BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

Integ-Ebasco - Hat Creek Project - Alternative "B" Ash Disposal Study - November 1978, Revisions December 1980.

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B. C. HYDRO & POWER AUTHORITY

HAT CREEK PROJECT

ALTERNATIVE 'B' ASH DISPOSAL STUDY

Integ-Ebasco
Vancouver, B.C.

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ALTERNATIVE 'B' ASH DISPOSAL STUDY

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Alternative 'B' Ash Disposal Study

A. SUMMARY

1. Introduction

During 1977 Integ-Ebasco studied several alternative ash handling and disposal schemes based on proven North American equipment and practice. A wet ash sluicing scheme for both bottom ash and fly ash was recommended with a disposal pond in Upper Medicine Creek Valley. In this study the above scheme is referred as "Base Scheme". Contingent dry disposal schemes were selected should it be discovered that leaching problems in the Upper Hat Creek Valley preclude this as a site for an ash disposal pond on economic grounds. All the dry ash and wet ash handling schemes were based on intermittent sluicing of bottom ash from the boilers. For dry ash schemes dewatering bins or intermediate ponds were envisioned for bottom ash "drying" prior to its final disposal.

In conjunction with any one of the above schemes a makeup water reservoir relatively close to the SE corner of the power plant was planned with water supplied from the Thompson River only.

A further study performed by Integ-Ebasco in May 1978 showed the economic and technical advantages of continuous removal of bottom ash from the boiler by means of a drag bar conveyor - a method frequently used in Continental European power stations. The scope of that study did not, however, include alternative ash handling and disposal methods.

In July 1978, B.C. Hydro requested that Integ-Ebasco study another alternative dry ash handling scheme in conjunction with a relocation of the makeup water reservoir. The request originated from an analysis of the two Integ-Ebasco studies referenced above, along with work performed by B.C. Hydro on potential dry ash disposal sites and other aspects of the project. This analysis indicated and apparent overall saving, particularly in the costs of the "off site" facilities, through dry ash disposal and by utilizing Medicine Creek water to supplement the makeup water supply from the Thompson River. The study was not to limit the power plant water management to effect zero liquid discharge and was titled "Alternative 'B' Ash Disposal System". In contrast to previous schemes for ash disposal the request for the new study did not require fly ash and bottom ash storage to be segregated for possible future use or commercial sale.

2. Purpose

The purpose of this study is:

- To develop an alternative ash handling scheme based on the use of drag bar conveyors for bottom ash removal and on disposal of dry fly ash and bottom ash, along with mine waste material, in Mid Medicine Creek.
- To relocate the makeup water reservoir to Upper Medicine Creek and to evaluate the use of Medicine Creek water for power plant consumption purposes.
- To perform a comparative technical and economic evaluation of the new Alternative 'B' with the present design "Base" ash sluicing and wet disposal scheme and its modification entitled Alternative 'A'.

3. Scope

The scope of the study required Integ-Ebasco to:

3.1 Recommend a bottom ash removal system (incorporating bottom ash drag bar conveyors), a fly ash removal system and a dry ash transportation system from the power plant site to Mid Medicine Creek disposal area.

3.2 Recommend a system of ash disposal in dry form in a specific section of Mid Medicine Creek Valley complete with revegetation and reclamation methods for the area.

3.3 Determine the finished surface configuration of the ash and mine waste disposal area.

3.4 Recommend a makeup water intake and pumphouse at the relocated reservoir based on extreme water levels given by B.C. Hydro.

3.5 Estimate the varying water quality in the reservoir due to mixing of Medicine Creek runoff and Thompson River water. Study the effect on the power plant of a different makeup water quality due to the mixing of Medicine Creek runoff water and Thompson River water in the reservoir and due to the ash removal/transportation/disposal system in this report.

3.6 Recommend a method of controlling seepage and direct precipitation runoff from the ash disposal area for the first 15 years of plant operation (prior to mine waste disposal in Medicine Creek Valley).

3.7 Determine any imbalance of water resulting from water management of the power plant and ensure that the quality of water discharged by the power plant be not lower than that of cooling tower blowdown.

3.8 Develop the major features and economics of a modified wet "base" scheme (Alternative 'A') which should utilize:
- drag bar conveyors for continuous bottom ash removal (as opposed to intermittent removal in Base Scheme)
- Medicine Creek water entering the ash disposal pond to supplement Thompson River makeup.

3.9 Provide a comparative technical and economic evaluation (capital and operating costs) of the new Alternative 'B' Dry Ash Disposal Scheme and wet disposal schemes ("Base" and Alternative 'A').

4. Results and Conclusions

This section addresses and provides results for all the items listed in the scope of work (Section 3). It concludes that, based on the information currently available, Alternative 'B' is technically feasible and economically attractive in both capital and operating costs.

Referring to the scope of work listed in Section 3 the results and conclusions of the individual items are as follows:

4.1 A dry system using pressurized air to convey fly ash to silos and then using two 100% capacity belt conveyors to transport a mixture of conditioned fly ash from the silos and damp bottom ash to Mid Medicine Creek Valley appears to be the preferred system. However, manufacturers should be allowed to bid other proven systems.

Drag bar conveyors with above ground interconnecting and collecting belt conveyors are the preferred bottom ash removal system.

4.2 Mixed bottom and fly ash should be stacked in inclined, compacted tiers in the valley using a system of movable/ mobile conveyors and bulldozers. The inclined tiers would alternate between ash produced in freezing and nonfreezing conditions to provide area stability for any ash not compacted fully due to its frozen water content. A system of interposed layers of bottom ash and fly ash should be provided for drainage courses for ash and reservoir water seepage and direct precipitation. Finished ash surfaces should be reached as rapidly as practical to enable topsoil to be placed and seeded to reduce dusting and for reclamation purposes.

Reclaiming the dry ash disposal area in Alternative 'B' is greatly simplified in comparison with the ash ponds of the base scheme and Alternative 'A'.

4.3 The finished surface configuration should generally slope to the south and west as shown on Drawing BCH 0064 SK 151.

4.4 The proposed makeup water pumphouse and intake configuration in the makeup reservoir is shown on Drawings BCH 0064 SK156, 157 and 158. Material excavated in building this structure would be used in construction of the reservoir dam. A single makeup water pipeline is proposed along the route indicated on Drawing BCH 0064 SK 151.

Alternative 'B' Ash Disposal Study

4.5 Reservoir water quality was developed for several possible Medicine Creek and Thompson River water input combinations and took into account the increasing water consumption of the station as the units are brought into service. The calculations show the water quality to be variable and inferior to that of the Base Scheme utilizing Thompson River water only. Power plant water balances were prepared for these different operating conditions. The circulating water system maximum cycles of concentration, blowdown rate and acid dosing, the method of economizer ash disposal, the boiler makeup water treatment system, the methods of disposal of boiler cleaning wastes and coal storage area runoff would be affected by the change in water quality. However, the impact in general is not drastic.

4.6 Precipitation on the ash disposal area and ash pile seepage would be retained by a small berm in the valley. The collected water would be pumped to the power plant and coal storage runoff water retention pond. This pond would serve as a source of water for damping down the ash deposits and would also have provision for draining and overflowing via the north cutoff canal to the reservoir. R1

4.7 For Alternative 'B' the net imbalance of water represents an excess from the power plant of 0.6 l/s to 21.1 l/s of cooling tower blowdown water and of quality as indicated by the various water balances generated (Drawings BCH 0064 SK 153 and 154 and Table 4). For average meteorological conditions and lifetime average plant capacity factor of 0.65 (case 4 of this study) the excess cooling tower blowdown amounted to 6.1 l/s. As instructed by B.C. Hydro no allowance was made at this stage for any costs arising due to disposal of excess power plant water. Several possiblilities are considered by B.C. Hydro, including utilization for coal washing, mine waste disposal, agriculture needs, etc.

Alternative 'B' Ash Disposal Study

4.8 Potential freezing problems were considered in the study on the following equipment and/or systems:

- Ash Conveying
- Ash Compaction
- Ash Pile Runoff
- Makeup Water Pumphouse

It is anticipated that no serious technical problems due to the severe winter conditions will be met if proper attention would be paid to operation and maintenance procedures, especially during shutdown and start-up operations. This is subject to further study in the detailed design of the power plant, to confirmation by visiting similar installations and by tests and analysis of the stability of the ash deposited under freezing conditions such that it cannot be fully compacted.

4.9 The economic comparison estimated capital, operating and maintenance (O & M) costs for the complete ash handling systems in the Base Scheme and Alternatives 'A' and 'B'. For other affected plant items, differential costs were estimated. Costs developed by others for the 'off site" facilities and Thompson River pumping system were incorporated in the overall costs.

The results are summarized in the following table in which all sums are given thousands of 1978 dollars.

A reconciliation of the base scheme in the present estimate with that presented in May 1978 is given in Part C of this study. Section C also includes a comparison of the updated dry disposal schemes of May 1978 with Alternative 'B'.

Section C confirms that Alternative 'B' is more attractive than the dry ash disposal schemes to Upper Medicine Creek in the May 1978 report.

Alternative 'B' Ash Disposal Study ($000 at 1978 levels)

	Base Scheme	Alternative 'A'	Alternative 'B'	
Ash Scheme:	wet	wet	dry	
Capital Costs				
Ash handling, transportation and disposal system (incl. ash pond and runoff ditches)	42,419	35,976	38,165	R
Ash pond and runoff ditches	31,101	31,101	3,550	
Water Treatment equipment	10,236	10,236	6,859	R
Makeup water system and reservoir	60,200	60,200	66,538	
Differential cost of other project equipment	--	--	1,604	
Total Capital Cost	143,956	137,513	116,716	R
Differential	27,240	20,797	Base Cost	R
Capitalized O & M Costs				
Ash handling, transportation and disposal system	36,576	40,834	41,384	R
Runoff ditches	500	500	250	
Water Treatment equipment	21,615	21,615	13,066	R
Makeup water system and reservoir	44,072	41,154	34,521	
Differential cost of other project equipment	--	--	1,124	
Total Capitalized O & M Cost	102,763	104,153	90,845	R
Differential	11,918	13,308	Base Cost	R
Total Capital & O & M Costs	246,719	241,666	207,561	R
Differential	39,158	34,105	Base Cost	R

Alternative 'B' Ash Disposal Study

The lowest capital cost and lowest operating and maintenance costs occur with the "dry" ash scheme Alternative 'B'. The implementation of the wet "Base Scheme" would require increased capital costs by approximately $27,240,000 or 23% and would result in increased Operating and Maintenance (O & M) Costs by approximately 13% (capitalized differential value of O & M $11,918,000). The economics for the modified wet scheme Alternative 'A' are very close to those of the base scheme and hence, substantially inferior to those of Alternative 'B'. R2

It is noted that further ash leaching tests have been recommended to establish the need for treatment of the ash return water. Should this equipment be found unnecessary the savings in adopting Alternative 'B' would be reduced as follows:

All Sums in $'000

	Base Scheme	Alternative 'A'	Alternative 'B'
Ash Scheme:	wet w/o return water treatment		dry
Total Capital Costs	133,720	127,277	116,716
Differential	23,863	17,420	Base Cost
Total Capitalized O & M Costs	81,148	82,538	90,845
Differential	(9,697)	(8,307)	Base Cost

R2

The Base Scheme and Alternative 'A' would still require increased capital costs by 14 and 9% respectively. The O & M costs of Alternative "B" would be approximately 10% higher than those of the Wet schemes.

5. Recommendations

Based on the technical and economic evaluation performed in this study it is recommended that Alternative 'B' Dry Ash Disposal Scheme be adopted in place of the current design incorporating wet ash disposal methods. The recommendation is subject to the following conditions:

Alternative 'B' Ash Disposal Study

- That the assumptions made in the study be verified or shown not to have a substantial impact on overall costs or feasibility.
- That costs and feasibility of the ash handling systems proposed be determined in the detailed engineering phase by inviting suppliers to bid also on alternatives to the proposed schemes.
- That an acceptable method of disposing of excess power plant water be determined and that its associated capital and operating costs do not substantially affect the project's overall differential costs.
- That the environmental impact of Alternative 'B' is acceptable.

Alternative 'B' Ash Disposal Study

B. DISCUSSION

1. Composition of Report

Section 2 of this report briefly describes the present design Base Scheme and its modification Alternative 'A'. Section 3 describes the systems studied and analyzed for Alternative 'B' Ash Disposal System in the following subsections:

- Ash removal from the boiler/precipitators and transfer outside the immediate power house area.
- Ash transportation from the power plant to Mid Medicine Creek, its handling there and method of disposal along with the method of reclaiming the disposal area.
- Pumphouse and makeup water pipeline arrangements for the relocated reservoir.
- Establishment of reservoir water quality due to the transient effects of Medicine Creek flow, Thompson River pumping and extraction of water for power plant purposes.
- Water management of the power plant commensurate with the makeup water quality and ash handling and disposal system recommended.

Section 4 provides estimates of the differential capital and operating costs of the Base Scheme and Alternatives 'A' and 'B'.

2. Brief Description of Base Scheme and Alternative 'A'

2.1 Base Scheme

The present design Base Scheme comprises:

a) Wet ash handling and storage.

b) Power plant makeup water reservoir located at a distance of 2 km from the SE corner of the plant.

c) Thompson River water supply system as the sole source of makeup to the reservoir.

Alternative 'B' Ash Disposal Study

The ash handling system provides for:

- intermittent bottom ash removal from boiler hoppers utilizing conventional jet pumps and slurry transporting pipes to a storage pond in Upper Medicine Creek Valley.
- Vacuum-pressurized dry fly ash collection from precipitator hoppers, wetting and sluicing as a slurry to another section of the aforementioned pond.
- Ash return water treatment to prevent carbonate scale formation in pipelines and equipment.

The Base Scheme is described in detail in Integ-Ebasco's Project Specification with its associate drawings and the Station Design Manual (S.D.M.). The layout for this scheme 604H-Z31-X020001R2 and flow diagrams BCH 0064- M114 Rev. B., and M 115 Rev. B are included in this report.

2.2 Alternative 'A'

With respect to ash handling, Alternative 'A' is assumed to be identical to the Base Scheme except for:

a) The intermittent boiler bottom ash sluiced removal system is replaced by a continuously operating drag bar conveyor discharging, along with sluiced mill rejects (as in the Base Scheme), to a slurry tank and grinders from which ash is sluiced directly to the ash pond in slurry form.

b) The bottom ash sluice lines to the ash pond are of smaller diameter than in the Base Scheme since the flow is continuous rather than intermittent.

A diagram of the ash handling system for Alternative 'A' is given in Drawing BCH 0064 Sk 161.

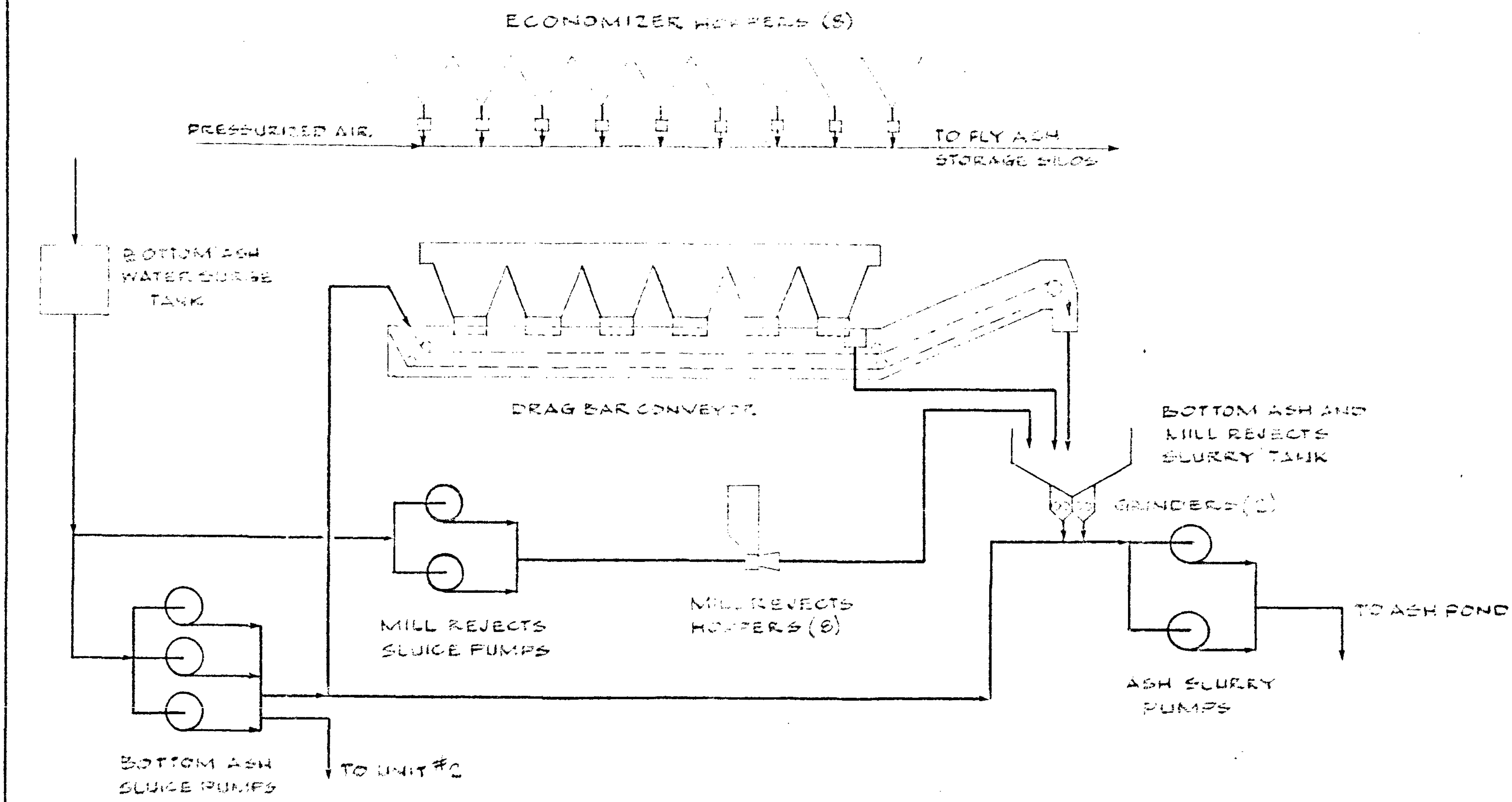
Separate pipelines for bottom ash and fly ash sluicing to the storage pond used for the base scheme were retained for Alternative 'A'. A brief examination indicates no decisive cost difference if the lines are combined. Further investigation would be required in detailed engineering if wet ash sluicing were to be retained.

Alternative 'B' Ash Disposal Study

With respect to water management Alternative 'A' utilizes Medicine Creek water to supplement the makeup water supply from the Thompson River (similar to Alternative 'B', but on a smaller scale). The water reservoir location is the same as in the Base Scheme. The arrangement adopted was to utilize Medicine Creek water by diverting part of its flow into the ash pond and to reduce cooling tower blowdown correspondingly by increasing the cycles of concentration from 12.8 to 20 (the blowdown is used as makeup for the ash system). Whereas this arrangement would require closer examination should Alternative 'A' be adopted, it was considered suitable for the purposes of this comparative study. It is possible that this arrangement could also be applied to the base scheme. If ash sluicing were to be retained, investigations should consider the possibility of pumping the balance of Medicine Creek's flow to the reservoir to save the greater costs of pumping from the Thompson River.

It has also been assumed that the return water treatment costs for Alternative 'A' are identical to those for the Base Scheme.

The layout for Alternative 'A' is the same as for the Base Scheme, namely as the attached drawing 604H-Z31-X020001R2.



Design	Drawn	Check	Appd	Issued for	Date	Rev

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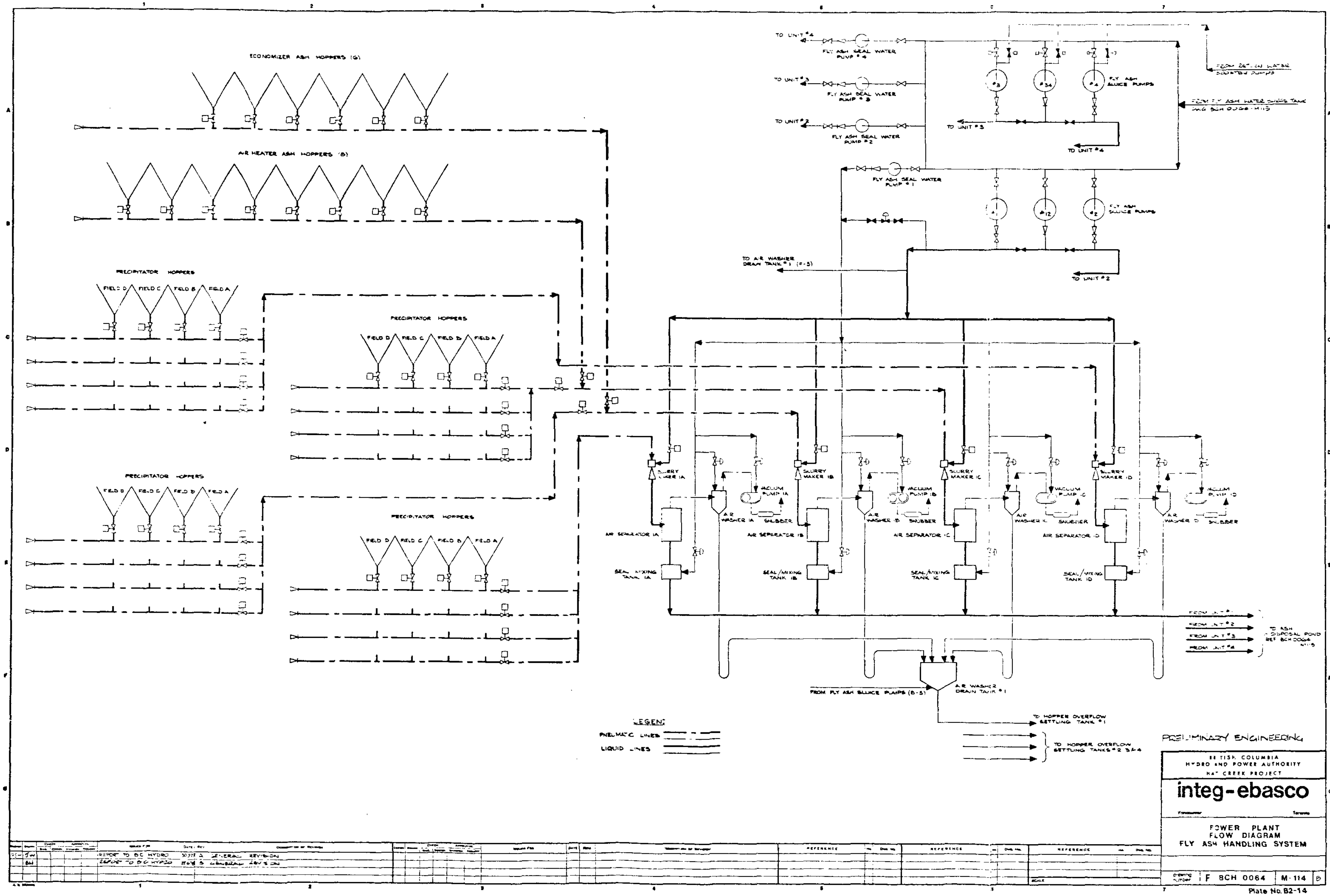
ALTERNATIVE A - ASH HANDLING SCHEME - SYSTEM DIAGRAM

B | BCH-2064 | SK.161



PRELIMINARY ENGINEERING

BRITISH COLUMBIA
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HAT CREEK PROJECT

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Vancouver Toronto

POWER PLANT
FLOW DIAGRAM
FLY ASH HANDLING SYSTEM

drawing number F 8CH 0064 M-114 B

Plate No. B2-14

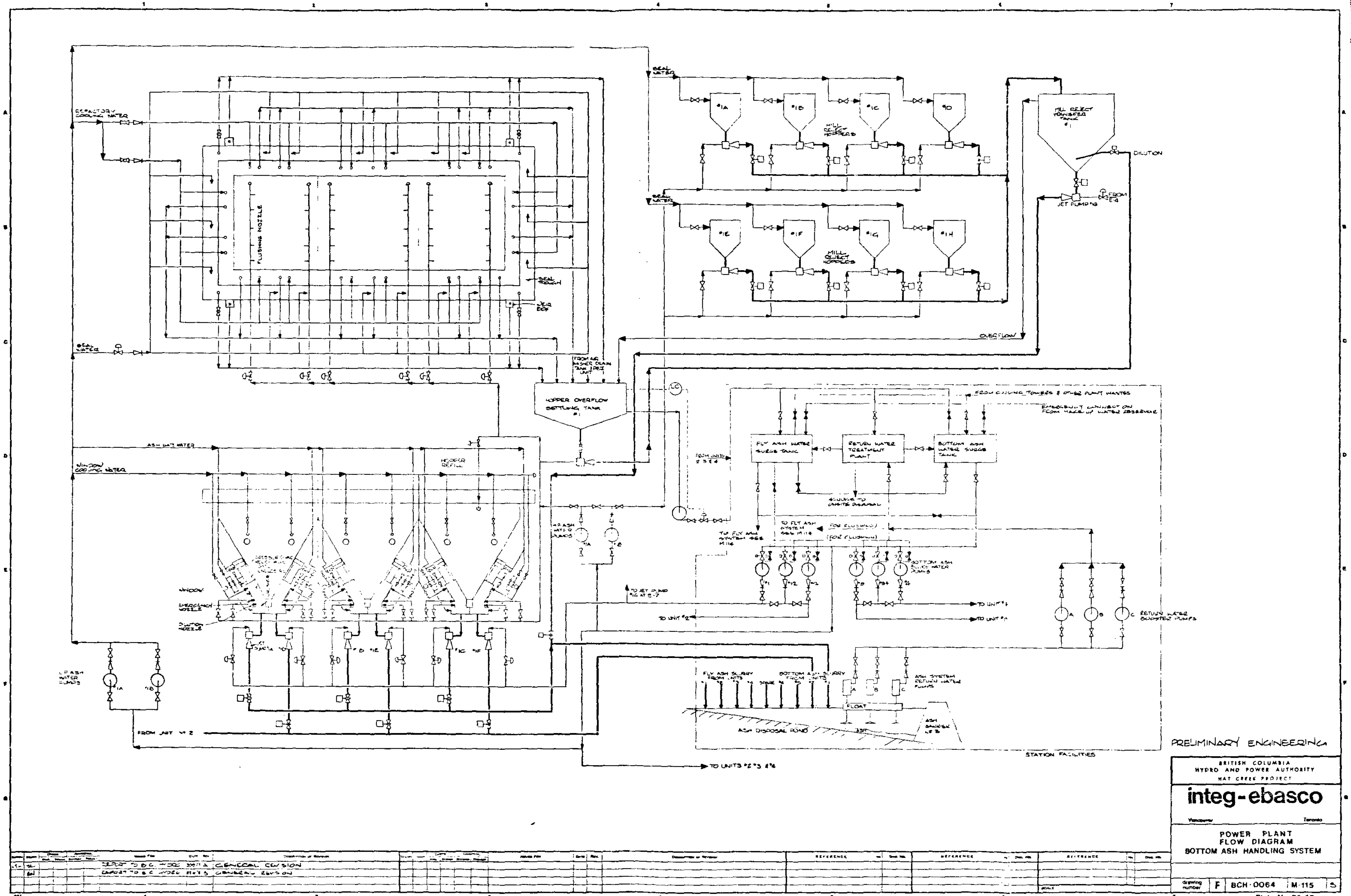

Plate No. B2-15

Alternative 'B' Ash Disposal Study

3. Description of Alternative 'B' (Site Plan SK 151 - See back cover)

3.1 Ash Handling System in Power Plant Area

3.1.1 Bottom Ash Removal System

Drawings BCH 0064 SK 147 and SK 149

A continuous bottom ash removal system utilizing a drag bar conveyor is considered as the preferred alternative system for Hat Creek Power Plant due to the extremely high ash content of the coal and anticipated bottom ash fallout up to 45% of total ash. Therefore it is used in Alternative 'B' and more detailed information on the merits of the system is given in Section 3.1.8.

It is assumed that the drag bar conveyor would be installed in the north-south direction (perpendicular to boiler center line). Based on technical information from McDowell-Wellman Company, the conveyor would be about 21 m long horizontally, 5 m on the inclined plane and 2 m wide. If the "crouton throat" is installed in the other (W-E) direction several potential problems should be examined. When the boiler manufacturer is selected a comparative evaluation of these two possible arrangements should be performed to establish:

- comparative costs due to boiler differential height
- the need for a conveyor to connect the drag bar and plant collecting conveyors
- convenience of system layout including inspection and maintenance aspects (there may be an interference between the interconnecting conveyor and the primary air and forced draft fans).

The drag bar conveyor would clear the ash continuously at a maximum capacity of 25.2 kg/s (100 TPH) of dry ash from beneath the boiler and discharge the ash onto a conventional belt conveyor and then onto the collecting belt conveyor. The above capacity was derived assuming boiler firing worst coal at maximum rating (corresponding to turbine Valves Wide Open operation), bottom ash 45% of total ash, mill rejects at 1% of coal and an approximate 20% surge capacity.

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The drag bar conveyor would be driven through a motor-gear box combination onto a chain and sprocket assembly. The drive could be designed to operate at fixed or variable speed. The variable speed would be related to boiler load and would reduce mechanical wear of the system and, probably, would reduce average water containment by bottom ash. The driving chain would be of the round link type. The design incorporating a dry return chain is the preferred arrangement for easy inspection and access during maintenance.

Since ash is removed continuously, the hopper with quenching water sprayers need not be large. On some European installations hoppers are almost completely eliminated. Spray water would cool and break up the ash effectively. A 150 m^3 (5000 $ft.^3$) capacity hopper for two hour storage was proposed for each Hat Creek boiler. Hoppers would be designed with shutoff gates for maintenance purposes.

As ash moves up the inclined section of the drag bar conveyor, water is separated and therefore neither dewatering bins nor settling tanks are required.

Mill rejects are hydraulically sluiced intermittently to the drag bar conveyor trough. The normal practice of removing mill rejects by hydraulic ejectors would be used. Alternatives would be reviewed during detailed engineering.

It is usually advantageous to collect economizer ash in a water tank below the economizer hoppers and sluice this ash continuously to the drag bar conveyor. However, it is not recommended for the described ash handling system since leaching properties of the Hat Creek fly ash may result in complicated and expensive water treatment of the recirculating water in the drag bar conveyor system. Additional leaching tests, as described in Integ-Ebasco's letter to B.C. Hydro of 25 October, 1978, could clarify the above technical decision.

Ash is cooled further in the drag bar conveyor trough to a temperature suitable for handling by belt conveyor. The normal practice to regulate the water tempeature in the trough is to control the makeup water supply and let the excess water overflow to drain. For a minimum discharge system, as in the case of Hat Creek, a cooling system consisting of heat exchangers and recirculating pumps would be required. In our calculations we assumed maximum water temperature in the trough of 62°C and a closed cycle cooling water flow of approximately 40 l/s (650 USgpm).

A surge tank would be incorporated to absorb the excess water during mill rejects removal cycles.

Ash from the drag bar conveyor would be discharged onto a unit cross belt conveyor. From the unit cross belt conveyor ash would be unloaded to either one of two aboveground collecting conveyors outside the boiler plant. There would be four unit cross belt conveyors (one per unit) and two bottom ash collecting conveyors per plant.

According to McDowell-Wellman, quenching water sprays could break the ash effectively for dry disposal purposes and no ash crusher would be required. Provision would be made for the installation of an ash crusher at the chute between the inclined section of the drag bar conveyor and the unit cross belt conveyor if it is established that such a crusher could reduce the compacting effort at the dry ash disposal field. A modification of the described bottom ash removal system that could be considered at a later stage of engineering is briefly described in Section 3.1.8.2.

3.1.2 Pressure Fly Ash Removal System (Drawing BCH 0064 SK 148)

In this study a pressure system for fly ash removal is tentatively selected for the Dry Scheme - Alternative 'B'-due to its anticipated higher reliability for plants located at high elevations. However, during the detail design phase, manufacturers should be allowed to bid alternative schemes. Some of the most common alternatives are briefly described in Section 3.1.9.

In a pressure system fly ash is discharged from collecting hoppers via an air lock valve and conveyed by an airstream inside a pressurized pipe. Pressure air is provided by a blower or compressor. This type of system can convey the dust over long distances. Dust leakage may be troublesome. Control requirements are more rigorous owing to sequential operation and the large pressure differential between flue gas in the hoppers and the conveying air.

For Hat Creek Plant there would be two 25.75 kg/s (100 TPH) pressure systems per boiler unit based on worst coal, 85% as fly ash and maximum unit output (Turbine Valves Wide Open rating).

Fly ash would be removed intermittently from the collecting hoppers to the fly ash silo. Total cycle time per each 8 hour shift would be approximately 5 hours based on datum coal, 85% of total ash as fly ash at 100% unit output. (Worst coal at 85% total ash and maximum unit output would require 30 minutes longer.) This would provide approximately 3 hours margin when the removal cycle is idle to allow for abnormally low removal rate due to plugging, maintenance, etc. The system capacity would be reviewed in detailed engineering.

To provide the conveying air for each pressure system one 700 hp blower would be required based on manufacturers' preliminary information. One spare blower would also be provided for each boiler unit.

Special provision, such as secondary hoppers, should be made for the removal of economizer ash to collect ash remote from the hot gas stream for the prevention of sintering. Large pieces of ash resulting from accumulations in the economizer tube banks are likely to occur. A debris box with sizing bars could be installed under the hoppers to prevent blockage in the system.

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Space would be provided for future installation of grinders at each hopper to break material down to sizes which can be handled pneumatically if such grinders are found necessary.

The cost of a pressure system would vary significantly with the number of collecting hoppers. In this study, based on interpolation of various manufacturers' data, 56 precipitator (or baghouse) hoppers, 8 economizer hoppers and 8 air preheater hoppers per boiler are assumed. For Hat Creek one airlock valve would cost approximately $10,000. It is recommended that during detailed engineering a study be performed to optimize the number of ash hoppers in relation to both ash system and precipitator designs.

3.1.3 Ash Transportation Within the Power Plant Area

Bottom ash is continuously removed and transported to the disposal site via unit cross belt, collecting and transport conveyors and no storage bins would be required. Space provision would be made for the installation of storage bins and unloading facilities to unload bottom ash to trucks for sale or other uses. In normal operation only one bottom ash collecting conveyor would operate. In case of breakdown, start up and transfer to the other conveyor would be automatic.

The particulars of each unit cross belt conveyor (4) will be as follows:

Length	48 m (150 ft.)
Belt Width	0.610 m (24 in.)
Belt Speed	1.016 m/s (200 ft/min.)
Design Capacity	127 tonnes/hr (140 TPH)*
Drive Horsepower	8 hp.

The particulars of each bottom ash collecting conveyor (2) will be as follows:

Length	310 m (1200 ft.)
Belt Width	0.914 m (36 in.)
Belt Speed	1.524 m/s (300 ft/min.)
Design Capacity	453 tonnes/hr (500 TPH)*
Drive Horsepower	50 hp.

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* Capacities are based on bottom ash at 40% water content. Unit cross belt capacity includes 20% surge capacity and collecting belt conveyors 10% surge capacity.

For the pressure fly ash removal system there would be two silos with 12 hour storage capacity per two units. The volume of each silo is 1400 m^3 (50,000 cu.ft.). One silo can be used as standby for the other. Less storage would be needed if a continuous fly ash removal system is selected at the stage of manufacturers' bid evaluation. Each fly ash silo would be equipped with two conditioner unloaders to feed fly ash to transport conveyors or directly to trucks. Each conditioner unloader would have 181 tonns/hr. (200 TPH) maximum capacity (dry basis) and could add 10 - 30% water by weight to moisturize fly ash. Since water consumed by the ash systems is less than cooling tower blowdown and other plant wastes, consideration would be given to a higher wetting capability, preferably up to 40%. Tests will show whether such a water content is feasible for ash transport by conveyors and compaction at the disposal area. The control of the unloaders would be integrated with the control of the transport conveyors to prevent the latter from overloading. The discharge chutes would be movable to allow emergency unloading into trucks. Another flexible chute for dry ash discharge would unload dry fly ash to trucks if, in the future, dry fly ash is to be sold.

The relatively small storage capacities of the fly ash silos are based on continuous transport, spreading and compaction of ash to and at the disposal site and high reliability of the conveyor system.

3.1.4 Manpower Requirement

Staffing varies from one plant to another. The following labour requirements is assumed:

Alternative 'B' Ash Disposal Study

Per Shift

Foreman and Control Panel	- 1
Operator Inside Power House	- 1
Operator for Precipitator Zone and Fly Ash System	- 1
Operator for Conveyors	- 1

Total	Operation	Maintenance
Ash Handling Equipment at Power Plant Area (5 crews for 3 shift operation)	20	3 (2 mechanics and 1 electrician
Transport Conveyors and Mobile Equipment at Disposal Site	(See Section 3.2.3)	

Alternative 'B' Ash Disposal Study

3.1.5 Ash Flow Rates (At Power Plant 100% Capacity Factor)

Coal Designation	Datum		Worst	
HHV MJ/Kg (Btu/lb) Ash Content	12.79 (5500) 29%		12.21 (5250) 30%	
	PER UNIT (560 MW)	PER 4 UNITS (560 MW)	PER UNIT (VWO)*	PER 4 UNITS (VWO)*
Coal Consumption				
Kg/sec	125.4	520.0	138.8	555.0
(TPH)	(498)	(1992)	(551)	(2203)
Total Ash Production				
Kg/sec	36.4	145.5 (4)	41.6	167.0 (2)
(TPH)	(145)	(578)	(165)	(660)
Mg/Shift	1048.3	4193.3	1198.1	4792.3
Mg/Day	3145.0	12579.8	3594.3	14376.9
Bottom Ash				
45% of Total Ash				
Kg/sec	16.4 (3)	65.5	18.7 (1)	78.9
(TPH)	(65)	(260)	(74)	(297)
Mg/Shift	471.7	1887.0	539.1	2156.5
Mg/Day	1415.0	5660.9	1617.4	6469.6
25% of Total Ash				
Kg/sec	9.1	36.4 (4)	10.4	41.6
(TPH)	(36)	(144)	(41)	(165)
Mg/Day	786.2	3145.0	898.6	3594.2
Fly Ash				
85% of Total Ash				
Kg/sec	30.9 (3)	123.8	35.4 (1)	141.4
(TPH)	(123)	(491)	(141)	(562)
Mg/Shift	891.1	3564.3	1018.4	4073.5
Mg/Day	2673.2	10692.9	3055.1	12220.4
75% of Total Ash				
Kg/sec	27.3	109.2 (4)	31.2	124.8
(TPH)	(108)	(433)	(124)	(495)
Mg/Day	2358.7	9434.9	2695.7	10782.7

* Turbine valves wide open rating.

Alternative 'B' Ash Disposal Study

3.1.6 Station Ash Reduction

Per Year (at 78% CF)	
Total Ash	3.67×10^6 Mg
35 Years Storage (at 65% CF)	
Total Ash	107.00×10^6 Mg
Bottom Ash, 25%	26.75×10^6 Mg
Fly Ash, 75%	80.25×10^6 Mg

Notes:
(1) Used for sizing in-plant ash removal equipment.
(2) Used in sizing of ash transport and disposal equipment (trucks, conveyors, graders, etc.)
(3) Used for determining ash BA hopper and FA silo storage requirement.
(4) Used for determining ash disposal requirement.

3.1.7 Assumed Ash Densities

		Bottom Ash	Fly Ash
Densities (Dry Basis)			
Dry Ash Loose	Mg/m^3 (lb./cu. ft.)	0.80 (50)	0.80 (50)
Packed in Storage Silo	Mg/m^3 (lb./cu. ft.)	--	0.96 (60)
Compacted in Field	Mg/m^3 (lb./cu. ft.)	1.28 (80)	1.28 (80)
Ash in Pond	Mg/m^3 (lb./cu. ft.)	0.80 (50)	0.80 (50)
Specific Gravity of Solid		2.3	2.3

3.1.8 Alternatives Considered

3.1.8.1 Continuous Bottom Ash Removal System

Below the boiler furnace, the conventional North American coal burning power plant has several flooded ash hoppers which store the ash for intermittent removal. The ash is discharged via a crusher and conveyed as a slurry either direct to disposal ponds or to dewatering bins.

Alternative 'B' Ash Disposal Study

An established method of proven reliability for handling bottom ash in Continental Europe is continuous removal by drag bar conveyor. This method is now being introduced into North America and facilities are available to manufacture the equipment under licence from proven European suppliers. Alberta Power Ltd. plans to put their 375 MW No. 5 Unit at Battle River Generating Station into service in 1981 with a drag bar conveyor for bottom ash removal. This would be the first North American utility plant with such a system.

OPERATING EXPERIENCE

DRAG BAR CONVEYOR

Some of the power plants that have successfully operating drag bar conveyors for bottom ash removal from boiler furances are listed below:

Utility	Station	Unit Size MW
Lausivannikon Vorma A.G. (Finland)	Thakoluoto	1 x 220
The Helsinki Electricity Works (Finland)	Hanasaari	2 x 120*
Rheinisch Wesfalisches Elektrizitätswerk (West Germany)	Niederaussen	2 x 150 4 x 300 2 x 600
Steinkohlen Elektrizität Aktiengesellschaft (West Germany)	Gemeinschafts-Kraftwerk-West	

The technical evaluation and cost estimate of the drag bar conveyor have been discussed in the report "Evaluation of a Continuous Bottom Ash Removal System Incorporating a Drag Bar Conveyor for Hat Creek Power Plant" by Integ-Ebasco in May 1978. The main advantages and disadvantages of the drag bar conveyor system are summarized below:

Advantages

- Continuous removal of bottom ash from the furnace especially attractive for high ash content coal.
- Low capital, operation and maintenance costs.

*Note - Boilers sized for 270 MW thermal output to cover industrial steam demand.

Alternative 'B' Ash Disposal Study

- Simple control requirements
- Low energy consumption
- No need for large storage hoppers under boiler and hence reduced boiler height
- Simple water treatment

Disadvantages

- No redundant or standby facilities
- Increased water evaporation into furnace

It is believed that for the high ash content in Hat Creek coal the advantages of the drag bar conveyor overweigh the above disadvantages and such a system is the preferred one.

3.1.8.2 Modifications of the Continuous Bottom Ash Removal System

In the preferred bottom ash removal system, bottom ash from the drag bar conveyors is unloaded onto unit cross belt conveyors and then transferred to aboveground collecting conveyors located outside the boiler plant as described in Section 3.1.1. Modifications of this system would be unloading of bottom ash from the drag bar conveyors directly onto underground or aboveground collecting conveyors without intermediate cross belt conveyors.

Underground collecting conveyors are more costly and maintenance could be less convenient. However, this is widely used in West Germany and deserves more detailed consideration at a later stage of engineering. Based on a preliminary evaluation performed in April 1978 the increased investment cost for the underground conveyors is approximately $715,000 or 6% of the total BA removal and collecting system cost.

Installation of the drag bar conveyors in the W-E direction (same as the unit center lines) and aboveground collecting conveyors inside the plant to receive bottom ash directly from the drag bar conveyors could also be considered during the detailed engineering after boiler manufacturer and design are selected since rearrangement of the boiler plant may be required.

3.1.9 Alternative Fly Ash Removal System

As discussed in Section 3.1.2, there could be several different fly ash removal systems capable of performing satisfactorily for Hat Creek Power Plant.

3.1.9.1 Vacuum System

The fly ash is intermittently removed from the collecting hoppers in a sequential operation and separated from the airstream in a cyclone before discharging into a storage silo. The vacuum can be produced by a hydraulic ejector or by a mechanical pump.

In wet ash sluicing schemes the vacuum system would operate in conjunction with slurry transportation. Hydraulic wetters would be installed remote from the precipitator collecting hoppers. Ash is removed dry and slurry is formed at the hydraulic wetters.

A complete vacuum system is effective. Dust leakage is minimized with this system. The cost of the vacuum system is usually lower than of a pressure system. However, it may be of limited use on plant where long conveying distance or high altitude are encountered.

3.1.9.2 Vacuum-Pressure System

A combined vacuum-pressure system can incorporate the merits of both systems, i.e. a vacuum system to collect the dust from numerous precipitator hoppers to a local buffer hopper or transfer tank and a pressure system to discharge from the buffer hopper to a remote silo.

Alternative 'B' Ash Disposal Study

The vacuum-pressure system was tentatively selected for Hat Creek Dry Contingent Ash Schemes in the "Evaluation of Ash Disposal Schemes for Hat Creek Thermal Plant" of July 1977. However, some manufacturers later informed Integ-Ebasco that the capability of the vacuum-pressure conveying system is marginal at the Hat Creek Plant elevation because of the extra vacuum required to overcome the resistance in the dust separation and transfer vessels (Reference Supplementary Station Design Manual Section 11.2-a dated 3 October, 1977).

The feasibility of the vacuum pressurized system for Hat Creek could only be confirmed by manufacturers at the detailed engineering phase when more ash data are available and exact arrangement of air pollution control equipment and conveying lines established.

3.1.9.3 Airslide (Drawing 0064 SK 159)

A number of collecting hoppers are connected to a dust pump by a steel duct which contains a porous diaphragm. The dust is discharged from the collecting hopper by balanced dual flap valves or similar devices to prevent air blowing into the hopper. The dust is fluidized by low pressure air which passes upwards through the diaphragm and is conveyed along the gradually falling incline of the duct to a dust pump or to a buffer hopper for subsequent removal to a silo through a pneumatic system.

The main advantages of the airslide system are:
- Low capital cost
- Significant reduction in moving parts
- Simple control requirement
- Low energy consumption
- Little maintenance requirement in case of dry, free flowing dust.

Disadvantages:
- May not be convenient for two shift operation or weekend shutdowns.

Alternative 'B' Ash Disposal Study

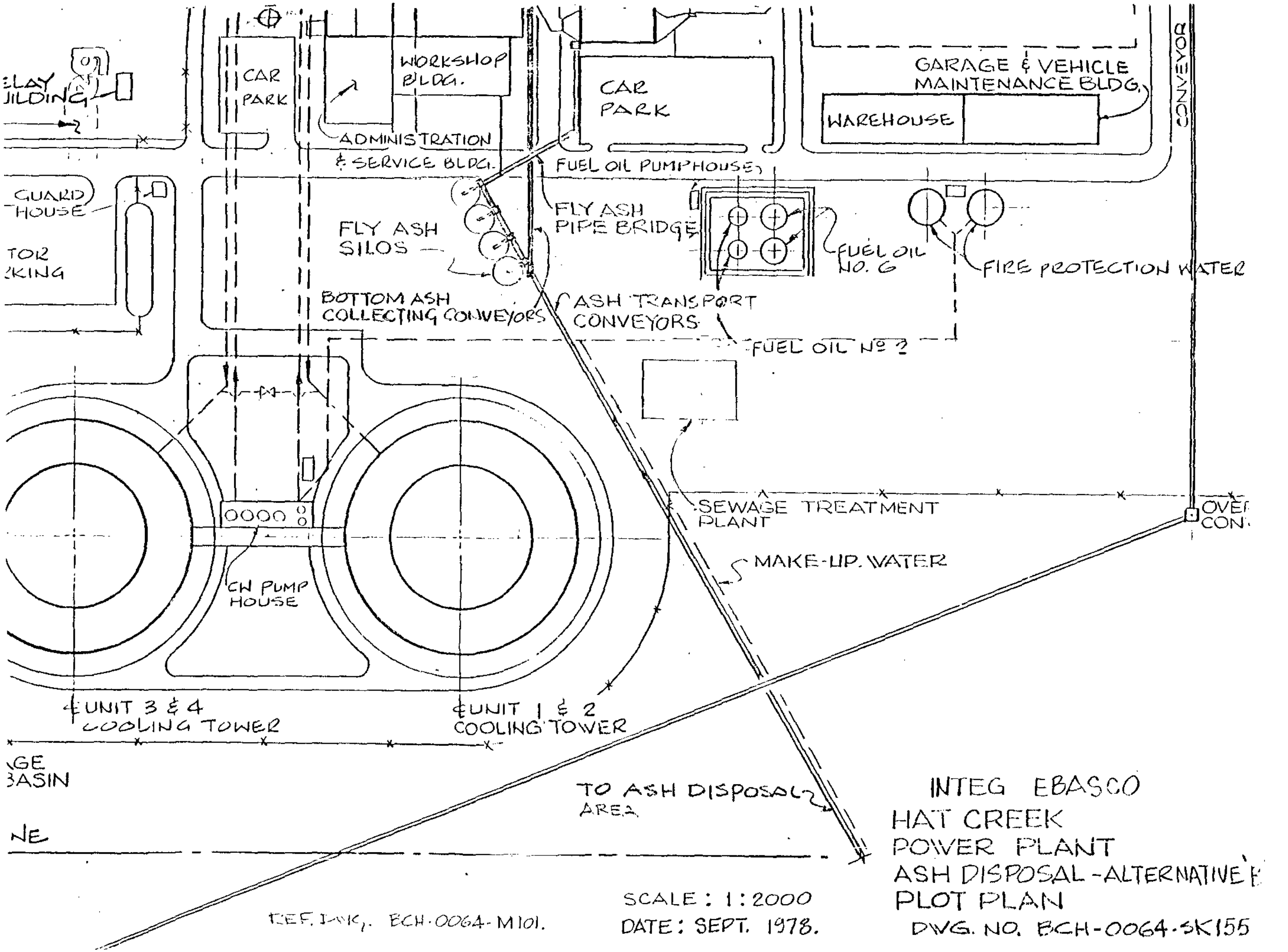
3.1.9.4 Air Jet System (Drawing 0064 SK 160)

Ash falls through the fly ash hoppers into individual rotary feeders. Each feeder delivers a controlled amount of ash to its associated air jet blower. The ash is delivered in a constant flow from the jet blowers to a buffer hopper which serves as a large collection point. Ash from the buffer hopper is conveyed to the fly ash silo through a pneumatic system.

The air jet system consumes more energy than the airslide, but it is more suitable for plants whose fly ash is difficult to fluidize.

3.1.9.5 General Notes on the Airslide and Air Jet Systems

With the high ash content and low heat value of Hat Creek coal, the continuous fly ash removal systems (airslide and air jet systems) may have advantages, particularly when the drag bar conveyor has been selected as the preferred system for continuous bottom ash removal. If ash is being removed continuously the equipment has smaller capacity, is operated without the rigors of frequent starting and stopping and installed kW ratings of motor drives are much lower. However, the airslide and air ejector systems could be considered as alternatives if later investigation show that they are suitable for Hat Creek coal. According to BR2 Burn Test Report by B.W., Hat Creek fly ash "acquired a greasy texture" and "slid in a viscous mass down the hopper slides". It was suggested that this effect arose due to boiler operation partially on oil fuel between test runs. If the Hat Creek boilers operate on a two shift basis, it is possible the same phenomenon may be experienced. In this case the manufacturers of airslide of air ejector systems should be invited to bid on their system during the formal enquiry stage, if they recommend it as the best system for Hat Creek. Proper evaluation of such a proposal, however, should probably include prior inspection of such operating facilities in the U.S.A., the U.K. or Continental Europe.



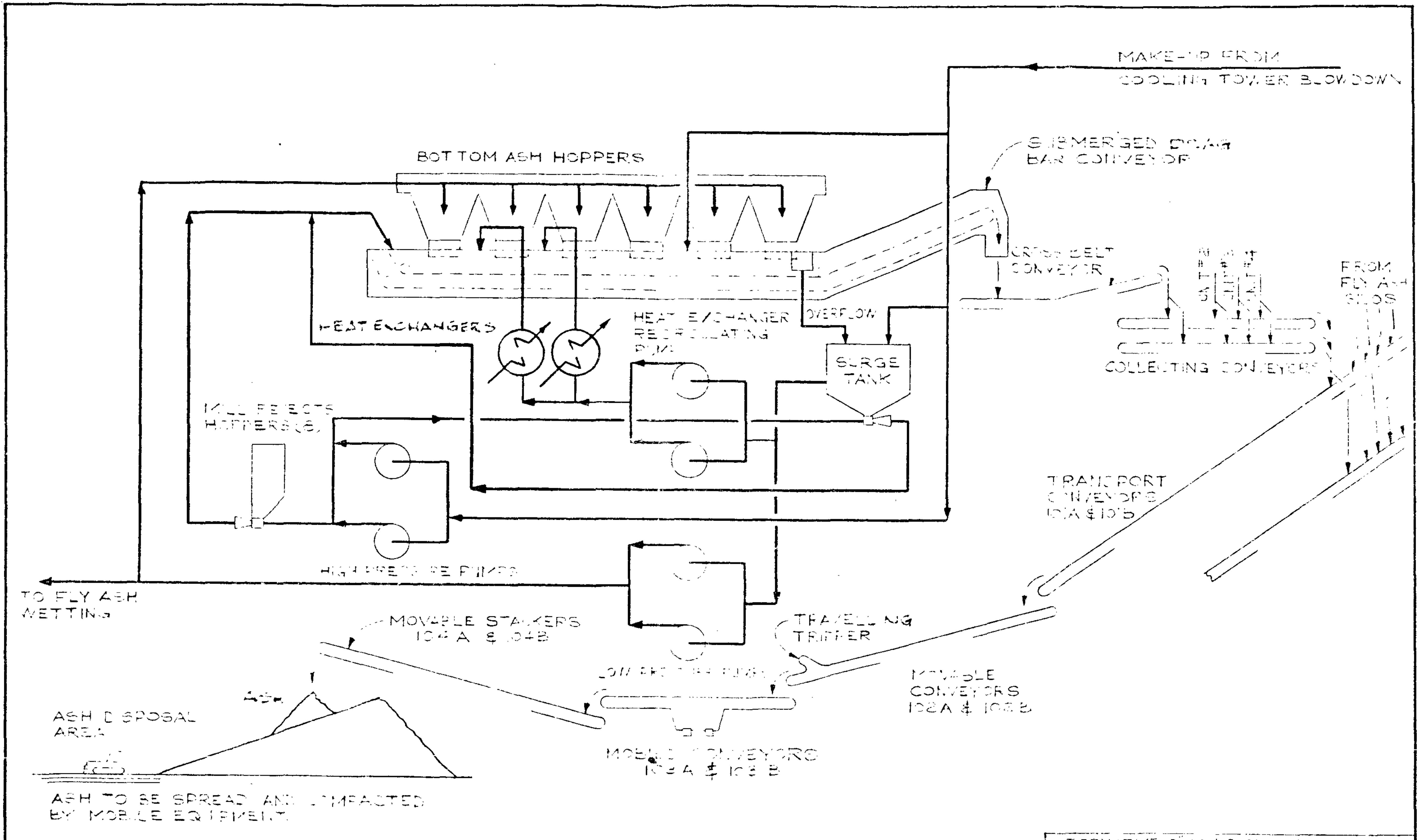
INTEG EBASCO
HAT CREEK
POWER PLANT
ASH DISPOSAL - ALTERNATIVE B
PLOT PLAN

REF. DWG. BCH-0064-M101.

SCALE: 1:2000
DATE: SEPT. 1978.

DWG. NO. BCH-0064-SK155


BRITISH COLUMBIA HYDRO & POWER AUTHORITY
HAT CREEK PROJECT
PROJECT LAYOUT MAP
604H-Z31-X02000
OPEN PIT NO. 1
WET ASH DISPOSAL POND
MINE SURFACE FACILITIES
POWER PLANT
STATION RESERVOIR
LOW GRADE COAL STOCKPILE
CORNWALL HILLS



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	K.T.H.				[illegible]	[illegible]

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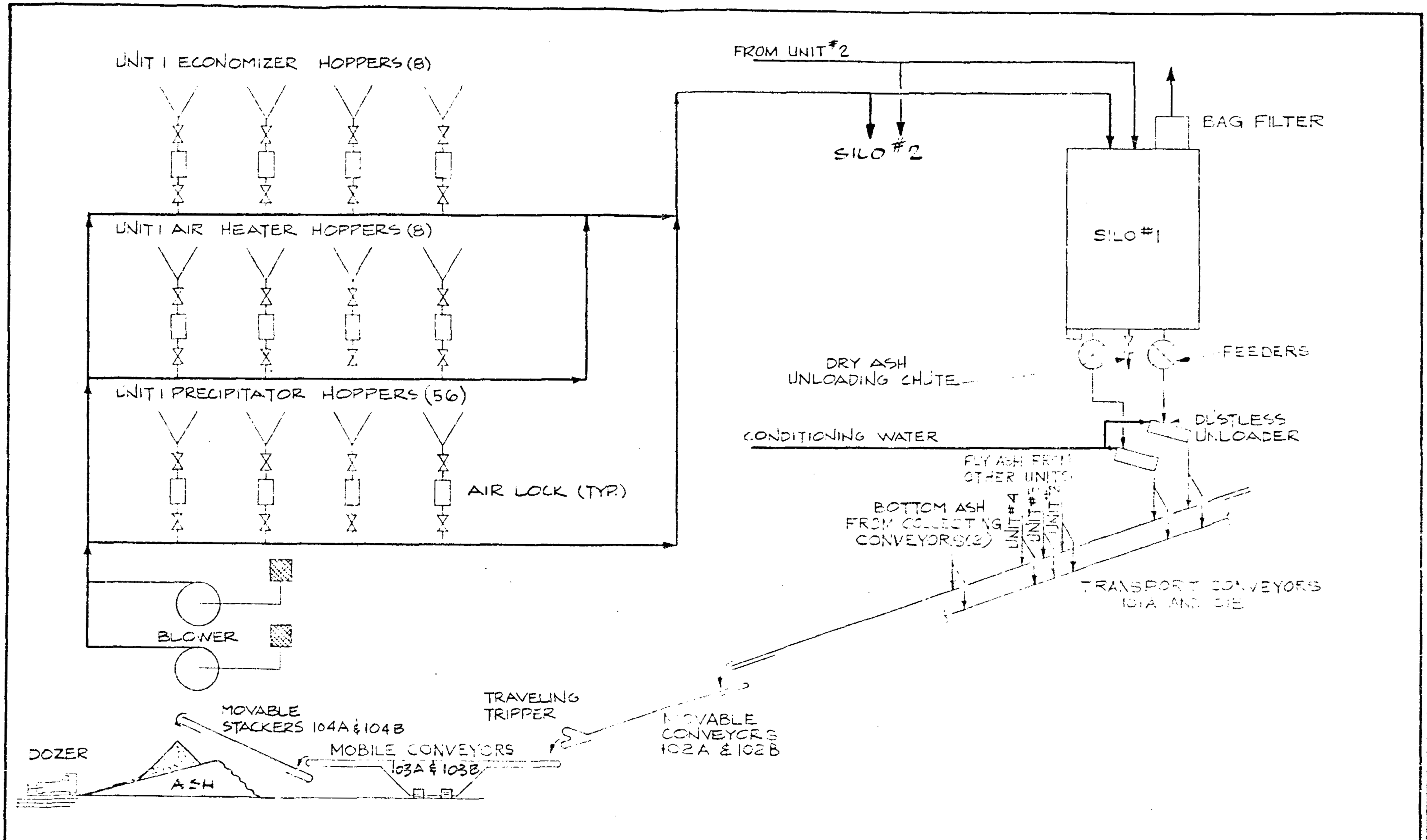
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

integ - ebasco
Vancouver Toronto

ALTERNATIVE B ASH DISPOSAL SCHEME
CONTINUOUS BOTTOM ASH
DRY REMOVAL SYSTEM
FLOW DIAGRAM

B | RCH - 0064 - | SK147 | A



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	MC				SEPT 1978	
	LTH				1978	A

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

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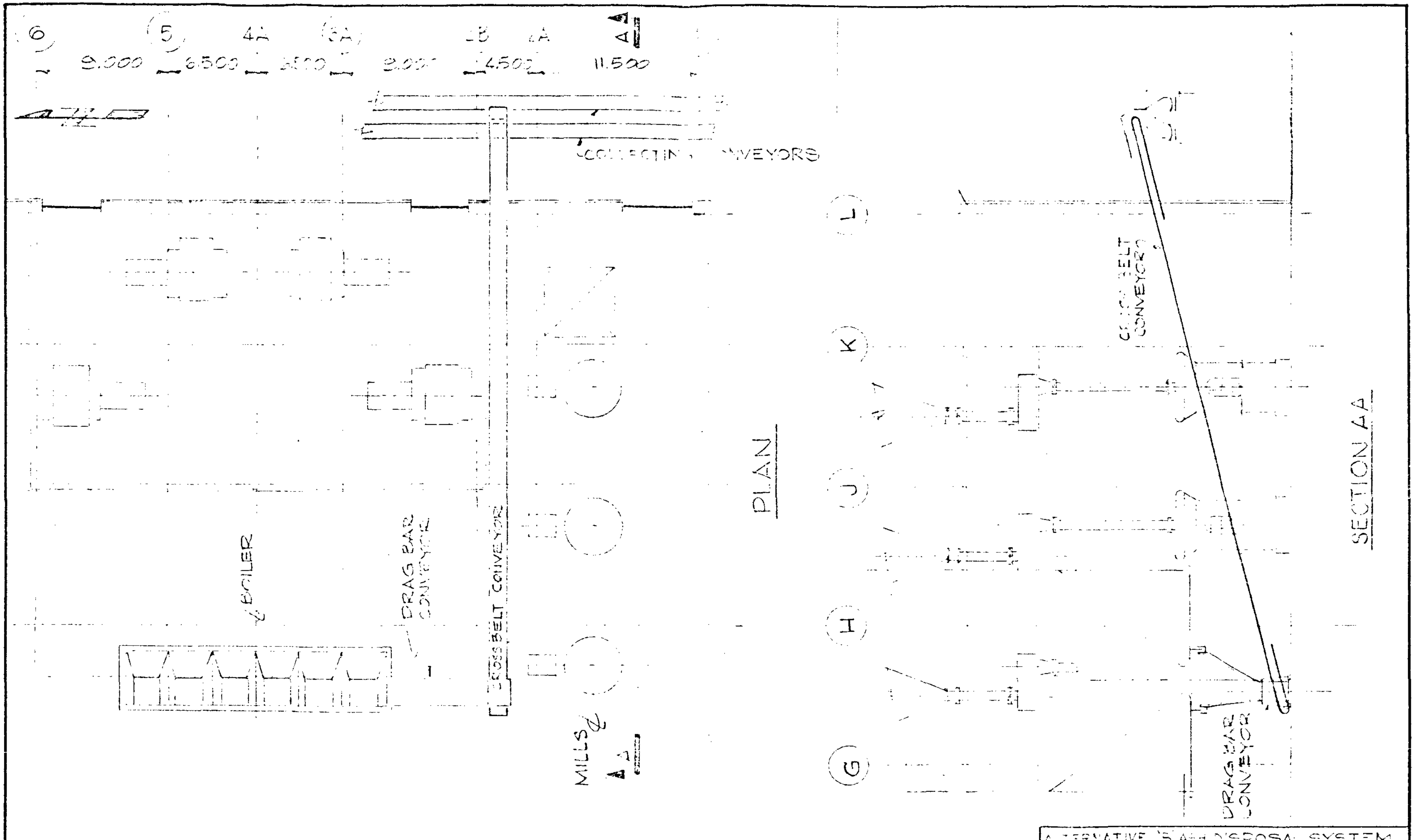
Vancouver Toronto

FLY ASH PRESSURE SYSTEM
FLOW DIAGRAM

B	ECH - 0064	SK-149	A



Design	Drawn	Check	Appd	Issued for	Date	Rev

BRITISH COLUMBIA
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HAT CREEK PROJECT

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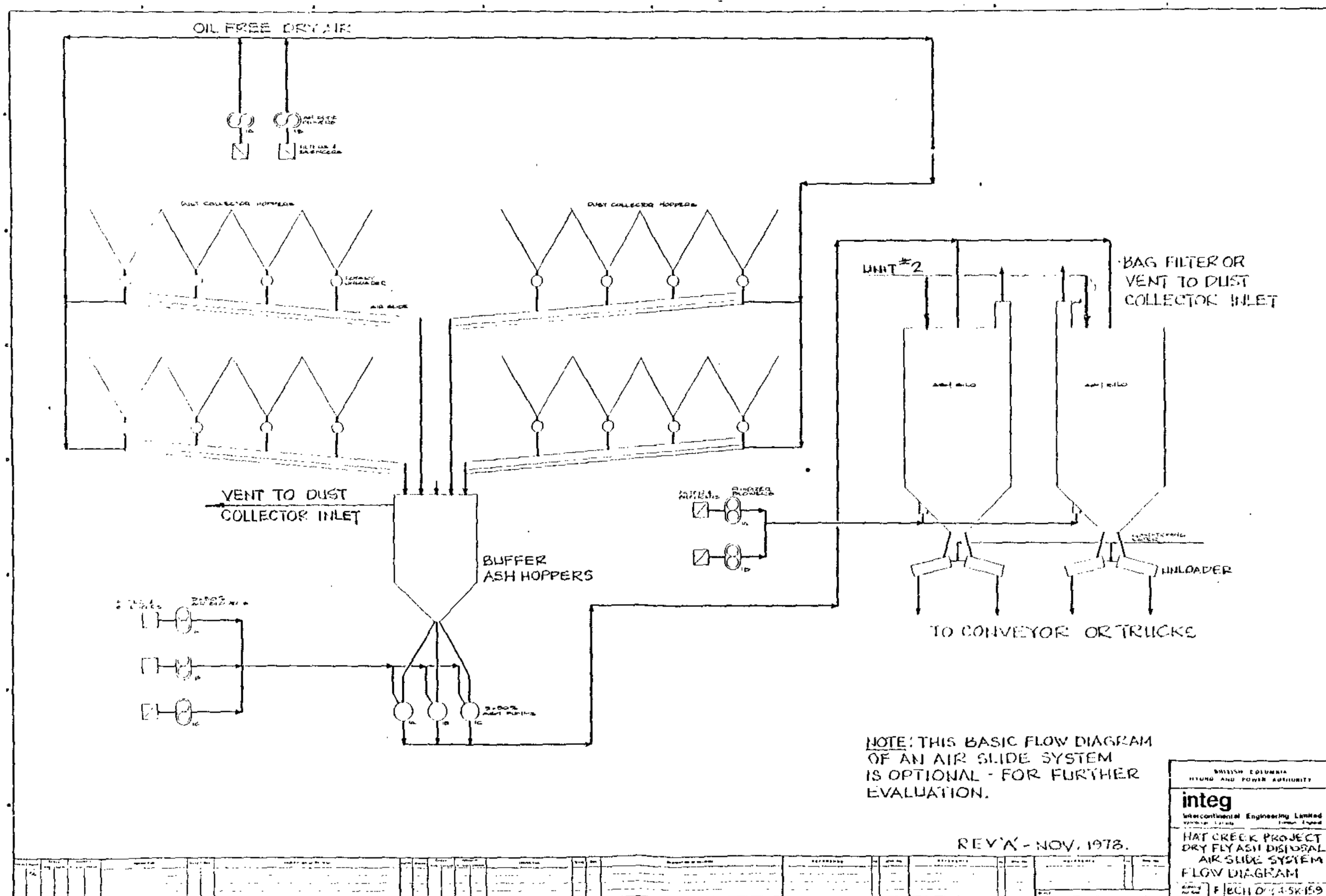
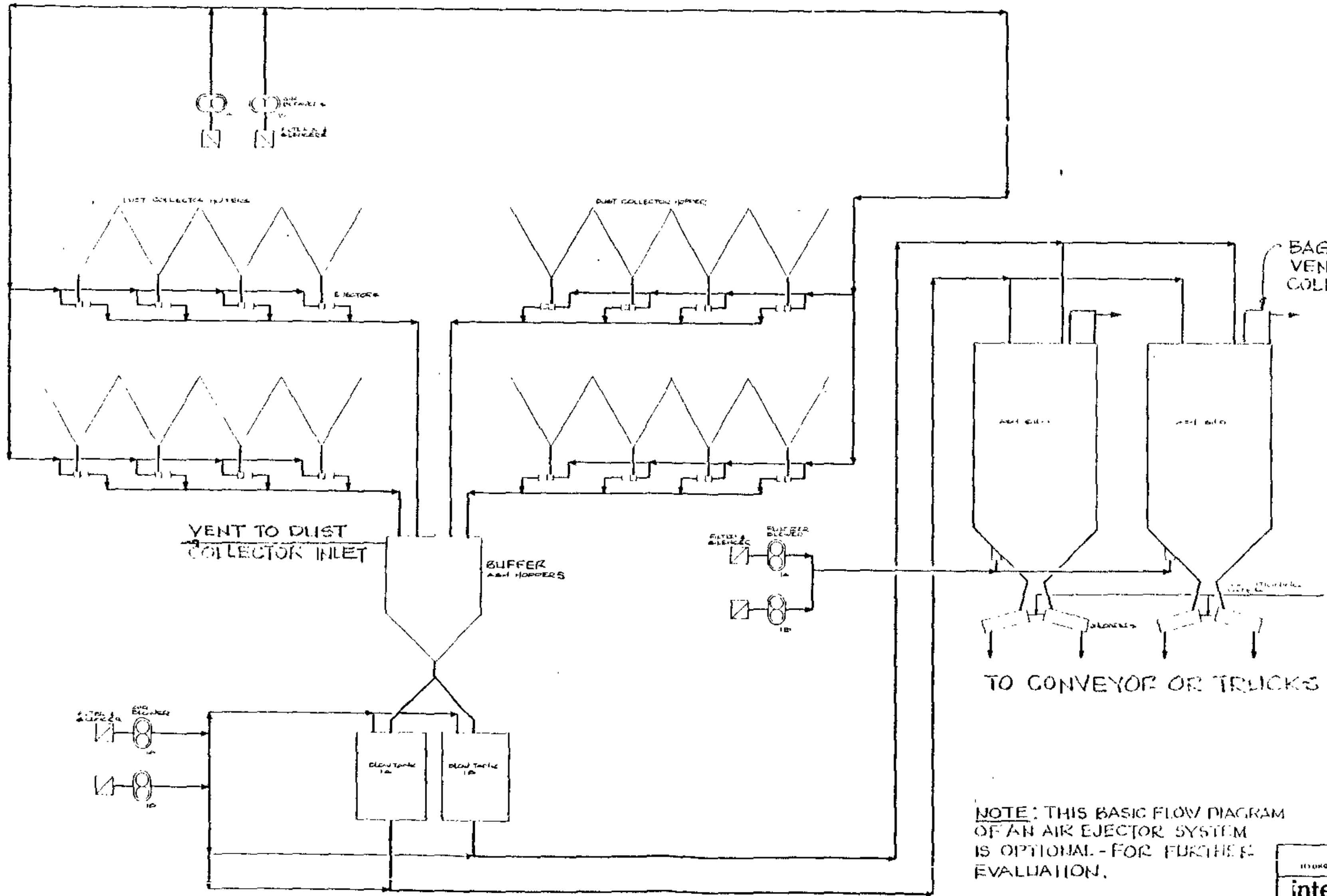
Vancouver Toronto

ALTERNATIVE 'B' ASH DISPOSAL SYSTEM
GENERAL ARRANGEMENT
OF BOTTOM ASH
DRAG BAR CONVEYORS

B | SK-149


OIL FREE DRY AIR
DUST COLLECTOR HOPPERS
DUST COLLECTOR HOPPERS
UNIT #2
BAG FILTER OR
VENT TO DUST
COLLECTOR INLET
VENT TO DUST
COLLECTOR INLET
BUFFER
ASH HOPPERS
UNLOADER
TO CONVEYOR OR TRUCKS
NOTE: THIS BASIC FLOW DIAGRAM
OF AN AIR SLIDE SYSTEM
IS OPTIONAL - FOR FURTHER
EVALUATION.
REV 'A' - NOV. 1978.
BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
integ
Intercontinental Engineering Limited
HAT CREEK PROJECT
DRY FLY ASH DISPOSAL
AIR SLIDE SYSTEM
FLOW DIAGRAM
F



NOTE: THIS BASIC FLOW DIAGRAM OF AN AIR EJECTOR SYSTEM IS OPTIONAL - FOR FURTHER EVALUATION.

REV'A' - NOV. 1978.

HYDRO AND POWER AUTHORITY

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Intercontinental Engineering Limited

HAT CREEK PROJECT
DRY FLY ASH DISPOSAL
AIR EJECTOR SYSTEM
FLOW DIAGRAM

F | 0064 KK 0

Alternative 'B' Ash Disposal Study

3.2 Ash Transportation, Distribution, Compaction and Disposal Area Reclamation

3.2.1 System Description

3.2.1.1 Ash Transportation (see Drawings BCH 0064 SK 147, 148 and 151)

Fly ash and bottom ash, discharged from the power plant, will be moved to a fixed point at the north side of the disposal area in Mid Medicine Creek by two belt conveyors (Nos. 101A and 101B). In previous studies a comparison was presented showing the economic advantages of using belt conveyors rather than trucks for ash transportation; so for the purpose of this study only belt conveyors will be considered. However, the above conclusion has to be checked at the stage of manufacturers' bid evaluation when more precise cost data become available. The conveyors and the transfer points will be arranged in such a manner that bottom ash will normally be deposited on the belts on top of fly ash, thereby reducing the risk of dusting.

The conveyor route has been selected so that a single direct flight to the edge of Mid Medicine Creek is possible. This will result in the shorter conveyor belts, the least number of transfer points and consequential lower capital cost. The absence of transfer points on the long flight will also reduce the possibility of fly ash and bottom ash becoming mixed on the belts before reaching the valley. With a fairly high moisture content in fly ash and bottom ash, a small amount of ash is expected to stick to the belt, particularly during winter operating conditions. To prevent a buildup of ash on the return idlers it is suggested the belt be turned over for the return run so that only the clean side of the belt is in contact with the idlers. Operating conveyors under winter conditions is not expected to present a problem. The conveyors would be unheated but have a hood allowing easy access for service and protection against direct precipitation and dusting. A large number of mines in the Yukon, British Columbia and across Canada successfully use unheated and unprotected conveyors for their production systems. Each conveyor will be capable of carrying the full ash production volume, so the ash transportation system can continue to function in the event that either of the two conveyors is unavailable due to repair or maintenance. For the purpose of building the drainage courses, bottom ash and fly ash would be loaded onto separate conveyors to the working area of Medicine Creek Valley. A roadway along the conveyors will provide easy access for the operation and maintenance of the conveyors.

The ash transportation conveyors (Nos. 101A and 101B) are downhill conveyors and when running loaded, they will feed power back to the plant. To ensure the safe stopping of the system, mechanical disk brakes will also be provided. This arrangement is becoming increasingly common wherever long conveyors are used for moving large volumes of material downhill.

The particulars of each conveyor (101A and 101B) will be as follows:

Length	2950 m (9678 ft.)	
Belt Width	0.914 m (36 in.)	
Belt Speed	2.24 m/s (440 ft./min.)	
Design Capacity	851 tonnes/hour (938 TPH)	
Tail End Elevation	1415 m (4642 ft.)	
Head End Elevation	1260 m (4133 ft.)	R1
Drive Horsepower	2 x 150 kW (2 x 200 hp)	

3.2.1.2 Ash Distribution and compaction (see Drawings BCH 0064 SK 147, 150, 151, and 162 to 167

A feasible method of ash distribution and deposition is generally described. Specifics of the actual procedure to be adopted will be developed in the detailed engineering phase on the basis of further studies and, possibly, a valley model. The adopted procedure shall have some flexibility for on-site adjustments required to improve the system as operational experience is gained.

Alternative 'B' Ash Disposal Study

When the disposal site in Mid Medicine Creek has been prepared by removing all vegetation and topsoil, fly ash and bottom ash will move from the power plant to the disposal area via two fixed conveyors (Nos. 101A and 101B), two movable conveyors with trippers (Nos. 102A and 102B), two mobile conveyors (Nos. 103A and 103B), and two mobile stacker conveyors (Nos. 104A and 104B). The final placing and compaction of the ash will be carried out by a pair of large rubber tired dozers. Drawing SK 150 shows a typical arrangement of the ash distribution equipment at the head end of conveyors 102A and 102B. The combined mobile conveyor (No. 103) and the mobile stacker conveyor (No. 104) operational radius is about 65 m. The ash pile produced by these systems of conveyors will be dozed outwards and down the slope to a further radius of about 85 m. Thus ash can be conveniently deposited over a distance of 150 m from the head end or tripper of a movable conveyor (No. 102A or 102B).

At the head end of transportation conveyors 101A and 101B a fixed transfer point will permit complete flexibility in routing so that ash from either conveyor 101A or 101B could be discharged to either conveyor 102A or 102B. Conveyors 102A and 102B will operate along radial lines emanating from the transfer point and will thus pivot around this point as they swing over the years, distributing ash sideways through the valley, covering an arc of about 170°.

Conveyors 102A and 102B will have an initial length (maximum) of about 1200 m, and will consist of skid mounted head and tail terminal units separated by a number of skid mounted conveyor support tables supported on prepared benches sloping down the northern face of the Mid Medicine Creek Valley. The conveyors can be shortened or lengthened, as required, and can be moved sideways on their skids to new locations by means of the spreading dozers.

Alternative 'B' Ash Disposal Study

A sequence of ash deposition with the movements of conveyors 102A and 102B from their initial location to their uppermost reach (shortest length) along the first prepared bench is illustrated on sketches 162 and 163 as follows:

STAGE 1:

The initial flow of ash will be via conveyor 102A which will terminate at, or near, elevation 1195 about 150 m west of the toe of the dam. The mobile conveyor 103A will probably not be needed for the first few weeks. Ash will flow directly from conveyor 102A to the mobile stacker conveyor 104A at which it will be stockpiled. The dozer will spread it out and compact it. The direction of movement of the mobile conveyor and the stacker is shown by arrows.

STAGE 2:

The conveyor 102B will follow a prepared bench at a higher level and will terminate at or near elevation 1215. The mobile conveyor 103B and the stacker 104B will be operating on a slope not exceeding 5 per cent. By maintaining a height differential of about 20 m between the stackers 104A and 104B, a suitable slope (about 20 percent) can be attained for the dozers operating over 85 m reach. The top surface of ash previously deposited by the conveyor 102A is outlined in dotted lines.

STAGE 3:

The conveyor 102A will be filling up only a portion of the valley width at elevation 1195 because of limitation on conveyor system reach. The remaining portion of the valley width will be filled on the next shift of the conveyor bench along a different radial line. The retracting conveyor 102B will be building up ash to elevation 1215 over the elevation 1195 surface built up by the conveyor 102A.

Alternative 'B' Ash Disposal Study

STAGE 4:

This is an extension of Stage 3 in the continuation of upward travel of both movable conveyors.

STAGE 5:

This will be the uppermost extent of retraction for both conveyors on the benches started in Stage 1.

STAGE 6:

The conveyor 102 B will be filling up to the next level, elevation 1230, as it extends downward on the previous bench.

The conveyor 102A will start on its downward extension along a different radial line on a new bench (projection shown in dotted lines). This bench will slope downward to elevation 1230, run horizontally thereon to the edge of the plateau and then slope down again to elevation 1195 to fill another part of the width of the valley.

Four isometric drawings (SK164 to 167) show the overall view of the Mid Medicine Creek Valley between the transfer point (head end of fixed conveyors 101A and 101B) and the make-up water reservoir dam at different times during the disposal operations as follows (references to time periods are approximate, and for illustration only).

SK164:

Approximately 6 months from the start of ash disposal, the movable conveyor 102A will be filling up to elevation 1195. The movable conveyor

Alternative 'B' Ash Disposal Study

102B will be following along on the next level, elevation 1215. Only a part of the total width of the valley is filled up to elevation 1195 at this stage.

SK165:

This sketch shows an extension of the disposal area activity shown on the previous sketch approximately 1 year from start. The entire width of the valley is filled to elevation 1195 along a strip adjacent to the dam. Further downstream, the valley is only partially filled.

SK166:

Approximately 3 to 4 years from start, the valley will be filled up to the top (approximate elevation 1243) along the dam. The movable conveyor 102A will be filling up to elevation 1230 followed by the movable conveyor 102B at elevation 1243.

SK167:

This sketch shows extension of the activities on the previous sketch. Adjacent to the dam, topsoil will be spread and seeded for protective vegetation cover.

The lowest 20 m layer in the valley will be filled by the conveyor 102A and the topmost 12 m layer by the conveyor 102B. The two intermediate layers of 20 m and 15 m thickness will be built up by either of the conveyors. Sufficient plateau will be provided by the movable conveyor 102A on which the following conveyor 102B can work.

Alternative 'B' Ash Disposal Study

Drawing SK 151 shows the plan of the ash disposal system. Drawing SK 152 shows a longitudinal section of the valley with the profiles of compacted (warm months) and not fully compacted (severe winter months) ash layers for the first 6 years of ash disposal. Thicknesses of these slices will depend largely on the quantities of ash produced during these two generally classified periods (warm months and severe winter months) in the year.

The ash will be deposited in layers of about 0.3 m (1.0 ft.) thickness and the compaction will be effected by the rubber tired dozers, used for spreading the material. Lined drainage courses will be provided in the ash pile as shown in Section B of Drawing SK 152. This will require proper sequencing of fly ash/bottom ash deposition on the 12 to 20 m high layers built by movable conveyors.

When bottom ash only is required as drainage layers in certain areas, bottom ash will be loaded at the power plant onto one of the ash transportation conveyors, either 101A or 101B and routed via conveyors 102A or 102B, as required, to the appropriate area for disposal.

An arrangement of conveyors and dozers for placing, spreading and compacting material has been used in the construction of several large dam projects including the Peace River Dam in B.C. By providing two full capacity, independent conveying systems it will be possible to continue the ash distribution and disposal operation at full plant output while one set of conveyors is being moved to a new position or is out of service due to breakdown or maintenance.

As the conveyors swing westward through the valley the conveyors will reach a position about normal to the actual contour lines of the terrain resulting in a steeper downwards angle of the conveyors. However, as the head end of the lower conveyor, conveyor 102A, will always be some 20 m above the valley bottom, the downward angle will not exceed six degrees, the maximum angle for movable conveyor operation.

The particulars of the ash distribution and compaction equipment are as follows:

Conveyors 102A and 102B (Movable, with trippers)

Length	1200 m (3937 ft.)	R1
Belt Width Maximum	0.914 m (36 in.)	
Belt Speed	2.24 m/s (440 ft./min.)	
Design Capacity (each)	851 Tonnes/hour (938 TPH)	
Tail End Elevation	1255 m (4117 ft.)	
Head End elevation	Varies down to 1195 m (3920 ft.)	
Drive Horsepower (each)	Varies to 225 kW (300 hp)	R1

Conveyors 103A and 103B (Mobile, Mounted on Caterpillar Tracks)

Length	30 m (100 ft.)
Belt Width	0.914 m (36 in.)
Belt Speed	2.24 m/s (440 ft./min.)
Design Capacity (each)	851 tonnes/hour (938 TPH)
Drive Horsepower (each)	15 kW (20 hp)

Conveyors 104A and 104B (Mobile Stackers, Mounted on Caterpillar Tracks)

Length	36 m (120 ft.)
Belt Width	0.914 m (36 in.)
Belt Speed	2.24 m/s (440 ft./min.)
Design Capacity (each)	851 tonnes/hour (938 TPH)
Drive Horsepower (each)	37 kW (50 hp)

Alternative 'B' Ash Disposal Study

Spreading Dozers (Two Required)

Make	Raygo Wagner (or equal)
Model No.	CHD-40/60
Spreading Capacity (each)	1000 m^3/hour (1308 cu. yds./hr.)

Water Truck (One Required)*

Capacity	22.73 m^3 (6000 US gals.)

Lighting

Several large light pylons, fitted with a battery of fixed lights, will provide adequate illumination for night operation in the disposal area. These will be skid mounted to enable their relocation as the disposal working area is adjusted.

* In emergency water for dust suppression would be supplied direct from the holding pond.

Alternative 'B' Ash Disposal Study

The final distribution plan will be subject to a detailed survey of the disposal area after removal of vegetation, topsoil, etc., creek diversion and drainage requirements, definitive ash production rates, ash characteristics, dozing and compaction data and equipment and methods proposed by manufacturers at the bidding stage. It is expected that the final distribution plan will be determined and monitored from studies of both a physical model and a computer model.

3.2.1.3 Reclamation

As soon as final elevation has been reached approximately two feet of topsoil (removed from the bottom and slopes of the disposal area prior to placing of ash) will be used for topping off the ash pile. This will be seeded to prevent erosion of the topsoil. Should the amount of topsoil collected from the disposal area not be sufficient to cover the ash pile, soil from other areas will be required.

It is also noted that reclamation of the dry ash disposal area in Alternative 'B' is effected during the operating life of the power plant and the process is greatly simplified in comparison with the ash ponds of the Base Scheme and Alternative 'A'. With an ash pond freestanding water must be removed and/or evaporated before the area can be covered with a suitable topping material. With a single pond, reclamation could not be initiated before the project's decommissioning phase.

3.2.2 Technical Data

3.2.2.1 Ash Bulk Density

Fly Ash:	Loose, dry basis	0.80 tonnes/m^3	(50 lbs./cu. ft.)
	Compacted, dry basis	1.28 tonnes/m^3	(80 lbs./cu. ft.)
	Conditioned, 20% H_2O	0.96 tonnes/m^3	(60 lbs./cu. ft.)
	Compacted, 20% H_2O	1.54 tonnes/m^3	(96 lbs./cu. ft.)
Bottom Ash:	Loose, dry basis	0.80 tonnes/m^3	(50 lbs./cu. ft.)
	Compacted, dry basis	1.28 tonnes/m^3	(80 lbs./cu. ft.)
	Conditioned, 40% H_2O	1.12 tonnes/m^3	(70 lbs./cu. ft.)
	Compacted, 40% H_2O	1.79 tonnes/m^3	(112 lbs./cu. ft.)
Ash Mixture:	(55% fly ash plus 45% bottom ash)*		
	Loose, dry basis	0.80 tonnes/m^3	(50 lbs./cu. ft.)
	Compacted, dry basis	1.28 tonnes/m^3	(80 lbs./cu. ft.)
	Conditioned, 29% H_2O	1.03 tonnes/m^3	(64.3 lbs./cu. ft.)
	Compacted, 29% H_2O	1.65 tonnes/m^3	(103 lbs./cu. ft.)

* Worst condition for ash transportation and disposal.

Alternative 'B' Ash Disposal Study

3.2.2.2 Annual Ash Production

(Based on B.C. Hydro Operating Regime dated 31 May, 1978)

	Annual Ash Production			Annual Average Conveying Rate t/h	Annual** Average Disposal Rate m^3/day
Year	Dry-Loose (Bulk SG=.80) Tonnes	Conditioned (Bulk SG =1.03) Tonnes	Compacted Volume m^3		
1	390,000	503,000	305,000	57	1,336
2	780,000	1,006,000	609,000	115	2,671
3	1,410,000	1,819,000	1,102,000	208	4,829
4	2,120,000	2,735,000	1,656,000	312	7,260
5	2,700,000	3,483,000	2,109,000	398	9,247
6 - 15	3,290,000	4,244,000	2,570,000	484	11,267
16 - 25	3,055,000	3,941,000	2,387,000	450	10,462
26 - 35	2,585,000	3,335,000	2,020,000	381	8,853
35 year Total	96,700,000*	124,746,000	75,551,000		

For conveyor design purposes an average hourly conveying rate of 774 tonnes/hour was used. *** This reflects the worst conditions as follows:

- Boiler firing worst coal
- Turbine valves wide open (VWO) rating
- Bottom ash/fly ash gravimetric split 45/55
- 40% water content in bottom ash****
- 20% water content in fly ash.

* Calculating the lifetime dry ash productions by the alternative method of applying the lifetime average capacity factor (65%) to the full load ash production rate gives 107,000,000 tonnes.

** Conditioned.

*** This rate was calculated on the basis of maximum total ash production of 166.6 kg/s (worst condition, 4 units operating)

**** Average is 30%, worst condition is 40%.

- Conditioned fly ash, 55%: 166.6 x .55 x 1.2 (20% H_2O) = 110 kg/s
- Dewatered bottom ash, 45%: 166.6 x .45 x 1.4 (40% H_2O) = 105 kg/s

Total = 215 kg/s
= 774 tonnes/hour.

The conveyor design capacity is 10% above the maximum ash production rate to allow for surges in ash production.

3.2.3 Labour Requirement

3.2.3.1 Operating Staff

The normal everyday operation of the ash transportation, distribution and compaction system will require a total crew of 7 per shift distributed as follows:

Conveyors 101A and B - one operator, one helper
Conveyors 102A and B}
Conveyors 103A and B}- three operators, one helper
Conveyors 104A and B}
Spreader dozer - one operator.

When conveyors 102A or B must be moved, shortened or lengthened an extra crew of two operators and two helpers will be needed for approximately 1-3 shifts depending on the complexity of the move. The frequency of moves will vary; moves will be more frequent initially when the equipment is working in the confined area of the creek bottom. Later when the ash can be spread over a large level area the need for frequent moves will be reduced. From time to time when dusting necessitates the use of a water truck, a truck driver will also be required.

3.2.3.2 Maintenance Staff

One electrician and one mechanic, both operating out of the power plant maintenance facilities, would be required for the transport conveyors and distribution/equipment. Full utilization could be achieved by extending the duties of this maintenance crew outside the ash transportation/disposal system.

3.2.4 Alternatives

The "Evaluation of Continuous Bottom Ash Removal System Incorporating a Drag Bar Conveyor for Hat Creek Power Plant" by Integ-Ebasco of May 1978 compared two transport systems, belt conveyors and trucks for the dry ash disposal scheme at Upper Medicine Creek Valley. For this case the belt conveyor system was indicated to be more economical than the trucking system. For the dry disposal scheme at Mid Medicine Creek Valley it is assumed that the belt conveyor system would have the same economic advantage and therefore no further consideration has been given to a trucking system.

The possibility of a single transport conveyor complete with emergency stockpile equipment for 2-3 days ash production was considered in lieu of two 100% capacity conveyors. Whereas specific costs have not been established, engineering judgement indicates this alternative to be uneconomic. The savings in capital costs of one conveyor is reduced by the increased capacity of a single conveyor to catch up after a period of unavailability and also by the cost of the stock out and reclaim equipment. Operating costs would also be higher due to double handling the ash. In addition a single conveyor precludes the possibility of transporting bottom ash and fly ash separately for the purpose of building the drainage layers of bottom ash in the ash pile unless bottom ash storage silos are installed.

3.2.5 Tests

It should be noted that this design concept has been developed without the benefit of any data or test work results identifying the physical properties and handling characteristics specific to the Hat Creek coal ash at various moisture contents and under varying climatic conditions. For the purpose of this concept it has been assumed that the ashes can be handled effectively by an arrangement of conveyors at the conditions encountered in the Hat Creek area. However, before final assessment of this ash disposal alternative the following basic test work is recommended for representative samples of Hat Creek coal ash:

- Atterberg limits (on fly ash)
- Grain size distribution (fly ash and bottom ash)

Alternative 'B' Ash Disposal Study

- Optimum density tests for fly ash, bottom ash and for different mixtures of both in loose and frozen forms.
- Permeability tests for both loose and compacted fly ash, bottom ash and for different mixtures of both
- Flow moisture point
- Heat of hydration tests
- Direct or triaxial shear tests
- Freezing tests on fly ash, bottom ash and on different mixtures of both - all at varying moisture content and duration
- Any other tests indicated from the results of above test work. (A test involving the movement of ash samples by belt conveyors under normal and freezing conditions should give a good impression of the practical problems which may be encountered.)
- Stability of mixed bottom ash and fly ash in the configuration proposed for ash disposal in Medicine Creek Valley.

3.2.6 Disposal Area Configuration

3.2.6.1 Required Capacity

The mine waste and ash disposal area will be contained by the makeup water reservoir dam (axis 3B as defined in HEDD Report No. 916) on the east, the mine waste embankment on the west, and the Medicine Creek Valley slopes on the north and south sides. The required capacity of the total disposal area is based on the following:

Material	Volume, m^3
1. Bottom ash and fly ash	
(relative density = 1.28 Mg/m^3)........	83.5×10^6
2. Mine waste (total volume = $139.55 \times 10^6 m^3$)	
Granular surficials in embankments	
(0% swell factor)........	26.2×10^6
Bedrock and surficial wastes	
$(139.55 - 26.2) \times 10^6 \times 1.25$	
(25% swell factor)........	141.7×10^6
TOTAL	251.4×10^6

Alternative 'B' Ash Disposal Study

3.2.6.2 Surface Profile

During the initial 15 years of power plant operation, the finished surface will be sloped a minimum of 1% to the west and south. Precipitation and reservoir seepage will be handled as described in Section 3.5.5. The slope to the south is proposed to divert runoff and snowmelt away from the ash and mine waste conveyors operating and access areas. On the north side of the disposal area no waste materials will be deposited over the reservoir outlet conduit to ease inspection and maintenance. The conduit will be buried just below the depth required for frost protection. R1

The lower part of the disposal area will be sloped 5% as shown on the Dwg. BCH 0064 SK 151. The capacity of the disposal area can be increased by raising the mine waste embankment and filling the area up to the minimum slope of 1% if so required. Additional disposal volumes may be required due to less densely compacted ash during freezing conditions and/or due to ash/mine waste volumetric production being higher than anticipated.

3.2.6.3 Disposal Pile Drainage and Stability

Lined drainage courses will be provided at the bottom and sides of the disposal area and also within the pile (as shown on SK 151) to prevent excessive accumulation of water and consequential pile instability. The stripped surface of the disposal area will be glacial till or other fairly impermeable surface. Bottom ash in the ash disposal area and suitable filter material in the mine waste area will be deposited against this surface. At specified vertical intervals within the ash pile alternate courses of fly ash and bottom ash will provide lined drainage courses - the fly ash layer forming the lining and the bottom ash providing the drainage course. Stability analyses of this scheme would be carried out in the detailed engineering phase.

3.2.6.4 Roads

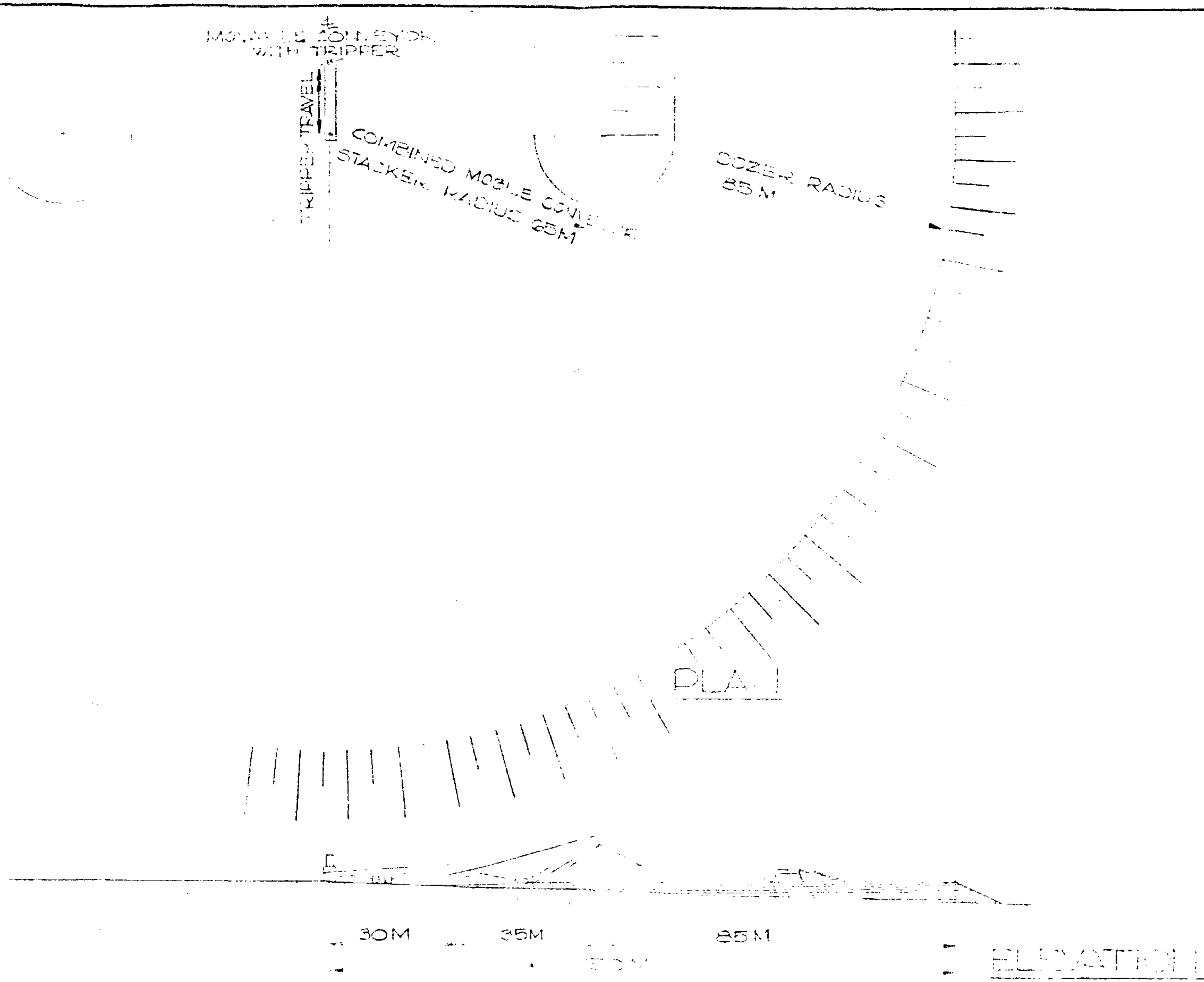
A road of varying widths and design will be constructed from the power plant area to the reservoir makeup water pumphouse. Between the power plant and the first conveyor underpass it will serve primarily as the conveyor service road. From this underpass to the project access road it will be designed as the plant access road. From the project access road to the fixed conveyor transfer point it will serve primarily as the conveyor service road. In this portion the road will have its maximum slope of 15%. The remaining part of the road will lead to the makeup water pumphouse.

Because of the relocation of the makeup water reservoir the project access road routing may have to be modified. This subject is not included in the scope of the present study.

3.2.7 Operating Experience - Dry Ash Disposal Areas

The following stations dispose of all or part of their fly ash and bottom ash production in dry disposal areas:

Utility	Station
Alberta Power Limited	Battle River
Calgary Power Limited	Sundance
Arizona Public Service	Four Corners
Southern California Edison	Mojave
Columbus and Southern Ohio	Conesville
Philadephia Electric	Cromby (bottom and fly ash)
	Eddystone
Duquesne Light (Pittsburgh)	Elrama (bottom and fly ash)
	Cheswick
Pennsylvania Electric	Conemaugh
Appalachian Power Company	Clinch River (fly ash)
	J. Amos (conversion to dry disposal for fly ash)



Design	Drawn	Check	Appd	Issued for	Date	Rev
	ES					

BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

integ - ebasco
Vancouver Toronto

[illegible]
METHOD OF ASH SPREADING
AT ASH [illegible] AREA

B | 5CH-0064 | SK-150

Alternative 'B' Ash Disposal Study

3.3 Makeup Water Pumphouse and Pipeline (see Drawings BCH 0064 SK 156, 157 and 158)

The pumphouse will be located within the reservoir area about 60 m from its north bank. It will consist of a vertical 3.05 x 6.1 m concrete shaft about 35 m in height with rectangular openings at its base and a steel framed building with insulated siding. The building will be approximately 4.9 x 7.3 m in size and will be connected to the access road by a concrete bridge. The base elevations are as follows:

Operating Floor Level:	El. 1245 m
P.M.F. Level:	1242.5 m
Normal High Water Level:	1230 m
Minimum Low Water Level:	1215 m

The pumphouse will have three (3) 50% duty, multi-stage vertical pumps, each of about 0.63 m^3/s (10,000 gpm) capacity and with a motor of approximately 2000 kW (2680 hp). The pumps will supply water to the cooling tower basin channel at an approximate elevation of 1410 m. The pump impellor and shaft assembly will be installed in approximately 3 m long sections. Motors will be installed 0.15 m above the operating floor. Pumps and motors will be serviced by an overhead bridge type electrically operated crane of 12 Mg capacity and 4.27 m span. The access bridge will be designed for the service truck loads. During freezing weather icing in any nonoperating pump shaft will be prevented by a compressed air bubbler system (see reference 28).

Excavation for the pumphouse will be used in the construction of the reservoir dam as this area has been designated as a borrow area for impervious core material. Volume of compacted backfill for foundations of the access bridge is negligible. An alternative arrangement with the pumphouse located on the bank and intake pipes at the bottom (Scheme 2) was considered. Its cost differential over the recommended scheme (Scheme 1) is considerable as shown in the following table. Since the saving using Scheme 1 could be applicable for both reservoir locations, the differential cost is excluded from the economic comparison of the alternative ash disposal schemes.

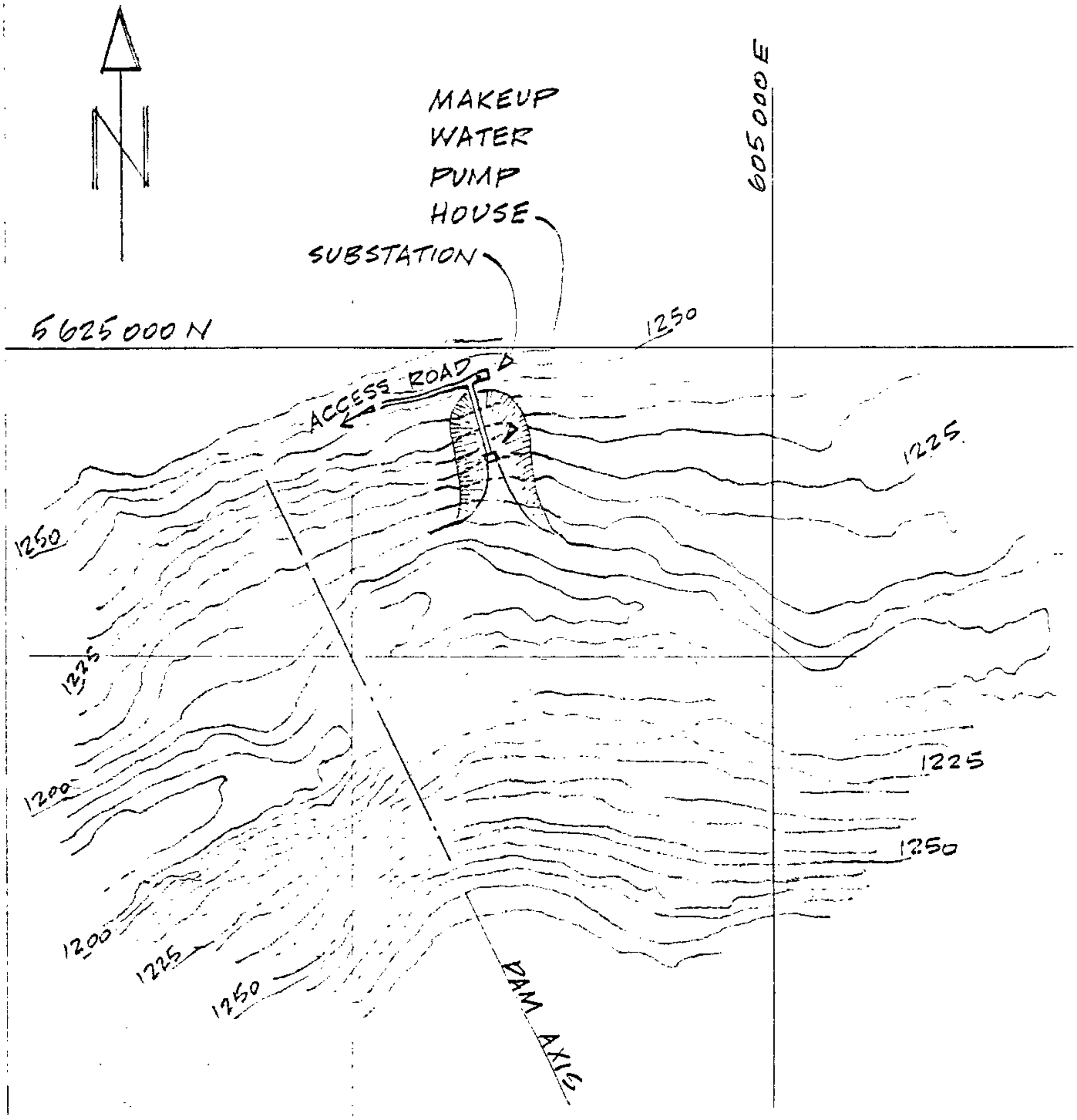
TABLE:
DIFFERENTIAL COST COMPARISON OF SCHEMES

Item	SCHEME 1				SCHEME 2			
	Quantity	Unit	Unit Price $	Cost	Quantity	Unit	Unit Price $	Cost
1. Excavation in Till	36,000	m^3	3.00	108,000	70,000	m^3	3.00	210,000
2. Excavation in Rock	-	-	-	-	70,000	m^3	19.00	1,330,000
3. Backfill	-	-	-	-	100,000	m^3	6.00	600,000
4. Cost of access bridge	52	m	1700.00	88,400	-	-	-	-
5. Cost of 3/ 1200 mm dia. intake pipes	-	-	-	-	170	m	600.00	102,000
6. Cost of 700 mm dia. discharge pipe	52	m	450.00	23,400	-	-	-	-
				$219,800				$2,242,000

Note: Direct costs only.

3.3.2 Pipeline

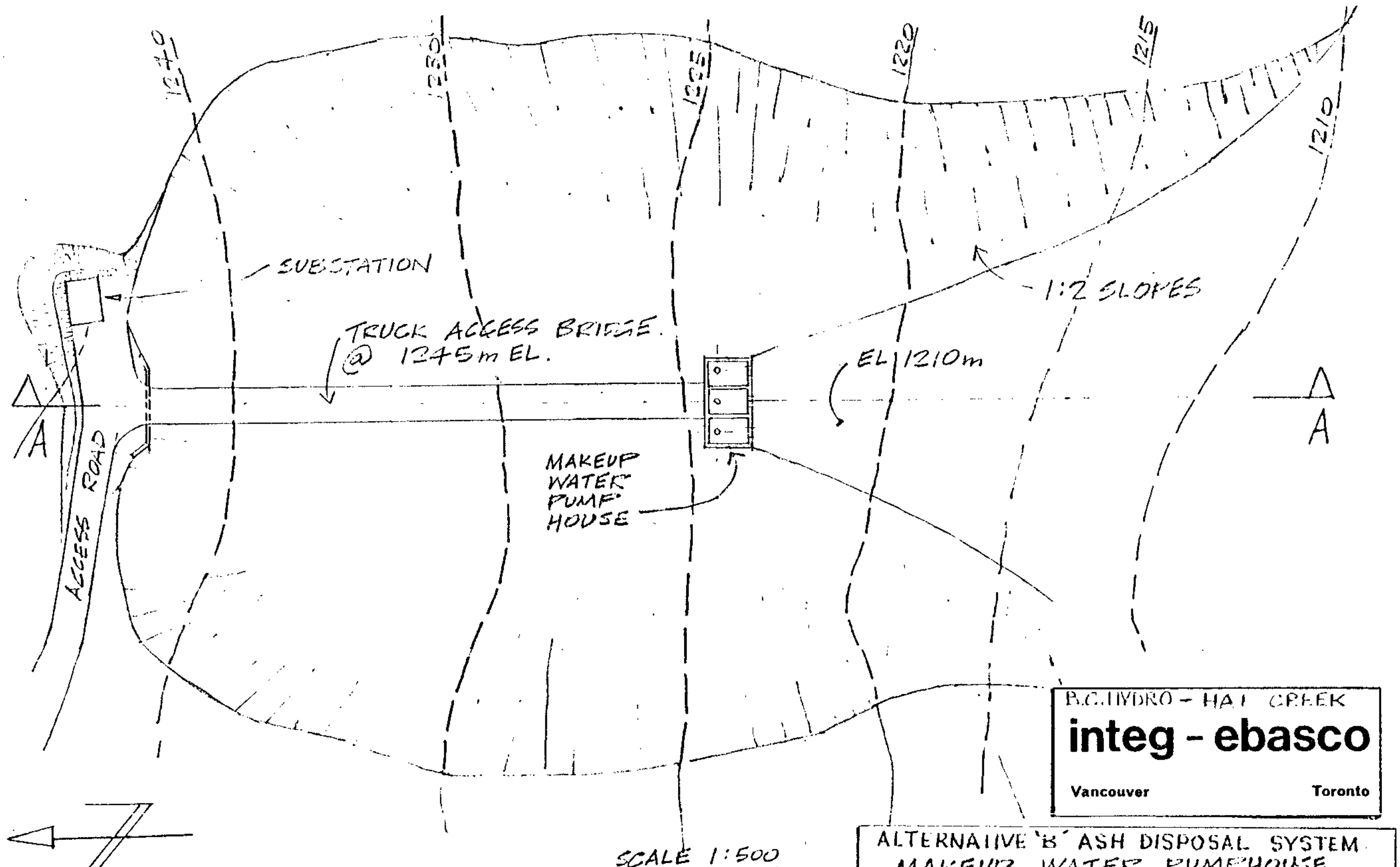
The makeup water pipeline will be a 711 m (28 in.) diameter steel pipe about 4.5 km long and will run underground along the pumphouse access and ash conveyor service road. The maximum velocity in the pipeline will be about 3 m/s (10 fps). Along the access bridge the pipe will be suitably insulated. The remaining part of the pipeline will be buried 2 m below ground level. It will be laid on the east side of the road. During the detailed engineering phase of the project consideration may be given to the provision of two partial capacity pipelines - one along the access road and the other along a separate direct route. A waterhammer analysis would be required in the detailed engineering phase to check the pipe size, water velocity and surge pressures.



LOCATION PLAN SCALE 1:5000

DATE : SEPT 1978
REVISED OCT 1978

B.C. HYDRO-HAT CREEK **integ - ebasco** Vancouver Toronto	ALTERNATIVE 'B' ASH DISPOSAL SYSTEM MAKEUP WATER PUMPHOUSE			
	B	BCH 0064	SK156	A



SCALE 1:500

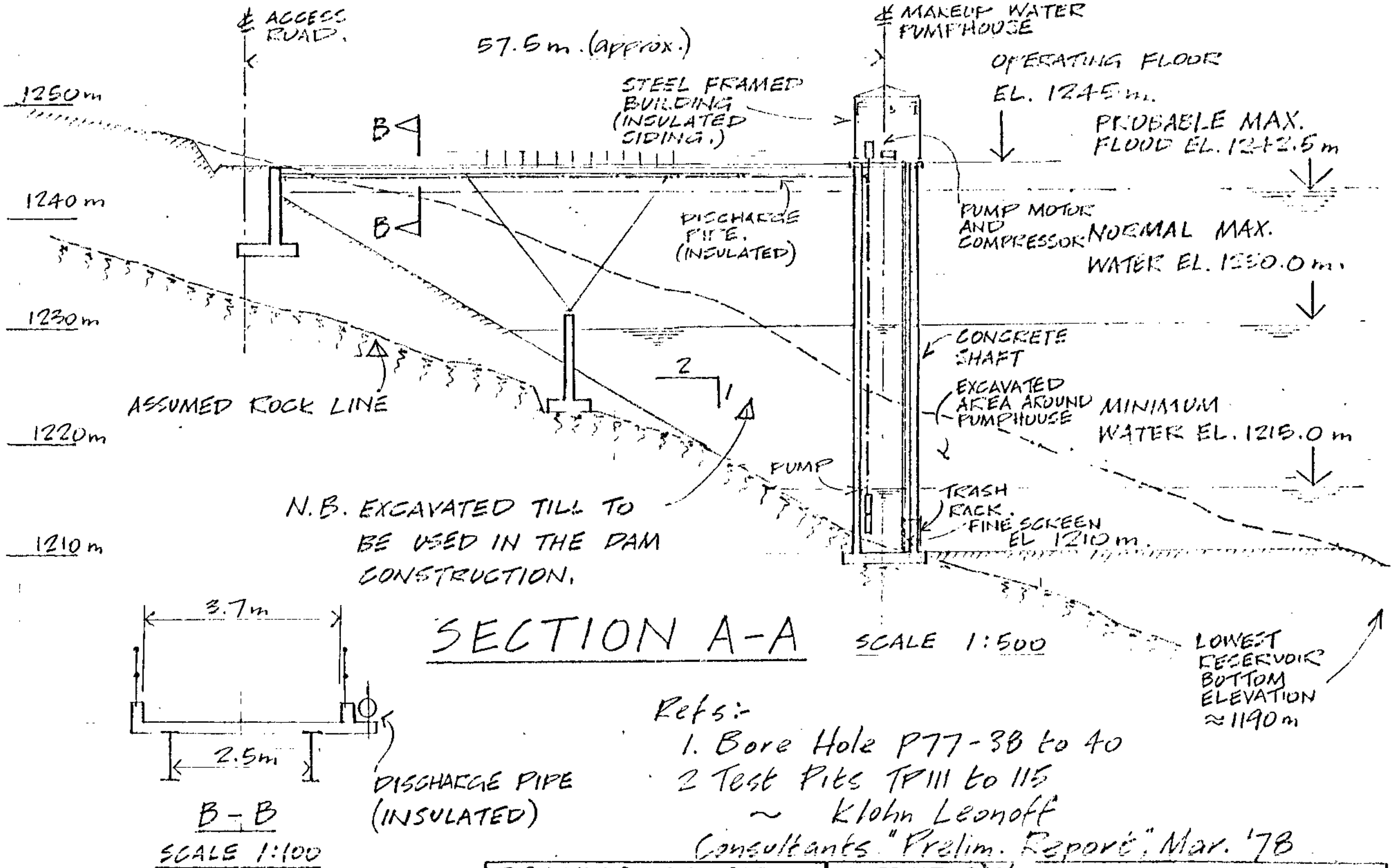
ENLARGED PLAN
(SHOWING EXCAVATION)

DATE : SEPT. 1978
REV'D OCT 1978

B.C.HYDRO – HAT CREEK
integ – ebasco
Vancouver Toronto

ALTERNATIVE 'B' ASH DISPOSAL SYSTEM
MAKEUP WATER PUMPHOUSE

B	BCH 0064	SK 157	A



Refs:-
1. Bore Hole P77-38 to 40
2 Test Pits TP111 to 115
~ Klohn Leonoff Consultants "Prelim. Report", Mar. '78

B.C. HYDRO - HAT CREEK **integ - ebasco** Vancouver Toronto	ALTERNATIVE 'B' - ASH DISPOSAL SYSTEM MAKEUP WATER PUMPHOUSE		
B	BCH 0064	SK 158	B

DATE: SEPT. 1978
REV'D NOV. 1978

Alternative 'B' Ash Disposal Study

3.4 Water Quality

The major effect of this design alternative on power plant makeup water quality stems from the location of the makeup water reservoir. Previous water balance and water treatment scenarios were solely based on Thompson River water quality. With the reservoir located in upper Medicine Creek, 3.95 x $10^6 m^3$ of Medicine Creek water could enter the reservoir on an average annual basis[1]. The creek's water quality is greatly inferior to that of the Thompson River, exhibiting elevated concentrations of most major parameters, especially total dissolved solids (TDS) and alkalinity. A variant water balance is illustrated in Integ - Ebasco drawing BCH 0064-SK153 Rev. B. This variant water balance based on Case 4 assumes a 1.5 x $10^6 m^3$/year diversion of Medicine Creek water for other uses (e.g. irrigation), and results in an improvement in the reservoir water quality in comparison to Case 4 in this study. R2

It is recommended that the power plant design currently be based on the more conservative water qualities and flows calculated for the condition in which no diversion exists. Should the diversion be incorporated in the project's final design, the accuracy of the base information available at present would not warrant designing to the variant of Case 4.

3.4.1 Methods Used and Results

To determine an average monthly and average yearly water quality for Medicine Creek, a Flow v. TDS relationship (algorithm) was developed based on six months of available Medicine Creek data. Average monthly flows (volumes) generated by B.C. Hydro[1] were then utilized to predict associated TDS values. Major ions were estimated by developing an average TDS v. parameter ratio based on the available data and applying it to the predicted TDS values. Conductivity was estimated by applying a developed Conductivity v. TDS algorithm and pH was estimated by nomographic method[2] assuming carbon dioxide concentrations and utilizing Hat Creek water temperature data. The results of these analyses are presented in Table 1.

A series of monthly mass balances was then performed to develop reasonable estimates of the temporal variation in water quality of the reservoir. The analyses utilized the following data sources:

1. Monthly Thompson River water quality[3]
2. Hat Creek Project Construction and Operating Schedules [4,5]
3. Anticipated power plant capacity factors[6], and
4. Medicine Creek reservoir design characteristics[7].

An initial reservoir water quality was developed given that the Thompson River makeup water system would be fully operational in July 1984[4,5] and assuming that the reservoir would be kept empty until this time by pumping any accumulated water to the Medicine Creek drainage canal. When power plant demand was evaluated, it was assumed that the Thompson River makeup water system would maintain the reservoir at its operating capacity, 8.0×10^6 m^3, if Medicine Creek's inflow was insufficient to do so. Power plant demand was also calculated on a monthly basis accounting for the commissioning and commercial service phases of each unit and the variability of the reservoir's water quality. This latter point affected the cooling water system's maximum permissible cycle of concentration which therefore had to be calculated for each monthly iteration. The resultant reservoir water quality determinations for the first fifteen years of power plant operation are presented in Table 2.

Three additional analyses were also performed to determine a "worst case" water quality for use in power plant facility design: the effect of the probable maximum flood on reservoir water quality and the effect of Thompson River makeup water system inoperation for 40 and 70 day periods (25 March to 5 May and 25 March to 5 June respectively). These periods of inoperation are consistent with previous studies of power plant makeup water requirements and reservoir drawdown levels[8]. The results of these analyses are presented in Table 3. The water quality values presented for the "with the diversion" cases reflect Beak Consultants Ltd.[9] estimates of the Medicine Creek diversion capacity. Their report states that only the topmost 15.3 km^2 of Medicine Creek's total drainage area (58.2 km^2) is affected by the diversion. This could result in a 26 percent reduction of Medicine Creek's inflow to the reservoir. This value was utilized because it was more conservative than B.C. Hydro's estimate of a 38 percent volumetric reduction (1.5×10^6 m^3 per annum)[10].

Another water quality modification created by the new reservoir location concerns the amount of accumulated sediment. Because the upper Medicine Creek reservoir lies within a natural drainage basin, it will be subject to natural sediment loads. Due to the substantial detention time provided by the reservoir, most of these solids will accumulate on the reservoir bottom. Suspended solids concentrations for Medicine Creek are not presently known. If corresponding Hat Creek data[9] is utilized and a bulk density of 801 kg/m^3 is assumed, then accumulations of approximately 407 m^3/yr can be anticipated.

This would result in a total accumulation of 14,249 m^3 over the 35 year plant life. Also, during freshet, elevated suspended solids concentrations possibly up to 300 mg/l[9], could be experienced in the plant's makeup line. This could affect the auxiliary cooling system.

3.4.2 Water Quality Summary and Recommendations

Power plant makeup water quality estimates have been generated for the life of the power plant. As the tables denote, reservoir water quality variations will be extensive. Due to the differences in water quality between the two water bodies, any operational action decreasing power plant water requirements, e.g. reducing the power plant capacity factor, extended unit shutdown, etc., will deteriorate reservoir water quality. Based on this fact the data presented in Column 3 of Table 3 should be utilized for water treatment facility design. This recommendation supposes that such a mode of operation could be implemented to mitigate possible impacts on andromous salmonids and that the water quality effects of Thompson River intake inoperation would endure longer than the 40 day shutdown period. The effect of the diversion must be ignored as there is no guarantee that it will be in operation. This recommendation also provides a 10 percent design margin in excess of the expected average water quality (Column 6 of Table 2) which would facilitate normal operation during disruptive operational actions or unexpected water quality fluctuations. Such reservoir water quality fluctuations could result from river and creek quality variations, airborne contamination, leaching of chemical species from the reservoir substrate or an accumulation of organic material. The water treatment system must also be capable of handling extreme water quality variations during the first three years of operation (Columns 2 and 3 of Table 2) and the anticipated "worst case" water quality occurring during a 70 day makeup water system inoperation period. The probable maximum flood (Column 6 of Table 3) will not greatly affect reservoir water quality or plant operation if this recommendation is implemented.

TABLE 1

DEVELOPED MONTHLY MEDICINE CREEK WATER QUALITY

Parameter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Total Dissolved Solids	248	245	237	215	179	167	197	231	235	234	235	243	222
Conductivity (μmho/cm)	378	374	361	325	266	247	296	351	357	356	357	370	336
Calcium	45	44	43	39	32	30	35	42	42	42	42	44	40
Magnesium	18	18	17	16	13	12	15	17	17	17	17	18	16
Potassium	1.8	1.7	1.7	1.5	1.3	1.2	1.4	1.6	1.7	1.7	1.7	1.7	1.6
Sodium	8.7	8.6	8.3	7.5	6.3	5.8	6.9	8.1	8.2	8.2	8.2	8.5	7.8
Chloride	0.35	0.34	0.33	0.30	0.25	0.23	0.28	0.32	0.33	0.33	0.33	0.34	0.31
Sulphate	18	17	17	15	13	12	14	16	17	17	17	17	16
Total Silica (SiO_2)	8.8	8.7	8.4	7.6	6.4	6.0	7.0	8.2	8.3	8.3	8.3	8.6	7.9
Dissolved Silica (SiO_2)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Alkalinity (as $CaCO_3$)	198	195	189	171	143	133	157	184	187	187	187	194	177
TOC	25	25	24	22	18	17	20	23	24	24	24	25	23
pH (units)	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
Flow (m^3/s)	0.035	0.039	0.05	0.105	0.330	0.492	0.184	0.061	0.053	0.056	0.053	0.041	0.125

Notes:
- All parameters expressed in mg/l unless otherwise noted.
- Total Dissolved Solids concentrations derived from Algorithm: Flow (m^3/s) = $113.8\ e^{-0.0326\,[\text{TDS (mg/l)}]}$.
- Conductivity values derived from Algorithm: TDS (mg/l) = (0.614) Conductivity (μmho/cm) + 15.6.

TABLE 2

DEVELOPED RESERVOIR WATER QUALITY

Parameter	Years 1 through 3		Year 4	Year 5	Years 6-15
Col. (1)	Minimum Col. (2)	Maximum Col. (3)	Col. (4)	Col. (5)	Col. (6)
Total Dissolved Solids	87.9	127.1	89.1	87.1	82.2
Conductivity (μmho/cm)	141	197	144	141	134
Calcium	17.1	23.7	17.5	17.1	16.3
Magnesium	4.5	8.2	4.6	4.4	4.0
Potassium	0.96	1.08	0.99	0.99	0.96
Sodium	3.29	4.52	3.3	3.2	3.1
Chloride	0.74	1.43	1.27	1.28	1.32
Sulphate	8.78	10.5	8.9	8.8	8.5
Total Silica (SiO_2)	5.04	5.7	5.4	5.4	5.3
Dissolved Silica (SiO_2)	-	-	-	-	-
Alkalinity	60.7	95.3	62.4	60.7	56.5
TOC	6.1	13.3	6.9	6.7	6.1
pH (units)	7.8	8.3	7.7	7.7	7.7

Notes:
- All parameters expressed in mg/l unless otherwise noted.
- The data presented in Column 6 should also approximate average water quality for the life of the power plant.
- The data presented in Column 3 should approximate worst water quality for water treatment system design (temporary basis).

TABLE 3

RESERVOIR WATER QUALITY AFTER THOMPSON RIVER INTAKE INOPERATION FOR 40 AND 70 DAY PERIODS* AND WATER QUALITY OF PROBABLE MAXIMUM FLOOD

Parameter	40 Day Period With Diversion	40 Day Period Without Diversion	70 Day Period With Diversion	70 Day Period Without Diversion	Probable Maximum Flood
Col. (1)	Col. (2)	Col. (3)	Col. (4)	Col. (5)	Col. (6)
Total Dissolved Solids	89.4	91.8	108	115	90
Conductivity (μmho/cm)	144	148	170	179	121
Calcium	17.5	17.9	20.6	21.7	16.2
Magnesium	4.7	4.9	5.5	7.0	6.7
Potassium	0.99	1.0	1.05	1.08	0.64
Sodium	3.4	3.4	4.0	4.2	3.2
Chloride	1.26	1.24	1.05	0.98	0.13
Sulphate	8.9	9.0	9.7	10.0	6.4
Total Silica (SiO_2)	5.4	5.5	5.6	5.7	3.2
Dissolved Silica (SiO_2)	-	-	-	-	0.2
Alkalinity (as $CaCO_3$)	62.8	64.8	79.6	85.5	71.7
TOC	7.0	7.3	9.3	10.1	9.1
pH (units)	7.8	7.8	7.9	8.0	8.6

Notes: * - Assumes 4 units operating at 78% capacity factor.
- All parameters expressed in mg/l unless otherwise noted.
- The 40 day period of Columns 2 and 3 represents 25 March to 5 May.
- The 70 day period of Columns 4 and 5 represents 25 March to 5 June.
- Probable Maximum Flood volume is 15 x 10^6 m^3; assumed flow is 6 m^3/s.

ALTERNATIVE 'B' ASH DISPOSAL STUDY

3.5 WATER MANAGEMENT FOR ALTERNATIVE 'B'

Under the present design philosophy, the power plant waste management system is committed to operation in a "no-liquid discharge" mode. To evaluate the required water management techniques to achieve this status, including the possibility of wastewater treatment and reuse, flow-chemical balances were developed for two worst case makeup water quality situations.[29/] Both cases considered had average meteorlogical conditions for the period corresponding to "normal worst case" reservoir water quality with the power plant operating at 100 percent capacity factor, performance blend coal, maximum ash hopper evaporation and no-liquid discharge. "Normal Worst Case" reservoir quality corresponds to the Thompson River supply inoperable for a 40 day period (column 3 of Table 3). Case 1 used a fly ash/bottom ash ratio of 55/45, while Case 2 considered a fly ash/bottom ratio of 85/15.

The calcium concentration must be maintained at a level of less than 400 mg/l as Ca (1000 mg/l as $CaCO_3$) in the recirculating cooling water system to prevent scaling, based on the results of previous studies.[11/] This level must also be maintained in all subsequent systems either by setting an appropriate flow/chemical balance between the primary systems' blowdown and secondary systems' makeup or by inserting a wastewater treatment system for calcium removal at an optimal point within the overall water management system.

Results of these analyses are given in Drawing BCH 0064 SK 170 and Table 4. Based on these findings and current available water quality data, a wastewater treatment/recycle facility is required to remove scale forming constituents. At the present time (Dec. 1980), a lime-soda ash treatment system is recommended for this purpose.

Changes in conceptual water management plans and facility designs from those presented in the Water Management Study[11/] resulted from investigating the new ash disposal alternative to ensure adequate handling of all wastes. The specifics of each system and associated assumptions are detailed in the following sections.

TABLE 4

SUMMARY OF RESULTS*

	Case 1	Case 2
Cooling Tower Makeup, l/s	1032	1013
Cooling Tower Cycles of Concentration	21.9	35.9
Cooling Tower Blowdown Calcium Concentration, mg/l Ca	131.0	129.2
Required Treatment Flow, Cooling Tower, l/s	91.5	149.1
Required Treatment Flow, Trough, l/s	169.4	12.3
Calcium Removal Rate, Kg/day	3,242	1,642
Hopper Calcium Concentration, mg/l Ca	<400	<400
Trough Calcium Concentration, mg/l Ca	200	<400
Surge Tank Calcium Concentration, mg/l Ca	157.9	303.5

*Case 1 represents maximum treatment requirements.

3.5.1 Ash Handling System

Bottom ash will be continually cleared by a drag bar conveyor and transported to the Mid Medicine Creek disposal area in a "dry" state. Fly ash, economizer ash, and air preheater ash will be collected dry in silos and also transported by belt conveyor to the ash disposal area. The specific major water use operations within the ash handling system will consist of: ash hopper quenching, bottom ash entrainment, mill rejects sluicing, and fly ash wetting.

Quenching water for the ash hopper will provide continuous cooling for the bottom ash and refractory walls of the hopper. This flow requirement has been estimated to be 42.3 l/s for 4 unit operation and was assumed to be independent of plant capacity factor. Bottom ash trough cooling water will be recirculated. A heat exchange system will maintain recirculating water temperature at a level conducive to system component protection. Mill rejects will be sluiced to the drag bar conveyor intermittently. This will require an instantaneous flow of approximately 25 l/s per unit. Since this material would be composed mainly of pyritic compounds, leachates are not expected to be significant and were not considered in the formulation of the system's chemical balance.

Fly ash (including economizer and air preheater ash) wetting is a major plant consumptive water use. Wetting is required to facilitate ash handling and compaction, and prevent dusting problems. Based on performance coal and a 20 percent water content (dry basis) for adequate wetting, 12.9 l/s of water for Case 1 and 20.0 l/s for Case 2 would be required at 100 percent capacity factor with 4 units in operation. An economizer ash dry handling system is presently recommended for this water management alternative and therefore potential leachates from this source have been neglected. If wet sluicing of this material is considered for economical reasons in the future, a leachate test program should be performed.

System consumptive water uses also include water entrained in the bottom ash and ash hopper evaporation. The quantity of water entrained in the bottom ash has been estimated to be 15.9 l/s for Case 1 and 5.3 l/s for Case 2 for 4 units at a plant capacity factor of 100 percent. These estimates are based on performance coal and a bottom ash water content of 30 percent (dry basis), which is conservative from a water management viewpoint. The quantity of water evaporated in the ash hopper has been estimated to be 25.6 l/s for Case 1 and 10.2 l/s for Case 2 based on a preliminary energy balance prepared for this system assuming bottom ash cooling from approximately 1100°C.

The total consumption of water in the ash handling system, therefore, totals 54.4 l/s for Case 1 and 35.5 l/s for Case 2. This is replenished through makeup derived from the wastewater collection sump and comprised of cooling tower blowdown and other plant wastewaters (refer to Drawing BCH 0064 SK 170).

3.5.2 Circulating Water System

Medicine Creek reservoir water quality (Column 6, Table 2 and Column 3, Table 3) would limit reciculating water system cycles of concentration to a maximum of approximately 20 (without a treatment/recycle facility) which is comparable to water obtained from the Thompson River as a single source. Worst case water quality (Column 5, Table 3) would reduce this maximum slightly. As noted earlier, however, a treatment/recycle facility is required to achieve no-liquid discharge, and therefore the recirculating water system can be operated at higher cycles with inclusion of this system. The flows and configuration of this system are given in Drawing BCH 0064 SK 170 and Table 4. On a flow basis the recirculating water system will be operated at cycles of concentration of 21.9 for Case 1 and 35.9 for Case 2. The treatment/recycle facility ensures the proper chemical operation of this system at these high cycles.

3.5.3 Water Treatment

The changes in the power plant's makeup water quality enumerated in preceding sections will require modifications to the base scheme water treatment system design. An increase in total organic carbon (TOC) concentrations will increase prechlorination dosages and the amount of the chlorine feed required. Increases in cation concentrations (primarily calcium and magnesium) will require cation exchange resin volumes in excess of those presently estimated to treat Thompson River water. This will also affect the acid regeneration requirements of the cation beds and the associated acid feed equipment. A change in the influent alkalinity concentration from 35.1 to 64.8 mg/l will require modification of the degasifier design. Moderate increases in influent anion concentrations may require either a small increase in anion exchange resin volumes or a change in regeneration frequencies.

The anticipated increases in resin bed volumes will also slightly increase the rinse water requirements of each bed. Since a substantial portion of this rinse water is recycled to the clarifier's influent line, slight changes in clarifier design are also anticipated. Disposal of clarifier underflow solids had previously been effected along with ash sluicewater treatment wastes. They will now be discharged to the drag bar conveyer at a point following the trough for disposal along with the bottom ash. This will be similar to the system proposed for mill rejects disposal.

3.5.4 Wastewater Treatment/Recycle Facility

The wastewater treatment/recycle system recommended at the present time involves the removal of dissolved calcium and magnesium via the lime-soda ash softening process. This recommendation is based upon the results of the Water Management Study,[11/] but should be re-evaluated during final engineering as alternative treatment technologies have experienced increased application in recent years. Softening removes dissolved calcium and magnesium from solution by causing exceedance of the solubility limits of calcium carbonate and magnesium hydroxide through the addition of lime and soda ash, thereby forming insoluble chemical precipitates which can readily be removed from solution.

The unit processes involved in this treatment system are: flocculation, coagulation, sedimentation, and recarbonation. The first three processes can be accomplished in a single coagulator/clarifier. Polymer(s) will be added in conjunction with the other chemical reagents to ensure the efficient removal of precipitates. The exact requirements for polymer addition should be determined by "jar" testing prior to final system design. These processes then result in the formation and sedimentation of insoluble calcium and magnesium precipitates. Recarbonation is the process whereby carbon dioxide gas is added to the softened, clarified water for the purpose of reducing the pH to 8.5 ± 0.2. At this pH (or lower) excess calcium would be stabilized. Carbon dioxide causes pH reduction through the conversion of the carbonate alkalinity species to bicarbonate. Effluent from this treatment system is expected to have a combined calcium and magnesium concentration (i.e., hardness) of 80 mg/l as calcium carbonate ($CaCO_3$). The softening treatment system also generates a solid waste residue (i.e., sludge). The sludge, consisting primarily of precipitated calcium carbonate, magnesium hydroxide and calcium sulfate will be pumped to the bottom ash conveyor system and disposed of with the ash.

Based upon the results of the worst case water quality analyses and an evaluation of treatment system scenarios, the maximum flow capacity of this treatment/recycle system will be approximately 92 l/s from the cooling tower and 169 l/s from the trough to accomodate the treatment requirements of Case 1, (refer to Drawing BCH 0064 SK 170). At present recirculating cooling water system sidestream treatment together with trough treatment is the preferred facility configuration. Within this design, water is withdrawn from the cooling water system, treated and then returned to the cooling tower basin, and trough water is removed, treated, and returned to the trough. In this manner, cooling tower blowdown flow and concentration levels are controlled to ensure the proper operation of all systems utilizing this source as makeup water, while scale formation is prevented in the trough and associated equipment.

3.5.5 Boiler Cleaning Wastes

Boiler cleaning wastes (previously estimated at 1,135,000 l/unit per cleaning event) were reused within the "wet" ash handling system[11/]. It is now proposed to inject and evaporate this waste at a controlled rate in the furnace. This technique has been utilized successfully by a number of utilities to dispose of this infrequent waste[12,13/]. It could, however, place a limitation on the type of acid that would be used for cleaning purposes. Ammoniated citric acid or hydroxyacetic acid would be preferred over hydrochloric acid to minimize the potential for corrosion problems within the furnace. This technique could present a heavy metals emissions potential; however, injecting at a properly determined and controlled feed rate can satisfactorily mitigate this potential.

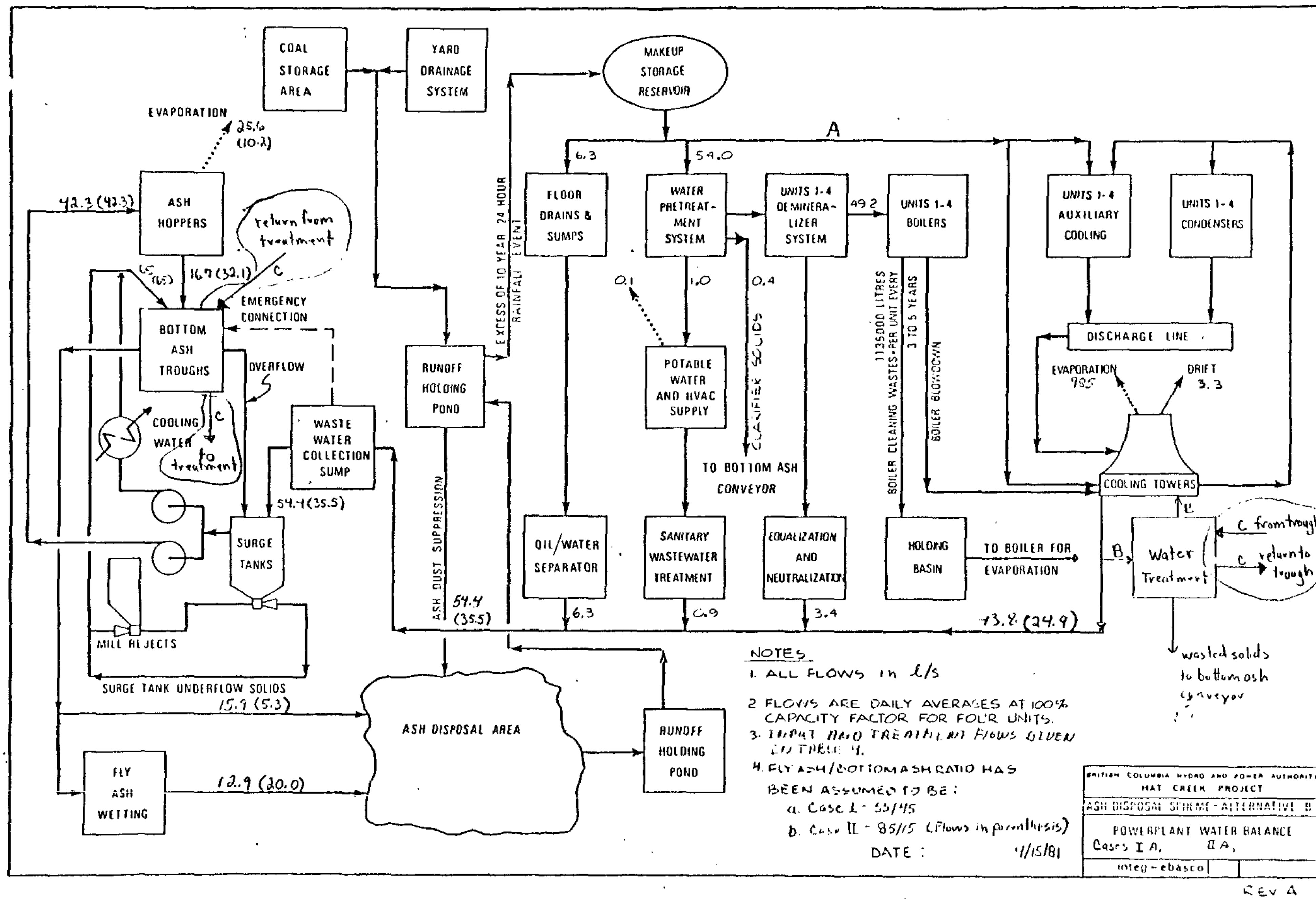
3.5.6 Yard Drainage, Coal Storage Area Runoff, and Ash Disposal Area Runoff

Rainfall runoff from the power plant site and the associated coal storage area will be collected in drainage ditches and conveyed by gravity to a holding pond located near the Mid Medicine Creek ash disposal area. This wastewater will then be utilized for ash dust suppression.

Ash disposal area runoff and seepage through the reservoir dam will be collected behind a berm located in Medicine Creek Valley. The berm will be constructed prior to the power plant start-up and will be located at a point anticipated to be the toe of the ash pile after 15 years operation. This wastewater will then be pumped to the runoff holding basin mentioned above and also used for ash dust suppression. Two pumps are provisionally provided, each capable of pumping 15.8 l/s (250 gpm). The required pipeline size is therefore presently estimated to be 150 mm (6 in.). It is envisaged that ash and mine waste will be deposited separately. However, some mixing is inevitable at the interface. After 15 years a new berm can be constructed further down the valley at the anticipated interface. As an alternative, the berm could be located initially as far out as this interface with additional capacities for pumping and pipeline. Suitable means will be provided to handle the runoff until the entire ash pile is topped off and seeded.

The runoff holding basin, approximately 150 m x 168 m x 3 m, is sized to accommodate the volume of the 10 year-24 hour rainfall event from the three specified areas. This volume (75,600 m^3) assumes that precipitation falling on undisturbed areas will be diverted directly to the reservoir. Runoff volumes in excess of this storm event will overflow to the drainage canal and subsequently enter the makeup water reservoir. Since overflow occurrences will be infrequent (approximately 3.5 events over the 35 year plant life) and the dilution potential of the runoff canal and reservoir will be substantial, a deterioration in power plant makeup water quality is not expected.

Flow Schematic, Side Stream Treatment, Cases I A, II A



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Alternative 'B' Ash Disposal Study

4. ECONOMIC ANALYSIS

The following financial criteria have been used in the cost estimate:

1) Costs in September 1978 dollars.
2) Plant start up date is January 1986.
3) For extension and replacement costs occuring after plant start up date, an inflation rate of 5.75% is applied. The present worth of payment factor is based on a discount rate of 10% and inflation rate of 5.75% per year. (per Appendix 4 of SDM 72.1-a Rev. 3).
4) To account for indirect construction cost, contingency, engineering and BCH corporate overhead 26% has been added to the direct construction cost.
5) Annual operating costs are capitalized by the following capitalization factor:

$$\frac{\text{Levelized cost of \$1 annual payment}}{\text{Levelized fixed change rate}} = \frac{1.98}{0.156} = 12.7$$

(per Appendix 4 and Appendix 5, SDM 72.1-a Rev. 3)

6) The auxiliary energy cost of 49.5 mills/kWh in SDM 72.1-a Rev. 3 is deflated to 1978 dollars to give 33.23 mills/kWh.
7) The labour cost is assumed at $18.3/hr. Based on 5 crews for 3 shift operation, one man-year would be equivalent to 1752 hours. The capitalized cost per man would be $18.3 x 12.7 x 1752 = $407,000.

The capital and operation and maintenance cost for the Base Wet Scheme and two alternatives 'A' and 'B' are summarized in Table 6 COST COMPARISON and include the offiste facilities by B.C. Hydro and other consultants.

A reconciliation (C.1) of the May 1978 wet ash disposal scheme and updating (C.2) of the May 1978 dry ash disposal schemes are given in Section C of this report. Section C also includes a comparison (C.3) of Alternative 'B' with the updated May 1978 dry ash disposal schemes.

Table 6 - COST COMPARISON ($ 000)

A. Capital Cost	Base Wet Scheme		Alternative 'A'		Alternative 'B'		Remarks (Item No. per appendi
Bottom ash removal system	10,049		5,715		5,145		Item 1
Fly ash removal system	12,508		12,508		15,219		Item 1
Transportation and distribution system	15,300		13,191		16,276	R1	Items 1&2
Disposal equipment	4,562	42,419	4,562	35,976	1,525	38,165	Items 1&2 R1
Ash pond & runoff ditches		31,101		31,101	(dry storage)	3,550	Item 10
Water Treatment system		10,236		10,236		6,859	Item 9 R2
Make up water supply costs							
- Thompson River to Reservoir	48,000		48,000		46,600		Item 10
- Reservoir	12,200		12,200		17,450		Item 10
- Reservoir to power plant (differential)	---	60,200	---	60,200	2,488	66,538	Item 2
Differential cost of other project facilities		---		---		1,604	Item 2
Total Capital Cost		143,956		137,513		116,716	R2
Differential Capital Cost		27,240		20,797		Base Cost	
Percentage Differential		23.3%		17.8%		Base Cost	R2
B. Capitalized O & M Costs							
Reclamation costs	2,660		2,660		682		Item 3
Ash system energy	6,057		6,067		3,708		Item 4
Labour cost	9,361		9,361		24,420		Item 5
Equipment replacement and supplies	18,498	36,576	22,796	40,884	13,074	41,884	Item 6 R1 R1
Run off ditches		500		500		250	Item 10
Water Treatment system		21,615		21,615		13,066	Item 9 R2
Make up water supply	44,072				29,273		
- Thompson River to Reservoir			41,154				Item 10
- Reservoir to power plant (differential)	---	44,072	---	41,154	5,248	34,521	Item 8 R2
Differential cost of other project equipment		---		---		1,124	Item 7
Total Capitalized Operating Costs		102,763		104,153		90,845	
Differential Operating Cost		11,918		13,308		Base Cost	R2
Percentage Differential		13.1%		14.6%		Base Cost	

Rev.R2

APPENDIX

DETAILED COST ESTIMATE

Item 1 Capital Cost ($ 000)

Description	Base Scheme	Alternative 'A'	Alternative 'B'
1. Bottom Ash Handling System			
- BA hopper or drag bar conveyor & associated equipment	10,049	9,468	6,570
- Less saving in lower boiler height		-(3,753)	-(3,753)
- BA crossbelt conveyors	--	--	312
- BA collecting belt conveyors	--	--	2,016
Total Cost	10,049	5,715	5,145
2. Fly Ash Handling System			
- Fly ash and economizer ash removal system	12,508	12,508	11,159
- Fly ash silos	--	--	4,060
Total Cost	12,508	12,508	15,219
3. Transportation & Dist. System			
- BA slurry pipes	9,783	7,674	See
- FA slurry pipes	5,517	5,517	Item 2a
Total Cost	15,300	13,191	
4. Disposal System			
Return water system	4,182	4,182	
Disposal Equipment			
- boat with boom & drag scraper(200 x 1.0775 x 1.26)	272	272	See
- service vehicle			Item 2b
(64.4 x 1.0775 x 1.26)	87	87	
- 3/4 ton truck (15.16 x 1.0775 x 1.26)	21	21	
Total Cost	4,562	4,562	

Notes: 1) Cost for Alternative 'B' provided by Estimating Department.

2) Costs for "Base Scheme" and Alternative 'A' taken from previous reports adjusted as follows to 1978 price level and revised indirect costs of 26%:

$$\frac{1 \times 1.26}{1.25} \times 1.0775 = 1.08612$$

3) For the Base Scheme and Alternative 'A' the return water system costs have been increased by 30%. This allows for the increased ash generation arising from change of coal specification from "typical" in 1977 to "datum blended" in 1978.

Alternative 'B' Ash Disposal Study

APPENDIX

Item 2 - Capital Cost (continued)

a) Transport and Distribution System (Alternative 'B')

	Direct Costs	
- Conveyors 101A and 101B	$ 7,742,400	
- Conveyors 102A and 102B	$ 3,542,000	R1
- Conveyors 103A and 103B	$ 180,000	
- Conveyors 104A and 104B	$ 210,000	
- Electrical	$ 650,000	
- Earth preparation and miscellaneous	$ 593,000	
Total Direct Cost	$12,917,400	R1
Total Cost (x1.26)	$16,276,000	R1

Note: Costs provided by Wright Engineers Ltd.

b) Disposal Equipment (Alternative 'B')

- Spreading Dozers (2 x $490,000)	$ 980,000
- Water truck	$ 45,000
- Lighting	$ 100,000
- Service vehicle & 3/4 ton truck (64,400 + 15,164) x 1.0775	$ 85,700
Total Direct Cost	$ 1,210,700
Total Cost (x1.26)	$ 1,525,000

Note: Costs provided by Wright Engineers Ltd.

Alternative 'B' Ash Disposal Study

c) Differential cost of makeup water supply system (extra cost for Alt. 'B')

A capital cost saving in pumphouse intake and structure is possible due to relocating the pumphouse in the reservoir instead of in the bank. This saving is not included in this comparison. Hence, only equipment and makeup water pipeline differential costs as follows are taken into account.

- Pumps (increased pumping head)	$ 178,000
- Water pipeline (increased pipe length)	$ 2,310,000
Total Cost	$ 2,488,000

Note: Costs provided by Estimating Department.

d) Differential cost of other facilities (extra cost for Alt. 'B')

- Differential cost of plant water treatment system (poor quality water)	$ 60,000
- Differential cost of runoff ditch from power plant and coal storage area to holding pond	115,000
- Plant site runoff holding pond less cost of retention basin for Base Scheme and Alternative 'A'	1,017,000
- Ash site runoff pumps and pipeline	338,000
- Differential cost of access road	74,000
Total Cost	$ 1,604,000

Note: Costs provided by Estimating Department.

Item 3 Reclamation Costs

a) Base Scheme and Alternative 'A'

Previous reports have used an indicative cost of $2,660,000.

b) Alternative 'B'

Assuming
- reclamation costs are proportioned to area to be reclaimed.
- pond area (Base Scheme & Alternative 'A') = 3.9 sq. km.
- ash disposal area for Alternative 'B' = approx. 1 sq. km. (excluding mine waste disposal in Medicine Creek)

Alternative 'B' reclamation costs are 2,660,000 x $\frac{1}{3.9}$ = $ 682,000

Item 4 Capitalized Annual Energy Cost of Ash Removal and Transportation

1) SDM Section 72.1-a, Appendix 6, Section 3 gives levelized cost of Incremental Net Energy in 1986 dollars. The overall inflation factor of 1.45 (derived from Financial Criteria Appendix 2, Case B) would be used to deflate the Fixed charges portion and the 1978-86 inflation factor of 1.53 (derived from Financial Criteria Appendix 2, Case A) would be applied to deflate the variable operating portions. The levelized cost of Increment Net Energy in $ 1978 becomes:

- Incremental Levelized Fixed Charges = $\frac{23.88}{1.45}$ = 16.47 mills/kWh
- Levelized Variable O & M costs = $\frac{1.67}{1.53}$ = 1.09
- Levelized Fuel Cost = $\frac{23.97}{1.53}$ = 15.67

33.23 mills/kWh

This energy cost of 33.23 mills/kWh is used in the evaluation of auxiliary energy cost and differential pumping cost.

$$\text{Energy Costs (in \$)} = \frac{\text{kW x hr/shift x 1095 (shifts/year x .656(CF) x .03323 (\$/kWh)}}{\text{.156 (Levelized FCR)}}$$

$$= \text{\$153/kWh x kW x Hr/shift (capitalized value)}$$

2) For equipment operating at capacity factors less than the power plant

$$\text{Power penalty (in \$)} = \text{108 \$/kWh} \left[\text{kW} - \frac{\text{kW x Hr/shift x 1095 (shifts/year) x .656 (CF)}}{\text{8760 x .78}}\right]$$

$$= \text{108 \$/kWh (kW - .105 kW x Hr/shift)}$$

$$= \text{108 \$/kWh x kW x (1 - .105 Hr/shift)}$$

3) Energy cost and power penalty for the Base Scheme, Alternative 'A' and Alternative 'B' are given in the following tables 4a, b and c. (Small motors such as low pressure pumps, heat exchanger, recirculating pumps, ash grinders, are not considered.)

Notes:
1) kW - Number of kW consumed by auxilaries
2) Hr/shift - Number of operating hours per 8 hour shift
3) Shifts per year($\frac{8760}{8}$) = 1095
4) Levelized capacity factor - 65.6%
5) Auxiliary energy cost - 33.23 mill/kWh
6) Levelized fixed charge rate - 15.6%
7) Power penalty - $108/kW (in 1978 dollars)
8) Hours per year - 8,760
9) Maximum yearly capacity factor - 78%

Alternative 'B' Ash Disposal Study

Table 4A Base Scheme ($ 000)

	HP	kW	Running hours/shift	Energy Cost	Power Penalty
Bottom Ash sluice pumps	4 x 400	1194	4.5	822	68
MP Ash water pumps	4 x 150	448	1	69	43
Return water pumps	2 x 400	597	7	639	17
Return water booster pumps	2 x 1300	1940	7	2078	56
Vacuum pumps	4 x 4 x 155	1850	5	1415	95
Fly Ash sluice pumps	4 x 310	925	5	708	47
				5731	326

Total capitalized energy cost = $5,731,000 + 326,000

= $6,057,000

Note: 1) Motor horsepower from S.D.M. Section 74.2-a, Rev. 1.

Alternative 'B' Ash Disposal Study

Table 4B Alternative 'A' ($ 000)

	HP	kW	Running hours/shift	Energy Cost	Power Penalty
Bottom Ash slurry pumps	4 x 230	686	8	840	--*
MP Ash water pumps	4 x 40	119	4	73	7
Drag bar conveyor drives	4 x 25	75	8	92	--*
Return water pumps	2 x 400	597	7	639	17
Return water booster pumps	2 x1300	1940	7	2078	56
Vacuum pumps	4 x 4 x 155	1850	5	1415	95
Fly Ash sluice pumps	4 x 310	925	5	708	47
				5845	222

Total capitalized energy cost = $5,845,000 + 222,000

= $6,067,000

* No power penalty as equipment operated at the same capacity as the power plant.

Alternative 'B' to Ash Disposal Study

Table 4C Alternative 'B' ($ 000)

	HP	kW	Running hours/shift	Energy Cost	Power Penalty
MP Ash water pumps	4 x 40	119	4	73	7
Drag bar conveyor drives	4 x 25	75	8	92	--(1)
Unit cross belt conveyor	4 x 7	21	8	26	--(1)
BA collecting conveyor	50	37	8	42	--(1)
Fly Ash blowers	4 x 2 x 700	4178	5	3196	214
Conveyor system	720	537	8	--(2)	58
				3429	279

Total capitalized energy cost for Item 4(c) = \$3,429,000 + 279,000
= \$3,708,000

Notes:

(1) No power penalty as equipment is operated at the same capacity factor as the power plant.

(2) Transport and distribution system (for normal operation, assume only 1 of each pair running)

	Horsepower Installed	Horsepower Operating (Average)	Remarks
Conveyors 101A and 101B	2 x 200	- (50)	Except conveyor 104A & 104B, all other conveyors are inclined downward, therefore energy generated would balance the energy need.
Conveyors 102A and 102B	250	0	
Conveyors 103A and 103B	20	0	
Conveyors 104A and 104B	50	30	
	720	- (20)	

(3) Fuel for dozers and water truck included in supply costs (Item 6).

Alternative 'B' to Ash Disposal Study

Item 5 Differential Labour Cost

Description	Base Scheme	Alternative 'A'	Alternative 'B'
	Number of Persons		
- Ash handling in plant area			
Operation	15	15	20
Maintenance	3	3	3
- Ash return water system	5	5	-
- Ash transport and disposal			
Operation	-	-	35
Maintenance	-	-	2
Total Personnel	23	23	60
Capitalized Cost	$9,361,000	$9,361,000	$24,420,000

Notes:
1) Five crews would be required for 3 shift operation (including 1 relief crew).
2) For transport and disposal, wet ash scheme would require only labour to move pipes around on ash pond (assumed negligible).
3) Capitalized cost is estimated at $407,000 per capita.
4) The labour cost for ash return water treatment plant(5 persons) is taken into account in Item 9 and therefore not considered in this Item.

Alternative 'B' Ash Disposal Study

Item 6 Equipment Replacement and Supplies

a) Base Scheme and Alternative 'A'

i) Replacement of Slurry Pipes ($1000)

Year	Cost (1978 dollars) Base Scheme	Alt. 'A'	P.W. of Payment Factor	Cost Base Scheme	Alt. 'A'
93/94	406	5,278	.7296	296	3,851
96/97	6,211		.6484	4,027	
98/99	406	5,278	.5991	243	3,162
99/00	4,379	4,379	.5758	2,521	2,521
03/04	406	5,278	.4922	200	2,598
05/06	6,211		.4546	2,823	
08/09	406	5,278	.4041	164	2,133
11/12	4,379	4,379	.3589	1,572	1,572
13/14	406	5,278	.3316	135	1,750
14/15	6,211		.3188	1,980	
18/19	406	5,278	.2727	111	1,439
			Total	14,072	19,026

ii) Replacement and Supplies for Remaining Equipment

Base Scheme:

$$\$ \frac{(10{,}049 + 12{,}508 + 4{,}182) \times 10^3 \times 0.015 \times 12.7}{1.26} = \$4{,}043 \times 10^3$$

(capitalized value)

Alternative 'A'

$$\$ \frac{(5{,}715 + 12{,}508 + 4{,}182) \times 10^3 \times 0.015 \times 12.7}{1.26} = \$3{,}387 \times 10^3$$

(capitalized value)

iii) Mobile Equipment $= \frac{\$380 \times 10^3 \times 0.10 \times 12.7}{1.26} = \$383 \times 10^3$

(capitalized value)

Total for Base Scheme = $\$ (14{,}072 + 4{,}043 + 383) \times 10^3 = \$18{,}498 \times 10^3$

Total for Alternative 'A' = $\$ (19{,}026 + 3{,}387 + 383) \times 10^3 = \$22{,}796 \times 10^3$

Notes:
1) Replacement cost is based on direct cost.
2) BA lines would be replaced every 9 years for Base Scheme (intermittent operation) and 6 years for Alternative 'A' (continuous operation).
3) FA lines would be replaced every 12 years and extended every 6 years, 2000 ft. each time.
4) For remaining equipment, replacement and supplies cost is estimated at 1.5% of direct capital cost per year.
5) Replacement and supplies cost of mobile equipment is estimated at 10% of direct capital cost per year.

Alternative 'B' Ash Disposal Study

b) Alternative 'B'

i) Mobile equipment, spare parts and supplies

	Fuel, Repairs, Maintenance and Supplies per hour	Equipment Hrs. used per year	Cost
Dozer Compactor	51.4	7300	$375,220
Sprinkler Truck	7.0	3650	25,550
Total			$400,770
Capitalized value =			$5,089,779

ii) Replacement and supplies for transport conveyors

$\left(\frac{\$16,276,000 \times .02}{1.26}\right) =$ 258,350 R1

Capitalized value = $3,281,030 R1

iii) Mobile equipment replacement costs

	Year	P.W. of Payment Factor	Cost
Dozer Compactors	(1978 costs = $490,000 x 2)		
	1994/95	.7015	$687,000
	2003/04	.4922	482,000
	2012/13	.3452	338,000
Sprinkler Truck	(1978 cost = $45,000)		
	1991/92	.7897	$ 36,000
	1997/98	.6232	28,000
	2003/04	.4922	22,000
	2009/10	.3883	17,000
	2015/16	.3066	14,000
		TOTAL	$1,624,000

iv) Ash Handling Equipment in Plant Area

$$\$\frac{(5,145 + 15,219) \times 10^3 \times 0.015}{1.26} \times 12.7 = \$3,079 \times 10^3 \text{ (capitalized value)}$$

v) Service Vehicle & 3/4 Ton Truck

$\$\ 85,700 \times 0.10 \times 12.7 = \$109 \times 10^3$ (capitalized value)

Total for Alternative 'B' = $5,090,000 + 3,281,000 + 1,624,000 + 3,079,000 + + 109,000 = $13,074,000 R1

Alternative 'B' Ash Disposal Study

Notes:

1) Replacement and supplies for ash handling equipment for plant area is estimated at 1.5% of direct capital cost per year.

2) Replacement and supplies for conveyors is estimated at 2% of direct capital cost per year.

3) Replacement cost for mobile equipment is based on direct capital cost.

4) Dozer compactor life is assumed 9 years and sprinkler truck 6 years.

5) O & M supplies per hour and equipment hours used per year based on Cost Summary Report of April 1978.

Alternative 'B' to Ash Disposal Study

Item 7 Differential operating costs of other project facilities
(extra costs for Alternative 'B')

a) Boiler make up water treatment

For boiler make up water treatment cost it is assumed that with the supplementary water supply of lower quality Medicine Creek, it would cost an additional $50,000 per year in chemical supplies. Other cost differentials are assumed negligible. The capitalized value of $50,000 is $635,000.

b) CW System

For the CW system, additional acid dosing is required for the lower quality make up water. This is estimated to be $181,000.

c) Energy cost of pumping ash disposal area run-off water to holding basin

Assumptions:

- Level of ash disposal area berm	1140 m (3740 ft.)
- Level of run-off holding basin	1380 m (4528 ft.)
- Static head	240 m (787 ft.)
- Friction loss (for 6" pipe)	* 6.5 ft. per 1000 ft. lengths (250 USgpm) 20.6 ft. per 1000 ft. length (500 USgpm)
- Pipe length	1600 m (5250 ft.)
- Flow	5033 hours @ 15.8 l/s (250 USgpm) 3727 hours @ 31.6 l/s (500 USgpm)
- Energy required for pumping 1000 USG per ft. head	0.00315/ kWh
- Energy Cost	$0.03323/ kWh
- Overall pumping efficiency	70%

Calculations

- Total TDH (250 USgpm) = 787 + 6.5 x 5.25 = 821 ft.
  (500 USgpm) = 787 + 20.6 x 5.25 = 895 ft.

- Energy pumping cost (Annual) = $\frac{0.00315 \times 0.03323 \times 0.25 \times 5033 \times 60 \times 821}{.70}$

$+ \frac{0.00315 \times 0.03323 \times 0.5 \times 3727 \times 60 \times 895}{.70}$

= 9268 + 14964 = $24,232

- Energy pumping cost (Capitalized) = $307,746

* Byron Jackson Friction head loss curve (C=130)

Total for Item 7 = \$635,000 + 181,000 + 308,000

= \$1,124,000

Alternative 'B' to Ash Disposal Study

Item 8 Differential Pumping Cost from UMC Reservoir to Power Plant (extra cost for Alt. 'B')

Assumptions:

- Normal level of original location	4500 feet
- Normal level at UMC location	4036 feet
- Static head	464 feet
- Friction loss (for 28" pipe)*	3 ft per 1000 ft lengths
- Differential pipe length	2600 m (8530 feet)
- Flow (average, at 65% CF)	677 l/s (10730 USgpm)
- Energy required for pumping 1000 USG per ft. head	.00315 kWh
- Energy cost	$.03323/kWh
- Overall pumping efficiency	70%

Calculation:

- Total differential TDH = 464 + 3 x 8.53 = 490 ft.

- Differential energy cost (Annual) = $\frac{0.00315 \times 0.03323 \times 10.73 \times 8760 \times 60 \times 409}{.70}$

= $413,232

- Differential energy cost (Capitalized) = $5,248,000

* Reference Byron Jackson Friction Loss Diagram for Water, Assume C=130.

Alternative 'B' Ash Disposal Study

Item 9 Water Treatment for the Ash Return Water System

The need for this equipment has to be established from comprehensive leachate tests.

a) Capital Cost $9,500,000 x 1.0775 = $10,236,000

b) O & M Cost

Chemicals	1,266,738* x 1.0775 =	$ 1,365,000
Labour	5 x 1752 x 18.3 =	160,000
Energy	47,870* x $\frac{33.23}{32.3}$ =	49,000
Maintenance	(1.25% of Capital Cost) =	128,000
	Total annual costs	$ 1,702,000
	Capitalized value	$21,615,000

Notes:

1) The power plant Water Management Study issued in March, 1978 was based on "typical" coal (1977 specification) giving lower coal consumption and ash production rates than for present design "datum blended" coal (1978 specification). The capital and operating costs of the return ash water treatment plant as proposed in the above study, should be therefore increased to allow for a 30% increase in ash production rate and corresponding sluicewater flow. However, this effect is not considered in this study. It is noted that for Alternative 'A', an offsetting effect is achieved by the improved quality of return sluicewater due to the addition of relatively good quality Medicine Creek water to the ash pond, but that this effect has not been taken into account in this estimate.
2) Capital and chemical costs are escalated to 1978 dollars (Inflation rate 77/78 = 7.75%).
3) Labour cost is based on 1 operator/shift i.e. 5 operators per shift operation.
4) WMS uses energy cost of 32.2 mills/kWh. This report uses 33.23 mills/kWh.
5) Thompson makeup Energy Pumping cost differential is not included in this item.

Alternative 'B' Ash Disposal Study

Item 10 Thompson River Pumphouse and Pipeline and "off-Sites" Costs

(in 1978 dollars x 1000)

	Base	Alternative 'A'	Alternative 'B'
Capital cost of Thompson River pumphouse and pipeline to reservoir (1)	48,000	48,000	46,600
Energy costs of pumping from Thompson River to reservoir	44,072 (6)	41,154 (2)	29,273 (3)
Reservoir Capital Cost (4)	12,200	12,200	17,450
Ash Pond and Run-off handling facilities capital cost (4)	31,101	31,101	3,550
Capitalized maintenance cost of run-off handling facilities (5)	500	500	250

(1) Per Sandwell report V4251/4 dated 8 September 1978.

(2) Per Sandwell report V4251/4 adjusted for levelized energy cost of 33.23 mills/kWhr, for average flow rate of 677 l/s and capitalization factor of 12.7.

(3) Per Sandwell report V4251/4 adjusted for levelized energy cost of 33.23 mills/kWhr, for average flow rate of 552 l/s and capitalization factor of 12.7.

(4) Per BCH report DD 122 dated August 1978 adjusted for PW as per item 10(a).

(5) Per BCH report DD 122 (average $40,000 p.a. assumed for base scheme and alternative 'A') capitalized at FCR of 12.7.

(6) Per Sandwell report V4251/4 adjusted for levelized energy cost of 33.23 mills/kWhr and capitalization factor lf 12.7.

Alternative 'B' Ash Disposal Study

Item 10(a)

ASH DISPOSAL RESERVOIR & RUNOFF HANDLING FACILITIES ($'000)

BASE SCHEME & ALTERNATIVE 'A'

		Cost	P.W. of Payment Factor	P.W.
Ash Disposal Reservoir				
Stage 1	(9390 x 1.15 x 1.13 x 1.05)	12,800	1	12,800
Stage 2	1993/94	340	.7296	248
	1994/95	270	.7015	189
	1995/96	6,150	.6742	4,146
Stage 3	2003/04	210	.4922	103
	2004/05	160	.4728	76
	2005/06	3,740	.4546	1,700
Run-off Handling Facilities				
Stage 1	(4590 x 1.20 x 1.13 x 1.05)	6,500	1	6,500
Stage 2	1997/98	680	.6232	424
	1998/99	380	.5991	228
	1999/2000	4,100	.5758	2,361
	2000/2001	4,200	.5537	2,326
Total PW of Ash Disposal Reservoir and Run-off Handling Facilities				31,101
Water Supply Reservoir				
(8910 x 1.15 x 1.13 x 1.05)		12,200	1	12,200

ALTERNATIVE 'B'

	Cost	P.W. of Payment Factor	P.W.
Run-off Handling Facilities			
(2430 x 1.20 x 1.16 x 1.05)	3,550	1	3,550
Water Supply Reservoir			
(12460 x 1.15 x 1.16 x 1.05)	17,450	1	17,450

C.1 RECONCILIATION OF MAY 1978 ESTIMATE WITH PRESENT ESTIMATE OF BASE SCHEME ($ '000)

DESCRIPTION	May 1978 Estimate	Present Estimate	Remarks (See att. notes)
CAPITAL COST			
Bottom Ash Removal System	9,252	10,049	(A)
Fly Ash Removal System	11,516	12,508	(A)
Transport & Distribution System	14,087	15,300	(A)
Disposal System	14,253	4,562	(A) & (B)
Total Capital Costs	49,108	42,419	
OPERATION & MAINTENANCE			
Reclamation Cost of Wet Pond	2,660	2,660	(C)
Energy	3,229	6,057	(D) a),b),c) & d)
Labour	2,920	9,361	(E) a) and b)
Equipment Replacement & Supplies for Transport & Distribution System	11,486	18,115	(F)
Supporting Equipment Replacement & O & M (for topsoil removal, ash spreading & compacting, site reclaiming)	511	383	(G)
Total O & M Costs	20,806	36,576	
TOTAL COSTS (not including water treatment)	69,914	78,995	
- Water Treatment Capital Cost	9,500	10,236	(A)
- Water Treatment O & M Costs	31,432	21,615	(H)
TOTAL COSTS	110,846	110,846	

Alternative 'B' Ash Disposal Study

C.2 UPDATED COST ESTIMATE

of Alternative Dry Ash Handling Systems

Studied in I-E Report of May 1978

In May 1978 two alternative schemes of dry ash disposal to Upper Medicine Creek (UMC) Valley were considered. These used drag bar conveyors for bottom ash removal and transportation of fly ash and bottom ash by conveyors or truck to the disposal site.

The following tabulation provides updated estimates of the above two schemes. The updating accounts for 1977/1978 inflation, new financial criteria, more precisely calculated indirect costs and new offsite costs as provided by B.C. Hydro in October, 1978. The updating was performed to have a comparable basis with Alternative 'B'.

Ash Transportation System	By Conveyor to UMC		By Trucks to UMC		REMARKS
	May 1978 Estimate	Updated Estimate	May 1978 Estimate	Updated Estimate	(see att notes)
CAPITAL COST					
-Bottom ash removal system	5,958	6,471	5,958	6,471	(A)
-Fly Ash removal System	15,850	17,215	15,850	17,215	(A)
-Trans. & Dist. System	12,651	13,212	7,193*	7,512	(A)
-Disposal Equipment	2,251	2,351	2,251	2,351	(A)&(J)
-Run-off ditches	720	11,839	720	11,839	(J)
TOTAL CAPITAL COSTS	37,430	51,088	31,972	45,388	
OPERATION & MAINTENANCE					
-Relamation cost	-	-	-	-	(K)
-Energy	3,060	3,638	3,060	3,638	(D)a)
-Labour	7,787	6,512	12,166	10,175	(E)a)
-Equip. replacement & supplies for trans. & distr. system	5,765	6,212	9,095	9,800	(L)
-Supporting equip. replacement & O & M (for top soil removal, ash spreading, & compacting, site reclaming)	21,311	20,952	21,311	20,952	(M)
TOTAL O & M COSTS	37,923	37,314	45,632	44,565	
TOTAL COST (not incl. water treatment)	75,353	88,402	77,604	89,953	
-water treatment capit. cost	12,740	-	12,740	-	(N)
-water treatment O & M cost	11,640	-	11,640	-	(N)
	99,733	88,402	101,984	89,953	

*This was shown erroneously as 7913 in Table III-1 of May 1978 report.

Alternative 'B' Ash Disposal Study

Notes on C.1 and C.2

(A) Adjusted to 1978 price level and revised indirect portion of 26% instead of 25% used for in plant equipment and 30% for mobile equipment in May 1978 estimate (adjustment due to more precise calculations).

(B) In May 1978 estimate, Disposal System included ash barriers and creek diversion (total $10,040,000). These are separate items in present estimate and are based on costs supplied by B.C. Hydro.

(C) This cost would need further investigation therefore not adjusted at this time.

(D) Energy cost in present estimate is adjusted to:

(a) Updated levelized energy cost of 33.23 mills/kWh (instead of 25 mills/kWh used in the Ash Disposal Evaluation report of July 1977 and retained in the May 1978 study, which was based on lower fuel and power costs) and capitalization factor of 12.7 (instead of 14.2).

(b) Revised motor horsepower due to new coal specification provided by B.C. Hydro and increased ash generation by approximately 30%.

(c) Adjusted power penalty.

(d) Include Bottom Ash Sluice pumps and MP pumps which were not considered in previous estimates.

(E) (a) May 1978 estimate used $17/hour, 2016 hours/year/capita and 14.2 capitalization factor. Present estimate uses $18.3/hour, 1752 hours/year/capita and 12.7 capitalization factor.

(b) May 1978 estimate included labour for ash transport and distribution only. In plant labour was excluded since it was assumed to be the same for all schemes. Present estimate for the Base Scheme is based on an additional requirement of 23 persons to complete the ash handling system.

(F) May 1978 estimate included replacement of slurry lines only (in-plant ash removal equipment replacement cost was not included). Present estimate includes replacement and supplies for complete ash handling equipment.

Replacement equipment costs increased for 1 year's inflation and present worth factors increased due to revised inflation rates.

(G) In present estimate, the cost is inflated as (A) to 1978 levels and capitalization factor of 12.7 used in place of 14.2.

(H) In the present estimate the Thompson river water differential pumping cost ($10,394,400 in the May 1978 estimate) is shown as a separate item based on costs supplied by Sandwell.

(J) In May 1978 estimate disposal system cost ($\$2,971 \times 10^3$) comprised disposal equipment and creek diversion (run-off ditches).

In updated estimate disposal equipment adjusted as (A) and run-off ditches to new offsite costs provided by B.C. Hydro in October 1978 (cost of run-off ditches for dry ash disposal schemes to UMC assumed same as Base Scheme and Alternative 'A' in Item 10(a) of Section B.4 Economic Analysis of this Report).

(K) In May 1978 estimate reclamation cost included in Supporting Equipment Replacement and O & M.

Alternative 'B' Ash Disposal Study

(L) May 1978 estimate adjusted by 1977/1978 inflation factor of 1.0775.

(M) May 1978 estimate adjusted by 1977/1978 inflation factor of 1.0775 and revised capitalization factor of 12.7 (instead of 14.2).

(N) Updated price not relevant for comparison with Alternative 'B' since for all dry ash disposal schemes it is assumed that excess plant water will be disposed of or used without treatment.

C.3 COMPARISON OF UPDATED MAY 1978 DRY ASH DISPOSAL SCHEMES TO UPPER MEDICINE CREEK WITH ALTERNATIVE 'B'

In May 1978 two alternative schemes of dry ash disposal to Upper Medicine Creek (UMC) were considered. These used drag bar conveyors for bottom ash removal and transportation of fly ash and bottom ash by conveyors or trucks to the disposal site. The following table (C.3.1) compares the updated estimates of these schemes with Alternative 'B' on similar financial bases.

The comparison indicates the trucking scheme to have the lowest capital cost by approximately 3½% over the conveying scheme to UMC and Alternative 'B'. Because of this small differential all three schemes are considered to be comparable in capital costs.

The most favourable operating and maintenance costs are incurred by Alternative 'B'(by a differential of approximately 19% and 28% relative to the conveying and trucking schemes to UMC respectively).

In total capital and O & M cost conveying and trucking to UMC are more expensive than Alternative 'B' by approximately 8% and 10% respectively.

Therefore Alternative 'B' is preferred to the compared schemes due to its lower O & M costs and its technical advantages as listed in C.3.2 and C.3.3 of this report.

C.3.1 COST COMPARISON OF UPDATED DRY ASH DISPOSAL SCHEMES TO UPPER MEDICINE CREEK WITH ALTERNATIVE 'B' ($ 000)

	Updated May 1978 Estimate		Present est. Alternative B Conv. to UMC	Remark (see at notes	
	Conveyor to UMC	Trucking to UMC			
A. Capital Cost					
Bottom ash removal system	5,145	5,145	5,145	(A)	
Fly ash removal system	15,219	17,215	15,219	(B)	
Transportation and distribution system	13,212	7,512	16,276	(C)	R1
Disposal equipment	2,351	2,351	1,525	(D)	
Run-off ditches	11,839	11,839	3,550		
Water treatment system	6,859	6,849	6,859		R2
Makeup water supply costs					
- Thompson River to Reservoir	48,000	48,000	46,600	(E)	
- Reservoir	12,200	12,200	17,450	(E)	
- Reservoir to power plant (differential)	-	-	2,488		
Differential cost of other project facilities	1,091	1,091	1,604	(F)	
Total Capital Cost	115,916	112,212	116,716		
Differential Capital Cost	3,704	Base Cost	4,504		R2
Percentage Differential	3.3%	Base Cost	4%		
B. Capitalized Operating & Maintenance Costs					
Complete ash handling system	50,554	58,186	41,843	(G)	
Run-off ditches	500	500	250	(H)	
Water treatment system	13,066	13,066	13,066		R2
Makeup water supply costs					
- Thompson River to Reservoir	41,154	41,154	29,273	(J)	
- Reservoir to power plant (differential)	-	-	5,248		
Differential cost of other other project facilities	-	-	1,124		
Total Capitalized O & M Cost	105,274	112,906	90,845		
Differential Operating Cost	14,429	22,061	Base Cost		
Percentage Differential	15.9%	24.2%	Base Cost		R2
Total Capital & O & M Costs	221,190	225,118	207,561		
Differential Capital & O & M Costs	13,629	17,557	Base Cost		
Percentage Differential	6.6%	8.5%	Base Cost		

Rev. R2

Alternative 'B' Ash Disposal Study

Notes on C.3.1

(A) Updated May 1978 cost in C.2 is based on underground B.A. collecting conveyors. For comparison purposes, Alternative 'B' estimate is based on above ground B.A. collecting conveyors and therefore the same cost is used for all three schemes.

(B) May 1978 schemes use silos of 24 hour capacity. For the updated conveying scheme to UMC 12 hour capacity silos (Same as for Alternative 'B' - see B.3.1.3 in this report) are assumed for comparison of the schemes.

(C) Updated capital cost of conveyor system to UMC does not include future conveyor extension costs which are considered in O & M costs. No such extension is required for Alternative 'B' conveyor arrangement.

(D) Alternative 'B' assumes that the reclamation of the disposal area would be performed entirely by contractors and therefore less disposal equipment is required.

(E) Makeup water supply system costs for dry ash disposal schemes to UMC assumed same as those for Base Scheme and Alternative 'A' in item 10 of economic analysis (Section B.4 of this report).

(F) Dry ash disposal schemes to UMC assumed to include the following features from item 2(e) of economic analysis (Section B.4 of this report):

Differential cost of plant site run off holding pond	$ 1,017,000
Differential cost of access road	74,000
	$ 1,091,000

Alternative 'B' Ash Disposal Study

(G) Capitalized O & M costs for the complete ash handling system in updated dry ash disposal schemes to UMC, are taken from C.2 and made complete by the following adjustments:

- labour content increased by staff of 23 to give total staffing requirement for ash system. At the capitalized cost of $407,000 per capita this amounts to an addition of $\$9,361 \times 10^3$ for each updated scheme.

- equipment replacement content increased to include inplant equipment replacement as follows:

Conveying scheme $\$(5145 + 15219) \times 10^3 \times 0.015 \times 12.7 = \$3879 \times 10^3$

Truck Scheme $\$(5145 + 17215) \times 10^3 \times 0.015 \times 12.7 = \$4260 \times 10^3$

(H) O & M costs for run off ditches for dry schemes to UMC assumed to be the same as for the Base Scheme and Alternative 'A'.

(J) Dry ash disposal schemes to UMC assume same energy cost for makeup water supply pumping as Alternative 'A' (power plant water consumption same as Alternative 'A' and no Medicine Creek makeup to ash pond is required).

(K) Differential O & M costs relating to items in Note (F) above, assumed negligible.

C.3.2 Technical Advantages of Alternative 'B' Over Conveying to UMC

1. Conveyor arrangement of Alternative 'B' is simpler and permits bottom ash to cover fly ash on the main conveyor to the valley. This reduces dusting potential. It is noted, however, that the conveyor arrangement to UMC, if adopted, could possibly be revised in detailed engineering to give the same advantage.

2. Alternative 'B' provides the opportunity to dispose of ash together with mine waste in Medicine Creek Valley. In such a case savings may be realized through the possibility of obviating the need for ash compaction and the reduction of some distribution and mobile supporting equipment. It is believed that the addition of ash could also provide greater stability to the mine waste storage. These possibilities are not available with ash disposal in UMC.

3. Should maintenance of the runoff facilities be necessary after plant decommissioning, Alternative 'B' would be less costly due to the reduced length of ditches.

C.3.3 Technical Advantages of Alternative 'B' over Trucking to UMC

1. Alternative 'B' is less labour intensive. Should trucking be performed by BCH staff there could be complications in personnel scheduling of the trucking operation to match ash production under varying plant load conditions.
2. Truck movements, particularly at intersections of the truck roads with other roads, may be hazardous and interfere with other project operations. Trucking requires a larger maintenance operation and is also more vulnerable to icy road conditions in hilly terrain than conveying.
3. Alternative 'B' also has the advantages 2 and 3 of Section C.2.3 when compared with the trucking operation to UMC.

Alternative 'B' Ash Disposal Study

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Alternative 'B' Ash Disposal Study

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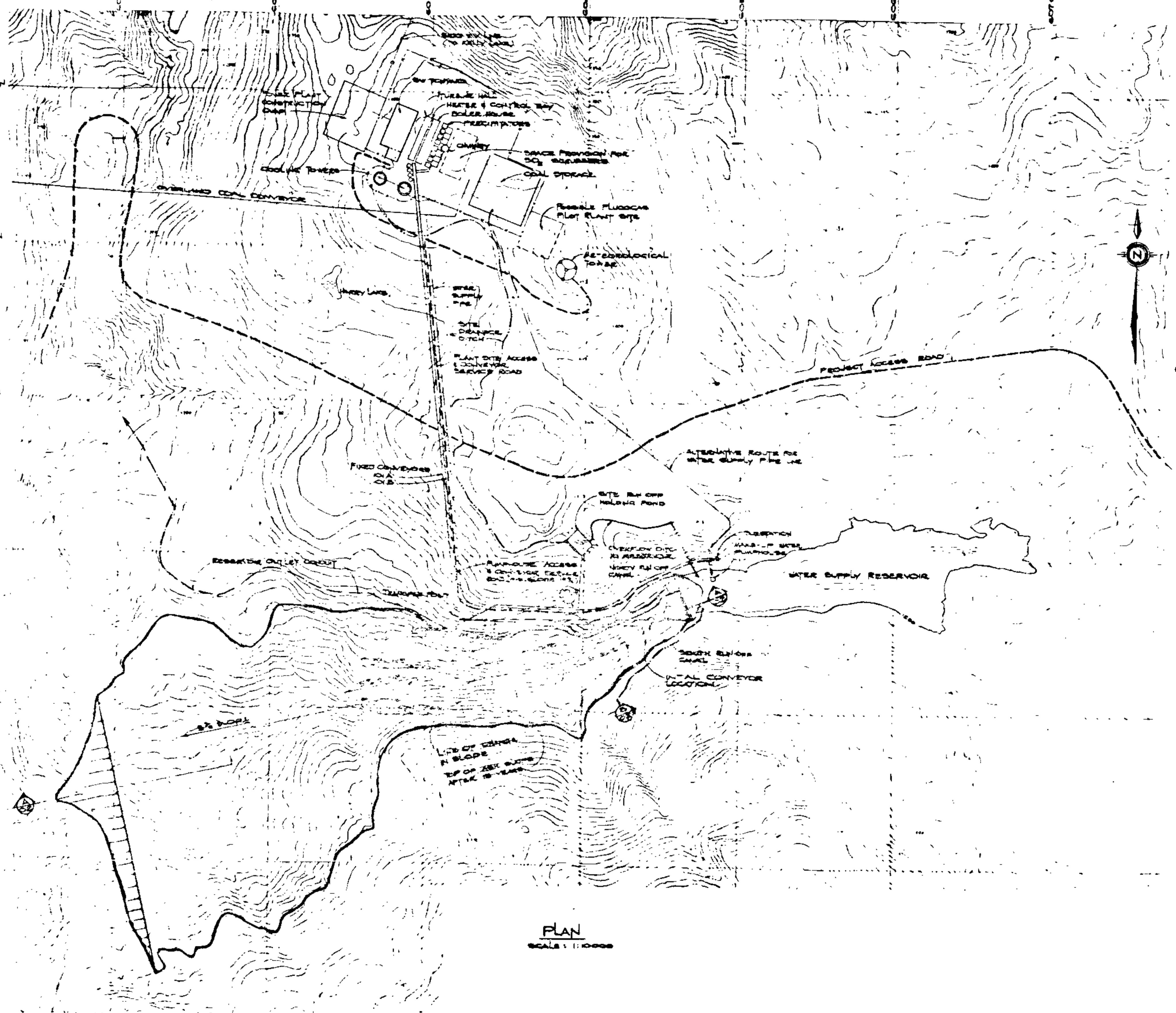

PLAN
SCALE 1:10000

LEGEND

— — — —	ACCESS OR SERVICE RD.
—·—·—	CANAL OR DITCH
—·— —	RESERVOIR OUTLET CONDUIT
——·——	WATER SUPPLY PIPE LINE
——o——	500 KV POWER LINE
—··——	ASH PILE RUNOFF PIPELINE.

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HAT CREEK PROJECT

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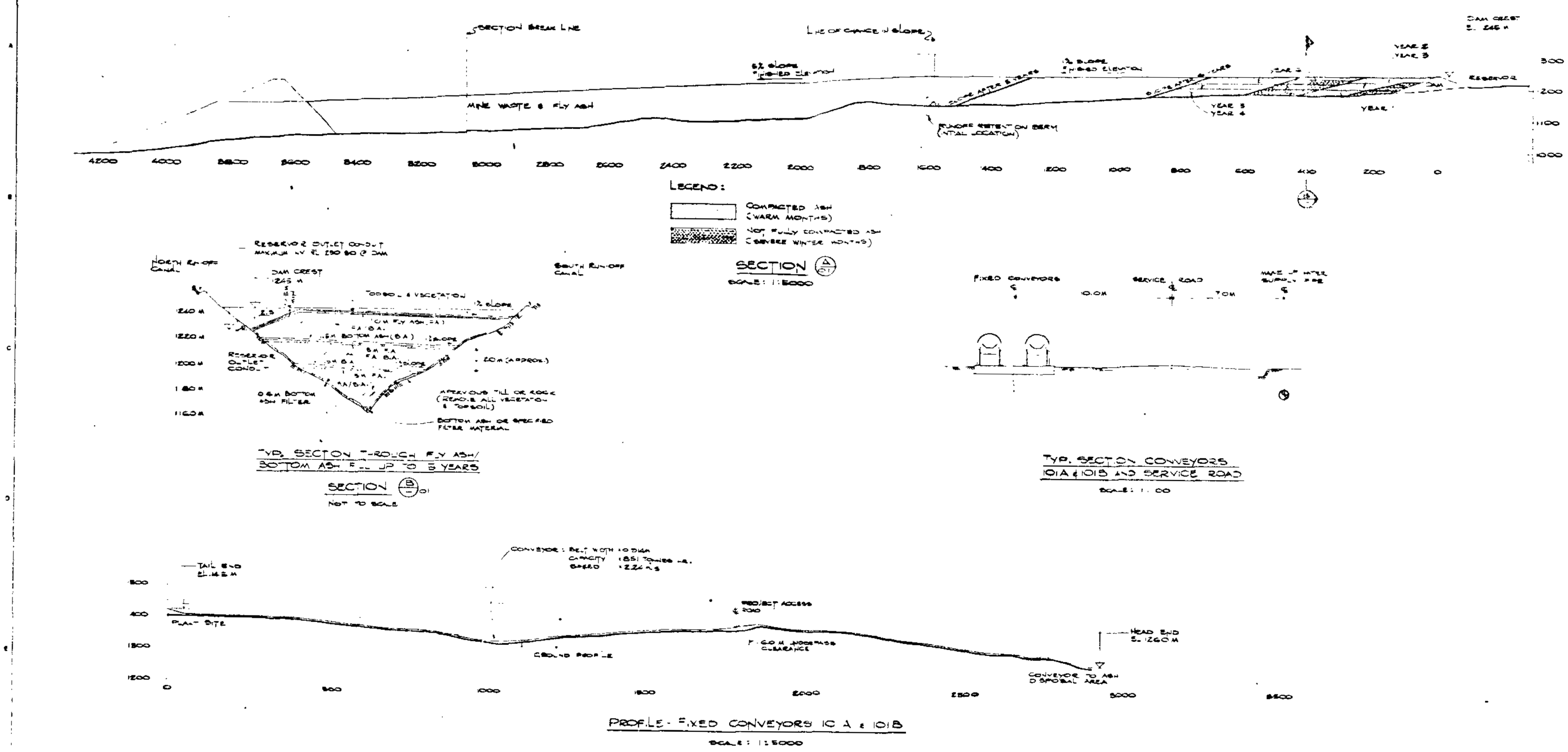
ASH DISPOSAL SYSTEM
ALTERNATIVE 5
SITE PLAN

Drawing Number F 8.C.H SK. 51 B



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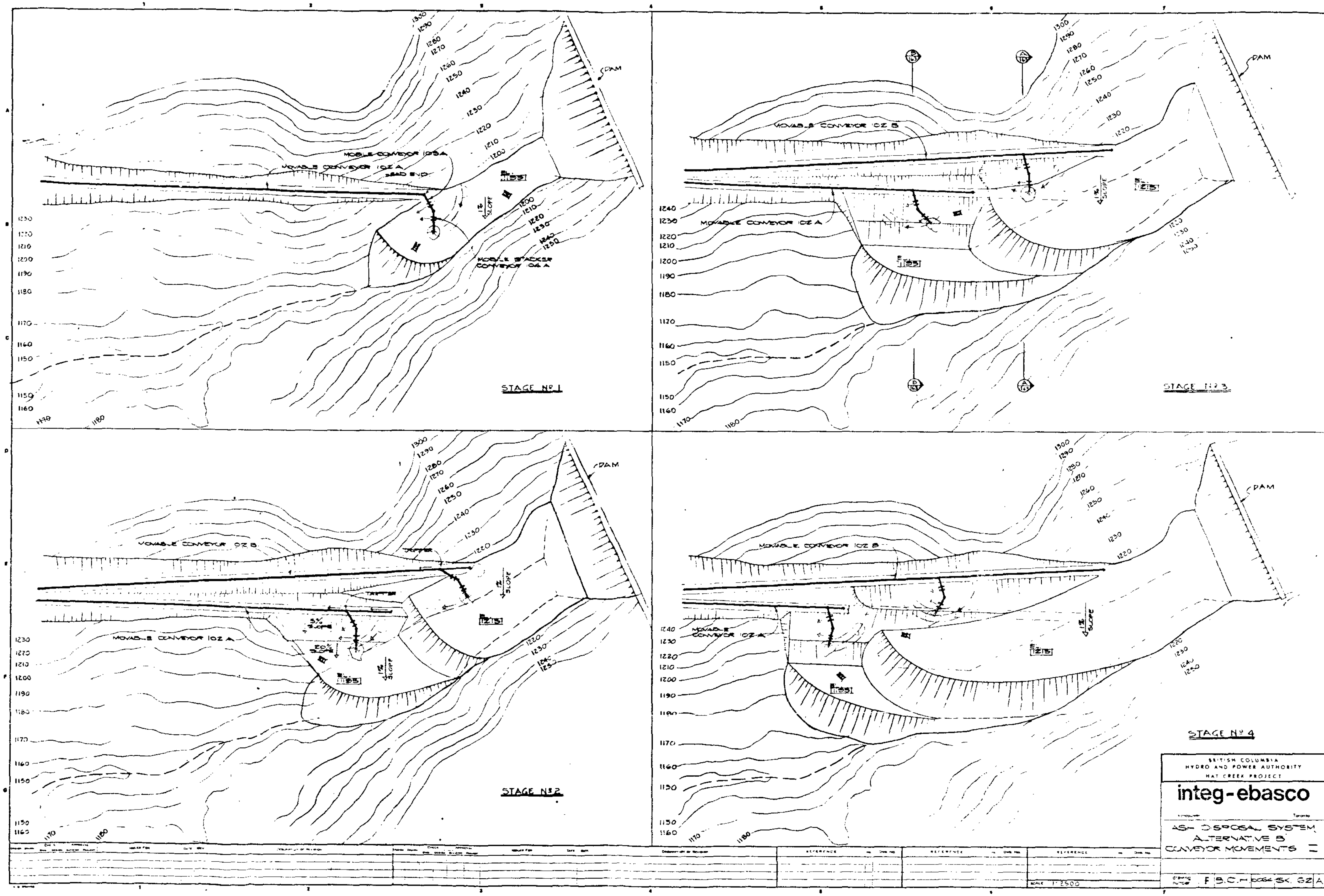
Vancouver Toronto

ASH DISPOSAL SYSTEM
ALTERNATIVE 5
SECTIONS

SCALE AS NOTED

drawing number F B.C.H. 0004 SK 32 A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DAM
MOBILE CONVEYOR 103 A
MOVABLE CONVEYOR 102 A
HEAD END
MOBILE STACKER CONVEYOR 104 A
1:6 SLOPE
STAGE Nº 2
MOVABLE CONVEYOR 102 B
MOVABLE CONVEYOR 102 A
TRIPPER
5% SLOPE
1:6 SLOPE
STAGE Nº 3
MOVABLE CONVEYOR 102 B
MOVABLE CONVEYOR 102 A
STAGE Nº 4
MOVABLE CONVEYOR 102 B
MOVABLE CONVEYOR 102 A
BRITISH COLUMBIA
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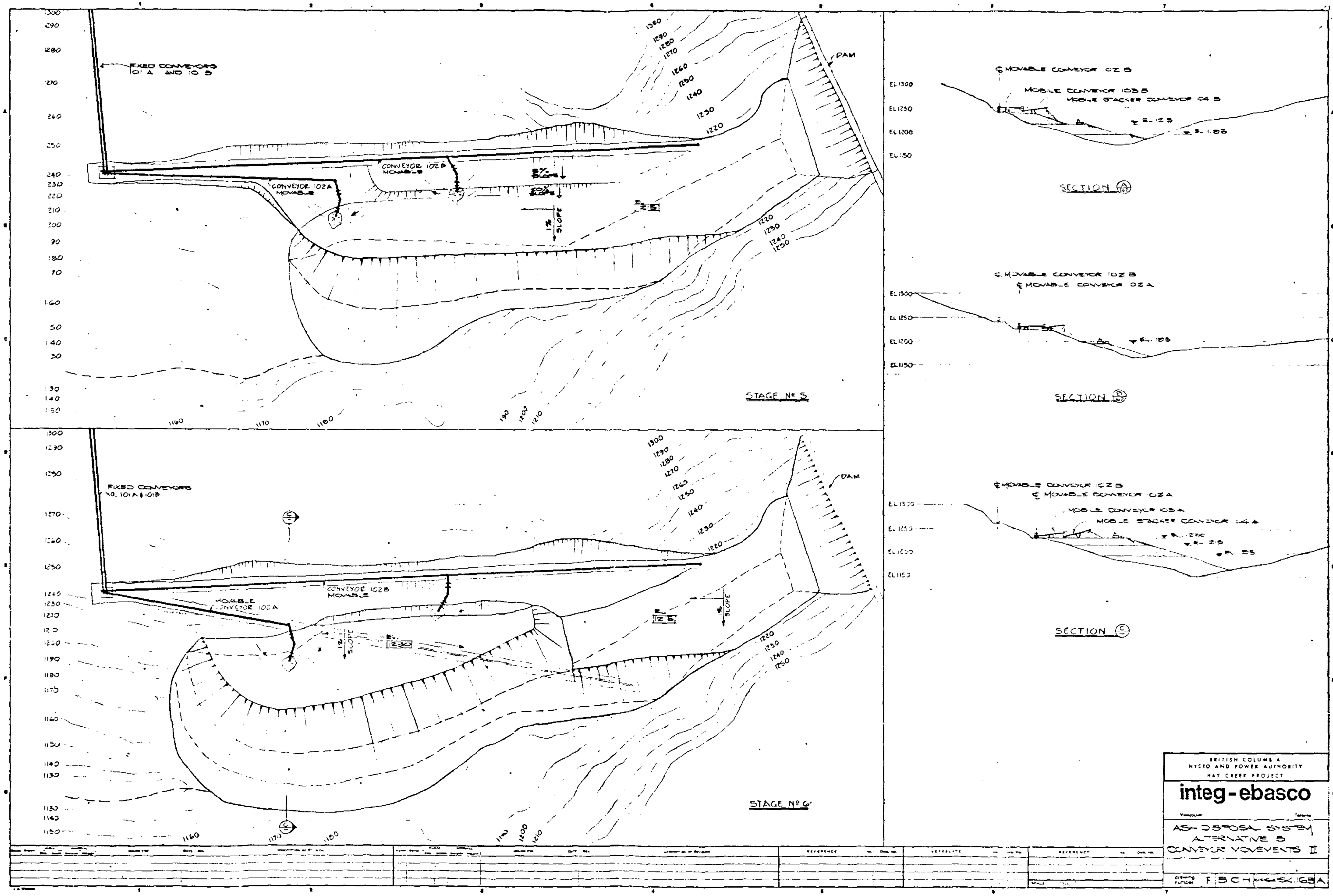
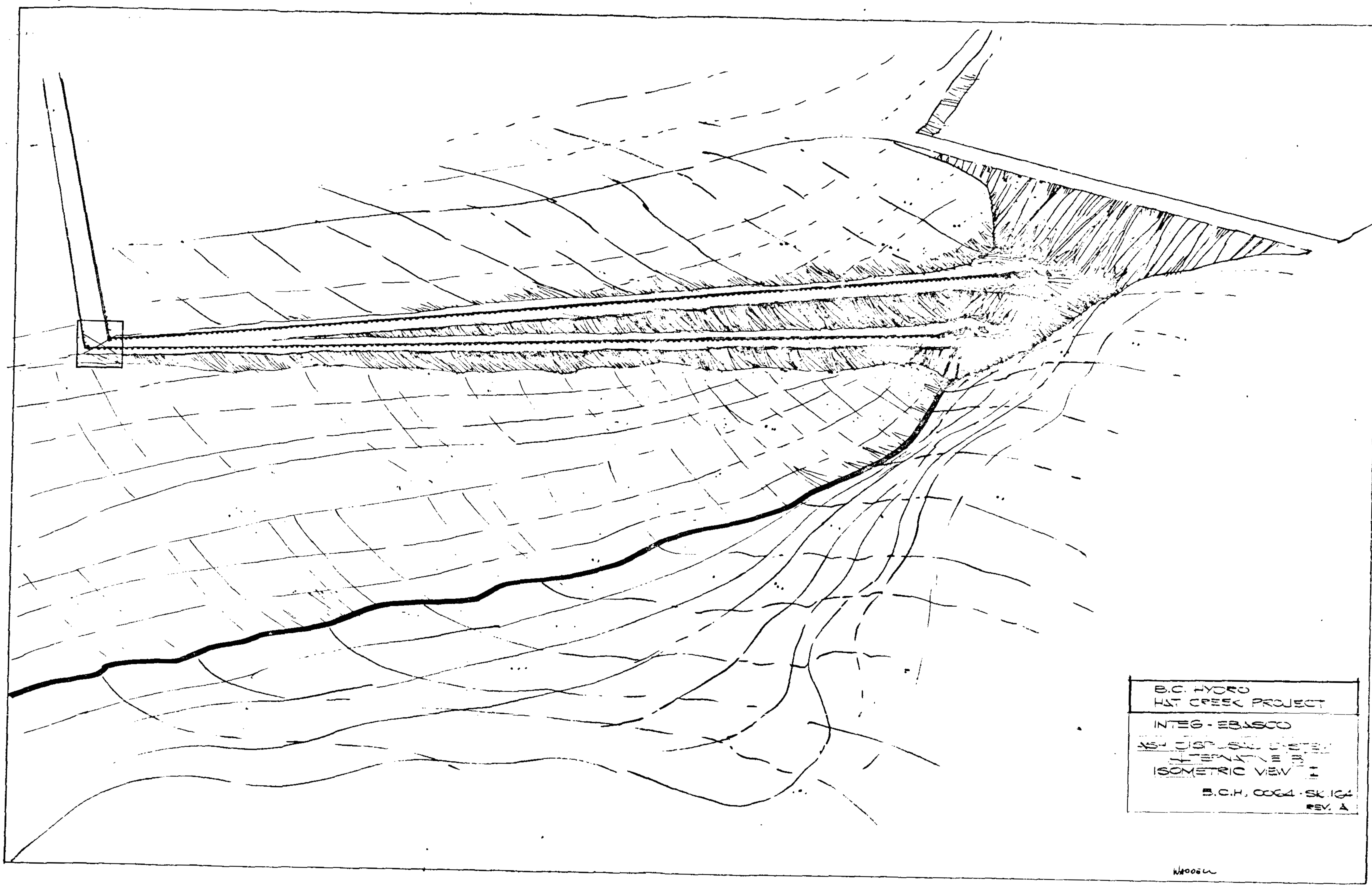
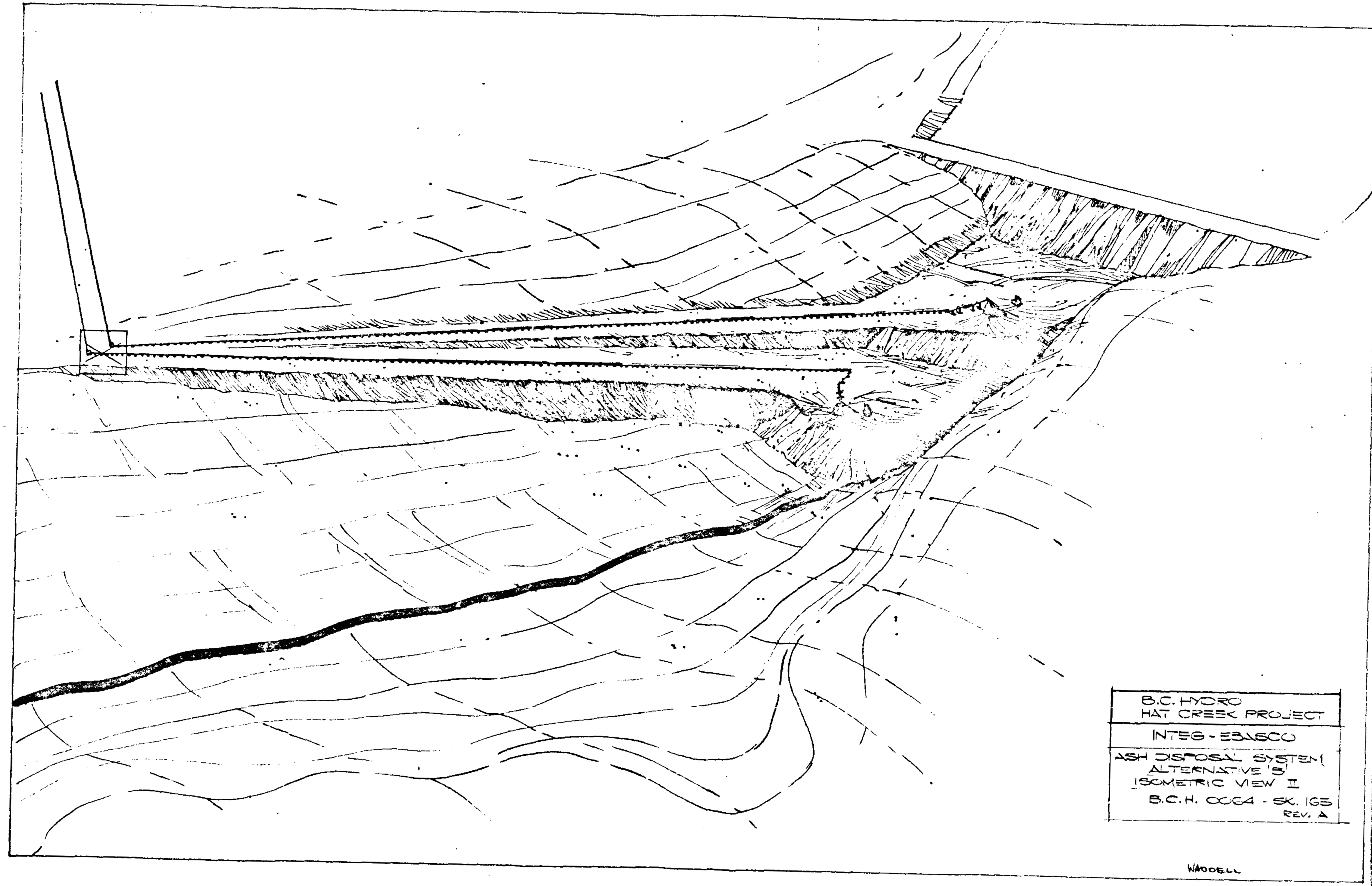
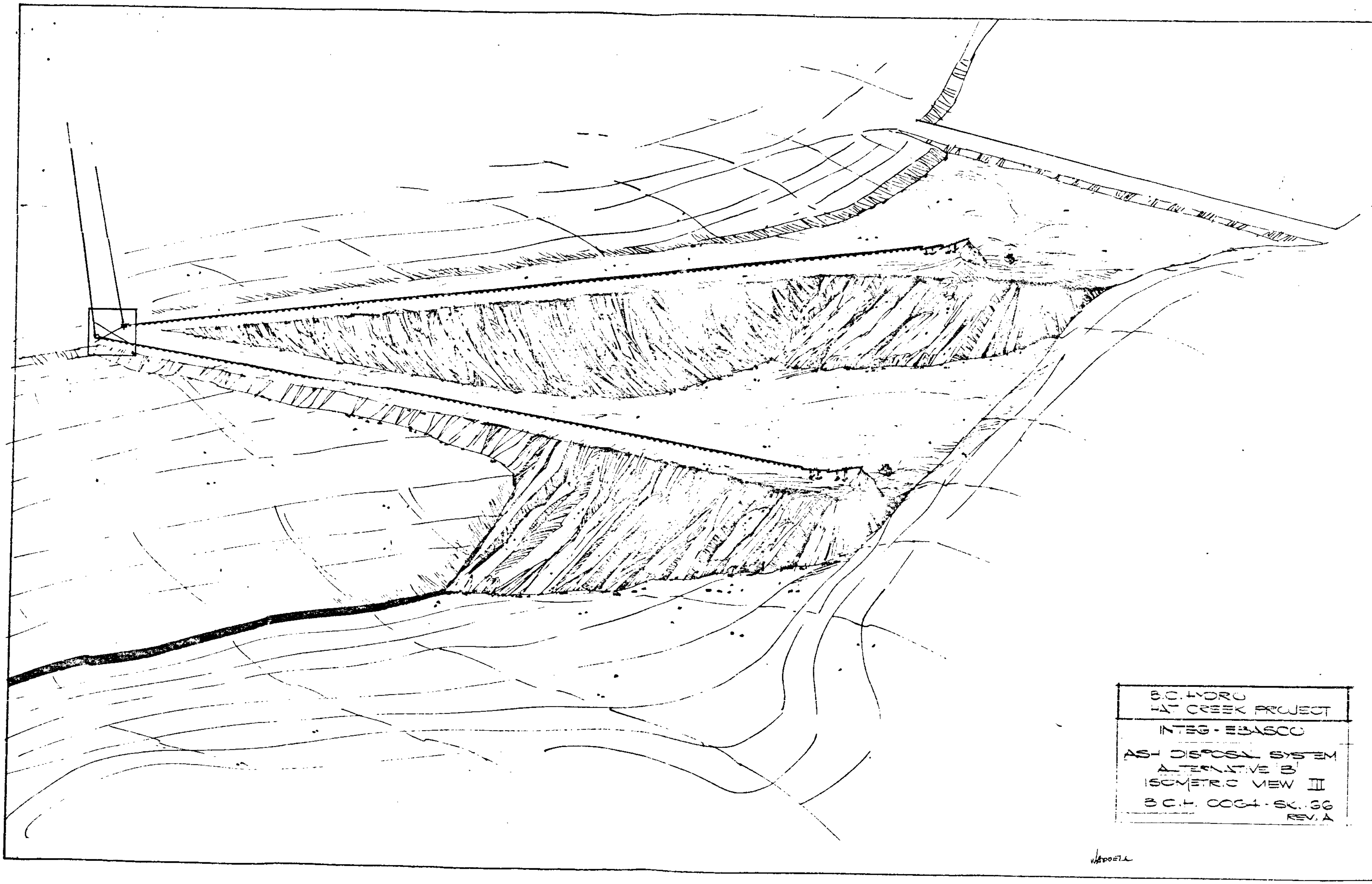
HAT CREEK PROJECT
integ-ebasco
Toronto
ASH DISPOSAL SYSTEM
ALTERNATIVE B
CONVEYOR MOVEMENTS
SCALE 1:2500
drawing number F B.C.H 0064 SK. 62 A



FIXED CONVEYORS 101 A AND 101 B
DAM
CONVEYOR 102 B MOVABLE
CONVEYOR 102 A MOVABLE
8% SLOPE
10% SLOPE
1% SLOPE
STAGE № 5
℄ MOVABLE CONVEYOR 102 B
MOBILE CONVEYOR 103 B
MOBILE STACKER CONVEYOR 104 B
SECTION A
℄ MOVABLE CONVEYOR 102 B
℄ MOVABLE CONVEYOR 102 A
SECTION B
FIXED CONVEYORS NO. 101 A & 101 B
MOVABLE CONVEYOR 102 A
CONVEYOR 102 B MOVABLE
STAGE № 6
℄ MOVABLE CONVEYOR 102 B
℄ MOVABLE CONVEYOR 102 A
MOBILE CONVEYOR 103 A
MOBILE STACKER CONVEYOR 104 A
SECTION C
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
integ-ebasco
ASH DISPOSAL SYSTEM ALTERNATIVE 3 CONVEYOR MOVEMENTS II
F B C H SK.163 A


B.C. HYDRO
HAT CREEK PROJECT
INTEG - EBASCO
ISOMETRIC VIEW I
B.C.H. 0064 - SK.164
REV. A


B.C. HYDRO
HAT CREEK PROJECT
INTEG - EBASCO
ASH DISPOSAL SYSTEM
ALTERNATIVE 'B'
ISOMETRIC VIEW II
B.C.H. 0064 - SK. 165
REV. A
WADDELL


B.C. HYDRO
HAT CREEK PROJECT
INTEG - EBASCO
ASH DISPOSAL SYSTEM
ALTERNATIVE 'B'
ISOMETRIC VIEW III
BCH 0064 - SK. 36
REV. A

B.C. HYDRO
HAT CREEK PROJECT

INTEG - EBASCO

ASH DISPOSAL SYSTEM
ALTERNATIVE 'B'
ISOMETRIC VIEW IV

B.C.H. 0064 - SK 167
REV. A

WADDELL