Whitehorse Copper Mines

A Division of Hudson Bay Mining and Smelting Co. Ltd.

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date ?

Mr. J. Nickel
Regional Manager
Water Resources
200 Range Road
Whitehorse, Yukon

Dear Mr. Nickel:

Enclosed are 15 copies of the Whitehorse Copper Mines abandonment plan as prepared by Thompson Geotechnical Consultants Ltd. We are in agreement with the recommendations contained in the report and are prepared to carry them out over the next year.

We would welcome any comments or suggestions that you and the Water Board may have regarding abandonment at Whitehorse Copper Mines. If you feel that it would be worthwhile, we would also be pleased to host a tour of the areas under consideration for the Board.

We believe that this report addresses the issues which fall under the jurisdiction of the Water Board, and as outlined in your letter of 19 May 1982. Please accept our apologies for the timing - we did not want to release a premature product.

Please feel free to call me or Joe Janssens for any questions on policy, or Brian Thompson regarding technical details.

Yours very truly,

D. LINZEY
Vice President

DL:sm

Encs.

GEOTECHNICAL CONSULTANTS LTD.
THOMPSON

WHITEHORSE COPPER MINES
TAILINGS STORAGE AND
WATER RECLAIM SYSTEM

FINAL OPERATIONS
AND ABANDONMENT

Distribution:

5 copies	Whitehorse Copper Mines Whitehorse, Yukon
15 copies	Yukon Territorial Water Board Whitehorse, Yukon
2 copies	Thompson Geotechnical Consultants Ltd. West Vancouver, B.C.

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SYNOPSIS

This report provides detailed information on the Whitehorse Copper Mines tailings storage and water reclaim system and presents recommendations for final storage operations and the abandonment of each of the tailings storage and water reclaim facilities.

The report has been prepared for Whitehorse Copper and for submission to the Yukon Territorial Water Board for review and approval. It has been compiled from an earlier report which examined final operations and abandonment planning and the impact of a possible extension to the predicted mine life. The information contained herein follows directly from the conclusions of that study and from conclusions reached during a subsequent review.

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PART I

GENERAL BACKGROUND INFORMATION

1.0 WHITEHORSE COPPER MINES

1.1 Location

The Whitehorse Copper Mine is located about 5 miles south of the city of Whitehorse on the western side of the Yukon River as shown on Figure 1.

1.2 General Operations

Present operations involve underground mining based on a crater retreat method of caving. Milling is carried out using conventional grinding and flotation procedures and the average throughput is about 2500 tons per day. All of the mill tailings are stored in surface ponds and there is no underground backfilling.

Previous operations involved surface mining at several different sites. One of these is located immediately adjacent to the existing mine-mill complex. The others are located to the north and south along a common axis.

1.3 General History

Development of the surface deposits, the millsite, and the initial tailings storage facilities began in about 1966 and milling commenced in mid 1967. The surface deposits were relatively limited however, and milling was discontinued in mid 1971. Development of the underground orebody began in early 1971 and milling recommenced in early 1973.

1.4 Mine Life

Current estimates indicate that operations will be terminated in December, 1982. The shutdown will be permanent and there are no plans for further mining.

2.0 GENERAL SITE CONDITIONS

2.1 Topography

The area in the in the vicinity of the Whitehorse Copper mine is comprised of two gently sloping benches as indicated on Figure 2. The upper bench is bounded by a group of mountains to the west while the lower bench is bounded by the Yukon River.

Each bench is typified by a steep eastern slope. The slope below the lower bench rises directly from the Yukon River and is relatively uniform. The slope below the upper bench is quite irregular and is broken by several short, deeply incised valleys.

The upper bench contains the mine-mill complex and the tailings storage facilities as indicated on Figure 2. The lower bench contains the Alaska Highway, the White Pass Railway and several small industrial and residential developments.

2.2 Geology

The local topography was formed by both glacial and post glacial events and by general river erosion. The geology of the area reflects this history and in general, it is very complex.

The upper bench is typically underlain with outwash deposits, glacial till and bedrock. The outwash deposits are generally comprised of clean granular materials and are typically of limited extent. The glacial tills are generally sandy although several areas of finer grained material are also present. The till deposits are also highly erratic and in several locations there ar up to three or more separate, discontinuous sheets. The bedrock is comprised mainly of metamorphic units although basaltic lava flows are also present. The rock tends to be highly fractured and in some areas it is severely weathered.

The lower bench is typically underlain with outwash deposits and glacial till. The outwash deposits are relatively extensive and are comprised primarily of clean sand and gravel sized material.

2.3 Climate and Environmental Conditions

The Whitehorse climate is typified by hot summers and extremely cold winters. The area is generally considered to have a semi-arid climate and it typically receives less than 12 inches of precipitation a year as indicated in the summary of climatic data shown on Figure 3. Most of the precipitation falls during the late summer months as scattered showers although intense, short duration storms are also common.

Winter snow falls result in an average accumulation of about 3 to 4 feet and the snow cover is usually present from mid October to mid April. The extreme winter temperatures and light snow cover cause seasonal freezing of the ground to a depth of about 5 to 7 feet. Permafrost is not common but it is present in isolated pockets.

2.4 Surface Hydrology

Because of the local topography and geological conditions and because of the relatively dry environment, there are no major lakes or streams within the general site area. Most of the runoff is carried in the groundwater system or in perched surface flows and many of the smaller ponds and streams are seasonal and/or discontinuous.

Most of the summer precipitation is lost to evaporation and it has very little effect on surface and ground water conditions. The more intense or prolonged storms allow some recharge but significant changes in surface and groundwater flows are not usually observed.

The most severe runoff occurs in the late spring with melting of the winter snow pack. Because of the frozen ground conditions, virtually all of the meltwater becomes runoff and very little moisture is lost to the groundwater system. The spring thaw usually extends over a period of several weeks but rapid thaw and severe runoff condtions are quite common. Both surface and groundwater flows tend to decrease continually following the peak flows which accompany the spring runoff.

2.5 Vegetation

The area around the mine site is heavily forested with both deciduous and evergreen species. The trees have an average diameter of 6 to 12 inches and extend to an average height of about 30 feet. The deciduous species vary in age up to a maximum of about 20 years. The evergreens tend to be considerably older and range up to 80 years or more.

PART II

TAILINGS STORAGE AND WATER RECLAIM FACILITIES

1.0 TAILINGS STORAGE AND WATER RECLAIM SYSTEM

1.1 General Description

The Whitehorse Copper tailings storage and water reclaim system includes three tailings storage areas - the Old Pond, the 'A' Valley, and the 'B' Valley - and two water reclaim ponds - Copper Lake and Crater Lake - located as shown on Figures 4 and 5.

The three tailings storage areas operate independently and, in general, only one area is in use at any given time. Typical operations involve pipeline transport using a combination of pumped and gravity flow and direct discharge to the ponds from selected sites. The discharge sites are located so as to promote controlled deposition and the development of optimum conditions within each pond. The pond water levels are also controlled in conjunction with the above and in accordance with seasonal operating criteria.

The two water reclaim ponds operate together in a series configuration and form part of a closed circuit reclaim system. Virtually all of the effluent from the tailings ponds is recycled but a limited flow is spilled from the Crater Lake facility to accommodate variations in natural runoff and variations in demand. Make up water to offset these and other losses is provided as required by pumping from the Yukon River.

1.2 General History

The tailings storage and water reclaim system was developed in stages over the 15 year life of the mine from a small tailings pond located within the old pond area. The general progression included a major expansion of this original pond in the late 1960's and addition of the Crater Lake reclaim system in 1968. This was followed by development of the 'A' Valley storage area and the Copper Lake reclaim pond in 1976 and development of the 'B' Valley in 1979.

2.0 OLD POND STORAGE AREA

2.1 General Information

General Description

The old pond storage area is located immediately adjacent to the millsite as shown on Figure 5. It is the largest of the three storage facilities and presently contains more than 6.5 million cu. yd. of tailings. The tailings cover an area of approximately 140 acres and extend to a maximum depth of about 60 feet.

The tailings are retained by natural topography and by an extensive perimeter dyke system. Tailings are also retained within the pond itself by a series of internal dykes which are arranged in a terrace-like configuration.

The area is drained by a single, tower type decant located at the south end of the pond and by an overflow spillway located in the eastern portion of the perimeter dyke. Both outlets discharge to a common surface channel which drains to the Crater Lake reclaim pond.

History

The old pond was developed during early mining operations and the perimeter dyke system was completed to its present configuration by about 1968. The pond was filled to capacity in early 1976 but operations were extended until the fall of that year through construction of the 1976 cross dyke.

Since the fall of 1976, the southern portion of the pond has been used continuously for short term emergency storage and for the clarification of thicker overflow water. The remainder of the pond, with the exception of the area enclosed by the 1979 cross dyke, has been drained and out of service. This latter area was used for an experimental sand storage scheme in the summer of 1979 and for emergency storage during the first 9 months of 1980. It was drained shortly thereafter and is no longer in active service.

2.2 Geotechnical Conditions

The old pond and perimeter dyke are underlain with outwash deposits, glacial till and bedrock. The outwash deposits are most predominant and probably underlie most of the pond area. The glacial till is evident between the 'A' and 'B' Valleys and at local sites along the southeast periphery of the dyke. The bedrock is exposed at the head of the 'A' and 'B' Valleys.

2.3 Tailings Storage and Water Reclaim Facilities

2.3.1 Perimeter Dyke

General Description

The perimeter dyke is some 5500 feet in length and is comprised of two distinct sections - the main dyke and the north dyke - as shown on Figure 5. The dyke varies in height from a low of 10 to 15 feet along the southernmost edge of the pond to a maximum of 60 feet at the head of the 'A' Valley. The main portion of the dyke has a horizontal crest with an average elevation of 2578 feet. The north dyke and the southern extention of the main dyke slope upwards to the west and have crest elevations ranging from 2580 to 2593 feet.

Most of the main dyke has a crest width of 25 feet and a downstream slope of about 30 degrees. Steeper slopes of up to 35 degrees are also present. The north dyke has a 15 foot wide crest and a downstream slope of up to 35 degrees. Typical sections through both dykes are shown on Figure 6.

Dyke Construction

The perimeter dyke was developed during the early life of the mine and was completed to its present configuration by about 1968. There are no records of the work and little is known about foundation condition, fill materials, or construction methods. All of the available information has been derived solely from visual inspection and from several early photographs.

The available information indicates that the dyke is comprised primarly of granular earthfill materials borrowed from within the pond area. These materials appear to have been placed in a relatively random manner without sorting, compaction or survey control. There are indications, however, that the foundation area was stripped and that most of the fill was placed in horizontal layers corresponding to the various stages of construction. There are also indications that mine waste rock may have been used in the lower portions of the dyke and particularly in the section of dyke at the head of the 'A' Valley.

The general history and the observed conditions suggest that the higher portions of the dyke were probably developed using an upstream construction technique. The lower portions along the east and southeast boundaries of the pond appear to be comprised of borrowed fill only.

The southeast portion of the dyke is flanked by a fill constructed in 1975 to control seepage and improve dyke stability conditions. The fill is about 1,000 feet long and is comprised of waste rock and a sand and gravel filter zone as shown on Figure 6. The section of dyke protected by the fill is comprised primarily of gravelly sand.

2.3.2 Internal Dykes

The internal dyke system is comprised of two cross dykes and two pipeline support berms located as shown on Figure 5. The 1976 cross dyke varies from 5 to 8 feet in height and has a crest elevation of 2583 to 2585 feet. The 1979 cross dyke has an average height of 12 feet and an average crest elevation of 2596 feet. The crest width of the dykes varies from 15 to 25 feet and all have a downstream slope of 1.5:1. A typical section through the 1979 cross dyke is shown on Figure 6.

The pipeline support berms slope away from the mill at an average gradient of about one percent. They have an average crest width of 15 feet and side slopes of about 1.5 to 1.

All of the dykes and pipeline berms are founded on tailings and all except one have been constructed of borrowed earthfill materials and/or mine waste rock. The one exception is the pipeline support berm within the 1979 cross dyke area which is constructed of sand fill only.

2.3.3 Decant System

The old pond decant system is comprised of a single 12 inch diameter victaulic type riser pipe and a steel discharge culvert which passes through the dam. The riser pipe is approximately 7 feet high and is supported by a timber tower founded on a concrete base. The tower has been distorted by ice movements and settlement of the tailings.

The remains of a second decant are located approximately 200 feet to the north-east of the existing structure. The second tower reportedly collapsed in 1976 due to ice loading during the winter period and the riser pipe broke off below the surface of the tailings. The structure could not be repaired and is now buried beneath slimes tailings.

3.0 'A' VALLEY STORAGE AREA

3.1 General Information

General Description

The 'A' Valley storage area is located to the north and downstream of the old pond as shown on Figure 5. It is the second largest storage facility and presently contains more than 2.5 million cu. yds. of tailings. The tailings cover an area of approximately 30 acres and extend to a maximum depth of about 95 feet.

The tailings are retained by a high earthfill dam located near the mouth of the valley. The pond is drained by a tower type decant structure located near the east abutment of the dam and all runoff is discharged to the Copper Lake reclaim pond. The decants are the only drainage outlet for the valley and there is no overflow spillway.

History

The 'A' Valley was developed over a three year period from 1975 to 1978 and the dam was raised to an initial height of 100 feet. Tailings storage operations commenced in the fall of 1976 and the area was used continuously until the pond was filled to capacity in the winter of 1979 - 80.

During the spring of 1980, a surficial failure occurred on the downstream slope of the dam. The failure did not encroach on the main body of the structure but the pond was drained as a precautionary measure. A subsequent investigation revealed that an uncontrolled seepage condition had developed within the dam and that stability conditions were limited. Interim stabilization measures were subsequently carried out in the fall of 1980 and major construction to stabilize and raise the dam was carried out during the summer of 1981. The pond is still in a drained condition and has not been used since.

3.2 Geotechnical Conditions

The 'A' Valley is formed in bedrock overlain with a sequence of glacial deposits. The deposits on the western side of the valley are relatively thin and are comprised primarily of a sandy till. The deposits on the eastern side are more extensive and include a thick cap of fine grained till and an underlying stratum comprised of various granular materials.

The underlying bedrock is quite variable. In the upper reaches of the valley it is typically intact and unweathered. In the lower reaches it tends to be highly weathered and in some places it has an almost soil-like consistancy.

The invert of the valley is underlain with alluvial deposits comprised primarily of clean sands and gravels. The depth of the alluvium varies along the length of the valley and generally increases in the downstream direction. Near the 'A' Dam it extends to a maximum depth of about 30 feet.

The lower 'A' Valley, downstream of the dam site, is underlain with extensive deposits of clean granular materials and a stratum of glacial till. The depth of the deposits appears to increase in the downstream direction.

3.3 Tailings Storage and Water Reclaim Facilities

3.3.1 'A' Dam

General Description

The 'A' Dam is approximately 115 feet high and has a crest elevation of 2516 feet. The crest width is 25 feet and the upstream and downstream slopes are 1.5:1 and 2:1 respectively.

Dam Construction

The 'A' Dam is a zoned earthfill structure with a relatively simple cross section as shown on Figure 7. It is comprised of a massive core of glacial till - the original structure - and a downstream shell of clean, free-draining gravel - the 1981 addition. It also includes a gravel and waste rock underdrain system which extends across the entire width of the valley bottom and up each abutment beneath the till core.

The dam is founded on weathered bedrock and alluvial deposits. The weathered bedrock underlies the east half of the valley bottom and extends up each abutment. The alluvial deposits underlie the west half of the valley bottom and extend to depths of up to 30 feet. There is no seepage cutoff system and seepage flows pass freely through the alluvial deposits and underdrain system to the Copper Lake reclaim pond located downstream.

The dam contains the remnants of the seepage interceptor drain constructed in 1980 as part of the interim stabilization works. The drain is approximately 2.5 feet wide and 20 feet deep and extends along the entire length of the dam. It contains a 4 inch diameter plastic collector drain and 5 vertical steel culverts (sumps) at intervals along the trench length. The sumps have been backfilled with sand and gravel and capped with concrete and the entire system has been buried with a cover of impervious fill.

The dam also contains extensive instrumentation to monitor seepage conditions and survey reference points to monitor possible settlements or horizontal movements of the crest.

3.3.2 Decant System

The 'A' Valley is drained by a tower type decant system. Each of the two decants consists of 12 inch diameter, victaulic type riser pipe, enclosed and supported by a timber tower structure. The riser pipes discharge to concrete encased steel culverts which pass through the dam section. The towers are enclosed on three sides with timber planking. The fourth side is open but screened to protect the riser pipe intake. The towers and riser pipes are founded on a common concrete base on a natural bench in the valley slope. The towers are approximately 40 feet in height and presently extend to elevation 2504 feet.

The towers are accessed by a walkway which extends from the original dam crest at elevation 2504 feet. The walkway is comprised of two steel sections 30 and 45 feet in length and is supported by the towers, the dam crest, and a central pier structure.

4.0 'B' VALLEY STORAGE AREA

4.1 General Information

General Description

The 'B' Valley storage area is located immediately west of the 'A' Valley as indicated on Figure 5. It is the smallest of the three storage facilities and presently contains about one million cubic yards of tailings. The tailings cover a surface area of approximately 17 acres and extend to a maximum depth of about 115 feet.

The tailings are retained by the natural topography and by a high earthfill dam located near the mouth of the valley. The pond is drained by a tower type decant structure located on the east abutment on the dam and all runoff is discharged to the Copper Lake reclaim pond by means of a 2000 foot long insulated, gravity pipeline. The decants are the only drainage outlet for the valley and there is no overflow spillway.

History

The 'B' Valley facilities were constructed over a three year period from 1979 to 1981. Tailings storage operations began in October 1980 and the valley has been in continuous use since that time. The various facilities have performed as expected and no problems have been encountered.

4.2 Geotechnical Conditions

Upper Valley

The upper and middle reaches of the 'B' Valley are formed in bedrock overlain with a shallow cover of glacial and post glacial deposits. The cover on the east side of the valley is relatively thin and is comprised primarily of a sandy till. The cover on the west side is somewhat thicker and is comprised of a stratum of outwash gravels overlain with a thin cap of ablation till.

The bedrock exposed along the valley walls is quite variable and both intact and highly weathered zones are present. In some areas the weathering has caused extensive fracturing while in others it has reduced the rock to an almost soil-like consistency.

Lower Valley

The lower portion of the valley is formed in a complex sequence of glacial and interglacial deposits and the valley invert is underlain with up to 50 feet of coarse granular alluvium. The glacial and interglacial deposits are horizontally bedded and overlie weathered bedrock. The general sequence includes three major till sheets, two thin interglacial strata, and a surficial mantle of outwash deposits. One of the interglacial strata is located below the original valley bottom while the other lies above.

The lower interglacial stratum is comprised of sand and gravel and large blocks of weathered till. It varies in thickness and tends to pinch out in a downstream direction. It extends into the east abutment of the 'B' Dam but does not continue into the west abutment.

The upper stratum is comprised of clean sand and it extends through each abutment of the 'B' Dam. On the eastern side of the valley, in the vicinity of the decants, the stratum has an average thickness of about 12 feet and it extends from elevation 2480 to elevation 2492 approximately. On the west side, the stratum is approximately 5 feet thick and is exposed between elevations 2497 and 2505 approximately. The western stratum supports a moderate flow of groundwater seepage which originates in the upland area to the west of the 'B' Valley.

The lower 'B' Valley area, downstream of the dam site, is underlain with extensive deposits of granular alluvium. Permafrost is also present in the large swampy area immediately west of the Canyon Crescent subdivision.

4.3 Tailings Storage and Water Reclaim Facilities

4.3.1 'B' Dam

General Description

The 'B' Dam is approximately 80 feet high. It has a crest width of 25 feet and a nominal downstream slope of 2:1. The downstream slope is benched and includes a sloping access ramp. The crest of the dam is located at elevation 2516 feet - the same as the 'A' Dam.

Dam Construction

The 'B' Dam is a zoned earthfill structure with a relatively complex section as shown on Figure 8. The section is comprised of a downstream zone of freely draining granular materials, an upstream zone of low permeability, fine grained fills, and an impervious upstream facing. The main body of the dam is founded on the coarse alluvial deposits which underlie the valley but the impervious facing extends to the till strata within each abutment and to the till and weathered bedrock underlying the valley alluvium.

Where the dam abuts the eastern sand stratum, the impervious facing is connected to a shotcrete seal which extends into the abutment and around the decant bay. Where the dam abuts the western exposure of the sand stratum, the impervious facing extends an additional 30 feet into the slope and the downstream slope of the dam has been extended and flattened so as to develop a berm-like configuration.

4.3.2 Decant System

The 'B' Valley decant system consists of two 24 inch diameter structural steel riser pipes and two 15 inch diameter discharge culverts which pass through the dam in a reinforced concrete box. The riser pipes are free standing and extend from a concrete foundation at elevation 2465 feet to the crest of the dam at elevation 2516 feet. The riser pipes and discharge culverts are founded on a bench excavated into dense glacial soils in the valley slope.

Water is removed from the pond through 12 inch diameter intakes located in the side of the riser pipes. The pond level is raised by closing off the intakes with a steel cover plate and installing new intakes at specific elevations. The two riser pipes and discharge culverts are separate units and one is always maintained for standby use and emergency overflow protection.

The riser pipes and decant intakes are protected by a floating building. The building is heated and insulated, and contains a bubbler system to prevent ice build-up during winter operations. The intakes are protected from floating debris by a series of screens. The decants and service building are accessed by an elevated walkway and ladder system.

5.0 COPPER LAKE RECLAIM POND

The Copper Lake reclaim pond is an artificial body of water. It was constructed in 1977 as part of the 'A' Valley project and has been in continual use since that time. It has a surface area of approximately one-half acre and a maximum depth of about 20 feet.

The pond is maintained by an impervious cutoff which extends across the entire width of the valley. The cutoff is comprised of a silty glacial till material which extends to a till stratum underlying the valley alluvium. The crest of the cutoff is located at elevation 2398 ft., approximately 2 feet above the valley floor.

The pond is charged by seepage flows from beneath the 'A' Dam and by decant outflows from both the 'A' and 'B' Valleys. There is no outlet to the pond and all inflows are discharged to the Crater Lake reclaim pond by a combination of pumping and gravity flow. The pond level generally fluctuates very little and is typically maintained at elevation 2495 - approximately 2 feet below the general valley floor.

6.0 CRATER LAKE RECLAIM POND

The Crater Lake reclaim pond is a natural body of water which is formed in bedrock. It has a surface area of approximately one acre and a maximum depth of about 25 feet.

The lake serves as a major collector in the water reclaim system. It is charged by natural runoff, by outflows from the old tailings pond, and by outflows from the Copper Lake reclaim system. It also receives water from the Yukon River by means of a pumping system and a gravity return line from storage tanks located at the millsite.

The combined inflows are pumped to the mill for reuse as process water but an outflow from the lake is always maintained. The outflow is controlled by the quantity of water pumped from the Yukon River and varies according to demand and reclaim flows.

PART III

GENERAL ABANDONMENT CONSIDERATIONS

1.0 OLD POND STORAGE AREA

1.1 Dyke Stability

1.1.1 General Stability Considerations

Little is known about the design and construction of the perimeter dyke and virtually nothing is known about fill or seepage conditions within the dyke itself. Hence, little is known about its existing state of stability.

To define the stability conditions, it would be necessary to carry out a drilling and instrumentation program to determine fill and seepage conditions at several representative sections along the length of the dyke. It might also be necessary to monitor seepage conditions over a one year period to determine seasonal variations.

1.1.2 Surface Erosion

Most of the crest and downstream slopes of the perimeter dyke are in fair condition but moderate surface erosion is occuring on the face of the north dyke and on the main dyke near the head of the 'A' Valley. The erosion is being caused by rainfall and meltwater runoff and by local mudflows which develop during the spring thaw period.

The erosion conditions do not present an immediate threat to the stability of the dyke. There are also indications that the conditions may be improving as a result of natural revegetation. There is, however, a general concern that the conditions could become more severe with time and could eventually jeopardize the stability of the dyke.

In view of these conditions, it would be desirable to carry out works to ensure that further erosion cannot occur. Because of the steep slopes and high fills, vegetation of the dyke slope would be the only practical treatment. This may not be all that successful, however, because of the general soil conditions and harsh environment. Nevertheless, it would be a reasonable first stage treatment, and further measures could be defined on the basis of its success.

1.2 Surface Drainage

1.2.1 Existing Conditions

Surface drainage within the old pond is controlled by topography and the system of internal dykes. These features have created four distinct 'watersheds' as shown on Figure 5 and summarized following:

Area 1:	Contained by the 1979 cross dyke
Area 2:	Contained by the 1976 and 1979 cross dykes and the north dyke.
Area 3:	Contained by the perimeter dyke, the 1976 cross dyke and the 1976 pipeline berm.
Area 4:	Contained by the perimeter dyke and the 1976 pipeline berm.

Area 1 includes approximately 50 acres. It is subdivided by the pipeline support berm but the two portions are hydraulically connected by a 24 inch diameter culvert located near the 1979 cross dyke. The area drains southward and into Area 4 by means of a flow through spillway near the south end of the cross dyke. Area 1 is generally well drained but water tends to pond adjacent to the cross dyke on the north side of the culvert and in the low area adjacent to the spillway.

Area 2 includes some 15 acres and is also subdivided by the pipeline berm. The two portions are hydraulically connected by a channel beneath a small bridge but because of elevation differences, there is only a limited flow between the two portions. The eastern half drains eastward into Area 3 and is generally well drained. The western half can only be drained through the bridge crossing and since it is lower than the eastern half, it tends to pond water.

Area 3 encloses approximately 30 acres. It is generally dry and well drained although ponding occasionally occurs in settled areas adjacent to the perimeter dyke. The area drains eastward and out an overflow spillway. The spillway discharges to an open channel which in turn discharges to the Crater Lake reclaim channel.

Area 4 includes some 40 acres. It collects runoff from Areas 1 and 2 and receives mill discharges as noted previously. Because of the topography of this area, and the location of the decant, the southern portion is not freely draining and a shallow pond is always present. This pond encroaches on the dyke during periods of heavy runoff and only a narrow beach of slimes tails is exposed when the pond is drained to its lowest level.

The surface drainage conditions in all of the above areas are generally becoming worse as a result of ongoing settlement of the tailings. The total area of ponded water has increased significantly since the pond was last used and many of the ponds have become perennial features.

1.2.2 Abandonment Considerations

The existing surface drainage system is not suitable for abandonment as it allows excessive ponding of water adjacent to the dykes and cannot provide fail-safe drainage under flood conditions. The surface ponding promotes continual recharge of subsurface waters and has an adverse effect on dyke stability conditions.

The general drainage conditions will continue to deteriorate with time as a result of ongoing settlement of the tailings. The settlement will result from consolidation of the tailings solids and from thawing of entrapped ice, and up to several feet of additional settlement would be expected in some areas over the next 5 to 10 years. The most extreme settlement will occur in those areas which presently pond water and the ponding will become more extensive as a result.

To meet basic abandonment requirements and to improve dyke stability conditions as best possible, it will be necessary to develop positive drainage conditions within all areas of the pond and provide fail-safe spillways as required. Several alternative drainage schemes are available and numerous variations can be applied to each scheme. The alternatives are limited, however, by topography and spillway considerations. The basic schemes and the most feasible variations are as follows:

Drainage Area			Drainage Alternatives
Area 1:		i)	Total runoff to Area 2
	or	ii)	Total runoff to Area 4
	or	iii)	Northern portion to northern portion of Area 2 via new cross dyke spillway -southern portion to Area 2
	or	iv)	Northern portion to northern portion of Area 2 via new cross dyke spillway - southern portion to Area 4
Area 2:		i)	Northern portion to new spillway in North Dyke - southern portion to Area 3
	or	ii)	Northern portion to southern portion - southern portion to Area 3
Area 3:		i)	Total runoff to existing spillway in perimeter dyke
	or	ii)	Total runoff to new spillway in perimeter dyke
Area 4:		i)	Total runoff to new spillway in perimeter dyke

The most suitable drainage scheme will depend on key drainage requirements and on the general drainage discharge considerations outlined in the following section.

1.3 Drainage Discharge

1.3.1 Original Conditions

The area now occupied by the old pond was originally comprised of a hummocky bench which contained several large depressions. It also contained the upper end of the 'A' Valley and the head of the 'B' Valley. The area was relatively well drained and there were no ponds or surface streams.

The main inflows to the area were direct precipitation and meltwater runoff. The northeast corner of the area was also charged by a small discontinuous surface flow which originated in several small lakes to the west.

All runoff was discharged to the 'A' and 'B' Valleys with the majority of the flow going to the former. There was no drainage to the Crater Lake watershed.

1.3.2 Operating Conditions

During initial operations in the old pond area, there was no reclaim system and both natural runoff and process water were discharged directly to the 'A' Valley. When the Crater Lake system was constructed, these flows were discharged to that area and the flows in both watersheds were changed accordingly. Later, with the continued expansion of the pond, the outflow to the Crater Lake watershed also included runoff which would normally have drained to the 'B' Valley.

Neither of the latter two changes appear to have had a significant impact on conditions in the 'A' or 'B' Valleys or on conditions in the lower Crater Lake watershed. There are, however, records which suggest that landsliding problems near the Yukon River may have been related to the discharge of process water to the 'A' Valley during initial operations. The problems reportedly developed shortly after operations began but were not experienced after the reclaim system was developed.

1.3.3 Abandonment Conditions

When operations are terminated, various portions of the total runoff from the old pond can be discharged to each of the three adjacent watersheds. The distribution of the runoff would depend on the surface drainage scheme and there are numerous flow combinations. There are, however, limits to these flows as summarized following.

Receiving Watershed	Minimum flow (% of total)	Maximum Flow (% of total)
Crater Lake	Total runoff from Area 4 (30%)	All surface runoff (100%)
'A' Valley	Nil	All surface runoff except Area 4 (70%)
'B' Valley	Nil	Runoff from northern portion of Area 1 plus runoff from northern portion of Area 2 (25%)

In order to discharge to Crater Lake and the 'B' Valley, it would be necessary to construct two new spillways in the perimeter dyke. In order to discharge to the 'A' Valley, it would be necessary to close the existing spillway and construct a new spillway approximately 200 feet to the north.

1.3.4 Abandonment Considerations

The most suitable discharge scheme for the old pond will depend on abandonment considerations for the 'A' and 'B' Valley storage areas and the Crater Lake reclaim pond. It will also depend on surface drainage requirements within the old pond area as discussed previously.

1.4 Other Abandonment Considerations

Revegetation of the old pond would be desirable from an environmental point of view It could also have a beneficial effect in reducing surface recharge and attenuating peak runoff flows. There is, however, a fine line between the merits of vegetation and the possible detrimental effect it could have on positive drainage. Because of the general stability conditions in the old pond area, positive surface drainage is of key importance and care must be taken to ensure that is is not inadvertantly lost through revegetation or other surface stabilization measures.

General clean up and reclamation of borrow areas and other construction peripherals would also be desirable. Some of this work has already been completed and only a minor amount is still outstanding.

2.0 'A' VALLEY STORAGE AREA

2.1 Dam Stability

The 'A' Dam has been designed for abandonment and there are no specific concerns regarding its long term stability. It will, however, be necessary to develop positive drainage conditions within the pond to minimize surface recharge and to promote drawdown of the phreatic surface. This is particularly important in view of previous experience which suggests that the phreatic surface may remain near the boundary of the core and shell zones as long as recharge can occur.

2.2 Surface Drainage

2.2.1 Existing Conditions

The tailings profile which presently exists within the 'A' Valley is somewhat atypical. It was developed during the last stages of previous operations by discharging slimes tailings to the head of the valley and by drawing off effluent at the east end of the dam near the saddle. The profile has also been affected by extreme settlements caused primarily by the melting of entrapped ice.

In the lower part of the valley, between the decants and the saddle, the surface of the tailings is nearly horizontal and lies at an average elevation of 2494 feet. Upstream of the decants, the tailings surface rises at an average gradient of 0.6 percent to elevation 2504 at a point approximately 900 feet below the old pond perimeter dyke. In the upper most end of the valley, the surface rises more steeply at an angle of 1.5 percent. At the extreme head of the valley, tailings have been deposited to elevation 2522 and a portion of the perimeter dyke has been buried to an estimated depth of 7 to 10 feet.

Under normal operating procedures, the middle and upper portions of the profile would rise at slightly steeper gradients and the lower portion would drop off sharply below the decants. The steeper slopes in the upper and middle portions of the valley would result from the wider gradation of tailings solids while the sharp drop off below the decants would result from the location of the decants relative to the downstream limits of the pond.

2.2.2 Abandonment Considerations

If future operations in the 'A' Valley are carried out as they have been in the past, the final tailings profile will resemble that which presently exists. The shallow depression in the lower valley area will tend to become deeper and more pronounced, however, and it is possible that the level of the tailings near the saddle may not rise at all during the remaining operating life. When operations cease, the upper and middle portions of the valley will be self draining but the lower portion will pond water.

To meet basic abandonment requirements and to satisfy the dam stability criteria outlined previously, it will be necessary to develop positive surface drainage conditions in the lower pond area. It will also be necessary to abandon the existing decant system and provide a fail-safe overflow spillway.

To develop positive drainage conditions, it will be necessary to discharge tailings to the head of the valley and remove effluent from the extreme downstream end of the pond near the saddle. It will not be feasible to use the existing decant system as it restricts deposition in the lower pond area and would prevent the development of a continuous slope.

The simplest means of meeting the general drainage requirements would be to construct a spillway through the saddle between the 'A' and 'B' Valleys and to utilize this as a decant during final operations. This would then promote deposition in the lower pond area and would develop a positive slope over the entire length of the valley. The feasibility of a saddle spillway is dependent, however, on the relative elevations of tailings in each valley during final operations.

An alternative to the saddle spillway would be a spillway to the 'A' Valley itself. The most feasible route would be along the existing Copper Lake access road which is underlain with bedrock and glacial till. However, because of the limited stability of the steep slope above the road, the spillway would be prone to blockage by debris and protective measures would be required. The 1,000 foot length of the spillway combined with the protective measures would make this a considerably more involved and more costly alternative.

The spillway would have to be designed to accommodate peak runoff flows from the total contributing watershed. It would not be subject to a continual flow and would not normally be subject to trickle flows during the winter period.

2.3 Drainage Discharge

2.3.1 Original Conditions

Prior to its development, the 'A' Valley was dry and well drained and there were no natural surface flows. A small discontinuous stream reportedly existed near the head of the valley but this was primarily a result of seepage from the old pond area.

The main inflows to the valley were runoff from the immediate watershed and runoff from the area now occupied by the old pond. All of the runoff was discharged to the lower 'A' Valley through groundwater flow.

2.3.2 Operating Conditions

When the old pond storage area was developed, the flows in the 'A' Valley were increased by an amount equal to the volume of mill process water. When the Crater Lake reclaim system was added, both the process water and the natural runoff were diverted and the flows in the valley were reduced below their original levels. When the 'A' Dam and Copper Lake were developed, the remainder of the runoff was diverted and the upper valley watershed was effectively lost.

The increased outflows experienced during the early operations may have caused problems along the Yukon River as noted previously. However, neither of the latter events, which resulted in reduced flows, appear to have had a significant impact and there are no reports of any problems or abnormal conditions.

2.3.3 Abandonment Conditions

When operations are terminated, the total discharge from the 'A' Valley will include runoff generated within the 'A' Valley watershed and up to 70 percent of the runoff from the old pond area depending on the surface drainage scheme. The flow can be discharged to the lower 'A' Valley or possibly to the 'B' Valley depending on final tailings elevations.

If the maximum combined flow is discharged to the lower 'A' Valley, the resulting conditions will be similar to what existed prior to development. If drainage from the old pond area is not included in the total runoff, the resulting conditions will be less like the original conditions but significantly better than what presently exists.

If the runoff from the 'A' Valley is discharged to the 'B' Valley, the lower 'A' Valley will receive only a limited inflow comprised of seepage from beneath the 'A' Dam. If this occurs, the conditions in the lower valley would remain virtually unchanged.

2.3.4 Abandonment Considerations

There are no concerns with respect to the discharge of runoff to the Lower 'A' Valley since the maximum possible flow will be similar to what existed prior to development and the minimum possible flow will be similar to what presently exists.

2.4 Other Abandonment Considerations

Revegetation of the 'A' Valley tailings pond would be desirable from an environmental point of view. It would also be desirable in that it would slow runoff and attenuate peak outflows. However, the latter is not a critical concern and would not warrant the costs involved.

General cleanup and reclamation of borrow areas, haul roads and other construction peripherals would also be desirable. This work was begun in the fall of 1981 and the bulk of it is now complete.

3.0 'B' VALLEY STORAGE AREA

3.1 Dam Stability

Because of the geotechnical conditions within the 'B' Valley, the valley will tend to pond water and the tailings will always remain in a saturated state. The 'B' Dam has been designed for these conditions and at this time there are no concerns regarding its long term stability. There are, however, various concerns with respect to seepage through the abutment sand strata and the long term stability of the abutment slopes.

The seepage and stability conditions within the abutment areas will vary with further use of the pond. The final, long term conditions will depend primarily on the final tailings configuration and the extent to which the sand strata are covered. To minimize long term seepage problems, the final tailings surface near the dam should be either :

i) at elevation 2496.5 feet

or, ii) higher than elevation 2508 feet.

Condition (i) would ensure that the eastern sand strata is covered to the maximum extent possible and that the western sand strata remains above the final pond level. Condition (ii) would ensure that the western stratum received the minimum cover needed to significantly reduce seepage flows.

If condition (i) is developed, a limited seepage problem would be expected along the east abutment and remedial measures to improve the stability of the slope would be required. If condition (ii) were in effect, only minor seepage would be expected on the east abutment and remedial measures should not be necessary. A limited seepage problem could exist on the west abutment, however, and treatment would likely be needed for that area. A configuration between (i) and (ii) would reduce seepage on the east abutment and increase seepage on the west abutment. A final tailings level above elevation 2508 would improve conditions on both abutments.

Remedial measures, if required, would depend on final conditions. On the east abutment, long term control could be attained through construction of a granular drainage blanket. On the west abutment, the most suitable alternative would depend on the final tailings configuration. If the pond was filled to near design capacity, a drainage blanket would probably be sufficient. However, if the final tailings surface was within or just above the sand stratum, the most suitable solution would probably involve a modified spillway design as outlined later in this report.

A full evaluation of seepage and stability conditions will require instrumentation of the dam and abutment areas. This work should be carried out while the pond is still in operation in order to assess changes which will occur when operations are terminated.

3.2 Surface Drainage

3.2.1 Existing Conditions

Tailings are presently being discharged from a site near the head of the 'B' Valley and the pond elevation is fixed at elevation 2496.5 feet. The tailings surface slopes continually downward towards the dam at an average angle of about 0.5 to 1.0 percent and there are no major discontinuities in the general profile. Near the dam itself, the surface of the tails is roughly horizontal and there is only a minor slope towards the east abutment and the decants.

3.2.2 Abandonment Considerations

Because of conditions within the 'B' Valley, the tailings will tend to remain in a saturated condition and complete internal drainage will probably never occur. However, in view of the concerns regarding abutment stability, it would be prudent to develop positive surface drainage conditions to reduce seepage recharge as best possible.

Positive drainage of the upper portion of the valley is presently available and will continue to be as long as tailings are discharged from the same site. Positive drainage of the lower part of the valley can be attained by constructing an overflow spillway through the western abutment of the dam and locating the invert of the spillway at a suitable elevation. Special measures to control infilling of the lower pond area will not be required since the location of the decants promotes a relatively even distribution of tailings.

The design and construction of the spillway will depend on further use of the pond and the final tailings configuration. It will be complicated by the presence of the sand stratum and by the presence of year round flows.

If the pond is filled to its maximum design level, construction of the spillway would require excavation of a channel of the order of 15 feet deep and approximately 250 feet long. If the pond is not filled to capacity. A larger excavation will be required. In the worst case, if the pond level is not raised at all, the spillway excavation would be approximately 25 feet deep and of 450 feet in length.

If the pond is not filled to design capacity, the invert of the spillway excavation may intersect or lie just above the sand stratum. Should this occur, it will be necessary to utilize a modified design to control internal erosion and prevent water loss into the sand stratum. The modified design would have an indirect benefit, however, in that it would automatically improve general seepage and stability conditions in the west abutment area.

The spillway will have to be designed to accommodate peak runoff flows from the total contributing watershed. It will also have to be designed to accommodate trickle flows during the winter period without glaciation.

3.3 Drainage Discharge

3.3.1 Original Conditions

Prior to its development, the 'B' Valley was dry and well drained and there were no surface flows. It was charged by runoff from the immediate watershed and by groundwater flows from the watershed areas to the east and south. The combined inflows were discharged to the lower valley and groundwater flow. The groundwater table was located at a depth of about 30 feet and the total outflow passing the dam site during the summer period was of the order of 15 to 20 gallons per minute.

3.3.2 Operating Conditions

When the old pond was developed, a small portion of the total inflow to the 'B' Valley was diverted and the outflow from the valley was reduced accordingly. When the 'B' Dam was constructed, the entire upper valley watershed was lost and the discharge to the lower valley area was reduced further. Neither of these events caused any noticeable changes in downstream conditions and no problems were reported.

However, during construction of the 'B' Dam, pumping was carried out to dewater the cutoff excavation. When the flow was discharged to Copper Lake (via the 'A' pond) problems were immediately experienced in the Canyon Crescent area and both surface and groundwater flows were reduced. When the flow was returned to the 'B' Valley, the conditions in the lower valley area returned to normal within a very short period of time.

3.3.3 Abandonment Conditions

When operations are terminated, the runoff from the 'B' Valley can be discharged to the lower 'B' Valley only. The minimum discharge would include runoff generated within the existing 'B' Valley watershed. The maximum discharge would depend on the drainage schemes chosen for the other two storage areas and could include up to 70 percent of the runoff from the old pond and virtually all of the runoff from the 'A' Valley.

If the discharge is comprised of runoff from the 'B' Valley only, the net outflow to the lower 'B' Valley will be the same as what existed prior to development and conditions will be returned to their original state. If however the discharge includes runoff from all or portions of the other storage areas as well, the net outflow will be correspondingly higher.

3.3.4 Abandonment Considerations

The impact of increased discharges to the lower 'B' Valley cannot be established with the available data. The available data and the experiences during construction of the dam would suggest, however, that the lower valley area is sensitive to changes and that any changes could create problems in the Canyon Crescent area.

In view of the above, it would be prudent to restrict inflows to the 'B' Valley and to attenuate peak outflows to reduce their impact on the lower valley system. It would also be prudent to continue monitoring conditions within the lower valley area in order to confirm the impact of any changes which might occur following abandonment of the 'B' Valley.

3.4 Other Abandonment Considerations

Revegetation of the 'B' Valley tailings pond would be desirable from an environmental point of view. It would also be desirable in that it would assist in the attenuation of peak runoff flows. However, because the tailings will probably remain in a saturated condition, it is unlikely that revegetation will be feasible.

General cleanup and reclamation of borrow area, haul roads and other construction peripherals would also be desirable. This work was begun in the fall of 1981 and only a limited amount is still outstanding.

4.0 COPPER LAKE RECLAIM POND

The Copper Lake reclaim pond presently receives surface runoff from the 'A' and 'B' Valleys and seepage flows from beneath the 'A' Dam. The combined flows are pumped to the Crater Lake reclaim pond and there is no discharge to the lower 'A' Valley.

When operations are terminated, the lake will receive seepage inflows from beneath the 'A' Dam. It may also receive runoff from the upper 'A' Valley and old pond areas depending on spillway configurations. These flows will not exceed the original 'A' Valley flows and can be safely discharged to the lower 'A' Valley as outlined previously.

Abandonment of the lake will require construction of a 'spillway' through the existing seepage cutoff and the excavation of a short length of channel to allow outflows to return to the groundwater system. The spillway and channel should be designed to accommodate trickle flows during the winter period and should be constructed before operations are terminated to prevent unnecessary flooding of the lake and damage to the floating pumphouse.

5.0 CRATER LAKE RECLAIM POND

Prior to the development of the Whitehorse Copper site, Crater Lake received inflows from an upland watershed only. The outflows from the lake discharged to another small lake located about one half mile downstream and the combined waters were drained by groundwater flow.

The lake now receives the natural inflow, an indirect inflow from the Yukon River, and reclaim flows from the old pond and Copper Lake. It also receives a portion of the runoff from the millsite area which previously drained to the 'A' Valley. The inflows are balanced by pumping and a controlled outflow. The outflow varies with conditions but is generally maintained so as to approximate the original discharge. It has on some occasions been considerably larger and has included runoff from all of the contributing areas plus normal recycle flows.

When operations are terminated, the lake will receive the natural inflow, the redirected millsite runoff, and a minimum of 30 percent of the runoff from the old pond area. It will also receive an estimated 50 to 100 gallons per minute of runoff which was formerly intercepted by the mine drainage system and discharged near the northwest corner of the old pond. All of the flows will be combined in the lake and will be discharged directly to the lower Crater Lake watershed.

If the minimum portion of the old pond runoff is drained to Crater Lake, the total outflow from the lake will be greater than what existed prior to development but significantly less than what has been experienced on occasions during the operating life. If all of the old pond runoff is drained to Crater Lake, the outflow will be correspondingly greater but will still be less than the previous maximum flow.

The long term effects of the increased flows on conditions within the lower Crater Lake watershed cannot be fully evaluated with the available data. It is our opinion, however, that the minimum increase can probably be accommodated without any problems. It is also likely that the maximum increase can be accommodated as well. It would, however, be prudent to restrict inflows as much as possible to avoid any risk of possible problems.

PART IV

FINAL OPERATIONS AND ABANDONMENT PLANNING

1.0 ABANDONMENT DRAINAGE SCHEMES

Because of the layout and design of the tailings storage and water reclaim facilities, long term drainage from the old pond can be subdivided and distributed to each of the three adjacent watersheds in various proportions. In addition, it may also be possible to discharge runoff from the 'A' Valley to either the lower 'A' Valley or to the 'B' Valley depending on the final conditions in each area.

In view of the various drainage discharge considerations discussed previously, it would be desirable to adopt a drainage scheme which would approximate the natural (predevelopment) drainage regimes as best possible. The ideal scheme would see the runoff from the old pond discharged to the 'A' and 'B' Valleys in a roughly 80-20 split and the total runoff from those areas discharged separately to their respective watersheds. There would be no drainage to Crater Lake and no drainage across the saddle between the 'A' and 'B' Valleys.

The development of a drainage scheme to meet these requirements is complicated by drainage restrictions in the old pond area and by the cost and feasibility of a spillway to the lower 'A' Valley. The former is a relatively minor problem and can be fairly well acommodated with a reasonable range of alternatives. The latter is a more severe problem and there are fewer alternatives available. These alternatives are also dependent on final conditions and have a much greater impact on the overall drainage scheme.

The following text outlines three possible drainage schemes for the old pond area and three alternative schemes for the 'A' Valley. This is followed by a general discussion and a comparison of each scheme.

1.1 Old Pond Storage Area

There is an infinite variety of drainage schemes available for the old pond area. In general however, these can be condensed into three basic alternatives. These are:

1) A simple, least cost scheme, which would meet minimum surface drainage requirements and would discharge all of the pond runoff to Crater Lake.

2) A more involved scheme which would provide improved surface drainage and would discharge the pond runoff to both Crater Lake and the 'A' Valley,

and, 3) An advanced scheme which would further improve surface drainage and would restore natural drainage conditions as best possible.

The basic components of each scheme are outlined following.

Alternative 1

The simple scheme would involve upgrading of all of the existing spillways and the construction of three new spillways. One of these would be located in the perimeter dyke near the existing decant while the other two would be located within the internal dykes as indicated on Figure 9. The general scheme would also involve a considerable amount of selective discharge to infill low areas and develop positive drainage conditions.

With these works, the general drainage pattern would be similar to what presently exists and all runoff would be discharged to Crater Lake. The general surface drainage conditions would be greatly improved however, and most of the surface ponding would be eliminated.

Alternative 2

The more involved scheme would include upgrading of the existing spillways in the 1976 and 1979 cross dykes and the construction of four new spillways as indicated on Figure 10. It would also include closure and relocation of the existing spillway at the head of the 'A' Valley and surface ditching in selected areas. In addition, it would include a limited amount of light earthworks to raise and level various portions of the internal dykes.

With these works, Areas 1, 2, and 3 would drain to the 'A' Valley while Area 4 would drain to Crater Lake. This would then discharge about 70 percent of the total runoff to the former and 30 percent to the latter.

Alternative 3

The advanced scheme would involve the same works as described above with one change: the spillway in the access road would be deleted and would be replaced with a spillway through the north dyke as indicated on Figure 11. It would also involve additional earthworks to raise the north dyke and access road, and additional tailings discharge to reverse the drainage pattern in that area.

With these works, Area 4 would drain to Crater Lake, Area 3 and the southern portions of Areas 1 and 2 would drain to the 'A' Valley, and the northern portions of Areas 1 and 2 would drain to the 'B' Valley. This configuration would discharge about 30 percent of the total runoff to Crater Lake, 45 percent ot the 'A' Valley and 25 percent to the 'B' Valley.

1.2 'A' Valley Storage Area

The alternatives available for drainage of the 'A' Valley will depend on the relative levels of tailings in the 'A' and 'B' Valleys when operations are terminated. There are three possible situations and three corresponding alternatives.

Alternative 1

If final conditions are such that the level of tailings in the 'A' Valley is significantly below that in the 'B' Valley, it will be necessary to construct a conventional spillway to the lower 'A' Valley. This would be a relatively involved project as it would be necessary to provide both erosion control and slide protection measures as outlined previously. In addition, and depending on the final tailings level, it might also require extensive excavation through weathered bedrock.

Alternative 2

If the final conditions are such that the level of tailings in the 'A' Valley is only slightly below the level of tailings in the 'B' Valley, there would then be the option of developing a hybrid spillway system. This system would include a buried pipeline to the lower 'A' Valley to provide positive drainage and drainage for normal runoff flows and a spillway across the saddle to provide fail safe drainage and drainage of excess peak flows.

The hybrid spillway could also be utilized if the level of tailings in the 'A' Valley was several feet below the level in the 'B' Valley since the pipe would provide the required positive drainage. The elevation difference would have to be limited to about 4 feet maximum however, to facilitate clearing of the pipe intake system in the event that it became blocked for any reason.

Alternative 3

If the final tailings level in the 'A' Valley was above that in the 'B' Valley, there would then be the option of providing total drainage through a spillway across the saddle. This would be a relatively simple project as it would only require rough excavation of a channel. It would not be necessary to provide erosion protection or a spillway structure as the channel invert would lie in relatively competant bedrock.

1.3 Discussion

1.3.1 Old Pond Storage Area

The simple drainage scheme would probably be the most suitable alternative if cost was a primary consideration. It would also be the most suitable scheme if a saddle spillway was developed and all of the 'A' Valley runoff was discharged to the 'B' Valley. Otherwise, it would be more desirable to utilize either of the latter two schemes since they would lead to improved surface drainage and a more reasonable distribution of runoff.

A comparison of the latter schemes indicates that there is only a limited difference in the works required for each. There is, however, a significant difference in the resulting drainage distribution and, as such, Alternative 3 would generally be more desirable. Alternative 2 could be more suitable though, if operating time is a key consideration.

1.3.2 'A' Valley Storage Area

Construction of a conventional spillway to the lower 'A' Valley presents several major design problems. As such, the hybrid spillway system would generally be the more desirable alternative if the option is available. The hybrid system would also be less costly to construct and would require less maintenance. It would also be the more reliable scheme under the worst case conditions.

Comparison of the hybrid and saddle spillway alternatives is difficult since there is a distinct trade off between cost and environmental suitability. The comparison is also complicated by the fact that the potential problems in the lower 'B' Valley cannot be fully defined or confirmed. Nevertheless, since the potential problems have been identified, it would be difficult to rationalize total drainage to the 'B' Valley without further studies. The cost of the studies would, however, likely be comparable to or greater than the difference in cost between the two schemes and, as such, it would appear that the logical alternative would be to accept the hybrid scheme as a matter of course.

2.0 FINAL STORAGE OPERATIONS

Final storage operations should be carried out so as to develop optimum abandonment conditions within each of the three tailings storage areas. In general, this will require a program of controlled discharge to develop positive drainage conditions in each area and additional discharge to infill the 'A' and 'B' Valleys to the most desirable levels. The available operating time is limited, however, and therefore the operations must be carefully scheduled.

2.1 Controlled Discharge

The controlled discharge work should be considered as a priority requirement and should be completed before any secondary discharge is carried out. As part of this program, it will be necessary to discharge to the old pond for a minimum of 1 to 2 weeks and to the 'A' Valley for a minimum of 1 to 2 months. It will also be necessary to continue discharging to the 'B' Valley for a minimum period of about 1 to 2 weeks to allow complete infilling of the lower pond area to elevation 2496.5 feet.

Since tailings are presently being discharged to the 'B' Valley and since controlled discharge to the old pond area cannot be carried out until the abandonment works are complete, the obvious approach will be to complete operations in the 'B' Valley and then discharge to the 'A' Valley and old pond area as required. The latter two operations do not have to follow any particular schedule and can be carried out simultaneously or in sequence.

2.2 Secondary Discharge - Alternative Operating Schedules

Once the basic abandonment conditions have been established, tailings can then be discharged to either the 'A' or the 'B' Valley for the remainder of the mine life. The following text outlines the final conditions which would be expected with each alternative and the effects of these conditions on final abandonment requirements. In each case, it is assumed that the secondary program would begin on October 1, 1982 and that operations would be terminated on December 31, 1982.

2.2.1 Alternative 1: 'A' Valley

If the 'A' Valley was used for the major portion of the remaining mine life and if operations were controlled so as to develop a continuous sloping profile, the tailings surface in the lower valley area would be raised by about 5 feet and the toe of the slope, near the saddle, would lie at about elevation 2500 or about 1 to 2 feet below the level of the tailings in the 'B' Valley. This predicted elevation is relatively approximate however, and variations of up to 2 feet in either direction would not be unexpected. The final elevation of the tails near the saddle could also be considerably lower depending on conditions encountered during final operations.

If the predicted conditions are realized, the hybrid spillway system will be feasible. If however, problems are encountered in final operations or if operations are terminated prematurely, the final level of the tailings in the 'A' Valley will be too low for that system and a conventional spillway will be required. It is highly unlikely that the final level would be high enough to allow use of a saddle spillway alone.

The conditions in the 'B' Valley would remain relatively unchanged with this alternative and any infilling would be restricted to the area immediately adjacent to the 'B' Dam. With these conditions, it would be necessary to construct a deep spillway to provide long term drainage for the valley. It might also be necessary to construct a seepage control blanket on the east abutment of the 'B' Dam to improve stability conditions in that area.

With this alternative, a temporary saddle spillway could be utilized for final operations and construction of the final spillway system could be delayed until final conditions had been established. There is, however, a distinct possibility that severe glaciation might occur during the final months of operation because of the extended length of the 'A' Valley and the return of reclaim water via the 'B' Valley. This problem could be offset slightly by using a pump or siphon system to bypass the 'B' Valley but little could be done in the 'A' Valley without forfeiting the desired final profile.

2.2.2 Alternative 2: 'B' Valley

If the 'B' Valley was used for the major portion of the remaining mine life and if operations were controlled so as to develop a continuous sloping profile, the level of the tailings would be raised by about 6 feet and the toe of the slope at the 'B' Dam would lie at about elevation 2502. The final elevation could also vary by 1 to 2 feet in either direction as noted previously.

This configuration would lead to improved seepage conditions on the east abutment of the 'B' Dam and a seepage control blanket would probably not be required for that area. However, the additional depth of tailings would not be sufficient to seal the sand stratum on the west abutment and a modified spillway design would be needed to control the seepage which would result. Because of the elevation of the final tailings surface relative to the sand stratum that design would be similar to the design for a deep spillway.

The conditions in the 'A' Valley would not be changed significantly with this schedule and the final tailings surface near the saddle would probably lie at about elevation 2497 or approximately 13 feet below the final level of the tailings in the 'B' Valley. These conditions would require the construction of a conventional spillway to the lower 'A' Valley as outlined previously. Drainage across the saddle or the development of a hybrid spillway system would not be feasible because of the extreme elevation difference between the two valleys.

With this alternative, the operating problems during the final months would be greatly reduced and there would be much less risk of glaciation and loss of reclaim flows.

2.3 Discussion

A comparison of the two alternative schedules indicates that the primary differences lie in ease of operations and total abandonment costs. From a strictly operations point of view, it would be more desirable to use Alternative 2 since it involves a reduced risk of glaciation and would require less attention. From a cost point of view Alternative 2 would be more desirable only if a conventional spillway is required in the 'A' Valley. Otherwise, (if a hybrid spillway is feasible) Alternative 1 would be preferred since it would involve a considerably reduced total cost.

3.0 GENERAL CONCLUSIONS - OPTIMUM APPROACH

Considering the alternative operating schedules and abandonment drainage schemes as a whole, it is our opinion that the optimum approach to final operations and abandonment would involve the following.

i) Discharge to the 'A' Valley for the remainder of the mine life,

and, ii) An abandonment drainage scheme comprised of the Alternative 2 configuration for the old pond and the hybrid spillway system for the 'A' Valley.

This combination is deemed to be the most suitable since:

i) It maximizes the feasibility of the hybrid spillway system by maximizing discharge to the 'A' Valley;

ii) It ensures a reasonable distribution of runoff consistent with the general drainage discharge requirements;

iii) It offers flexibility with respect to operating time and final abandonment options;

and, iv) It will likely be the most cost effective.

It is recognized that there is an element of risk with respect to the feasibility of the hybrid spillway and therefore some risk with respect to total costs. It is our opinion however, that the risk can be justified in view of the available alternatives and the substantial cost savings which could be realized.

PART V

RECOMMENDATIONS - PROPOSED ABANDONMENT PLANS

1.0 OLD POND STORAGE AREA

1.1 General Abandonment Plan

It is recommended that the old pond area be abandoned with a two stage program. Stage I should be carried out during final operations and should include:

i) An investigation to evaluate the long term stability of the perimeter dyke

ii) A program of surface drainage works and controlled tailings discharge

iii) A program of general clean up works

Stage II should be carried out during 1983 and should include:

i) Abandonment of the decant system

ii) Vegetation of the crest and downstream slopes of the north dyke and the perimeter dyke at the head of the 'A' Valley

iii) Any additional dyke stabilization works which might be required as a result of the Stage I investigation

Additional recommendations and details of the major works included in each stage of this plan are presented following:

1.2 Abandonment Works

1.2.1 Surface Drainage Works

The program of surface drainage works is relatively involved. General details are shown on Figure 12 and the various works are summarized following.

The works for Area 1 include:

i) Construction of an overflow spillway through the 1979 cross dyke on the north side of the existing pipeline berm

ii) Modification and improvement of the existing spillway at the south end of Area 1

iii) Excavation of a drainage swale parallel to the 1979 cross dyke

iv) Discharge of tailings to the north and south portions of Area 1 to infill low areas and promote drainage to the new spillways

The works for Area 2 include:

i) Closure of the existing channel through the 1976 pipeline support berm

ii) Closure of the existing channel in the north end of the pipeline access roadway

iii) Raising of the eastern portion of the north dyke to the elevations shown

iv) Raising of the southern end of the 1976 cross dyke and 1976 pipeline berm to the elevations shown.

v) Discharge of tailings to the north and south portions of Area 2 to infill low areas and promote drainage to the new spillways

The works required for Area 3 would include:

i) Closure of the existing spillway and construction of a new spillway immediately north of the access road

ii) Excavation of drainage swales parallel to the perimeter dyke and the 1976 pipeline berm

iii) Discharge of tailings to the north and south ends of Area 3 to infill low areas and promote drainage to the new spillway

The works required for Area 4 would include:

i) Construction of a spillway in the perimeter dyke near the existing decants

ii) Excavation of a ditch to drain the existing pond

The spillways should be constructed as indicated on Figure 12. Most of these spillways involve only a minor elevation change and will be relatively simple structures. Spillways 1, 6, and 7 are somewhat more complex, however, and should be constructed under direct supervision.

The various fills should be comprised of a well graded till material and the fill should be placed in lifts and compacted. The fill on the crest of the north dyke should be graded with a southward slope so as to direct runoff into the pond rather than down the face of the dyke.

1.2.2 Decant Abandonment

Both of the decant structures should be abandoned by filling the discharge culverts with concrete. The damaged structure should be filled from the bottom end using a standpipe arrangement. The undamaged structure can be filled in the same manner or, alternatively, the lower end of the culvert can be closed with a bulkhead and the concrete introduced through the vertical riser pipe.

The concrete mix should include a plasticizing agent to promote free flow and the mix design should be carefully controlled. The quantity of concrete should also be monitored to ensure that the entire culvert section is filled. It is strongly recommended that the work be carried out under direct supervision only.

2.0 'A' VALLEY STORAGE AREA

2.1 General Abandonment Plan

It is recommended that the 'A' Valley be abandoned with a two stage program. Stage I should be carried out during final operations and should include:

i) Controlled discharge to develop positive drainage conditions

ii) Development work for the hybrid spillway system

iii) General cleanup work

Stage II should be carried out during 1983 and should include:

i) Abandonment of the decant system

ii) Construction of the hybrid spillway system (or a spillway to the lower 'A' Valley, if required).

Additional recommendations and details of the major works included in each stage of this plan are presented following.

2.2 Abandonment Works

2.2.1. Hybrid Spillway

The feasibility of the hybrid spillway system will depend on the final tailings configuration in the 'A' Valley. The details of the design will also depend on the final conditions and, as such, specific recommendations cannot be provided at this time. There is, however, sufficient data available to provide preliminary information and conceptual details. These are outlined following.

General Description

The hybrid spillway would be comprised of a spillway - intake structure located in the saddle between the 'A' and 'B' Valleys and a buried pipeline to Copper Lake. The general configuration is shown on Figure 13 and specific details of each component are described following.

Buried Pipeline

The proposed pipeline would be comprised of the 12 inch diameter sclair pipe presently used for the 'B' Valley reclaim system. The pipe would be installed in a trench beneath the Copper Lake access road and would extend from the saddle spillway to Copper Lake, a distance of about 1100 feet. The trench would vary in depth from a minimum of 6 feet over most of the lower portion of the route to a maximum of 8 to 10 feet near the 'A' Dam and saddle. The lower portion of the trench would lie in till and colluvial deposits while the upper portion would lie in weathered bedrock.

Excavation of the lower portion of the trench would be relatively straight forward. Excavation of the upper portion would require pre-excavation of the saddle and access road to reduce the depth of the trench. It is expected that most of the bedrock would be highly weathered and relatively easy to excavate but local, unweathered sections could be encountered, and blasting might be required in these areas.

Spillway - Intake Structure

The spillway intake structure would be comprised of reinforced concrete. It would have a section similar to that shown on Figure 13 and would be approximately 6 feet wide, 8 feet high and 40 feet long. It would be located in the lowest part of the saddle and would be constructed after general excavation of the access roadway.

The details of the pipe connection and intake system will depend on the final tailings configuration and a variety of designs could be utilized. The setup shown on Figure 13 is schematic only.

2.2.2 Decant Abandonment

The decant system should be abandoned by filling the discharge culverts with concrete. Because of the length of the culverts, this will be relatively involved operation and as such, it is recommended that it be carried out under direct supervision only.

3.0 'B' VALLEY STORAGE AREA

3.1 General Abandonment Plan

It is recommended that the 'B' Valley be abandoned with a two stage program. Stage I should be carried out during final operations and should include:

i) Instrumentation of the dam and abutment areas to define seepage and stability conditions

ii) An investigation of the proposed spillway area to define soil and groundwater conditions

iii) Rough excavation of the overflow spillway

iv) General clean up works.

Stage II should be carried out during 1983 and should include:

i) Final construction of the overflow spillway

ii) Abandonment of the decant system

iii) Construction of a drainage blanket on the east abutment of the dam (if required).

Additional recommendations and details of the major works in each stage of the plan are outlined following.

3.2 Abandonment Works

3.2.1 Overflow Spillway

Details of the design of the overflow spillway will depend on the results of the investigation proposed as part of Stage I. As such, specific recommendations cannot be provided at this time. There is, however, sufficient date available to provide preliminary information and conceptual details. There are outlined following.

General Description

The proposed spillway would be comprised of 3 sections as shown on Figure 14. These are:

i) An open channel across the top of the abutment

ii) A steeply inclined discharge channel down the abutment slope

and, iii) A shallow surface channel across the valley bottom

The first two components would serve to return outflows to the valley bottom. The third would allow these flows to return to the groundwater system.

Open Channel

The main, open channel portion of the spillway would have a cross section similar to that shown on Figure 14. This section would include a lining of waste rock underlain with a synthetic filter fabric. It would also include an underdrain system designed to accommodate trickle flows during the winter period and control seepage from the sand stratum.

Discharge Channel

The proposed discharge channel would have a rectangular section approximately 8 ft. wide and 3 ft. deep and would be constructed of waste rock, synthetic filter fabric, and gabions as indicated on Figure 14. It would also be underlain with a buried pipe system to accommodate trickle flows during the winter period.

Valley Channel

The valley channel would be approximately 100 to 200 ft. in length, 10 to 15 ft. in width, and of the order of 2 to 3 ft. deep. The invert of the channel would be located in the coarse granular alluvium to allow free drainage of outflows into the groundwater system.

3.2.2 Seepage Blanket

The need for a seepage control blanket on the east abutment of the dam, and the details of its design will depend on the results of the instrumentation and monitoring programs recommended as part of Stage I. As such, specific recommendations cannot be presented at this time. Conceptual details for two possible configurations are shown on Figure 15.

3.2.3 Decant Abandonment

The decant system should be abandoned by filling the discharge culverts with concrete. Because of the length of the culverts, the operation will be relatively involved and it is recommended that it be carried out under direct supervision only.

4.0 COPPER LAKE RECLAIM POND

The abandonment program for the Copper Lake reclaim pond should include excavation of a spillway through the impervious cutoff and excavation of a short channel to allow outflows to return to the groundwater system. The spillway and channel should be of the order of 8 to 10 ft. in width and the channel should be about 100 ft. long. The invert of the spillway should be located at elevation 2495 or about 2 to 3 ft. below the surrounding ground surface. Both works should be constructed this year prior to shutdown.

5.0 CRATER LAKE RECLAIM POND

There are no specific abandonment works required for the Crater Lake reclaim pond.

6.0 GENERAL RECOMMENDATIONS

It is recommended that the tailings storage and water reclaim facilities be inspected at various intervals over the next few years to evaluate their general condition and performance. The inspection program should include monitoring of all instrumentation and a general review of stability conditions within each of the retaining structures. It should also include photo monitoring of all spillways and channels and photo monitoring of the areas to be treated as part of the erosion control program.

It is recommended that the inspections be carried out during the spring runoff period and during the late fall for a minimum of 3 to 4 years, or as required. It is also recommended that a more regular inspection and monitoring program be established if any abnormal conditions are experienced.

7.0 CLOSURE

We trust this report provides the information you require. Should you have any questions or require any further details, please do not hesitate to contact us.

Sincerely

THOMPSON GEOTECHNICAL CONSULTANTS LTD.

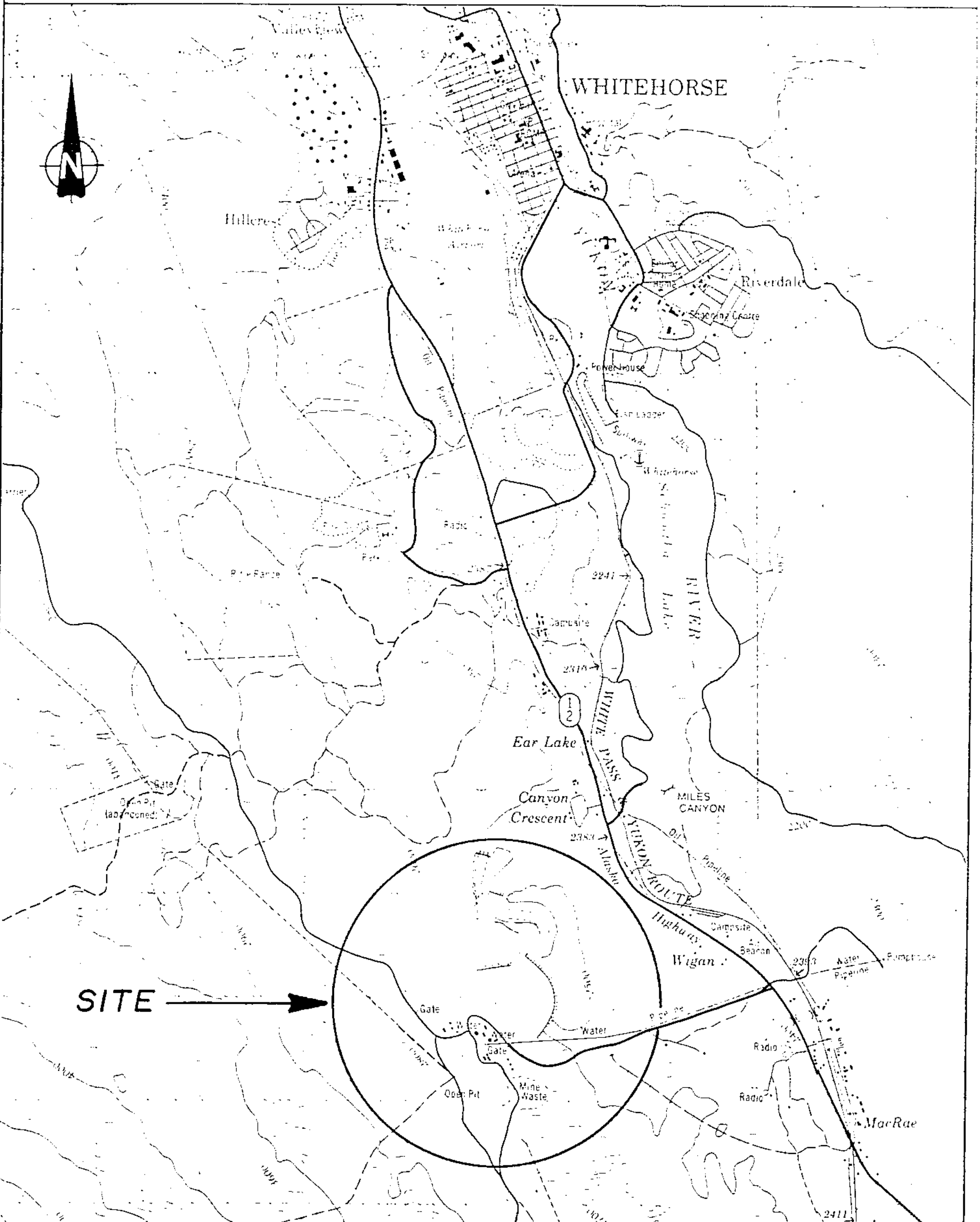
Brian Thompson

per: Brian E. Thompson, P. Eng.

80001 - D
September 20, 1982

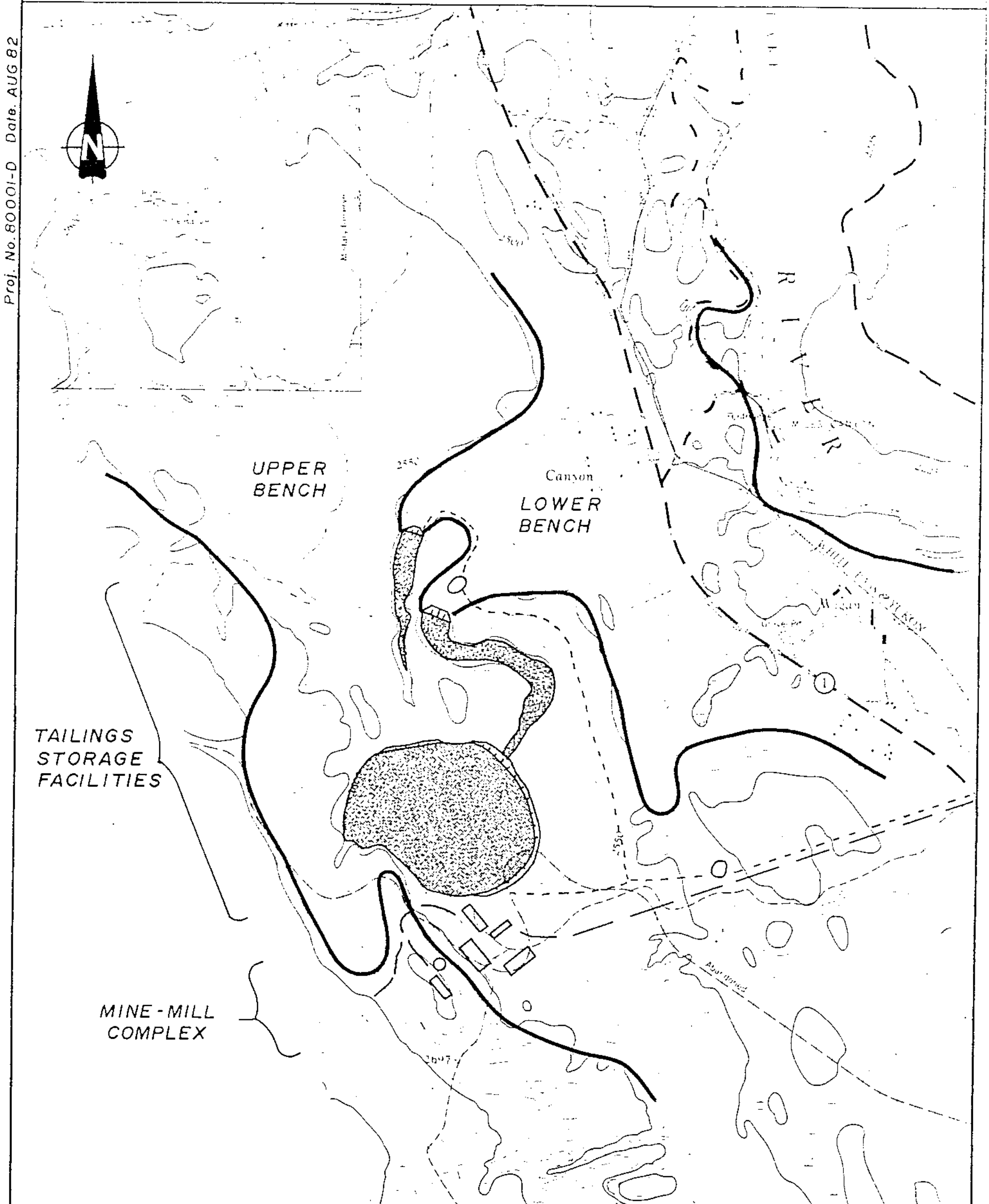
LOCATION PLAN FIGURE 1

Proj. No. 80001-D Date. AUG 82



THOMPSON GEOTECHNICAL SCALE: 1:50,000

GENERAL SITE CONDITIONS FIGURE 2



THOMPSON GEOTECHNICAL SCALE: 1:25,000

CLIMATIC DATA

FIGURE 3

WHITEHORSE, Y.T.[1]—60°43'N, 135°01'W. ALTITUDE ABOVE M.S.L. 2,289 FEET

	Air Temperature							Heating Factor	Relative Humidity			
	Mean Daily	Mean of Daily		Mean of Monthly		Absolute Extreme		Degree-Days Below 65°F.	0300 Y.S.T.	0900 Y.S.T.	1500 Y.S.T.	2100 Y.S.T.
		Maximum	Minimum	Maximum	Minimum	Highest Recorded	Lowest Recorded					
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	No.	p.c.	p.c.	p.c.	p.c.
Jan.	5.2	13.0	−2.7	38	−35	47	−62	1,850	86	86	79	86
Feb.	6.8	15.9	−2.2	41	−38	50	−59	1,640	88	87	77	85
Mar.	21.3	31.0	11.6	43	−16	51	−37	1,350	82	76	63	76
Apr.	31.8	41.2	22.3	52	−2	59	−15	1,000	79	60	49	66
May	45.5	57.2	33.8	73	22	86	19	600	75	51	41	58
June	54.6	66.5	42.7	80	31	89	28	310	76	54	43	54
July	56.2	67.2	45.3	80	34	91	29	280	80	60	49	63
Aug.	53.6	64.5	42.7	79	29	86	17	350	82	67	50	67
Sept.	46.0	54.7	37.2	70	22	80	14	570	84	74	56	78
Oct.	34.4	41.0	27.9	55	8	59	−12	940	79	75	65	75
Nov.	14.6	20.8	8.4	43	−22	51	−43	1,510	87	86	82	85
Dec.	3.2	10.4	−4.0	35	−35	47	−54	1,900	89	87	86	88
Year	31.1	40.3	21.9	83	−51	91	−62	12,300	...	...	...	...

	Precipitation						Wind			Bright Sunshine	Thunder	Freezing Temperatures[2]
	Rain		Snow		Total (water)		Most Prevalent		Average Speed (miles per hour)	Mean No. of Hours	Mean No. of Days	Mean No. of Days
	Mean Amount	Days	Mean Amount	Days	Mean Amount	Maximum Fall in 24 Hours	Direction	Percentage				
	in.	No.	in.	No.	in.	in.						
Jan.	T	[3]	6.4	11	0.64	0.37	S	29	8.6		0	31
Feb.	T	[3]	4.7	9	0.47	0.41	S	33	8.8		0	28
Mar.	T	[3]	6.0	7	0.60	0.80	S	31	9.1		0	30
Apr.	0.02	1	3.9	5	0.41	0.56	S	31	8.7		0	27
May	0.49	5	0.8	1	0.57	0.48	SE	34	8.7		0	13
June	1.00	8	0	0	1.00	0.52	SE	30	8.0		1	1
July	1.63	13	0	0	1.63	0.83	SE	36	7.4		2	[3]
Aug.	1.52	10	0.1	[3]	1.53	1.21	SE	33	7.8		1	2
Sept.	1.25	10	0.9	1	1.34	0.85	S,SE[4]	31	9.1		0	7
Oct.	0.30	4	4.1	4	0.71	0.47	S	38	10.4		0	20
Nov.	0.08	1	9.2	12	1.00	0.45	S	31	9.0		0	29
Dec.	0.01	[3]	7.6	11	0.77	0.42	S	30	8.7		0	31
Year	6.30	53	43.7	61	10.67	1.21	S	29	8.7		4	219

[1] Airport data. [2] Average date of last Spring frost June 10; of first Fall frost Aug. 27. [3] Average less than 0.5 days. [4] Two directions of equal prevalence.

WHITEHORSE COPPER MINES
TAILINGS STORAGE FACILITIES

FIGURE 4

SCALE: 1 in. to 1500 ft.

Reference Photo: Pacific Survey Corp.
No. 127955
Flown June 1980

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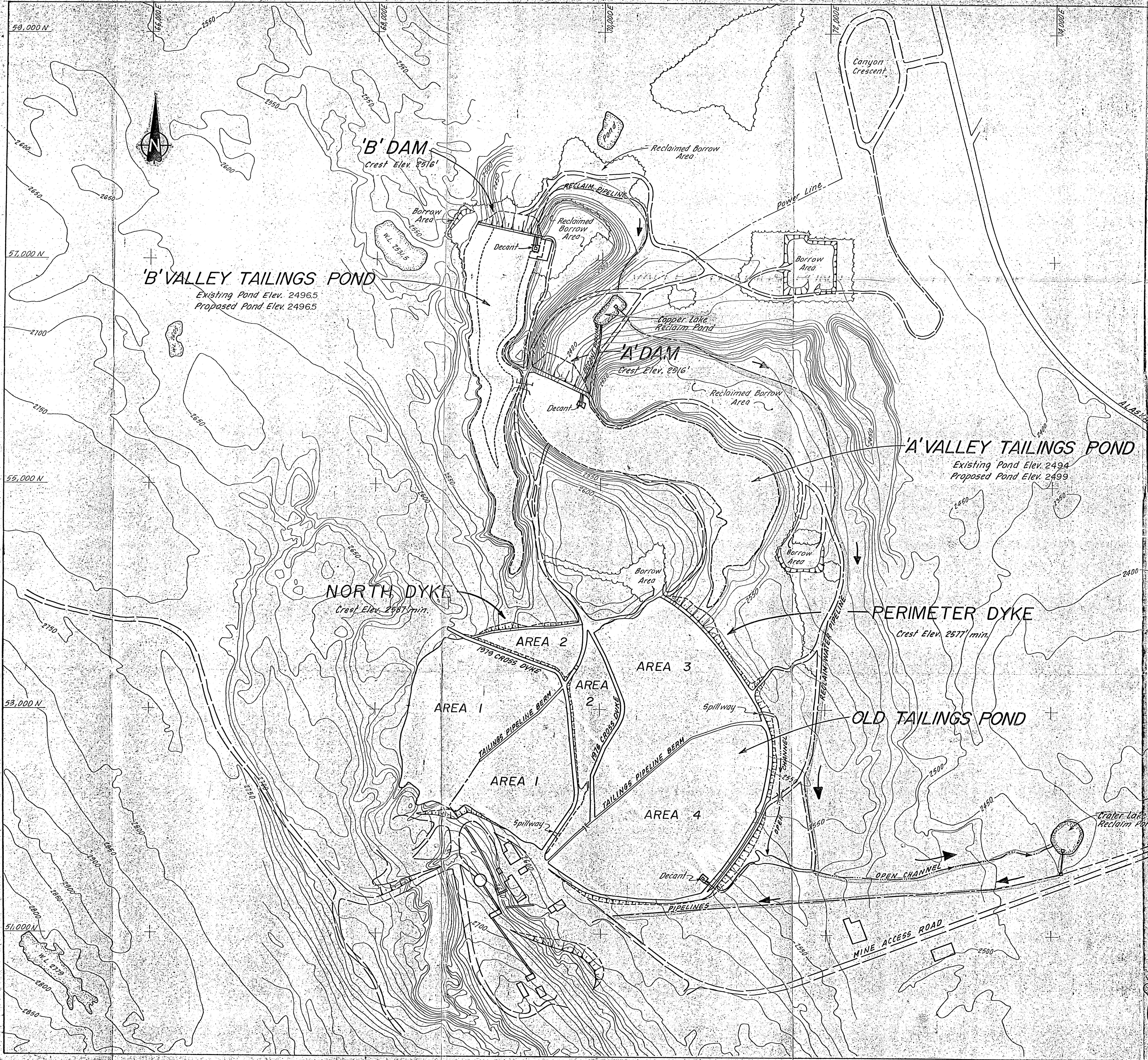
WHITEHORSE COPPER MINES
TAILINGS STORAGE FACILITIES
GENERAL SITE PLAN

FIGURE 5



NOTES: 1) Topography compiled from air photo contour mapping prepared in 1967 by Pacific Survey Corporation. Planimetric detail compiled from air photo enlargement of Pacific Survey Corp. Photo No. 127955, flown June 1980.
2) Planimetric detail updated Nov. 1981.

Scale: 1 inch to 400 feet

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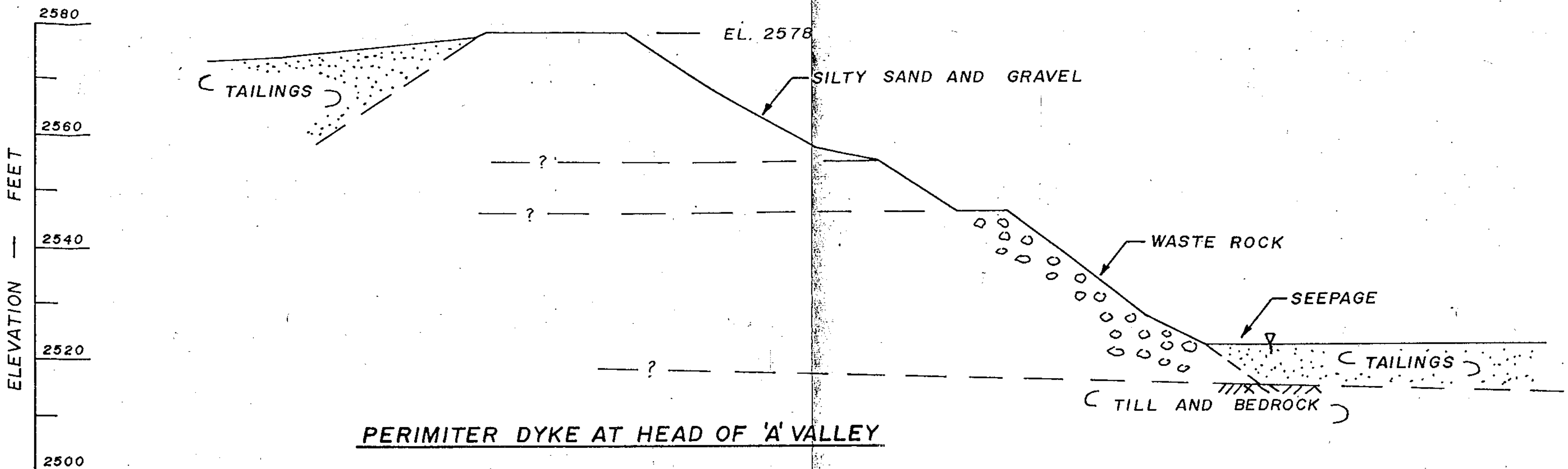
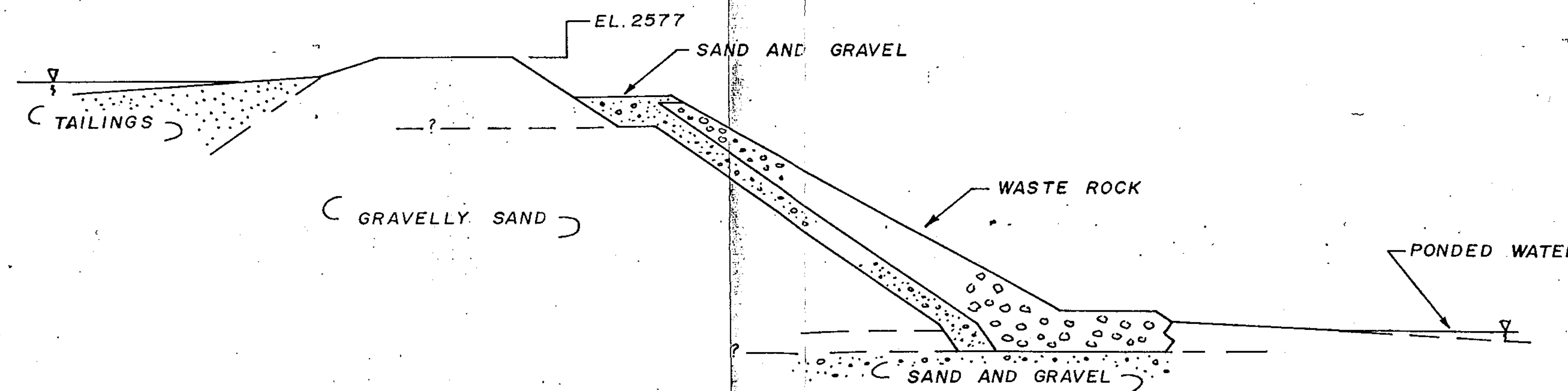
WHITEHORSE COPPER MINES
OLD TAILINGS POND
TYPICAL DYKE SECTIONS

FIGURE 6

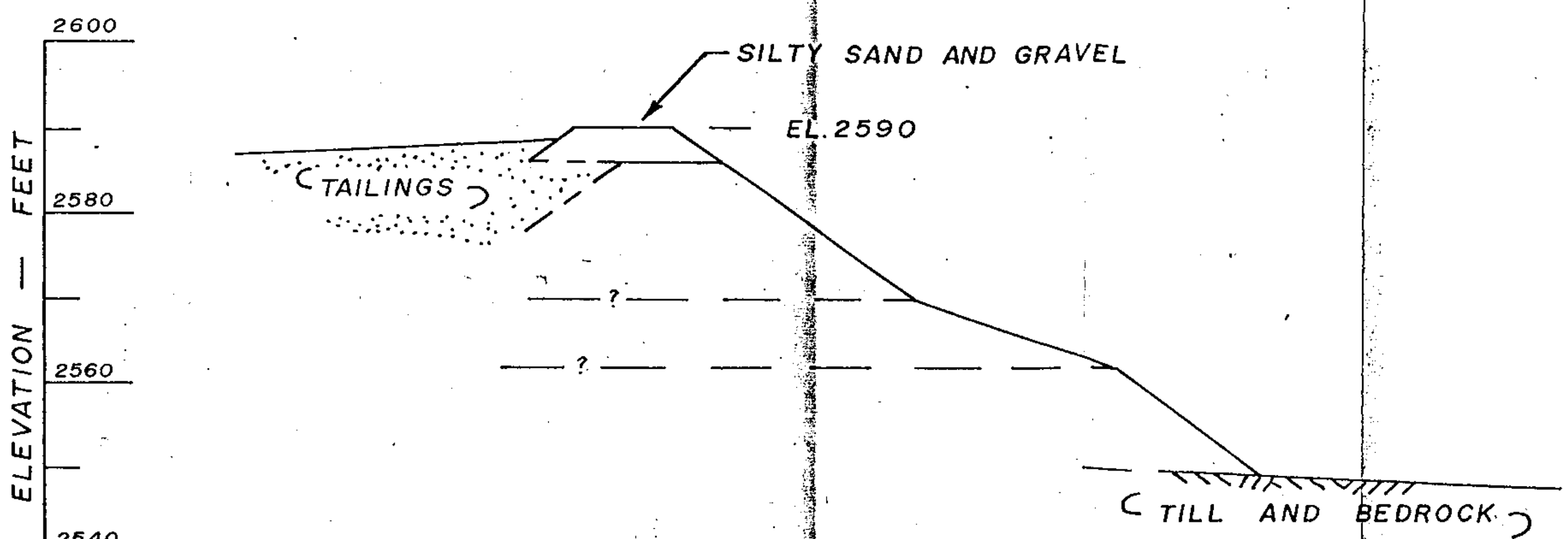


PERIMITER DYKE AT HEAD OF 'A' VALLEY

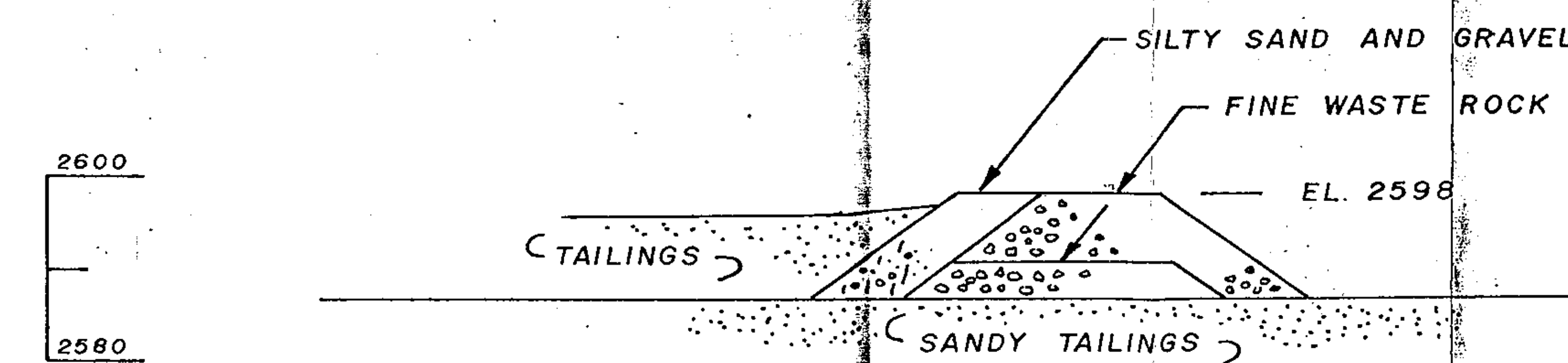


PERIMETER DYKE NEAR DECANT TOWER

80001-G NOV. 81



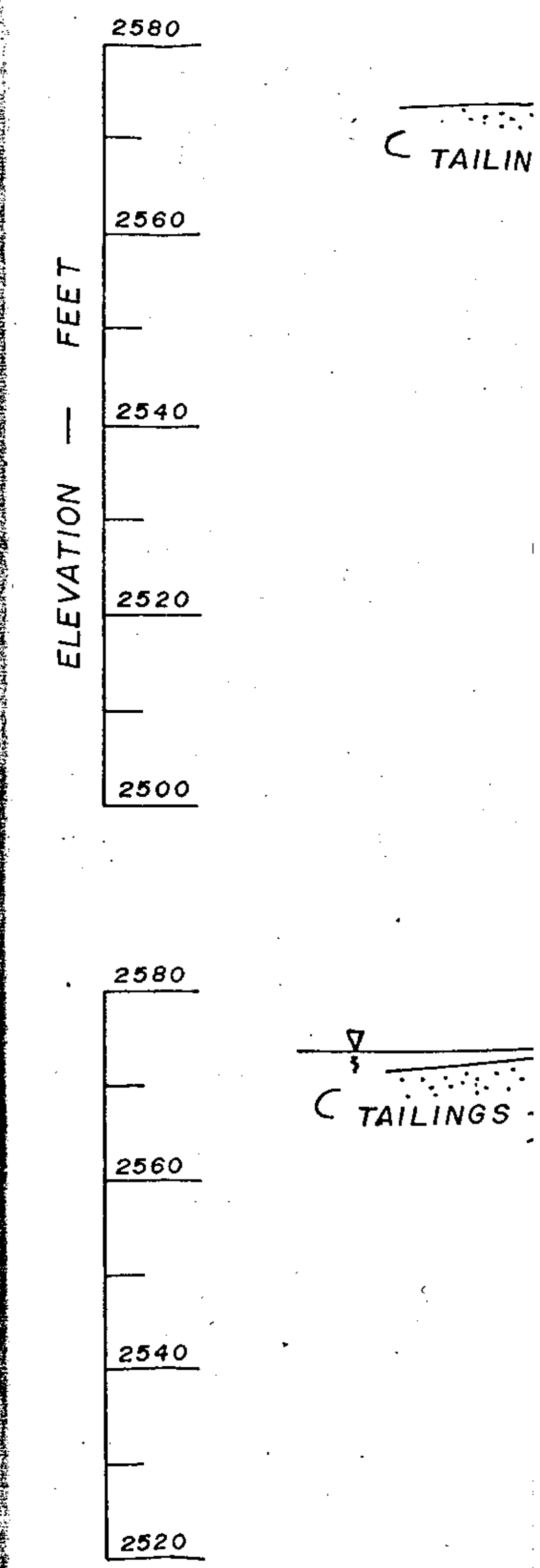
NORTH DYKE AT HEAD OF 'B' VALLEY



1979 CROSS DYKE

NOTE: SECTIONS ARE APPROXIMATE ONLY. INTERNAL ZONING AND FOUNDATION CONDITIONS HAVE BEEN INFERRED FROM LIMITED DATA.

SCALE: 1 IN. to 20 FT.



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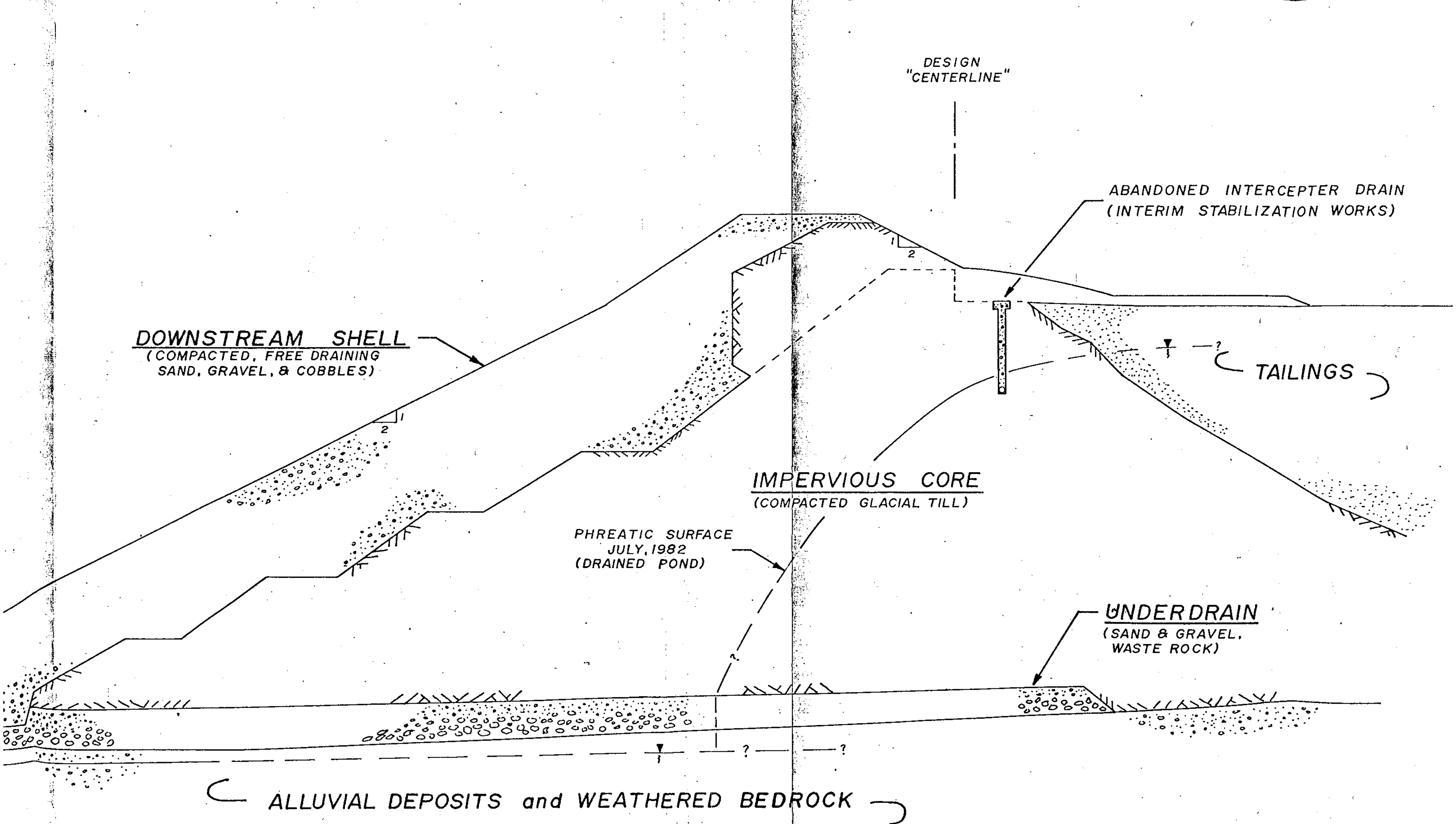
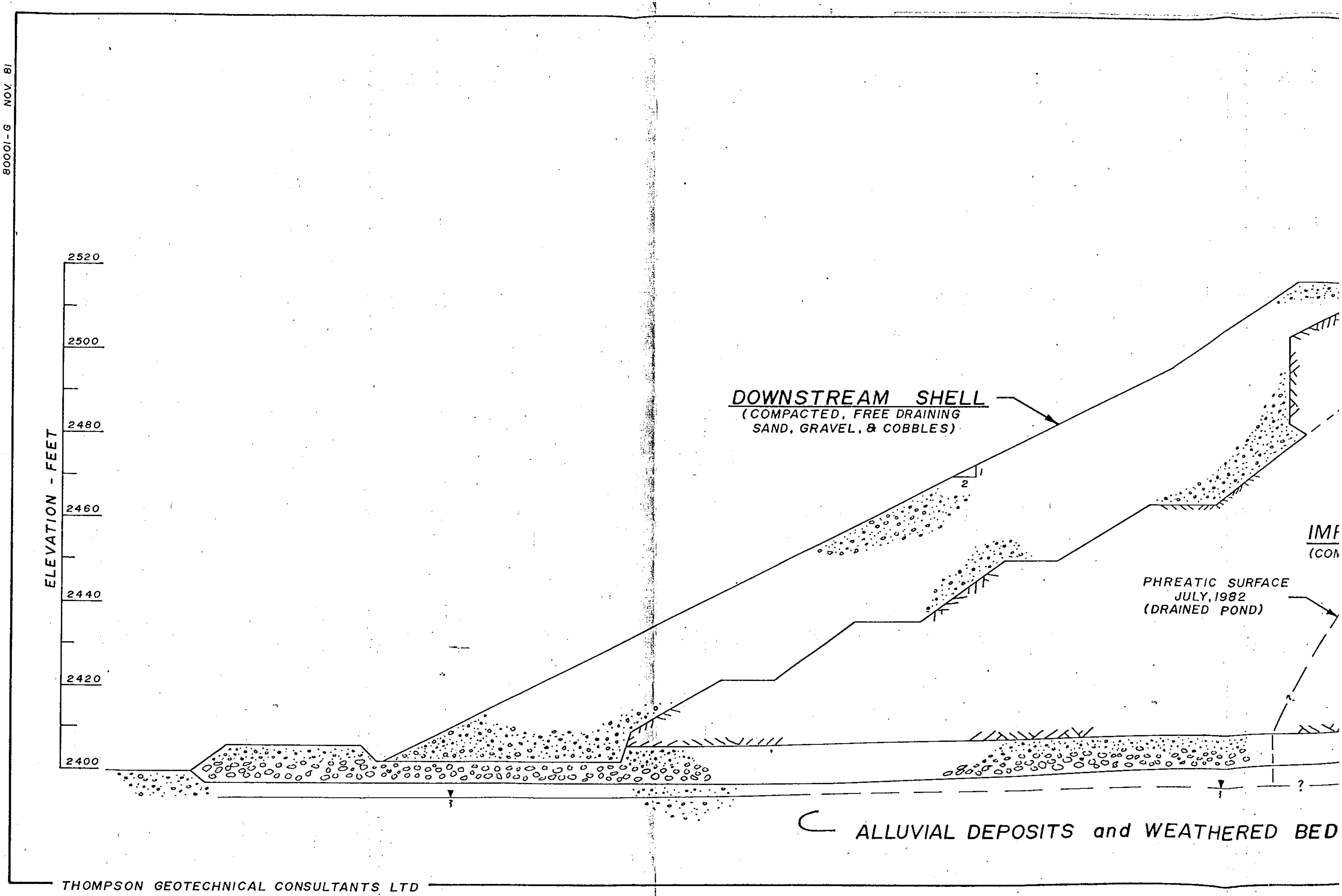
WHITEHORSE COPPER 'A' DAM TYPICAL SECTION

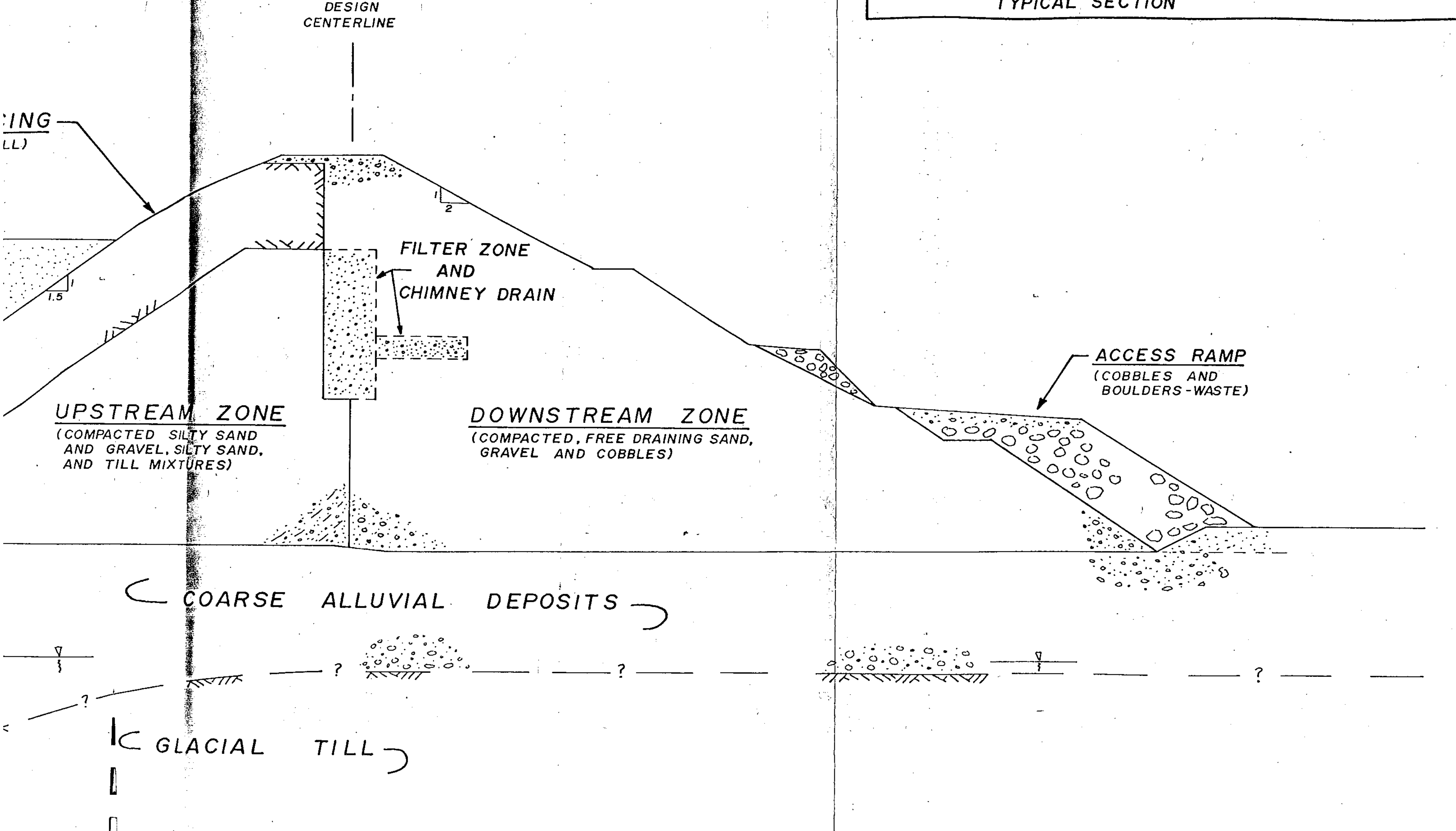
FIGURE 7



SCALE: 1 IN. to 20 FT.



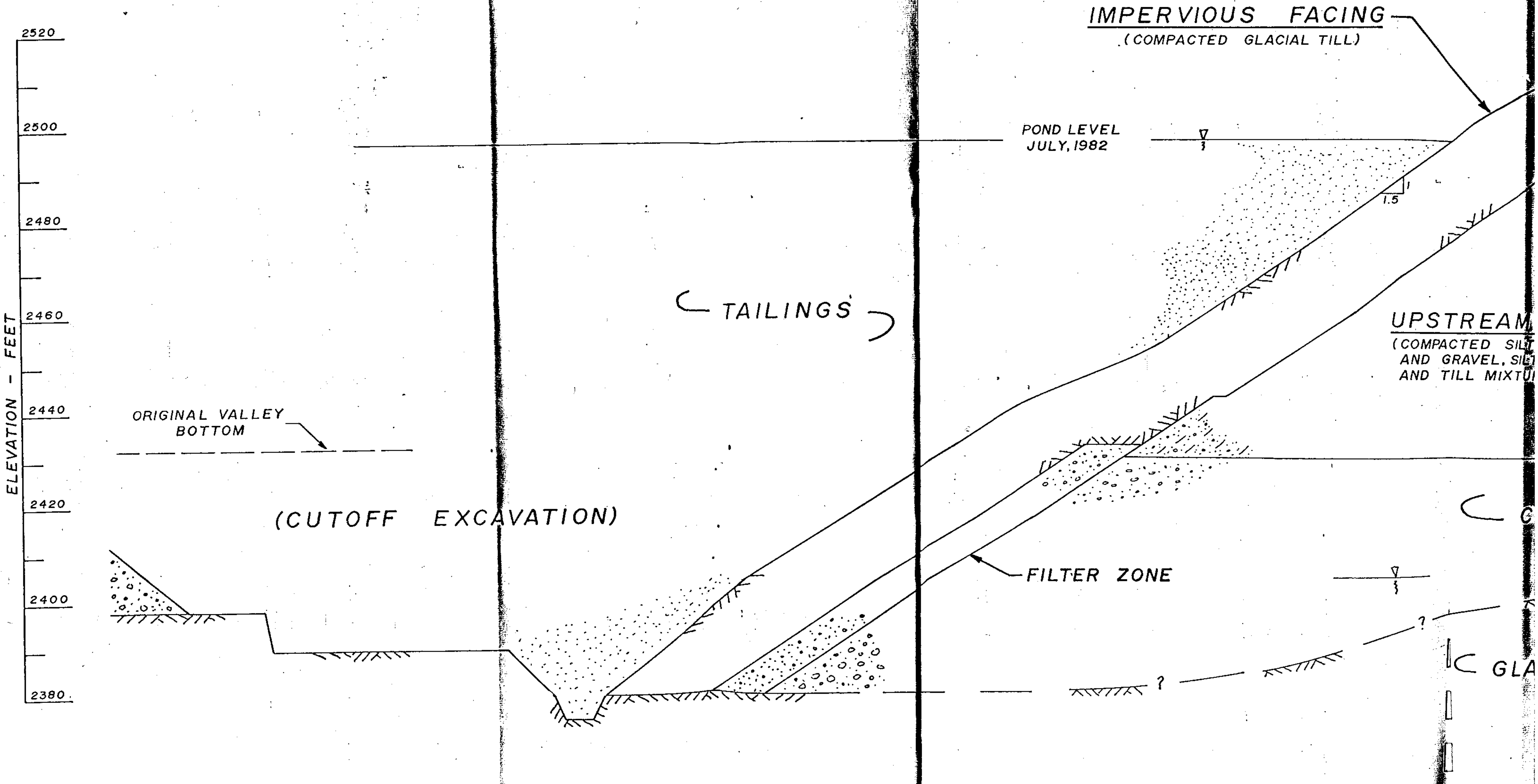
80001-G NOV. 81
ELEVATION - FEET
2520
2500
2480
2460
2440
2420
2400
DOWNSTREAM SHELL
(COMPACTED, FREE DRAINING
SAND, GRAVEL, & COBBLES)
2
1
PHREATIC SURFACE
JULY, 1982
(DRAINED POND)
IMF
(COM
?
ALLUVIAL DEPOSITS and WEATHERED BED
THOMPSON GEOTECHNICAL CONSULTANTS LTD



WHITEHORSE COPPER 'B' DAM
TYPICAL SECTION

FIGURE 8

SCALE: 1 IN. to 20 FT.



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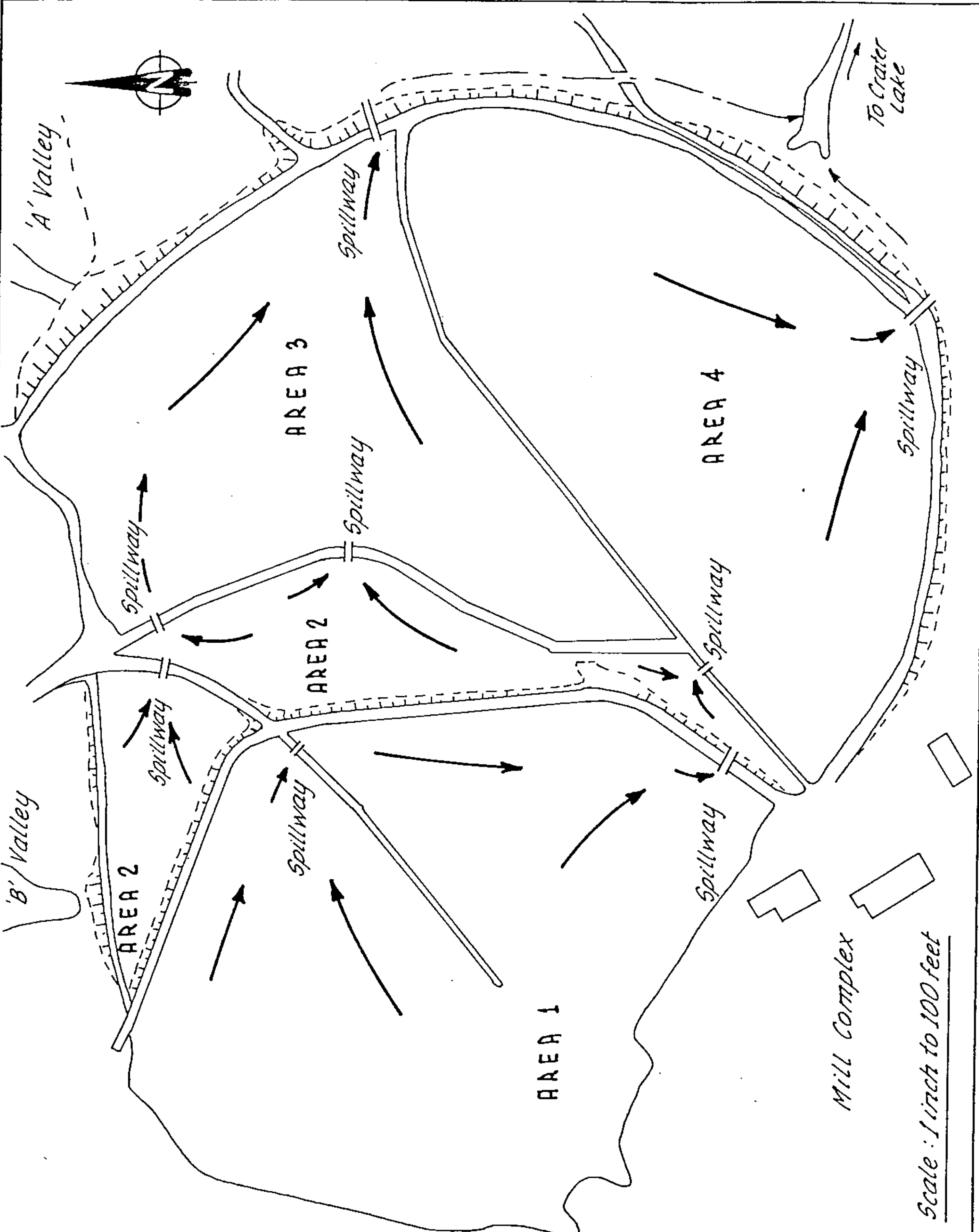
ABANDONMENT DRAINAGE SCHEMES
ALTERNATIVE I

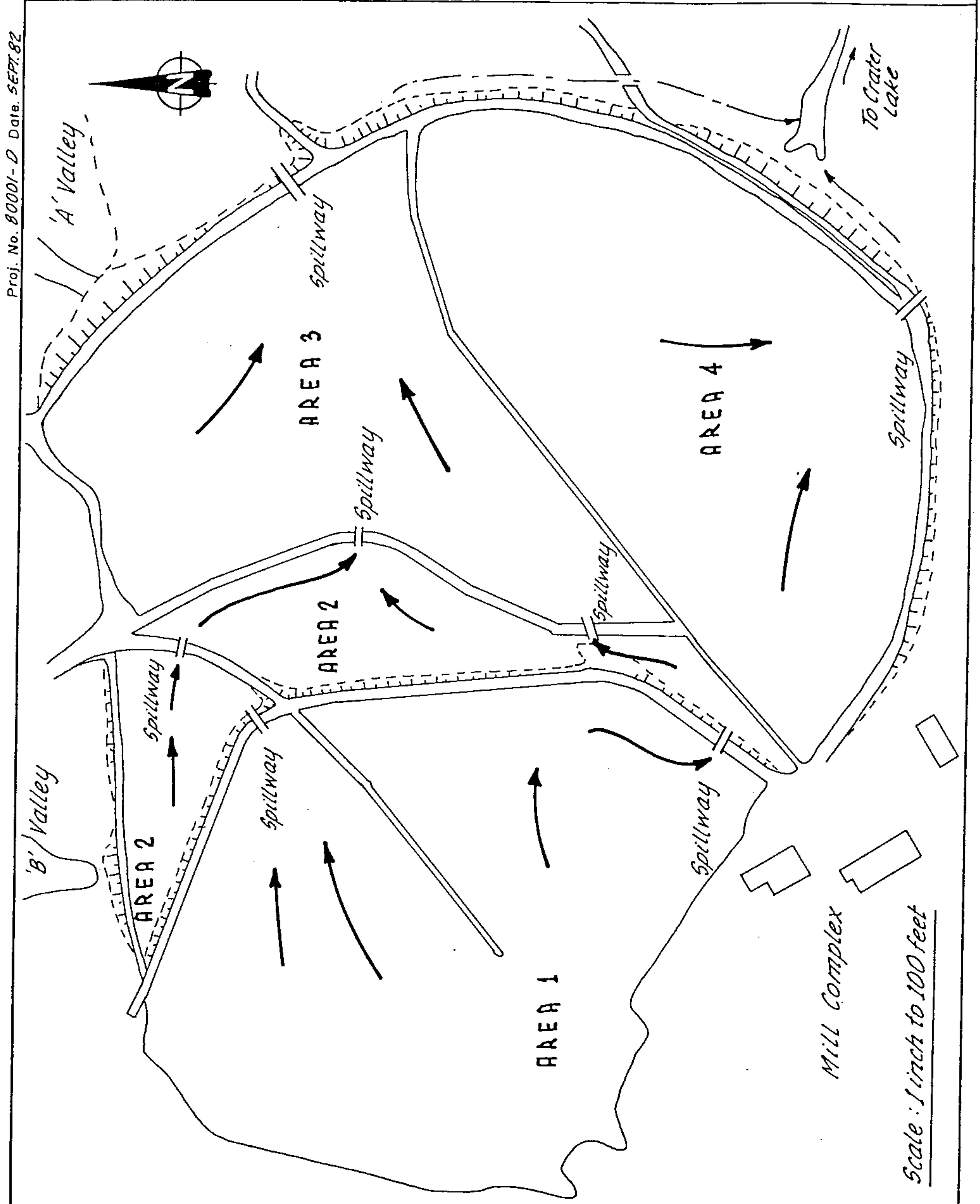
FIGURE 9



THOMPSON GEOTECHNICAL

ABANDONMENT DRAINAGE SCHEMES
ALTERNATIVE 2

FIGURE 10

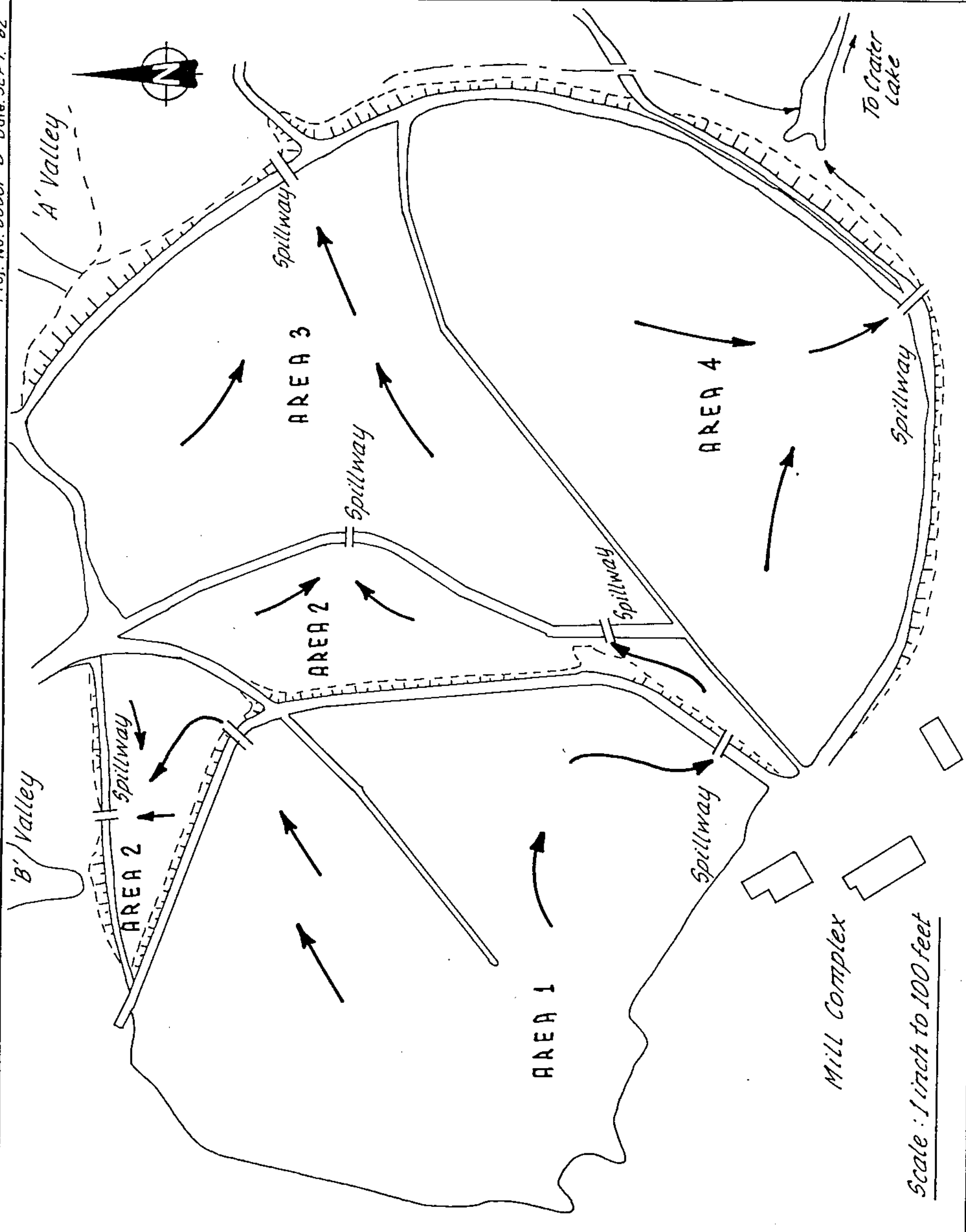


THOMPSON GEOTECHNICAL

ABANDONMENT DRAINAGE SCHEMES ALTERNATIVE 3

FIGURE 11

Proj. No. 80001-D Date. SEPT. '82



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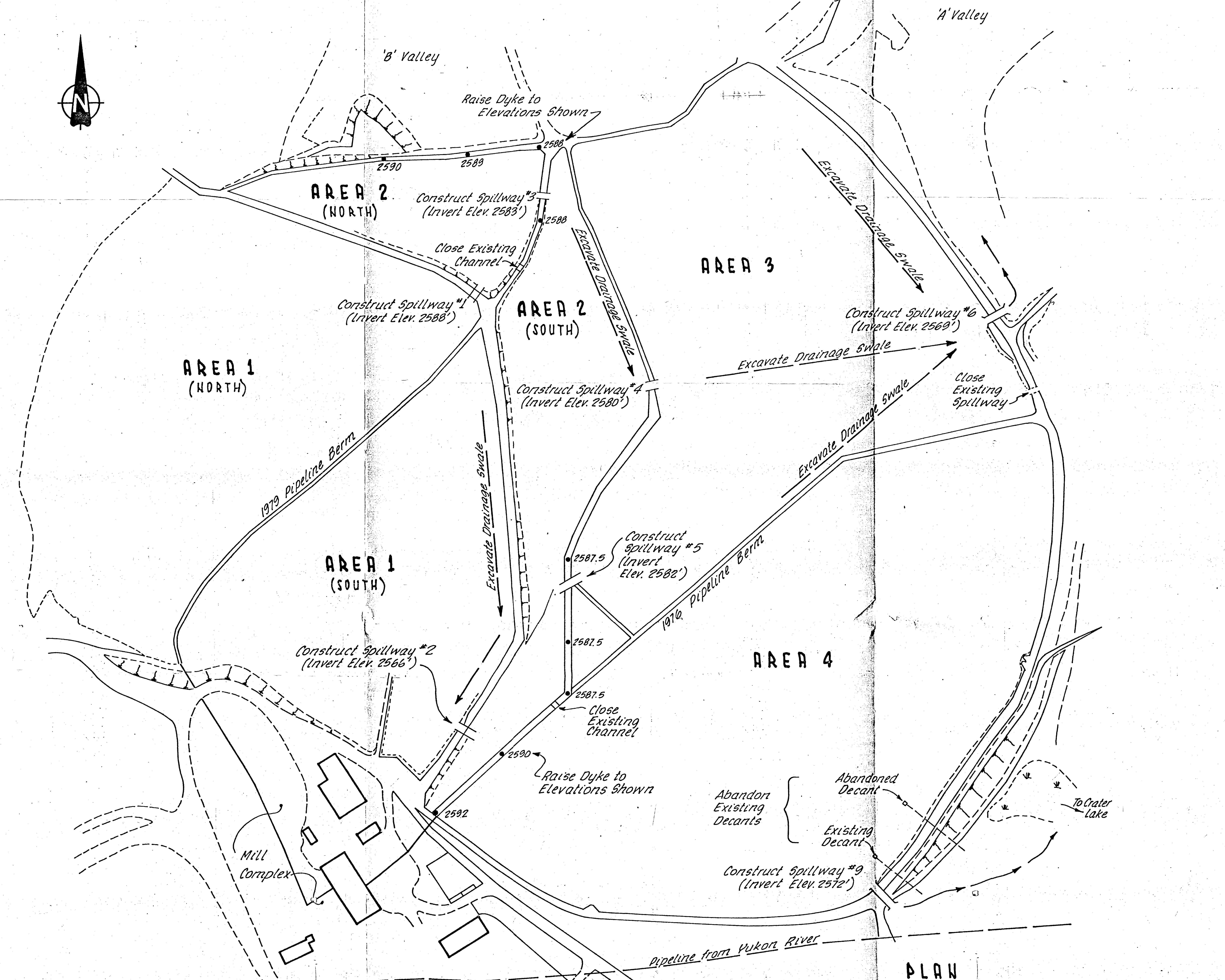
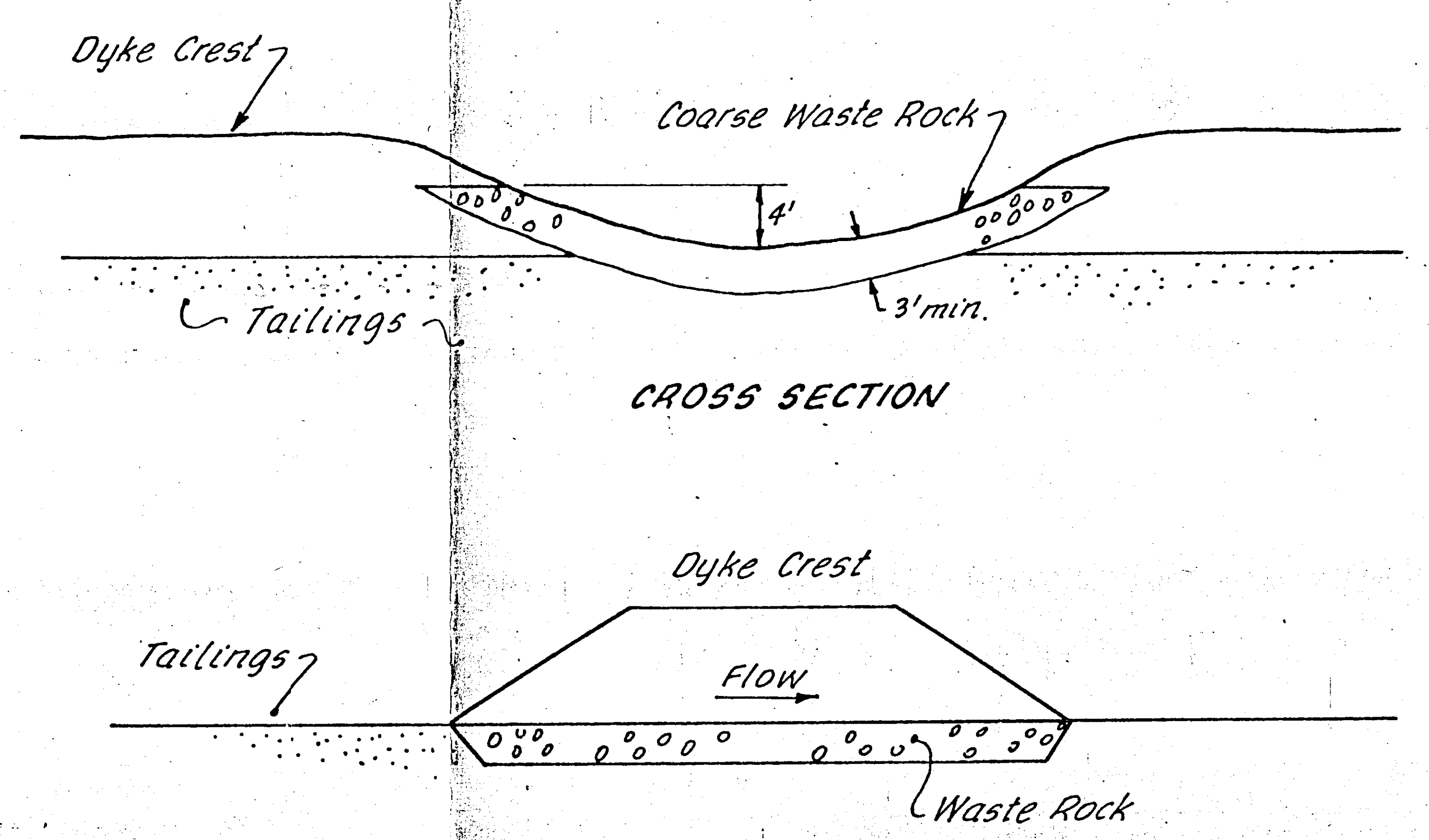
ABANDONMENT DRAINAGE WORKS
OLD POND STORAGE AREA

FIGURE 12

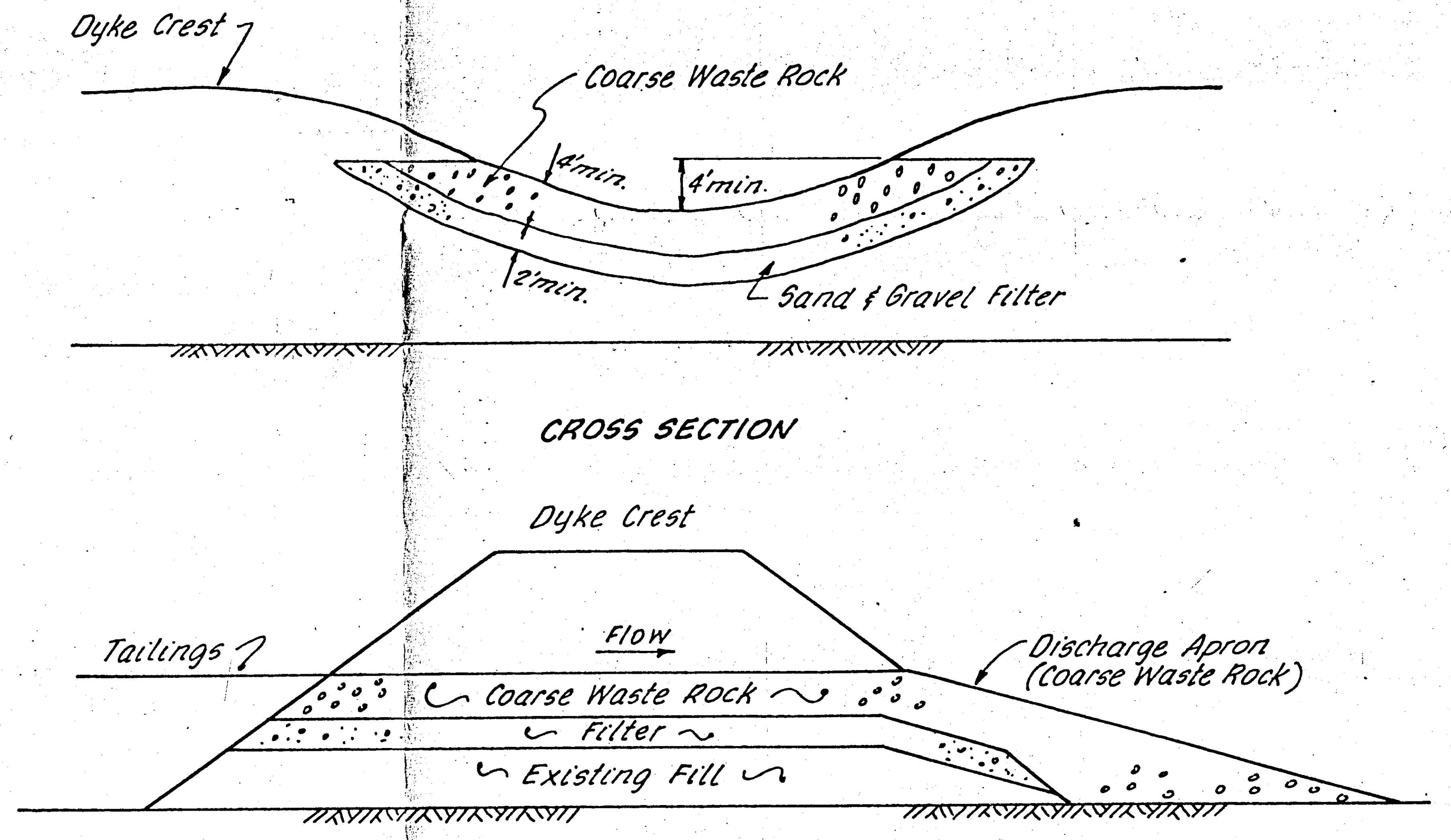
80001-0 SEPT.82



PLAN
SCALE: 1 inch to 200 feet



TYPICAL SPILLWAY SECTIONS – INTERNAL DYKES
Not to Scale.



TYPICAL SPILLWAY SECTIONS – PERIMETER DYKE
Not to Scale.

Note: Details of spillways No. 1, 5, 6 and 7 to be confirmed during construction.

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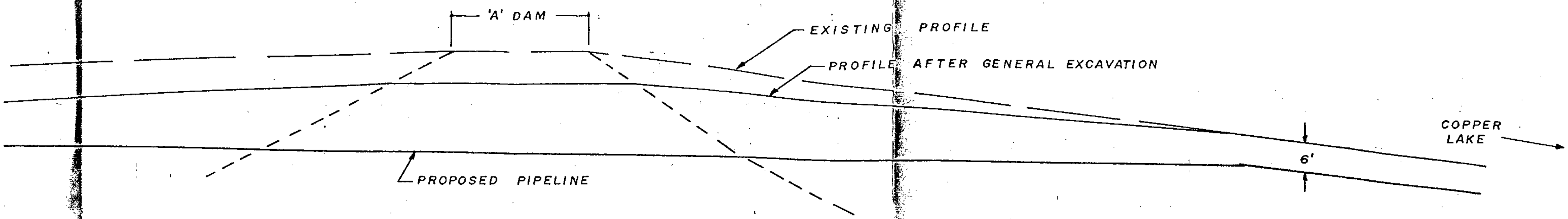
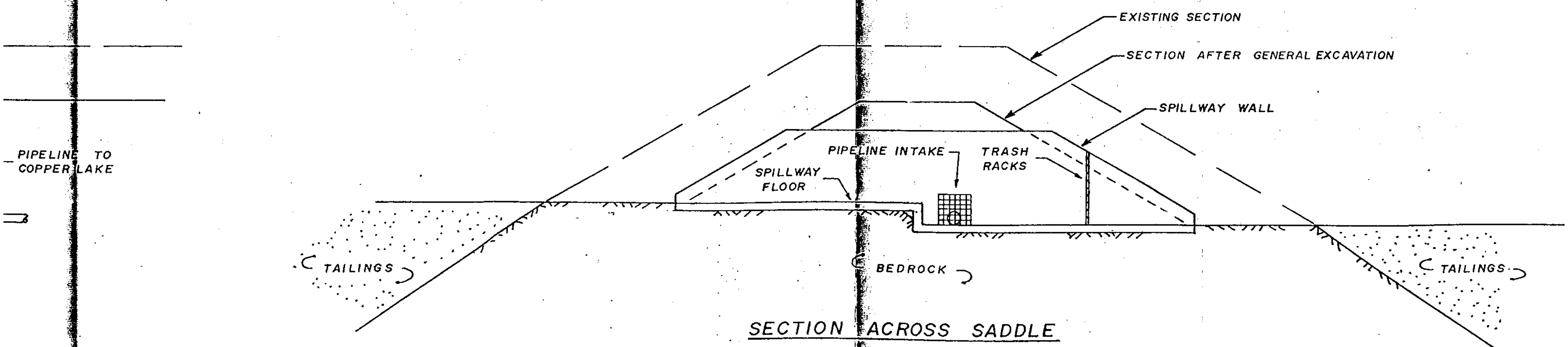
PROPOSED HYBRID SPILLWAY
(CONCEPTUAL DETAILS)

FIGURE 13



PROFILE ALONG ROADWAY

SCALE: 1 IN. = 20 FT.



SECTION ACROSS SADDLE

SCALE: 1 IN. = 10 FT.

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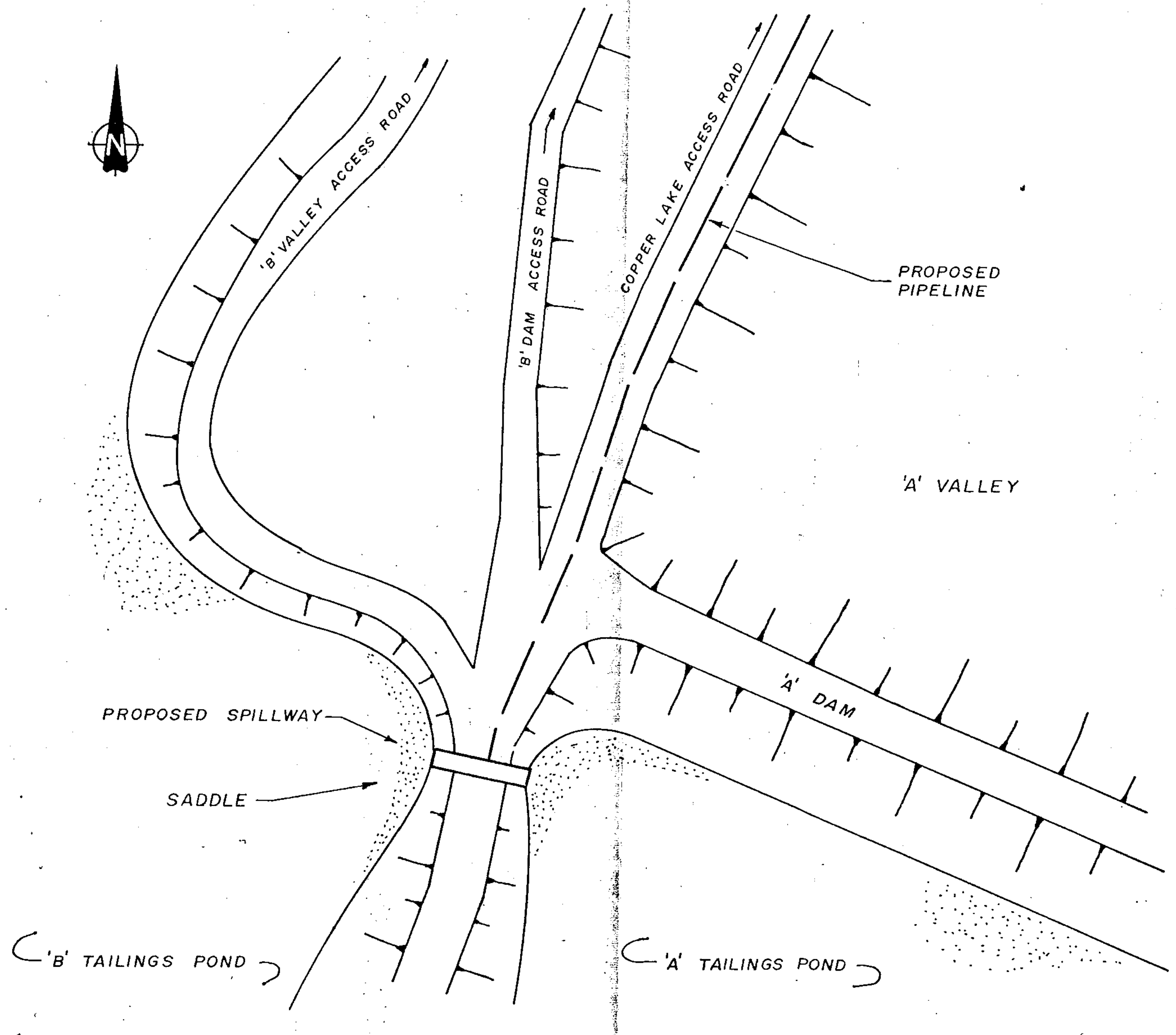
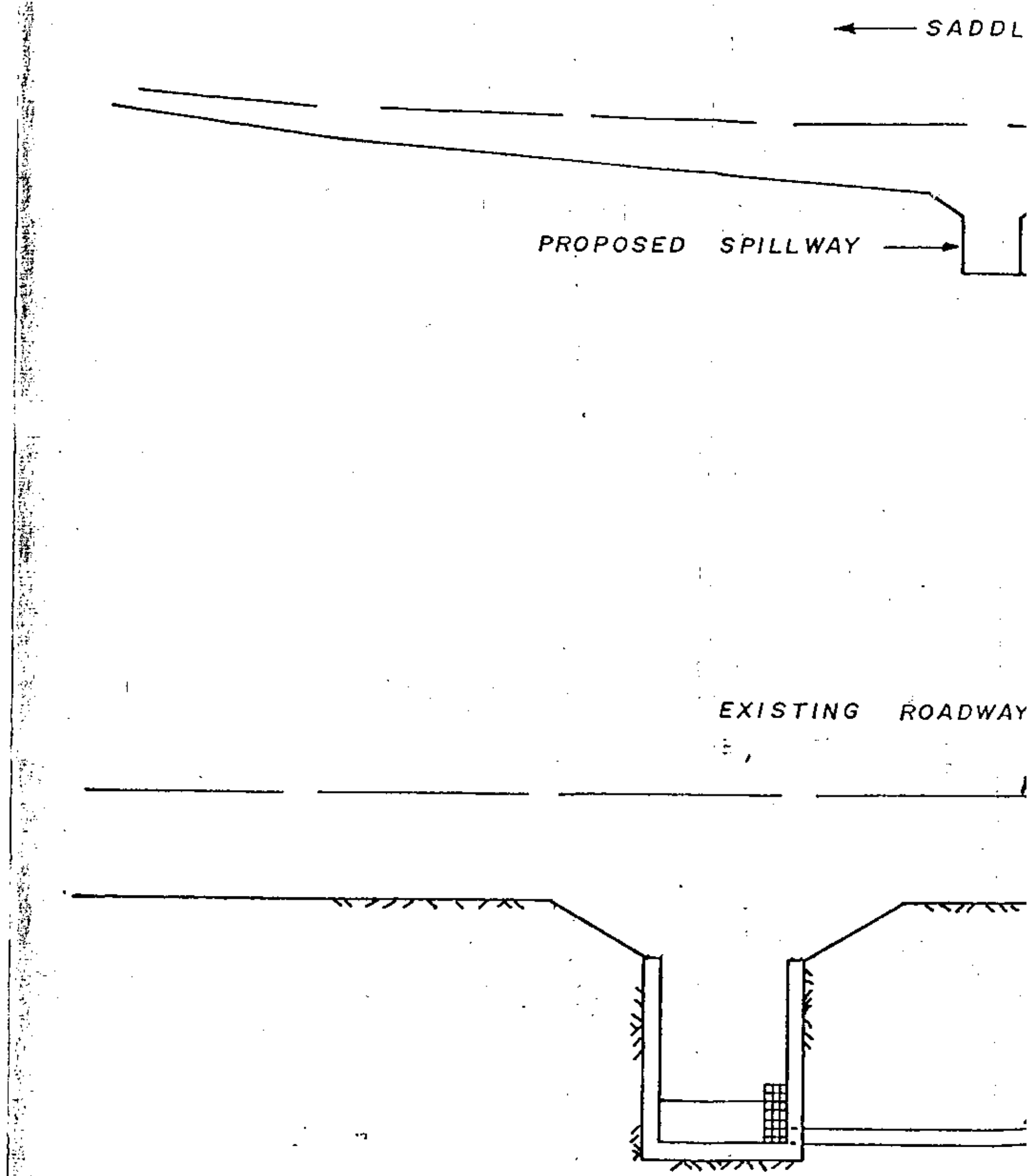


PLAN OF SADDLE AREA

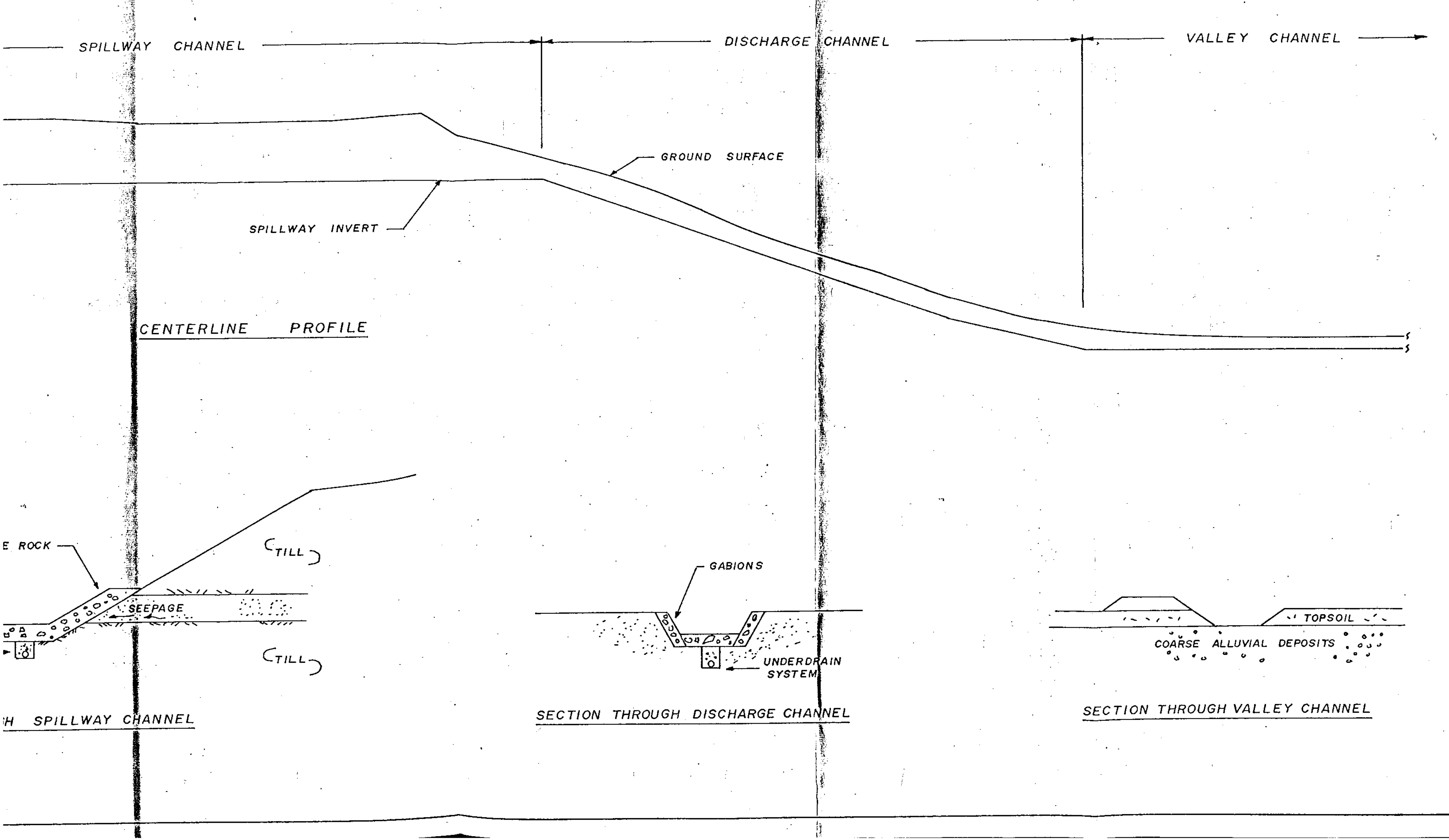


SECTION THROUGH SPILLWA

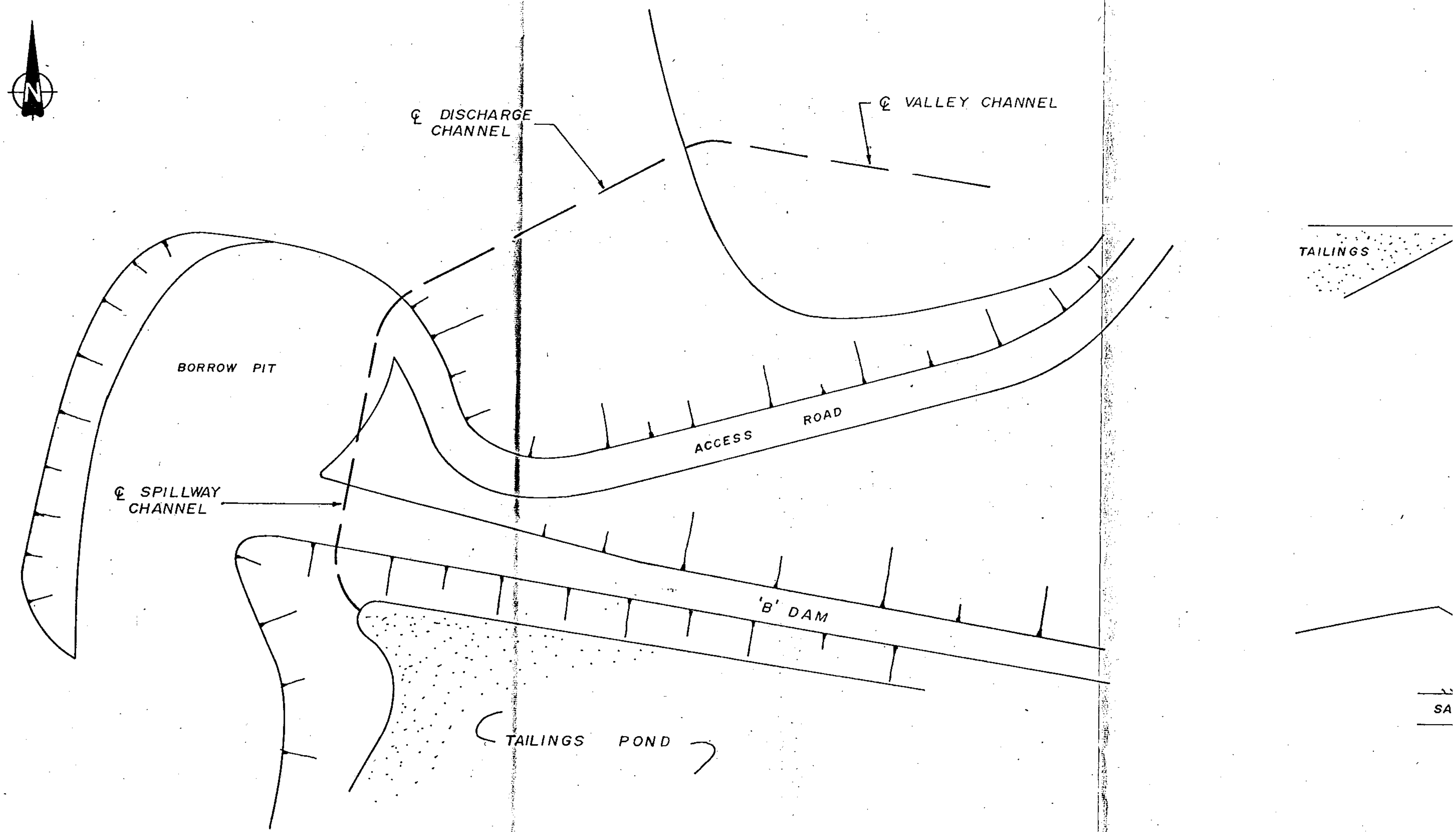
SCALE: 1 IN. = 10 FT.

PROPOSED 'B' VALLEY SPILLWAY
(CONCEPTUAL DETAILS)

FIGURE 14



2

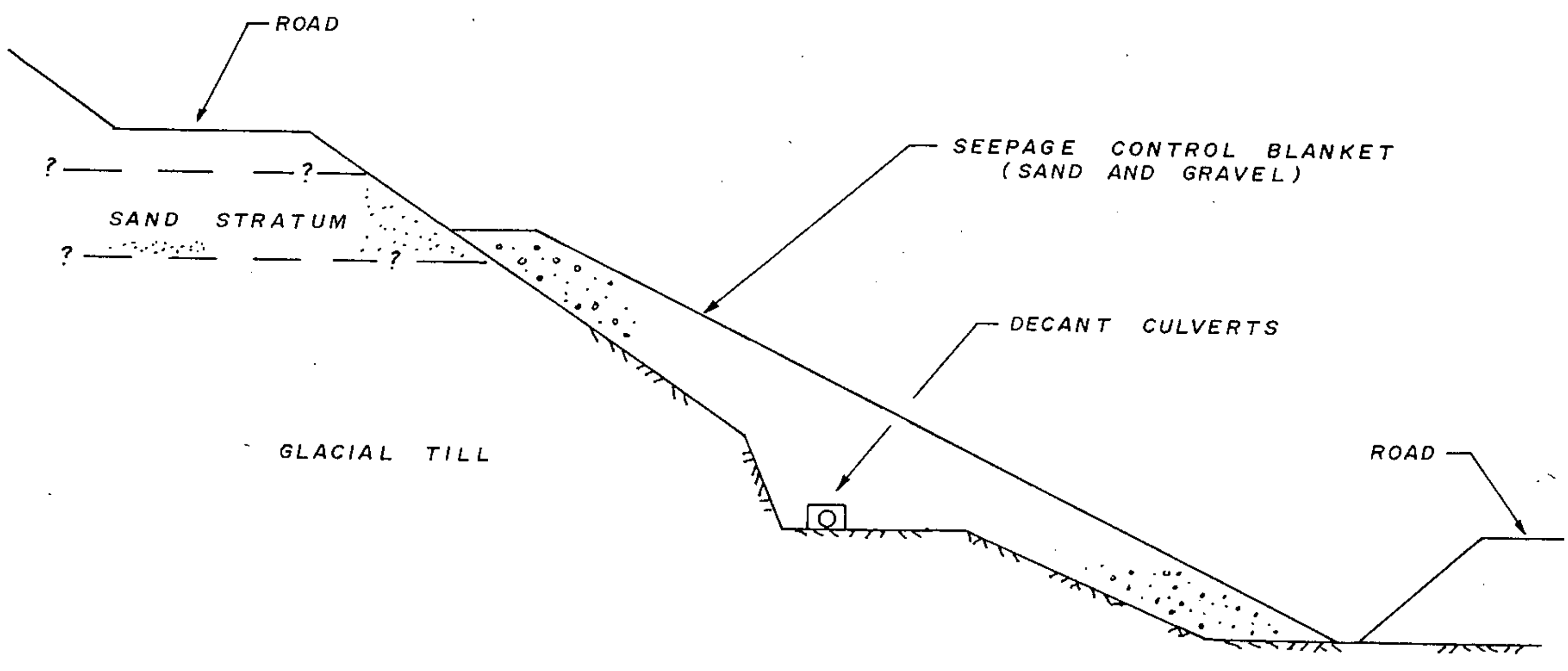


PLAN OF WEST ABUTMENT AREA

NOTE: PLAN AND SECTIONS DRAWN AT REDUCED SCALES.

Proj. No. 80001-D Date. SEPT. 82

THOMPSON GEOTECHNICAL



SECTION THROUGH EAST ABUTMENT

SCALE: 1 IN. = 20 FT.

SEEPAGE CONTROL BLANKET
(CONCEPTUAL DETAILS)

FIGURE 15