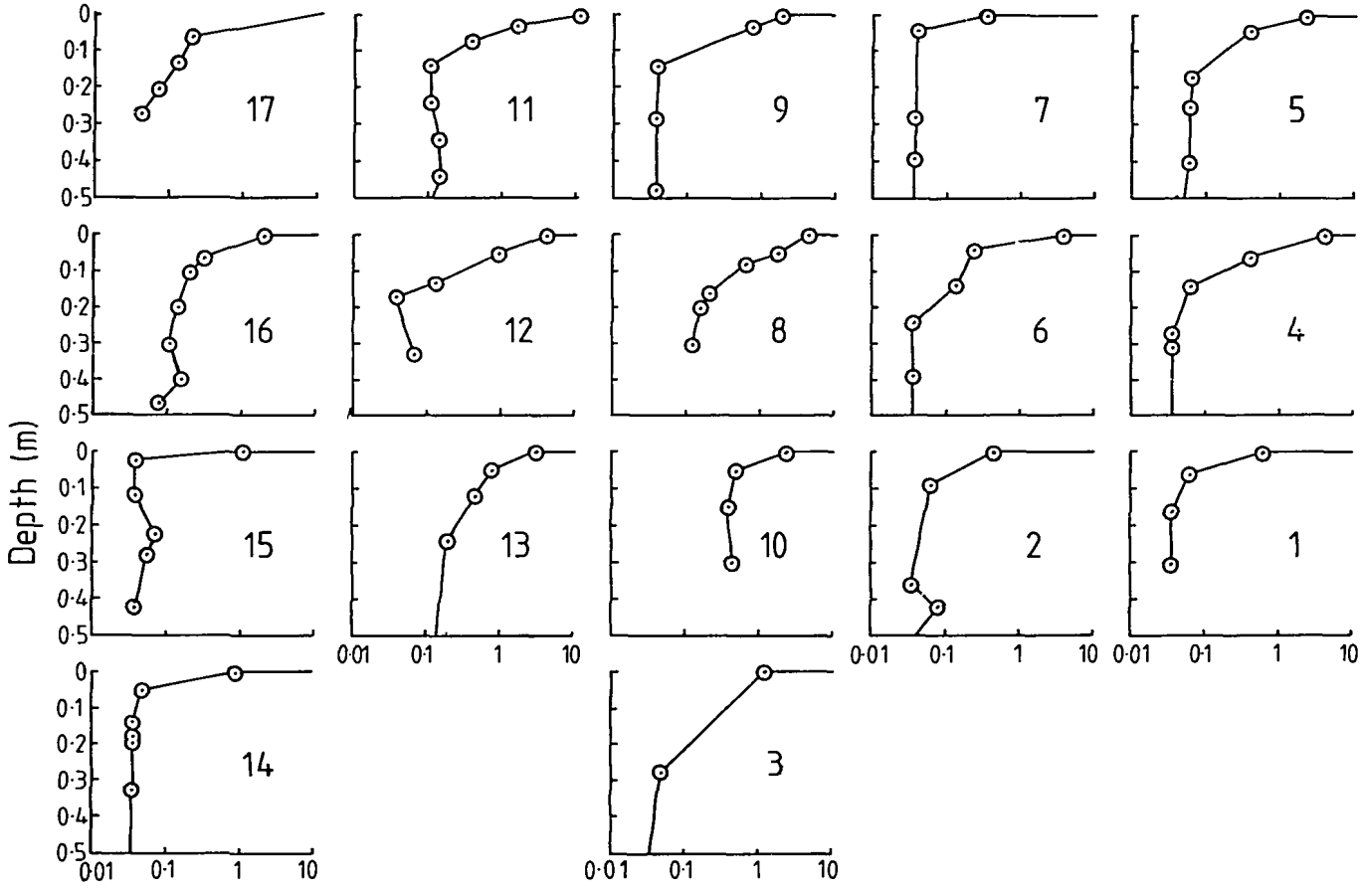


Figure 3 Radium distribution (Bq g^{-1})

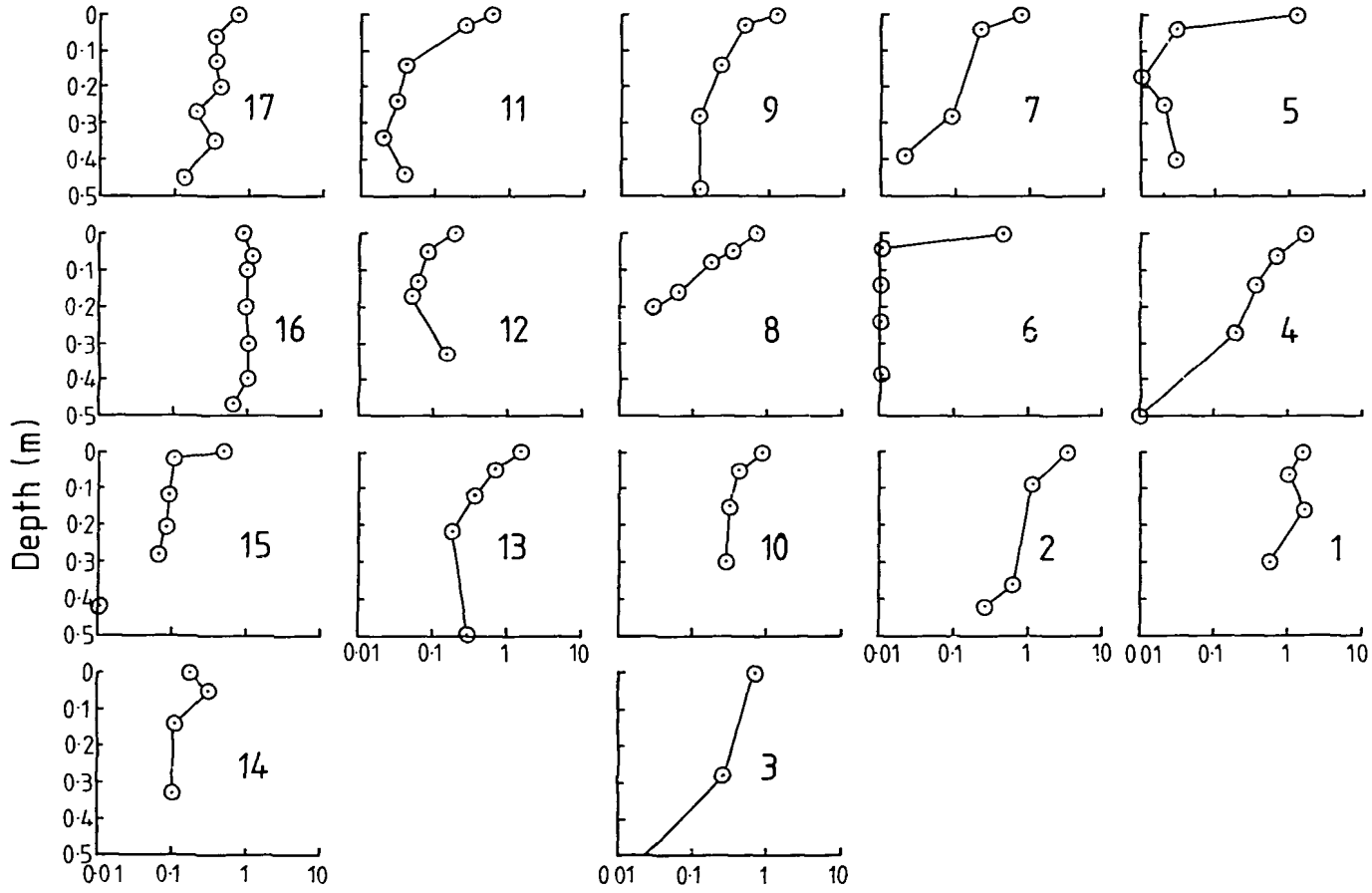


Figure 4 Copper distribution (mg g^{-1})

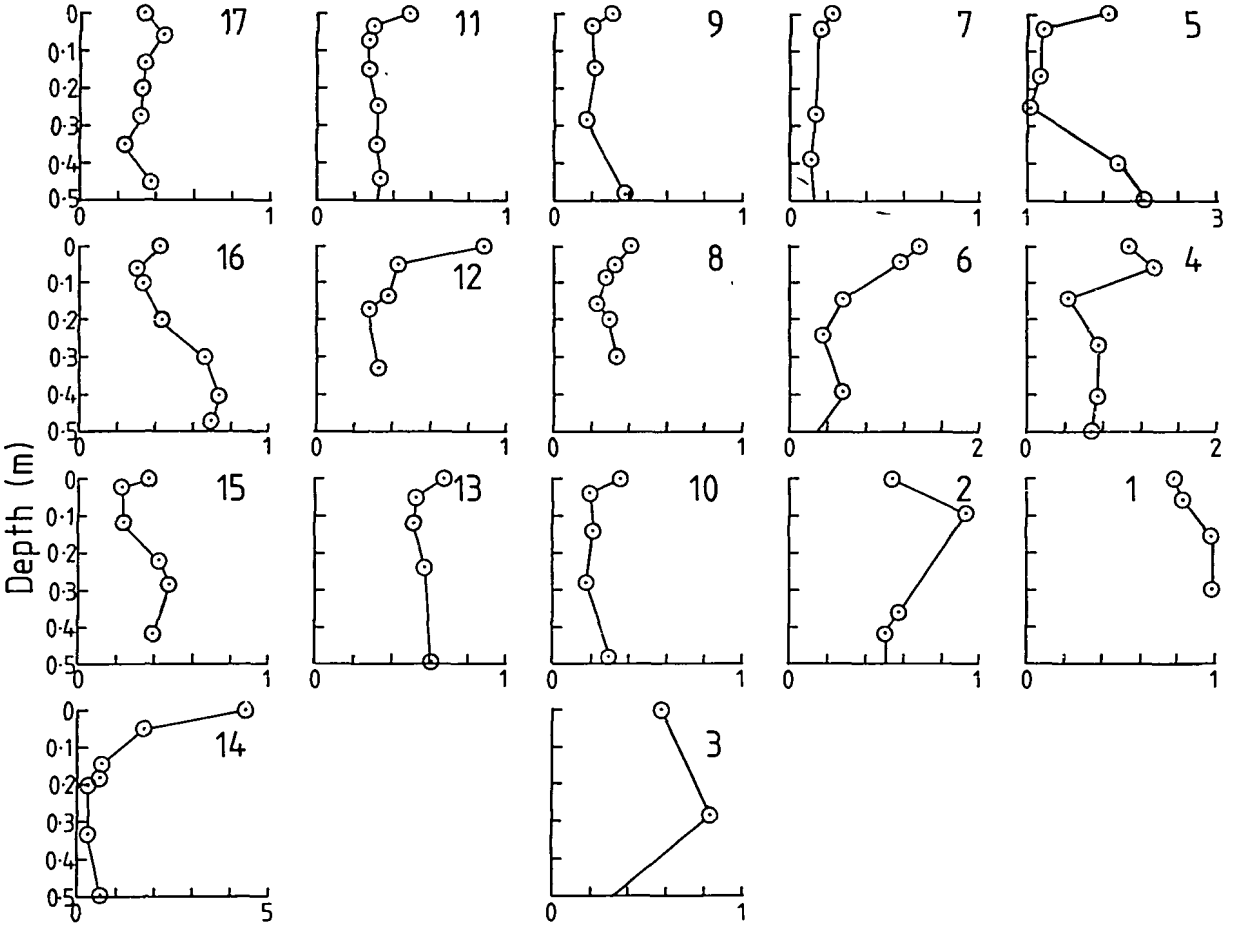


Figure 5 Sulphate distribution (mg g^{-1})

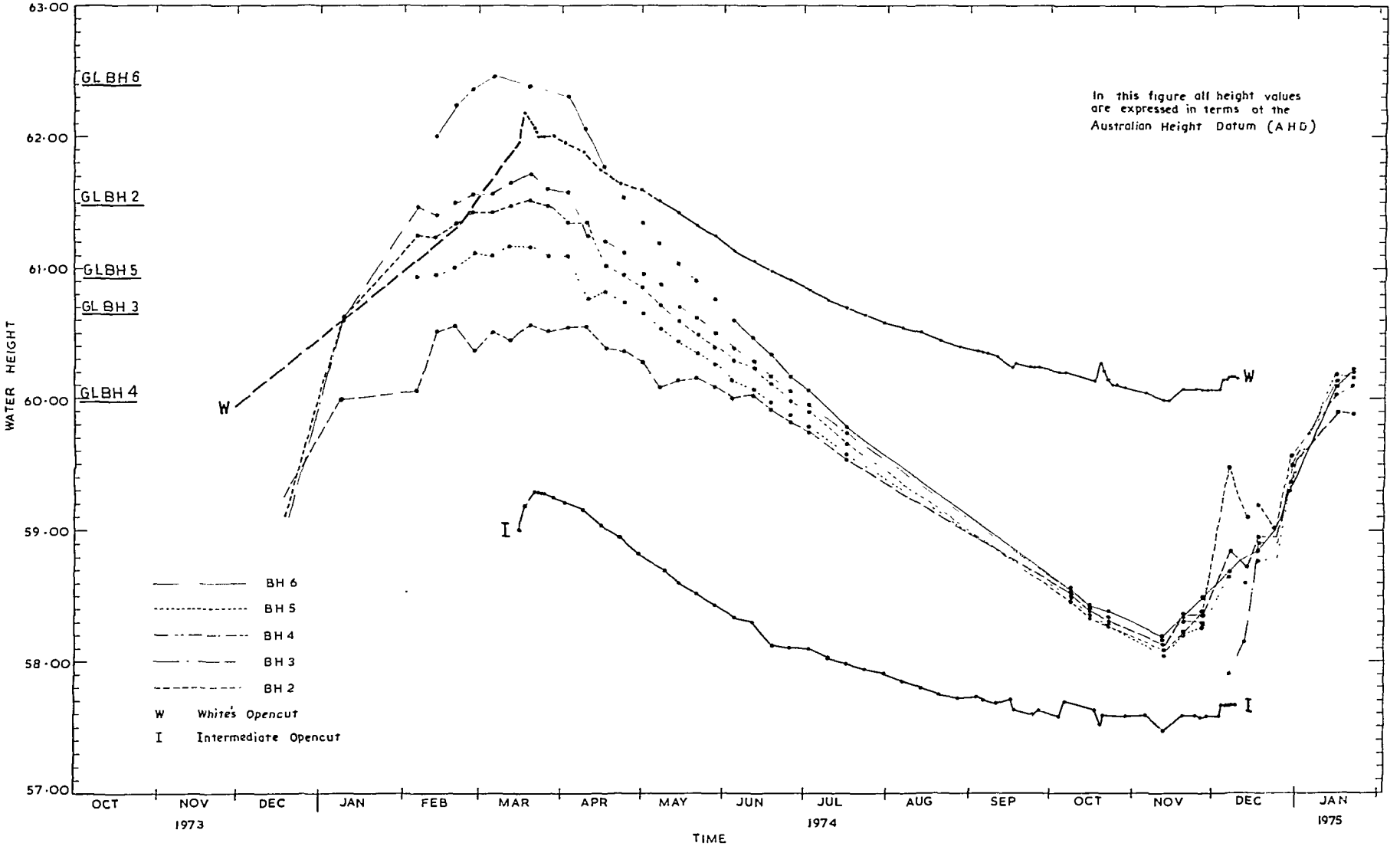


Figure 6 Water levels in bores

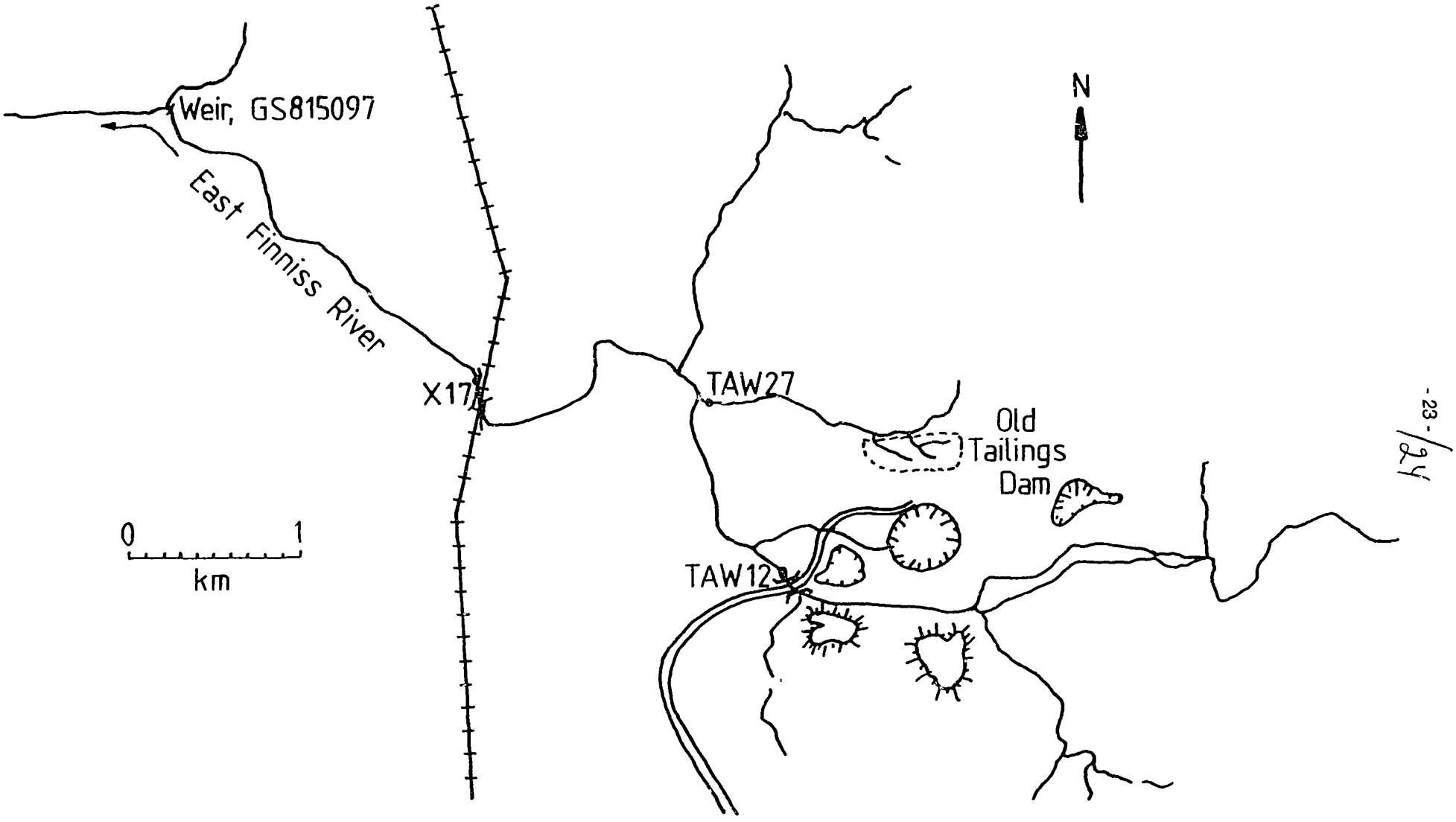


Figure 7 The Rum Jungle river system

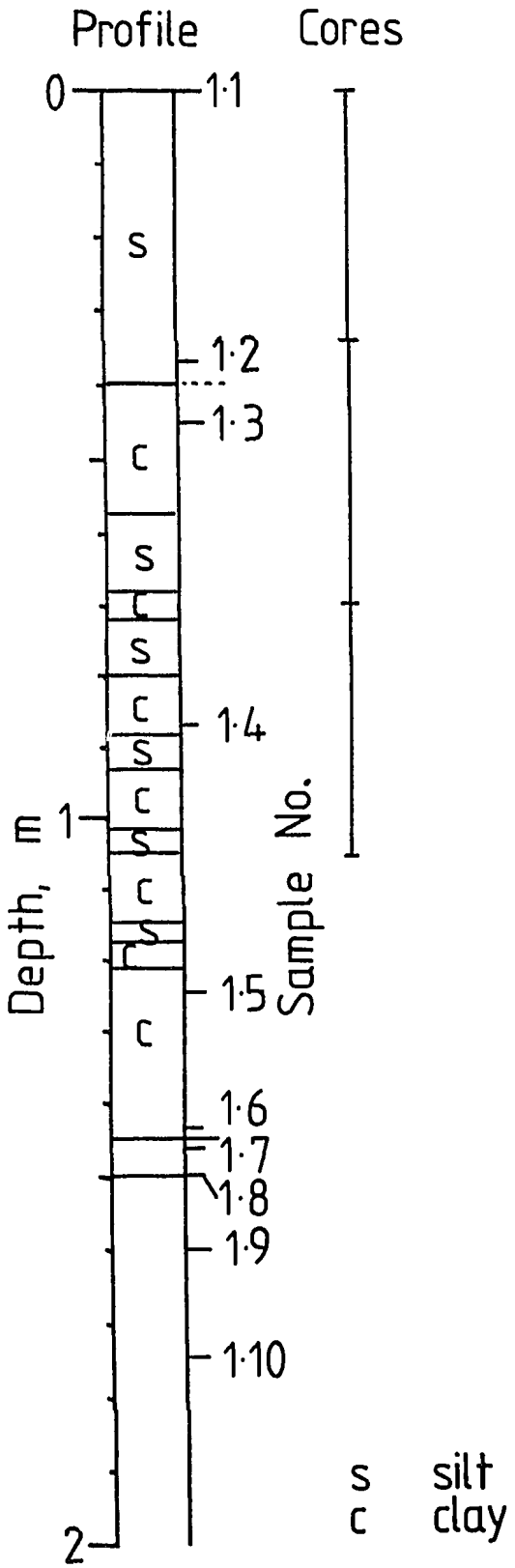
APPENDIX A
SOIL PROFILES

SITE 1

CO-ORDINATES 720E, 743N

DATE 1-5-84

Taken from side of exploratory trench.



COMMENTS

Surface sample.
A dry, layered, hard, grey silt.

Wet line.

A layered, purple clay with grey streaks.

Blue incrustations on side of trench at silt layers.
A black silt.

A grey, layered clay.

A brown clay.

A grey clay with red mottle.
Soil interface at 1440 mm.
Top soil ~ 20 mm.
No vegetation, no pyrite.
Red soil with a black line.

Red/orange soil, bottom sample unsaturated.

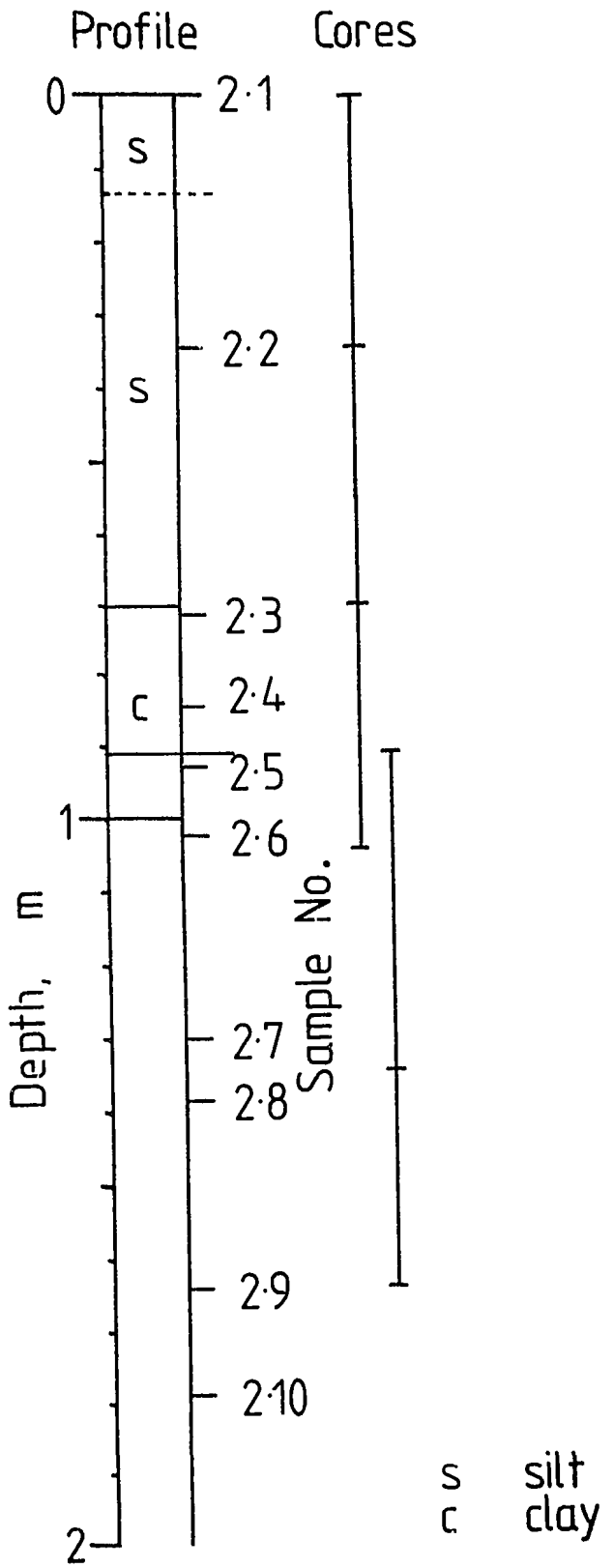
SITE 2

CO-ORDINATES 560E, 764N

DATE 1-5-84

Sampled from exploratory trench.

Dry trench.



COMMENTS

Surface sample, silt.
Dry, grey silt.

Wet line.

Silt with thin clay lenses.
Blue incrustations on exposed silt.

Purple clay with brown streaks.

Interface.
Top soil ~ 30 mm.
Roots, no pyrite.
Tan colour.

Orange colour.

Red colour.

Red clay with embedded red stones, bottom was unsaturated.

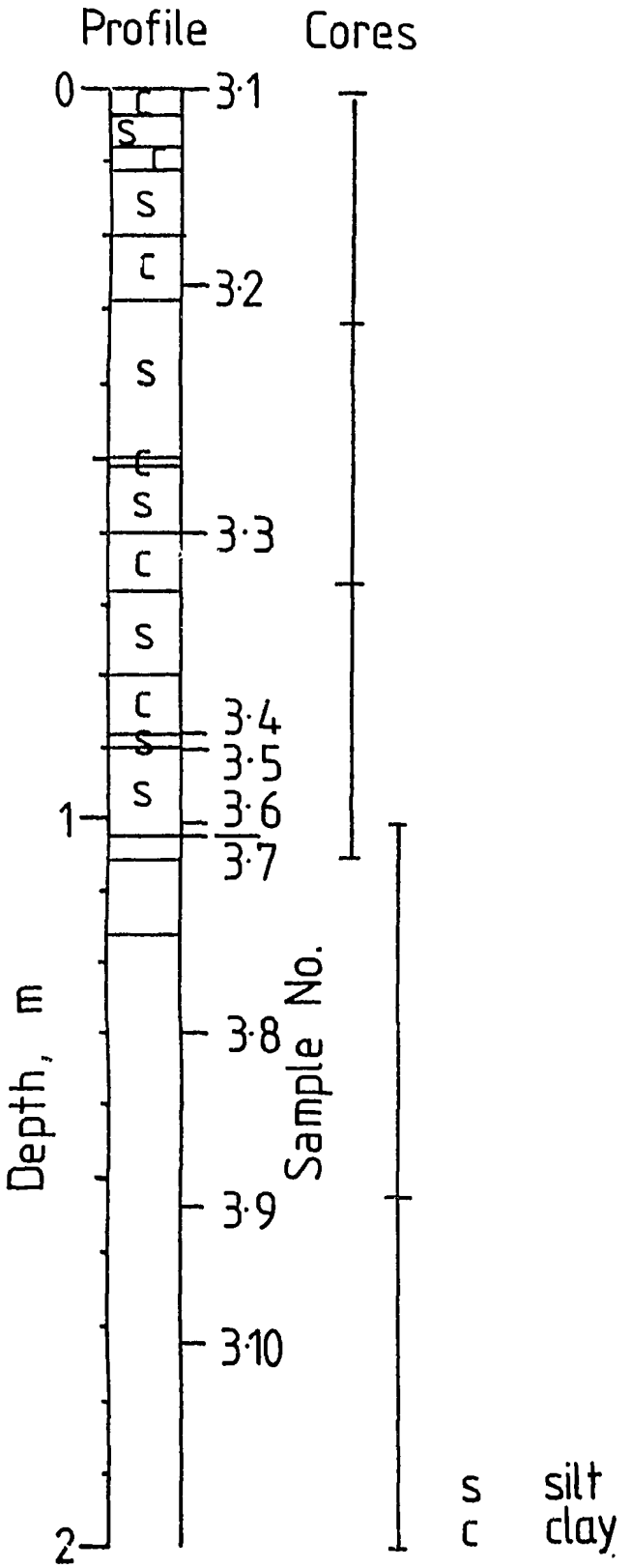
SITE 3

CO-ORDINATES 480E, 753N

DATE 1-5-84

Sampled from exploratory trench.

Dry trench.



COMMENTS

Surface sample.
Dry.

Grey silt.

Black silt.

Grey/purple clay.

Grey silt.
Brown silt.

Interface.
Top soil ~ 20 mm.
Roots, no pyrite.
Tan.

Orange with red mottle.

Red.

Below water table.

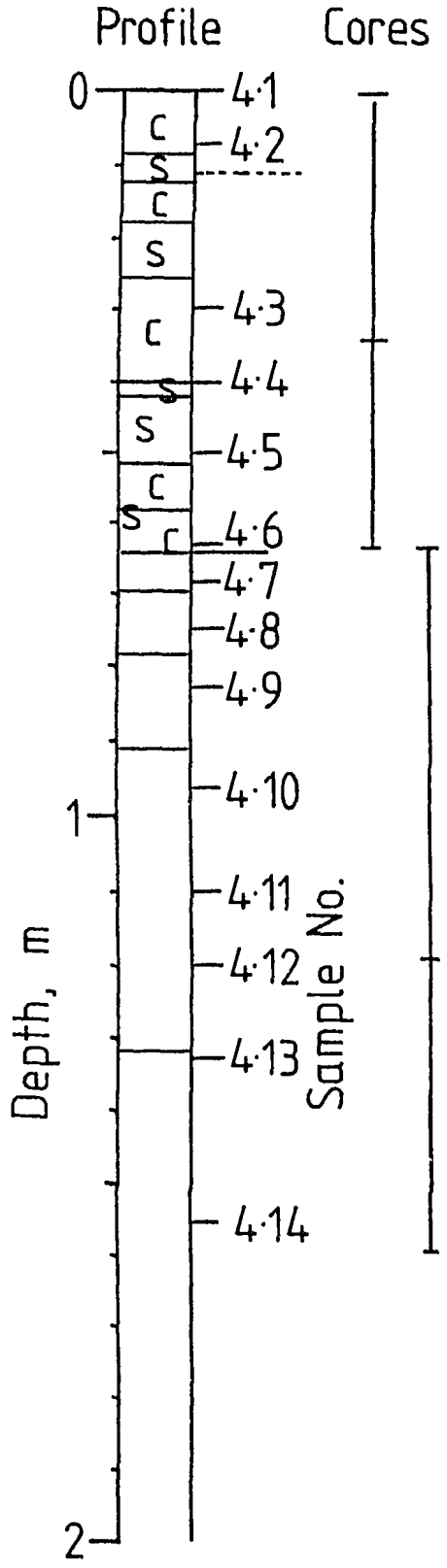
SITE 4

CO-ORDINATES 720E, 850N

DATE 3-5-84

Excavated by back-hoe.

Dry hole.



COMMENTS

Surface sample, clay.

Wet line.

Dark grey-purple clay.

Thin layer of grey silt.

Dark grey silt.

Silt changing to clay.
Interface, pyrite at interface.
Black soil + tails + pyrite.
Brown soil.

Orange soil.

Red soil.

Bottom was unsaturated.

s silt
c clay

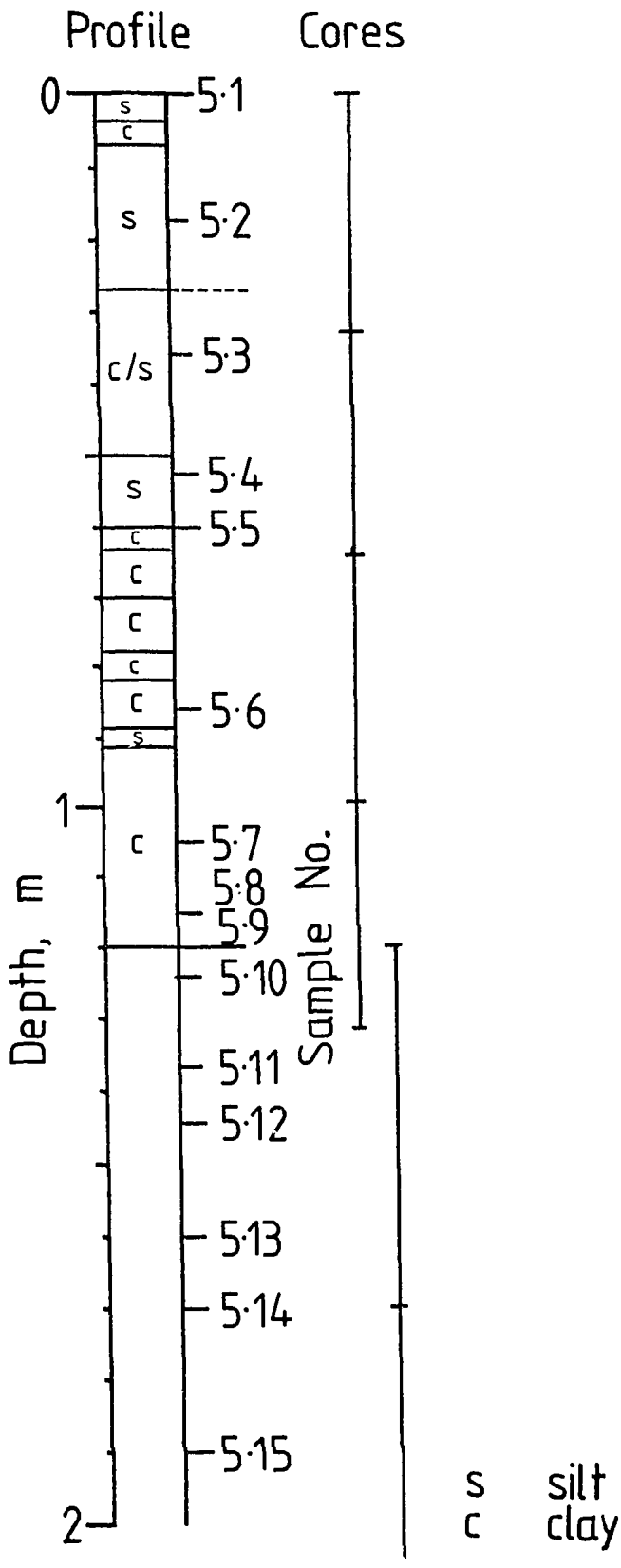
SITE 5

CO-ORDINATES 720E, 950N

DATE 3-5-84

Excavated by back-hoe.

Dry hole.



COMMENTS

Surface sample, silt.

Dry, grey material.

Wet line.

Laminates of clay and silt.

Black silt.

Purple clay.
Purple silt.

Purple clay.

Silt.
Clay.
Silt.

Clay.

Very plastic clay.

Interface.
Top soil, vegetation, no pyrite.
Sandy soil.

Orange zone.

Orange zone with red mottle.

Bottom sample, unsaturated.

SITE 6

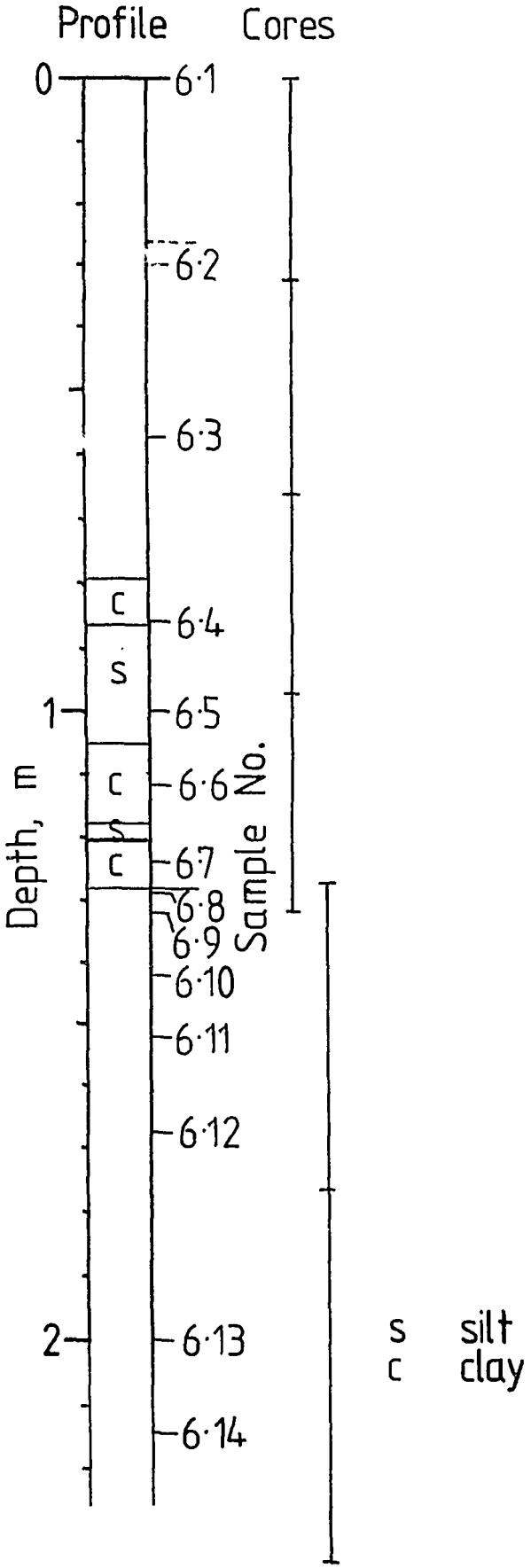
CO-ORDINATES 560E, 870N

DATE 3-5-84

Excavated by back-hoe.

Located at head of non-eroded peninsula

Dry hole.



COMMENTS

Surface.
Hard, purple-grey, silty clay.

Wet line.

Very hard, grey silt.

Bottom of hard silt layer - slightly clayey.

Fine, black silt.

Clay.

Interface.
Top soil, pyrite visible.
Black soil.

Dark sand.

Dark sand.

Yellow.

Orange sand with red mottle.

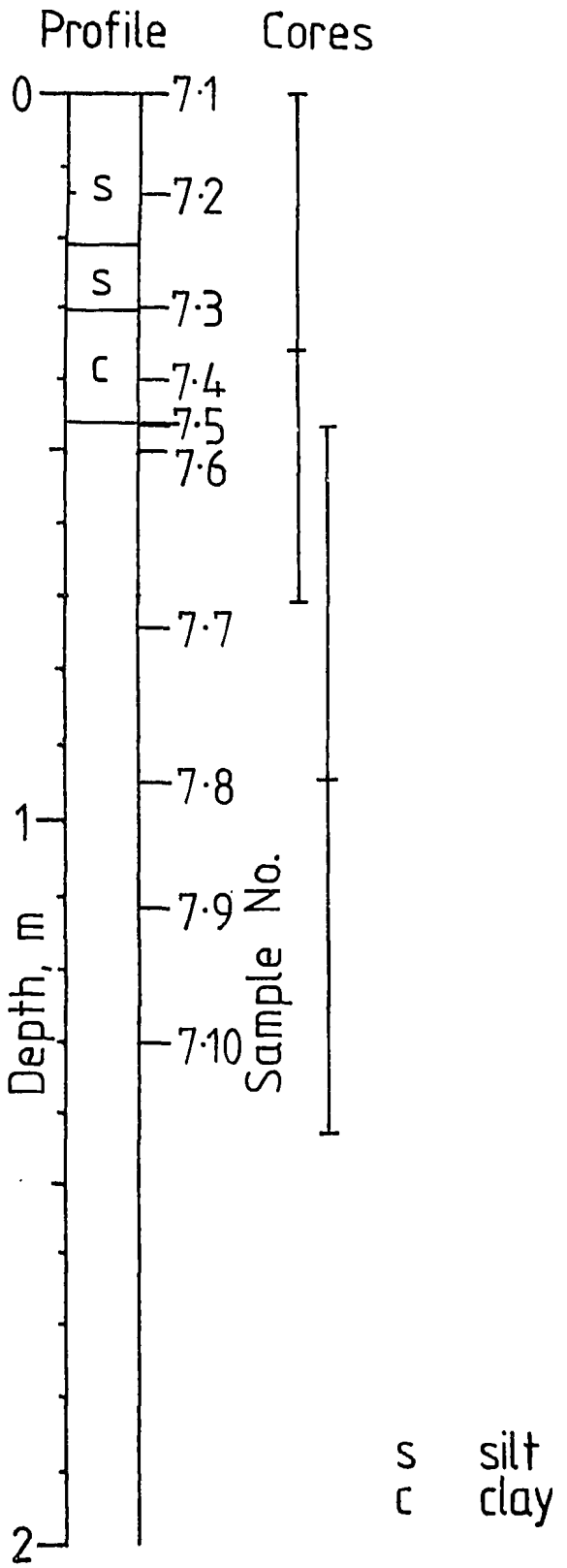
SITE 7

CO-ORDINATES 560E, 950N

DATE 3-5-84

Excavated by back-hoe.

Dry hole.



COMMENTS

Surface sample.

Hard, grey zone, silt and clay laminate.

Hard, grey silt.

Grey clay.

Interface.
Thin layer of white sand.
Dark sand.

Bottom of sand.

Orange with a red mottle.

Orange with a red mottle.

Orange with a red mottle.

SITE 8

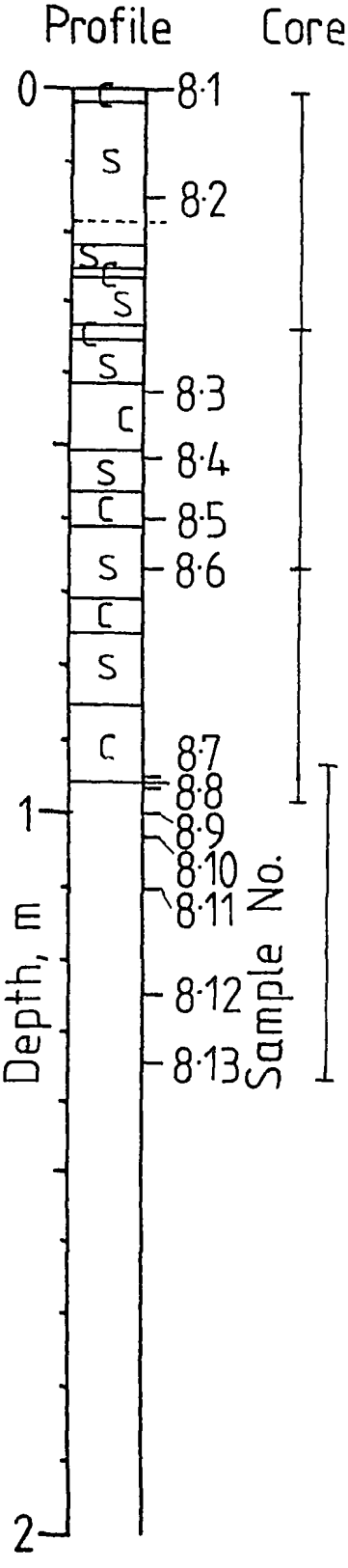
CO-ORDINATES 440E, 860N

DATE 7-5-84

Excavated by back-hoe.

Water seeped into hole.

Water was sampled.



COMMENTS

Surface.

Dry silt.

Wet line.

Definite sequence of layering.

Silt with iron crust and blue streaks.

Interface, leaf vegetation at surface.
Brown soil.
Brown soil with black mottle.
Yellow sand.

Yellow sand with orange mottle.

Orange zone.

s silt
c clay

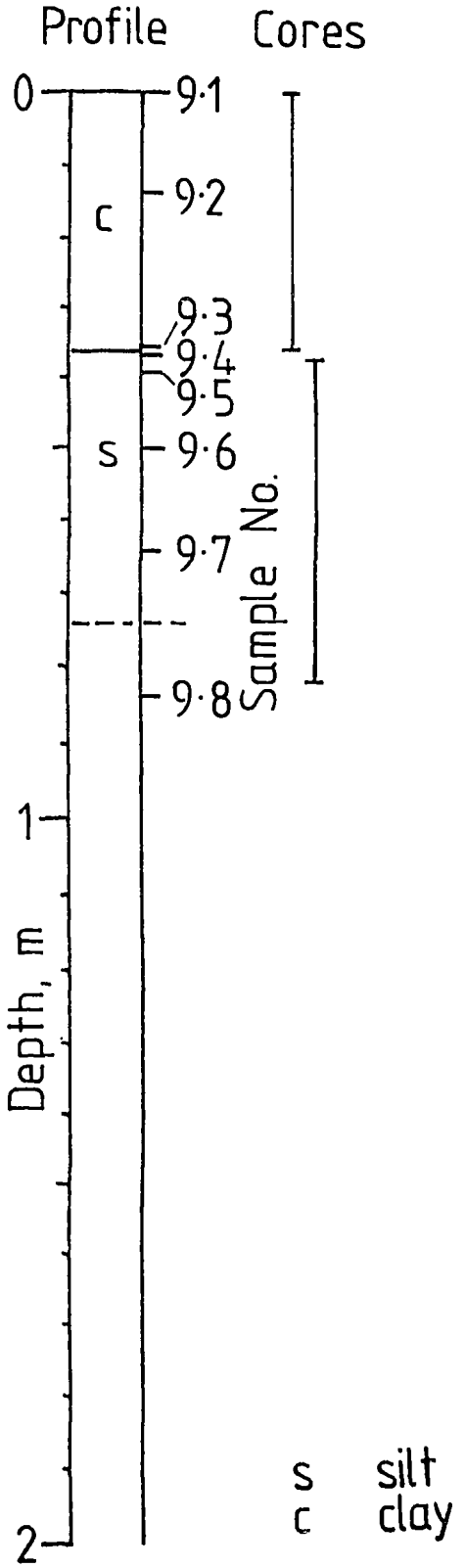
SITE 9

CO-ORDINATES 440E, 980N

DATE 7-5-84

Excavated manually.

Hole extended below water table.
Water was sampled.



Comments

Surface sample.
Damp clay.

Wet clay.

Interface.
Black top soil.

Red sand with live roots.

Water table.

Grey sand.

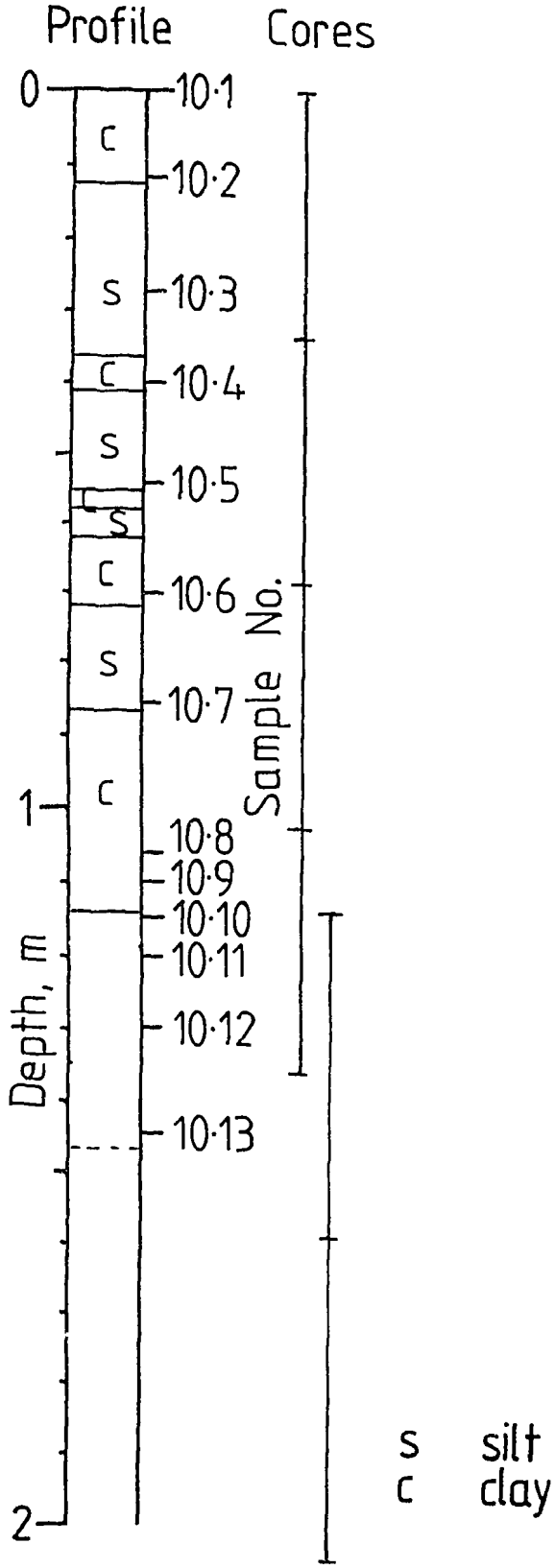
SITE 10

CO-ORDINATES 440E, 770N

DATE 4-5-84

Excavated by back-hoe.

Penetrated water table.
Water was sampled.



COMMENTS

Surface.

Bottom of dry, compacted clay.

Middle of a grey silt.

Clay.

Bottom of a silt zone.

Wet, dark clay.

Grey silt.

Yellow silt.
Clay.

Interface.
Black soil containing pyrite.
Black soil.

Bottom of black soil containing pyrite.

Dark orange.
Water table.

Dark orange with red mottle.

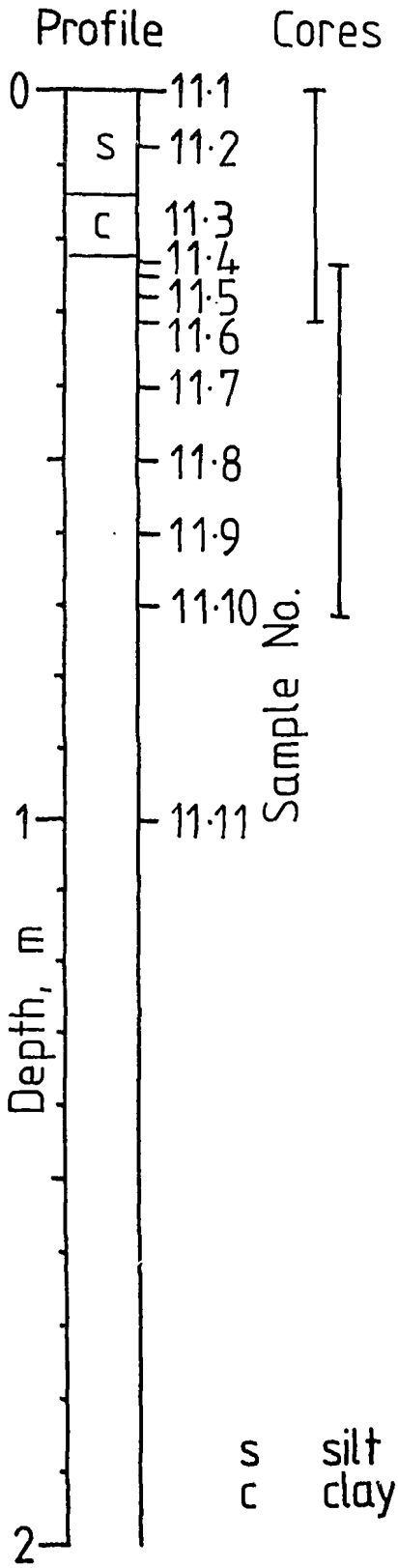
SITE 11

CO-ORDINATES 360E, 930N

DATE 7-5-84

Excavated manually.

Penetrated water table.
Water was sampled.



COMMENTS

Surface.
Silt.

Clay.
Interface.
Red layer.
Black layer.

Off-white sand with black mottle.

Clayey-sand.

Clay with orange mottle.

Clay with yellow mottle.

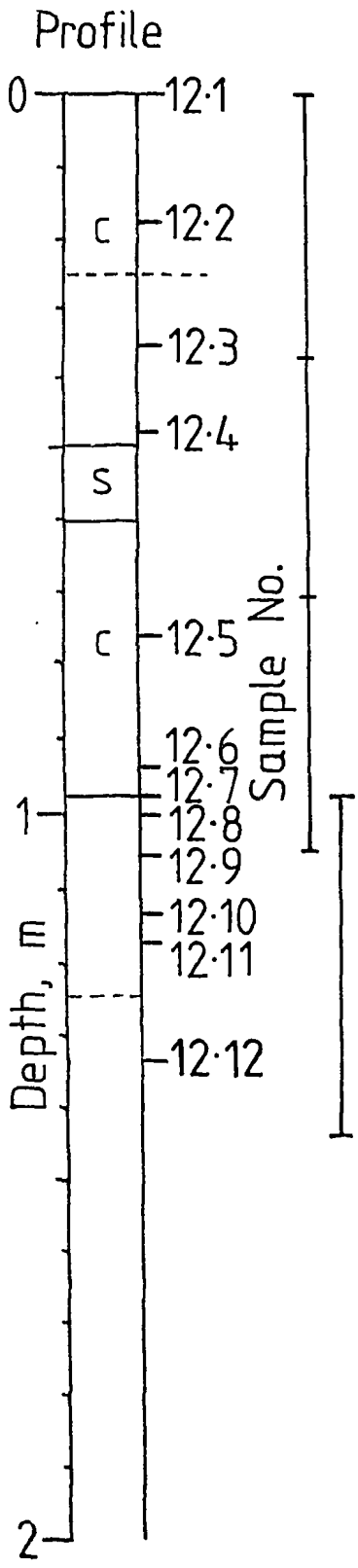
SITE 12

CO-ORDINATES 360E, 850N

DATE 6-5-84

Excavated by back-hoe.

Penetrated water table.
Water was sampled.



COMMENTS

Surface.

Hard clay-silt laminates.

Wet line.

Brown clay-silt laminates.

Silt.

Grey to purple clay.

Interface.
Yellow material at interface.

Grey sand with black mottle.

Grey sand.

Water table.

Grey sand with red mottle.

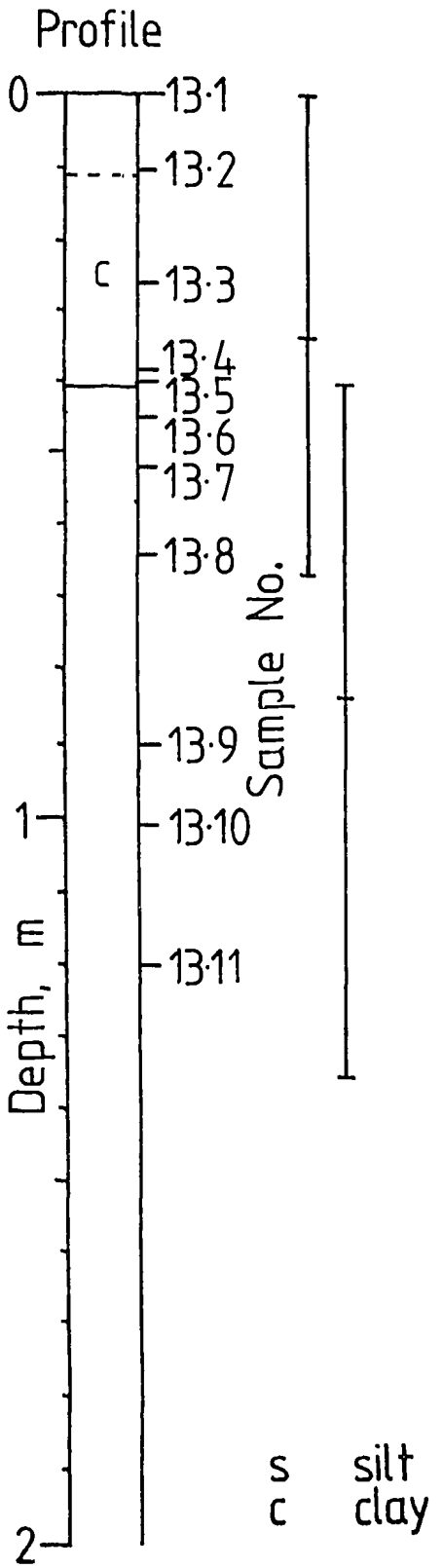
SITE 13

CO-ORDINATES 360E, 770N

DATE 4-5-84

Excavated by back-hoe.

Penetrated water table.
Water was sampled.



COMMENTS

Surface.

Dry hard laminate.
Wet line.

Clay and silt.

Light grey clay.
Interface.
Black and orange mottle.
Black soil.
Brown soil.

Orange soil.

Red mottle.
Water table.

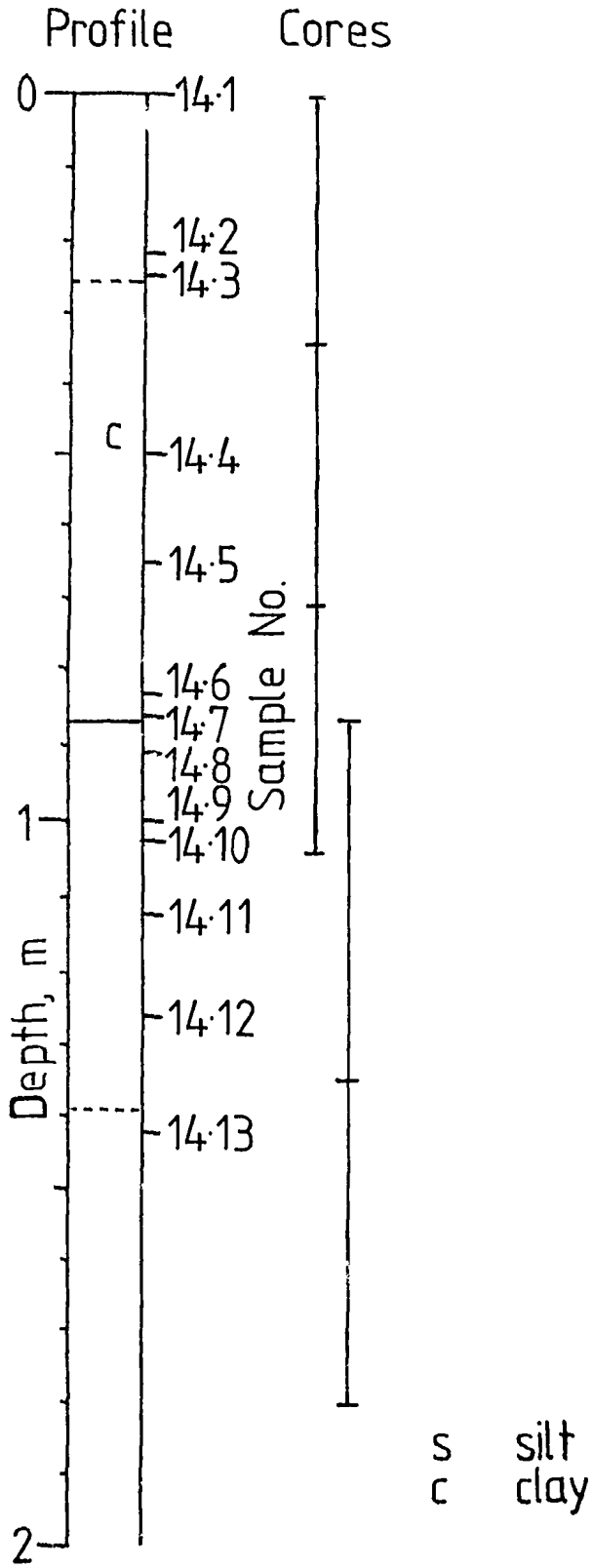
SITE 14

CO-ORDINATES 280E, 775N

DATE 4-5-84

Excavated by back-hoe.

Penetrated water table.
Water was sampled.



COMMENTS

Surface.

Dry.

Hard, grey silt.
Wet line.

Grey clay.

Grey clay.

Grey clay.

Interface.
Top soil, contains pyrite.
Black/brown soil.

Brown soil.
Orange soil, contains pyrite.

Orange soil, contains pyrite.

Orange soil, contains pyrite.

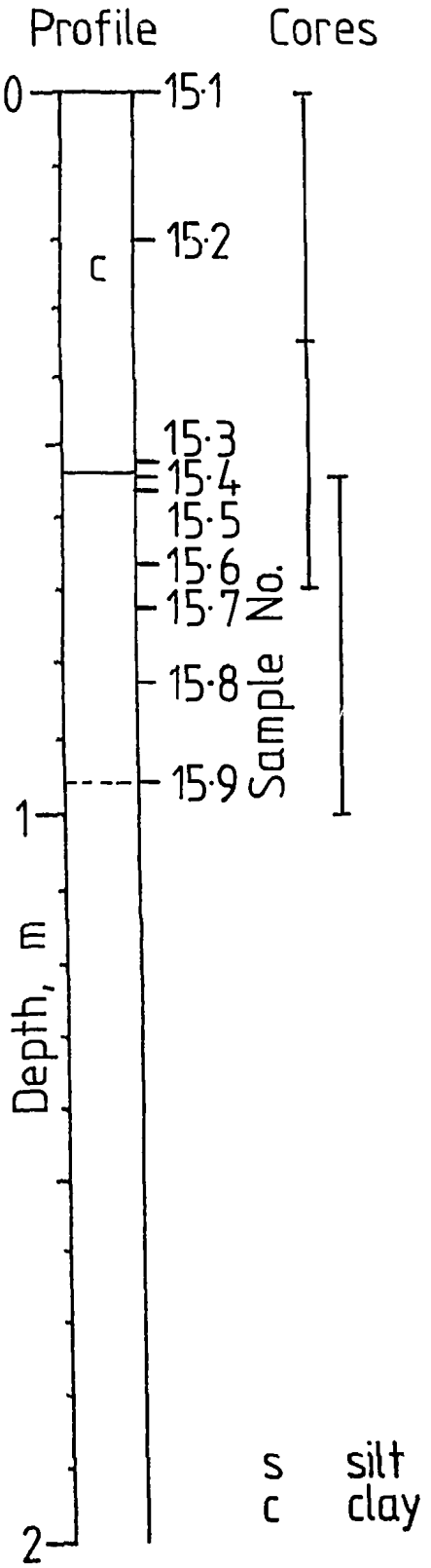
Water table.
Orange soil, contains pyrite.

SITE 15

CO-ORDINATES 260E, 830N

DATE 6-5-84

Excavated by back-hoe.



Penetrated water table.
Water was sampled.

COMMENTS

Surface.

A wet, purple clay with no distinctive silt layer.

Interface.
Top soil, contains roots.

Black soil.

Dark sand.

Brown sand.

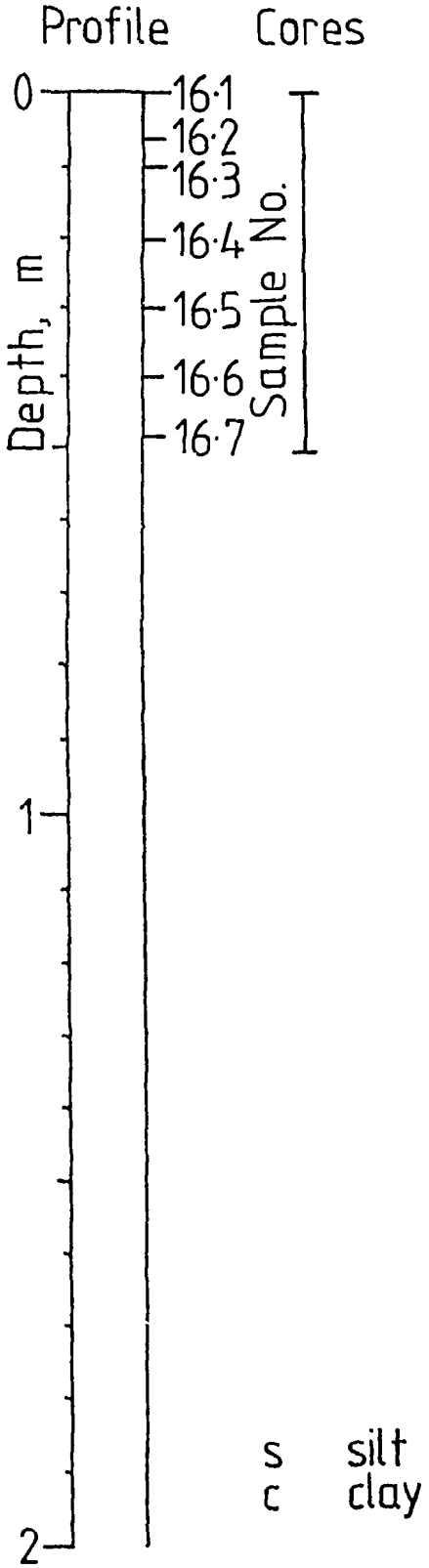
Water table.
Orange with red mottle.

SITE 16

CO-ORDINATES 195E, 900N

DATE 8-5-84

Excavated manually.



COMMENTS

Surface, dusted with tails.

Brown soil.
Slight orange mottle.

Strong orange mottle.

Water level in creek.

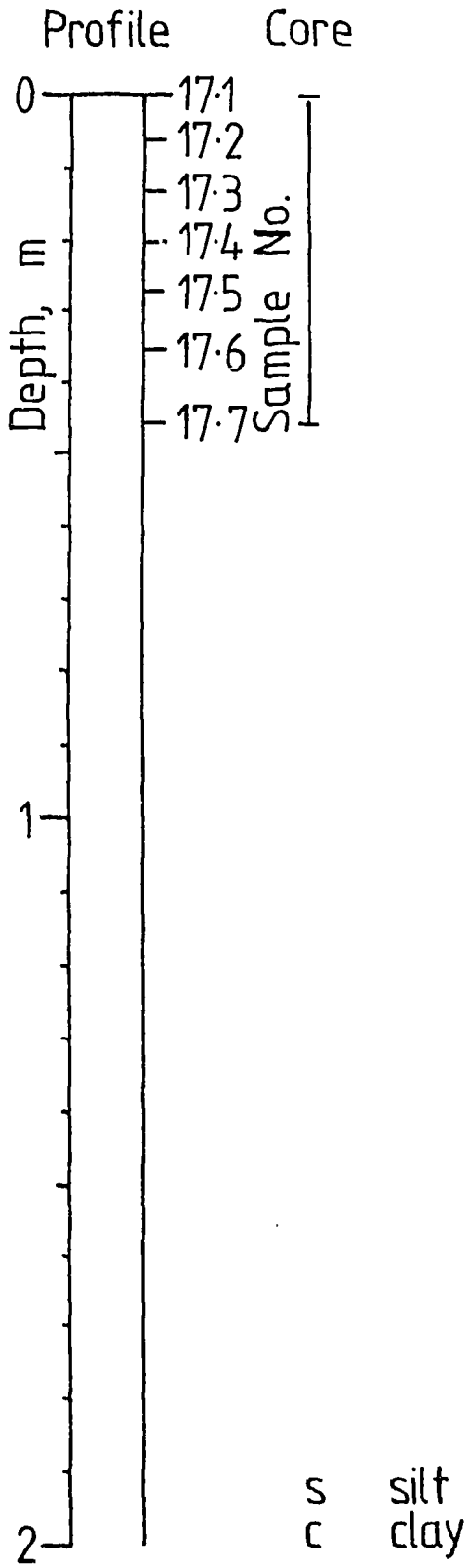
Grey mottle.

SITE 17

CO-ORDINATES 030E, (64)030N

DATE 8-5-84

Excavated manually.



COMMENTS

Surface, dusted with tails.
Damp, black soil.

Black gravel.

Black/red gravel.

Slightly grey gravel.

Grey gravel.

Orange mottle.

APPENDIX B

DESCRIPTION OF SUBSOIL SAMPLES

Sample numbers refer to complete profile listed in **appendix A.**

SITE 1 Co-ordinates 720E, 743N Date 1.5.84

Samples taken from the side of the exploratory trench. The bottom of the trench was dry.

Sample number	1.7
Depth below surface of tailings	1440 mm
Depth below interface with soil	0 mm
Description at time of sampling	Top soil, no vegetation or pyrite
Description after drying	A deep-red and orange mottled sand with tailings
Microscopic examination	Small crystals with a variety of colours, a lot of quartz

Sample number	1.8
Depth below surface of tailings	1500 mm
Depth below interface with soil	60 mm
Description at time of sampling	Red soil
Description after drying	Deep-red/brown fine sand
Microscopic examination	Small crystals with a variety of colours

Sample number	1.9
Depth below surface of tailings	1600 mm
Depth below interface with soil	160 mm
Description at time of sampling	A red soil with a black line in it
Description after drying	Orange and black mottled sand
Microscopic examination	Small crystals with a variety of colours, agglomerates of orange coloured crystals with massive black units

Sample number	1.10
Depth below surface of tailings	1740 mm
Depth below interface with soil	300 mm
Description at time of sampling	Red/orange soil
Description after drying	Fine orange sand
Microscopic examination	Variety of small orange crystals with strong orange colour

SITE 2 Co-ordinates 560E, 764N Date 1.5.84

Samples taken from the side of the exploratory trench. The bottom of the trench was damp.

Sample number	2.5
Depth below surface of tailings	940 mm
Depth below interface with soil	0 mm
Description at time of sampling	Top soil, roots, no pyrite
Description after drying	Fine brown/orange sand with roots
Microscopic examination	Variety of small crystals, a lot of quartz

Sample number	2.6
Depth below surface of tailings	1030 mm
Depth below interface with soil	90 mm
Description at time of sampling	Top of orange zone
Description after drying	Deep-red/brown fine sand with roots
Microscopic examination	Variety of small crystals, a lot of quartz, some tailings

Sample number	2.7
Depth below surface of tailings	1300 mm
Depth below interface with soil	360 mm
Description at time of sampling	Middle of orange zone
Description after drying	Bright orange sand
Microscopic examination	Microcrystalline aggregates, overall colour brown/orange

Sample number	2.8
Depth below surface of tailings	1380 mm
Depth below interface with soil	440 mm
Description at time of sampling	Bottom of orange zone
Description after drying	Orange sand with black gravel
Microscopic examination	Microcrystalline aggregates around black matt stones

Sample number	2.9
Depth below surface of tailings	1650 mm
Depth below interface with soil	710 mm
Description at time of sampling	Top of red zone
Description after drying	Dark orange clay
Microscopic examination	Dark orange microcrystalline mass around black matt stones

Sample number	2.10
Depth below surface of tailings	1780 mm
Depth below interface with soil	840 mm
Description at time of sampling	Red stony zone
Description after drying	Deep-orange/red clay with small black stones
Microscopic examination	Aggregates of small crystals with small black stones

SITE 3 Co-ordinates 480E, 753N Date 1.5.84

Samples taken from the side of the exploratory trench. The bottom of the trench was boggy.

Sample number	3.7
Depth below surface of tailings	1020 mm
Depth below interface with soil	0 mm
Description at time of sampling	Top soil, roots, no pyrite
Description after drying	Dark orange clay, friable with a trace of tailings
Microscopic examination	Variety of very small crystals, a lot of quartz

Sample number	3.8
Depth below surface of tailings	1300 mm
Depth below interface with soil	280 mm
Description at time of sampling	Orange zone with red mottle
Description after drying	Orange clay, friable
Microscopic examination	Variety of very small crystals, a lot of quartz

Sample number	3.9
Depth below surface of tailings	1550 mm
Depth below interface with soil	530 mm
Description at time of sampling	Bottom of orange zone
Description after drying	Orange clay/sand with some deep-orange spots
Microscopic examination	Microcrystalline aggregates with deep-orange zones

Sample number	3.10
Depth below surface of tailings	1720 mm
Depth below interface with soil	700 mm
Description at time of sampling	Red zone
Description after drying	Fine red/brown sand
Microscopic examination	Agglomerates of small red crystals

SITE 4 Co-ordinates 720E, 850N Date 3.5.84

Excavated by back-hoe. Bottom of hole was dry.

Sample number	4.7
Depth below surface of tailings	690 mm
Depth below interface with soil	0 mm
Description at time of sampling	Pyrite-laden soil
Description after drying	Fine black sand with a trace of tailings and roots
Microscopic examination	Variety of very small crystals, pyrite and a lot of quartz

Sample number	4.8
Depth below surface of tailings	750 mm
Depth below interface with soil	60 mm
Description at time of sampling	Black soil with pyrite and tailings penetration
Description after drying	Fine black/brown sand with roots
Microscopic examination	Variety of very small crystals, pyrite and a lot of quartz

Sample number	4.9
Depth below surface of tailings	830 mm
Depth below interface with soil	140 mm
Description at time of sampling	Dark orange soil
Description after drying	Fine dark brown to orange sand with roots
Microscopic examination	Agglomerates of very small crystals, overall dark grey

Sample number	4.10
Depth below surface of tailings	960 mm
Depth below interface with soil	270 mm
Description at time of sampling	Bottom of orange zone
Description after drying	Fine orange sand with roots
Microscopic examination	Agglomerates of very small crystals, overall orange

Sample number	4.11
Depth below surface of tailings	1100 mm
Depth below interface with soil	410 mm
Description at time of sampling	Middle of orange zone
Description after drying	Fine orange/yellow sand
Microscopic examination	Agglomerates of coarse yellow/orange crystals

Sample number	4.12
Depth below surface of tailings	1200 mm
Depth below interface with soil	510 mm
Description at time of sampling	Bottom of orange zone
Description after drying	Fine bright orange sand
Microscopic examination	Agglomerates of coarse yellow/orange crystals

Sample number	4.13
Depth below surface of tailings	1330 mm
Depth below interface with soil	640 mm
Description at time of sampling	Top of red zone
Description after drying	Fine bright orange/red sand with red zones
Microscopic examination	Agglomerates of coarse yellow/orange crystals with red zones

Sample number	4.14
Depth below surface of tailings	1560 mm
Depth below interface with soil	870 mm
Description at time of sampling	Bottom of red zone
Description after drying	Deep-red/orange sand with red gravel
Microscopic examination	Agglomerates of dark orange and red crystals and brick-red stones

SITE 5 Co-ordinates 720E, 950N Date 3.5.84

Excavated by back-hoe. Bottom of hole was dry.

Sample number	5.9
Depth below surface of tailings	1200 mm
Depth below interface with soil	0 mm
Description at time of sampling	Black soil, no pyrite
Description after drying	Fine mid-grey sand with traces of roots and tailings
Microscopic examination	Small mainly colourless crystals and some tailings

Sample number	5.10
Depth below surface of tailings	1240 mm
Depth below interface with soil	40 mm
Description at time of sampling	Sand
Description after drying	Fine grey/brown sand with traces of roots
Microscopic examination	Small mainly colourless crystals
Sample number	5.11
Depth below surface of tailings	1370 mm
Depth below interface with soil	170 mm
Description at time of sampling	Bottom of sand zone
Description after drying	Fine grey/brown sand with traces of roots
Microscopic examination	Variety of coarse grey crystals
Sample number	5.12
Depth below surface of tailings	1450 mm
Depth below interface with soil	250 mm
Description at time of sampling	Top of orange zone
Description after drying	Fine orange/brown sand
Microscopic examination	Aggregates of coarse crystals
Sample number	5.13
Depth below surface of tailings	1600 mm
Depth below interface with soil	400 mm
Description at time of sampling	Orange zone with red mottle
Description after drying	Fine brown sand with deep-red zones
Microscopic examination	Aggregates of coarse crystals, various colours with brick-red zones
Sample number	5.14
Depth below surface of tailings	1700 mm
Depth below interface with soil	500 mm
Description at time of sampling	Orange zone with red mottle
Description after drying	Fine orange-brown sand with deep-red zones
Microscopic examination	Aggregates of coarse crystals, various colours with brick-red zones
Sample number	5.15
Depth below surface of tailings	1900 mm
Depth below interface with soil	700 mm
Description at time of sampling	Orange zone with red mottle
Description after drying	Fine orange-brown sand with red and black zones
Microscopic examination	Aggregates of fine crystals, various colours with sections of red and black

SITE 6 Co-ordinates 560E, 870N Date 3.5.84

Excavated by back-hoe. Bottom of hole was dry.

Sample number	6.8
Depth below surface of tailings	1280 mm
Depth below interface with soil	0 mm
Description at time of sampling	Black soil with pyrite in it
Description after drying	Fine grey sand with roots
Microscopic examination	Small colourless crystals with tailings and pyrite

Sample number	6.9
Depth below surface of tailings	1320 mm
Depth below interface with soil	40 mm
Description at time of sampling	Black soil
Description after drying	Fine grey sand
Microscopic examination	Small colourless crystals

Sample number	6.10
Depth below surface of tailings	1420 mm
Depth below interface with soil	140 mm
Description at time of sampling	Sand
Description after drying	Fine grey sand
Microscopic examination	Agglomerates of small colourless crystals

Sample number	6.11
Depth below surface of tailings	1520 mm
Depth below interface with soil	240 mm
Description at time of sampling	Sand
Description after drying	Fine grey sand
Microscopic examination	Agglomerates of small colourless crystals

Sample number	6.12
Depth below surface of tailings	1670 mm
Depth below interface with soil	390 mm
Description at time of sampling	Sand
Description after drying	Coarse cemented grey sand
Microscopic examination	Microcrystalline aggregates with a few orange quartz grains

Sample number	6.13
Depth below surface of tailings	2000 mm
Depth below interface with soil	720 mm
Description at time of sampling	Orange zone with red mottle
Description after drying	Mid-tan fine cemented sand
Microscopic examination	Quartz crystals cemented by very small tan crystals

Sample number	6.14
Depth below surface of tailings	2150 mm
Depth below interface with soil	870 mm
Description at time of sampling	Orange zone with red mottle
Description after drying	Mid-tan fine cemented sand
Microscopic examination	Quartz crystals cemented by very small tan crystals

SITE 7 Co-ordinates 560E, 950N Date 3.5.84

Excavated by back-hoe. Bottom of hole was dry.

Sample number	7.5
Depth below surface of tailings	460 mm
Depth below interface with soil	0 mm
Description at time of sampling	Top soil
Description after drying	Fine light grey sand
Microscopic examination	Very small crystals, variety of colours, tailings

Sample number	7.6
Depth below surface of tailings	500 mm
Depth below interface with soil	40 mm
Description at time of sampling	Top of sand zone
Description after drying	Fine dark tan/grey sand
Microscopic examination	Very small crystals, variety of colours

Sample number	7.7
Depth below surface of tailings	740 mm
Depth below interface with soil	280 mm
Description at time of sampling	Bottom of sand
Description after drying	Fine buff-grey sand
Microscopic examination	Aggregates of fine grey and orange crystals

Sample number	7.8
Depth below surface of tailings	950 mm
Depth below interface with soil	490 mm
Description at time of sampling	Orange sand with red mottle
Description after drying	Fine buff sand with red mottle
Microscopic examination	Grey microcrystalline aggregates with red zones

Sample number	7.9
Depth below surface of tailings	1120 mm
Depth below interface with soil	660 mm
Description at time of sampling	Orange sand with red mottle
Description after drying	Orange sand with darker orange gravel
Microscopic examination	Massive aggregates of microcrystalline grey/orange crystals with orange stones

Sample number	7.10
Depth below surface of tailings	1300 mm
Depth below interface with soil	840 mm
Description at time of sampling	Orange sand with red mottle
Description after drying	Orange sand with darker orange zones
Microscopic examination	Mass of microcrystalline grey/orange crystals

SITE 8 Co-ordinates 440E, 860N Date 7.5.84

Excavated by back-hoe. Bottom of hole was 200 mm below water level before sampling.

Sample number	8.8
Depth below surface of tailings	950 mm
Depth below interface with soil	0 mm
Description at time of sampling	Top soil and leaves
Description after drying	Grey clay, friable, roots
Microscopic examination	Large crystals and tailings

Sample number	8.9
Depth below surface of tailings	1000 mm
Depth below interface with soil	50 mm
Description at time of sampling	Brown soil with tailings penetration
Description after drying	Grey clay, friable
Microscopic examination	Agglomerates of very small crystals

Sample number	8.10
Depth below surface of tailings	1030 mm
Depth below interface with soil	80 mm
Description at time of sampling	Brown soil with black mottle
Description after drying	Fine grey silt
Microscopic examination	Quartz crystals bonded by small grey crystals

Sample number	8.11
Depth below surface of tailings	1110 mm
Depth below interface with soil	160 mm
Description at time of sampling	Yellow sand
Description after drying	Grey sandy clay with orange mottle
Microscopic examination	Microcrystalline mass of orange-red and grey crystals

Sample number	8.12
Depth below surface of tailings	1250 mm
Depth below interface with soil	300 mm
Description at time of sampling	Yellow sand with orange mottle, below water table
Description after drying	Grey and yellow mottled clay
Microscopic examination	Microcrystalline aggregates of grey, red orange crystals

Sample number	8.13
Depth below surface of tailings	1350 mm
Depth below interface with soil	400 mm
Description at time of sampling	Orange zone
Description after drying	Tan and orange mottled clay/sand
Microscopic examination	Microcrystalline aggregates of grey zones and orange zones

SITE 9 Co-ordinates 440E, 980N Date 7.5.84

Excavated by back-hoe. Bottom of hole was 200 mm below water level before sampling.

Sample number	9.4
Depth below surface of tailings	360 mm
Depth below interface with soil	0 mm
Description at time of sampling	Black top soil
Description after drying	Grey cemented sand
Microscopic examination	Small, mainly colourless crystals

Sample number	9.5
Depth below surface of tailings	390 mm
Depth below interface with soil	30 mm
Description at time of sampling	Tan soil
Description after drying	Brown/grey cemented sand
Microscopic examination	Small, mainly colourless crystals

Sample number	9.6
Depth below surface of tailings	500 mm
Depth below interface with soil	140 mm
Description at time of sampling	Red soil with live roots
Description after drying	Light grey/tan cemented crystals
Microscopic examination	Very small crystals, various colours

Sample number	9.7
Depth below surface of tailings	640 mm
Depth below interface with soil	280 mm
Description at time of sampling	Red sand
Description after drying	Light grey/tan cemented sand
Microscopic examination	Aggregates of colourless crystals with some black and orange components

Sample number	9.8
Depth below surface of tailings	840 mm
Depth below interface with soil	480 mm
Description at time of sampling	Grey sand below water table
Description after drying	Pink/grey cemented sand
Microscopic examination	Aggregates of coarse red/yellow/grey crystals

SITE 10 Co-ordinates 770E, 440N Date 4.5.84

Excavated by back-hoe. Bottom of hole was wet.

Sample number	10.10
Depth below surface of tailings	1150 mm
Depth below interface with soil	0 mm
Description at time of sampling	Black soil, pyrite
Description after drying	Grey cemented sand, no roots
Microscopic examination	Small mainly colourless crystals

Sample number	10.11
Depth below surface of tailings	1200 mm
Depth below interface with soil	50 mm
Description at time of sampling	Black soil, pyrite
Description after drying	Grey with a slight orange mottle, fine cemented sand
Microscopic examination	Small mainly colourless crystals bound around black stones

Sample number	10.12
Depth below surface of tailings	1300 mm
Depth below interface with soil	150 mm
Description at time of sampling	Base of black soil zone, pyrite
Description after drying	Grey sand with some black gravel
Microscopic examination	Large and small quartz crystals agglomerated around large black balls

Sample number	10.13
Depth below surface of tailings	1450 mm
Depth below interface with soil	300 mm
Description at time of sampling	Dark orange, pyrite
Description after drying	Buff-grey clay with black gravel
Microscopic examination	Tan crystals around black stones

SITE 11 Co-ordinates 360E, 930N Date 7.5.84

Excavated manually. Penetrated water table.

Sample number	11.4
Depth below surface of tailings	260 mm
Depth below interface with soil	0 mm
Description at time of sampling	Red layer
Description after drying	Orange fine sand with tailings
Microscopic examination	Variety of small crystals and tailings

Sample number	11.5
Depth below surface of tailings	290 mm
Depth below interface with soil	30 mm
Description at time of sampling	Black layer
Description after drying	Grey fine sand
Microscopic examination	Variety of very small crystals irregularly bonded together to form a grey mass

Sample number	11.6
Depth below surface of tailings	330 mm
Depth below interface with soil	70 mm
Description at time of sampling	Black layer
Description after drying	Grey fine sand
Microscopic examination	Aggregates of very small grey crystals
Sample number	11.7
Depth below surface of tailings	400 mm
Depth below interface with soil	140 mm
Description at time of sampling	Off white sand with black mottle
Description after drying	White/grey clay with occasional orange mottle
Microscopic examination	Aggregates of very small grey crystals
Sample number	11.8
Depth below surface of tailings	500 mm
Depth below interface with soil	240 mm
Description at time of sampling	Off white sand with black mottle
Description after drying	White/grey clay with occasional orange mottle
Microscopic examination	Grey mass of microcrystals
Sample number	11.9
Depth below surface of tailings	600 mm
Depth below interface with soil	340 mm
Description at time of sampling	Off white sand with black mottle
Description after drying	White/grey clay with occasional orange mottle
Sample number	11.10
Depth below surface of tailings	700 mm
Depth below interface with soil	440 mm
Description at time of sampling	Starting to become a clay
Description after drying	Grey/white sand
Microscopic examination	Mass of grey microcrystals
Sample number	11.11
Depth below surface of tailings	1000 mm
Depth below interface with soil	740 mm
Description at time of sampling	Clay with a yellow mottle
Description after drying	Grey/white sand with yellow zones
Microscopic examination	Grey and orange microcrystalline aggregates

SITE 12 Co-ordinates 360E, 850N Date 6.5.84

Excavated by back-hoe. Bottom of hole was 100 mm below water level before sampling.

Sample number	12.8
Depth below surface of tailings	1000 mm
Depth below interface with soil	0 mm
Description at time of sampling	Brown sand with black mottle
Description after drying	Grey cemented sand with orange mottle, roots
Microscopic examination	Large quartz crystals surrounded by orange microcrystals and tailings
Sample number	12.9
Depth below surface of tailings	1050 mm
Depth below interface with soil	50 mm
Description at time of sampling	Grey sand with black mottle
Description after drying	No report
Microscopic examination	Aggregates of large quartz crystals cemented by very fine material
Sample number	12.10
Depth below surface of tailings	1130 mm
Depth below interface with soil	130 mm
Description at time of sampling	Grey sand with black mottle
Description after drying	Fine grey sand with a yellow top layer, smell of H_2S
Microscopic examination	Aggregates of grey microcrystals Yellow surface was very thin
Sample number	12.11
Depth below surface of tailings	1170 mm
Depth below interface with soil	170 mm
Description at time of sampling	Grey sand
Description after drying	Grey cemented sand with a yellow surface, smell of H_2S
Microscopic examination	Microcrystalline aggregates of grey crystals with some orange and black stones
Sample number	12.12
Depth below surface of tailings	1330 mm
Depth below interface with soil	330 mm
Description at time of sampling	Grey sand with red mottle
Description after drying	Grey to tan coarse material
Microscopic examination	Aggregate of coarse crystals with a variety of colours

SITE 13 Co-ordinates 360E, 770N Date 4.5.84

Excavated by back-hoe. Dry hole; water table at base of hole.

Sample number	13.5
Depth below surface of tailings	400 mm
Depth below interface with soil	0 mm
Description at time of sampling	Top soil with black and orange microzones, no pyrite
Description after drying	Deep-brown coarse soil with lumps of white clay material
Microscopic examination	Red, orange and black microcrystals with tailings. The white lumps were a very fine microcrystalline mass

Sample number	13.6
Depth below surface of tailings	450 mm
Depth below interface with soil	50 mm
Description at time of sampling	Black soil with vegetation
Description after drying	Deep-red brown coarse soil
Microscopic examination	Red, orange and black microcrystalline aggregates

Sample number	13.7
Depth below surface of tailings	520 mm
Depth below interface with soil	120 mm
Description at time of sampling	Base of black zone
Description after drying	Deep-orange with brown mottle
Microscopic examination	Red, orange and black microcrystalline aggregates

Sample number	13.8
Depth below surface of tailings	640 mm
Depth below interface with soil	240 mm
Description at time of sampling	Top of an orange zone
Description after drying	Fine deep-orange sand
Microscopic examination	Mass of orange coarse crystals

Sample number	13.9
Depth below surface of tailings	900 mm
Depth below interface with soil	500 mm
Description at time of sampling	Middle of orange zone
Description after drying	Fine deep-orange sand/clay
Microscopic examination	Microfine orange crystals

Sample number	13.10
Depth below surface of tailings	1030 mm
Depth below interface with soil	630 mm
Description at time of sampling	Orange zone, tailings in root hole
Description after drying	Round black stones bonded with orange sand/clay
Microscopic examination	Round black stones bonded with orange crystals

Sample number	13.11
Depth below surface of tailings	1200 mm
Depth below interface with soil	800 mm
Description at time of sampling	Start of red mottled zone
Description after drying	Round black stones bonded with orange sand/clay
Microscopic examination	Round black stones bonded by microfine orange crystals

SITE 14 Co-ordinates 280E, 775N Date 4.5.84

Excavated by back-hoe. Bottom of hole was 200 mm below water level before sampling.

Sample number	14.7
Depth below surface of tailings	860 mm
Depth below interface with soil	0 mm
Description at time of sampling	Top soil, pyrite in soil
Description after drying	Fine grey to orange mottled sand with occasional roots
Microscopic examination	Various small crystals with tailings penetration

Sample number	14.8
Depth below surface of tailings	910 mm
Depth below interface with soil	50 mm
Description at time of sampling	Black-brown soil
Description after drying	Dark brown-grey fine sand with occasional roots
Microscopic examination	Small grey, black or colourless crystals

Sample number	14.9
Depth below surface of tailings	1000 mm
Depth below interface with soil	140 mm
Description at time of sampling	Brown soil
Description after drying	Yellow-brown mottle
Microscopic examination	Dark mass of coarse crystal aggregates

Sample number	14.10
Depth below surface of tailings	1040 mm
Depth below interface with soil	180 mm
Description at time of sampling	Orange soil and pyrite
Description after drying	Deep-tan sandy clay with dark patches
Microscopic examination	Dark mass of medium-size crystals

Sample number	14.11
Depth below surface of tailings	1140 mm
Depth below interface with soil	280 mm
Description at time of sampling	Orange soil and pyrite
Description after drying	Orange clay
Microscopic examination	Dark mass of fine crystals

Sample number	14.12
Depth below surface of tailings	1270 mm
Depth below interface with soil	410 mm
Description at time of sampling	Orange soil and pyrite
Description after drying	Bright orange clay with occasional black stone
Microscopic examination	Orange microcrystalline mass with round black stones

Sample number	14.13
Depth below surface of tailings	1430 mm
Depth below interface with soil	570 mm
Description at time of sampling	Orange soil, pyrite, below water level
Description after drying	Bright orange clay
Microscopic examination	Microfine tan crystals

SITE 15 Co-ordinates 260E, 830N Date 6.5.84

Excavated by back-hoe. Bottom of hole was 200 mm below water level before sampling.

Sample number	15.4
Depth below surface of tailings	540 mm
Depth below interface with soil	0 mm
Description at time of sampling	Black top soil
Description after drying	Grey cemented sand, some tailings, no roots
Microscopic examination	Variety of large crystals with tailings penetration

Sample number	15.5
Depth below surface of tailings	560 mm
Depth below interface with soil	20 mm
Description at time of sampling	Black soil with roots
Description after drying	Dark grey cemented sand
Microscopic examination	Variety of large quartz crystals aggregated by tailings

Sample number	15.6
Depth below surface of tailings	660 mm
Depth below interface with soil	120 mm
Description at time of sampling	Tan soil
Description after drying	Dark grey sand with orange mottle
Microscopic examination	Aggregates of quartz and black and orange crystals

Sample number	15.7
Depth below surface of tailings	760 mm
Depth below interface with soil	220 mm
Description at time of sampling	Tan soil
Description after drying	Grey and orange mottled sand
Microscopic examination	Aggregates of large quartz crystals bound together by microcrystals

Sample number	15.8
Depth below surface of tailings	820 mm
Depth below interface with soil	280 mm
Description at time of sampling	Brown sand
Description after drying	Dark grey and orange mottled sand
Microscopic examination	Aggregates of dark grey crystals

Sample number	15.9
Depth below surface of tailings	960 mm
Depth below interface with soil	420 mm
Description at time of sampling	Orange with red mottle
Description after drying	Brown and orange mottled sand
Microscopic examination	Aggregates of grey, red and yellow microcrystals

SITE 16 Co-ordinates 195E, 900N Date 8.5.84

Excavated manually.

Sample number	16.1
Depth below surface of tailings	-
Depth below interface with soil	0 mm
Description at time of sampling	Top soil with a dusting of tailings
Description after drying	Sample not described
Microscopic examination	Sample not described

Sample number	16.2
Depth below surface of tailings	-
Depth below interface with soil	60 mm
Description at time of sampling	A brown top soil The surface sample was covered with a thin layer of tailings
Description after drying	A red-black sand with tailings
Microscopic examination	Aggregates of a variety of small crystals with black units

Sample number	16.3
Depth below surface of tailings	-
Depth below interface with soil	100 mm
Description at time of sampling	Brown soil with an orange mottle
Description after drying	Mottled brown-orange soil with tailings penetration
Microscopic examination	Aggregates of crystals with black units and aggregates with orange units

Sample number	16.4
Depth below surface of tailings	-
Depth below interface with soil	200 mm
Description at time of sampling	Brown to orange sand with tailings penetration
Description after drying	Orange cemented sand with tailings penetration
Microscopic examination	Aggregates of small crystals and aggregates of very small crystals of tailings

Sample number	16.5
Depth below surface of tailings	-
Depth below interface with soil	300 mm
Description at time of sampling	Orange sand with tailings penetration
Description after drying	Orange and black fine cemented sand with tailings
Microscopic examination	Aggregates of very small orange crystals with black units. Individual aggregates of ultra-fine tailings

Sample number	16.6
Depth below surface of tailings	-
Depth below interface with soil	400 mm
Description at time of sampling	Orange sand with a slight grey mottle
Description after drying	Orange, grey and black mottled clay
Microscopic examination	Aggregates of very small orange crystals with black units and aggregates of small water-white crystals

Sample number	16.7
Depth below surface of tailings	-
Depth below interface with soil	470 mm
Description at time of sampling	Orange sand with a grey mottle
Description after drying	Orange, grey and black mottled clay
Microscopic examination	Aggregates of orange and grey crystals with black (slate?) units

SITE 17 Co-ordinates 020E, (8564) 030N Date 8.5.84

Excavated manually.

Sample number	17.1
Depth below surface of tailings	-
Depth below interface with soil	0 mm
Description at time of sampling	Hard crust with a dusting of tailings
Description after drying	Fine dark-grey soil with roots
Microscopic examination	Colourless and dark to black microcrystalline aggregates

Sample number	17.2
Depth below surface of tailings	-
Depth below interface with soil	60 mm
Description at time of sampling	Black soil
Description after drying	Dark grey/black soil with roots and tailings
Microscopic examination	Colourless and dark to black microcrystalline aggregates

Sample number	17.3
Depth below surface of tailings	-
Depth below interface with soil	130 mm
Description at time of sampling	Top of a black gravel zone
Description after drying	Dark grey/black soil with orange flashes
Microscopic examination	Colourless and dark to black micro-crystalline aggregates

Sample number	17.4
Depth below surface of tailings	-
Depth below interface with soil	200 mm
Description at time of sampling	Black/red gravel
Description after drying	Dark grey to brown soils with small orange gravel
Microscopic examination	Quartz crystals bound into aggregates by microcrystals. Gravels are little orange stones

Sample number	17.5
Depth below surface of tailings	-
Depth below interface with soil	270 mm
Description at time of sampling	Changing to a grey gravel
Description after drying	Lighter grey soil with orange mottle, no gravel
Microscopic examination	Orange quartz crystals bound together into aggregates by microcrystals

Sample number	17.6
Depth below surface of tailings	-
Depth below interface with soil	350 mm
Description at time of sampling	Grey gravel with orange mottle
Description after drying	Lighter grey soil with orange mottle, no gravel
Microscopic examination	Orange and colourless quartz crystals bound into aggregates by microcrystals

Sample number	17.7
Depth below surface of tailings	-
Depth below interface with soil	450 mm
Description at time of sampling	Grey gravel with orange mottle
Description after drying	Light grey cemented soil with orange mottle
Microscopic examination	Orange quartz crystals bound together into aggregates by microcrystals