The management of fuel ash originating from power generation

Environmental Impact Assessment
Stage III
Summary Report on Ash Lagoon

March 1993

Binnie Consultants Limited

The Hongkong Electric Co Ltd

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1 INTRODUCTION

1.1 The Hongkong Electric Company Limited (HEC) commissioned Binnie Consultants Limited to carry out an environmental impact assessment (EIA) for the long term disposal strategy of pulverised fuel ash (PFA) arising from its power station on Lamma Island. A series of studies carried out by the consultants under the auspices of a Government Study Management Group developed a strategy for 30 years, giving the least environmental impact of all the available options.

1.2 The EIA followed a feasibility study of ash disposal options presented to Government in February 1987. The recommendations of the feasibility study had been accepted by Government as providing an outline strategy for the long term disposal of PFA and as providing a basis for more detailed assessments.

1.3 The EIA had three stages. Stage 1 comprised a review of the feasibility study in the context of possible power station expansion and was completed in November 1987. The review conclusions, endorsed by the Government's Study Management Group were that the preferred strategy would evolve from a combination of:

(i) the marketing of PFA for industrial uses

(ii) the use of PFA as fill for land formation

(iii) the use of PFA as fill to restore the Lamma Quarry site

(iv) the formation of an ash lagoon adjacent to the power station

1.4 Stage 2 of the EIA, the Initial Assessment Stage studied the environmental implications in sufficient detail to enable decisions to be reached on a preferred scheme. This included the restoration of the Lamma Quarry and the use of a lagoon as an interim measure. When quarrying activities ceased the site would be handed over to HEC for restoration, with PFA as the major fill source. The result would be the recreation of a vegetated hillside. The PFA would be transported through a purpose built tunnel with one portal within the power station and the other within the quarry. However, in the period before the handover of the quarry, a lagoon would be required to provide sufficient storage for the PFA produced in the interim. These studies culminated in the issue of the Initial Assessment Report (IAR) in November 1988.

1.5 Stage 3 of the EIA involved the preliminary design of the identified works and the detailed assessment of the environmental impacts for the preferred management strategy. The approach was iterative to allow assessments of environmental impacts and the incorporation of mitigation measures as the proposals for various options developed.

1.6 At the outset of Stage 3 Government decided that the availability of the quarry would be brought forward thus permitting the size of the lagoon to be reduced (to a capacity of 1.5 Mm^3) to cater for a shorter intermediate period. Another consequence of this agreement was that the location of the lagoon was fixed in a position adjacent to the south east of the power station.

1.7 Throughout the studies a series of working papers have been issued to Government for comment and approval, covering the environmental aspects of each of the elements of the strategy. This report is a summary of the studies carried out for the lagoon, covering proposals for the form of lagoon, its construction and operation. The intended readership of this report is not only government officials but also the general public.

2 THE SITE

2.1 The existing Power Station is on a platform on the northern side of Ha Mei Wan bay, on the western coast of Lamma Island (Figure 2.1). The headland behind the power station separates the power station from the island's main population centre of Yung Shue Wan. The platform for the station is some 950 m long by 450 m wide, with the fuel jetty off the western end in Lamma's Western Channel. The site of the lagoon is to be along the sea frontage on the south eastern corner of the platform. The lagoon will be some 529 m long, stretching from the eastern edge of the platform to about half way along, almost opposite the main control room and will extend some 250 m into the sea.

2.2 The water depth in Ha Mei Wan ranges from about 5 m near the coastline to about 11 m adjacent to the West Lamma Channel. In the area of the proposed lagoon the sea water depth is about 8 m and gradually becomes deeper toward the western end. The sea bed in the area consists of soft marine muds, below which are firmer alluvial deposits with bed rock below that.

2.3 The marine ecology in the area of the lagoon consists of diverse infauna and epifauna such as Echinoderms, Molluscs, Crustacea and Polycheates. These are common in shallow Hong Kong waters and this site provides no unique habitats or nursery grounds. It is therefore considered to be of low conservation value. Free swimming organisms, mainly fish, are commonly trapped in the power station's cooling water intakes adjacent to the site. The assemblage is not unusual, nor will the lagoon affect a significant portion of the habitat.

2.4 To the east of the site, along the shores of the Ha Mei Wan bay there are a number of beaches that support tourism, bathing and restaurants. There are two gazetted beaches in the bay, Lo So Shing some 1.5 km away, and Hung Shing Ye which also has restaurants above the beach. The closest beach is Tai Wan To, adjacent to the eastern perimeter of the power station but this is not gazetted. Attendance figures for the two gazetted beaches between 1985 and 1989 suggest that the popularity of the area is increasing. Although the data set is too small for a statistical analysis, the figures do indicate that much of the attendance occurs in the months of June, July and August. The bay is also used as an anchorage for pleasure craft in the summer months, particularly off Lo So Shing beach. Local observers suggest that pleasure craft attendance has been increasing in recent years, but there is no data to confirm this.

2.5 Extensive studies have been carried out to investigate the hydrodynamics of the bay for this project and others have been carried out for Hong Kong waters in general. The hydrodynamics in the area are dominated by the seasonal effects of the Pearl estuary, tidal effects and storms. The Ha Mei Wan bay is in general calm although there are rotation currents (a gyre) that sweep around the bay moving from east to west in front of the power station. The area has a slightly higher proportion of sediment than other parts of the bay. The construction of the lagoon will not affect the hydrodynamics of the bay although it may have minor effects on the area immediately around the site of the lagoon.

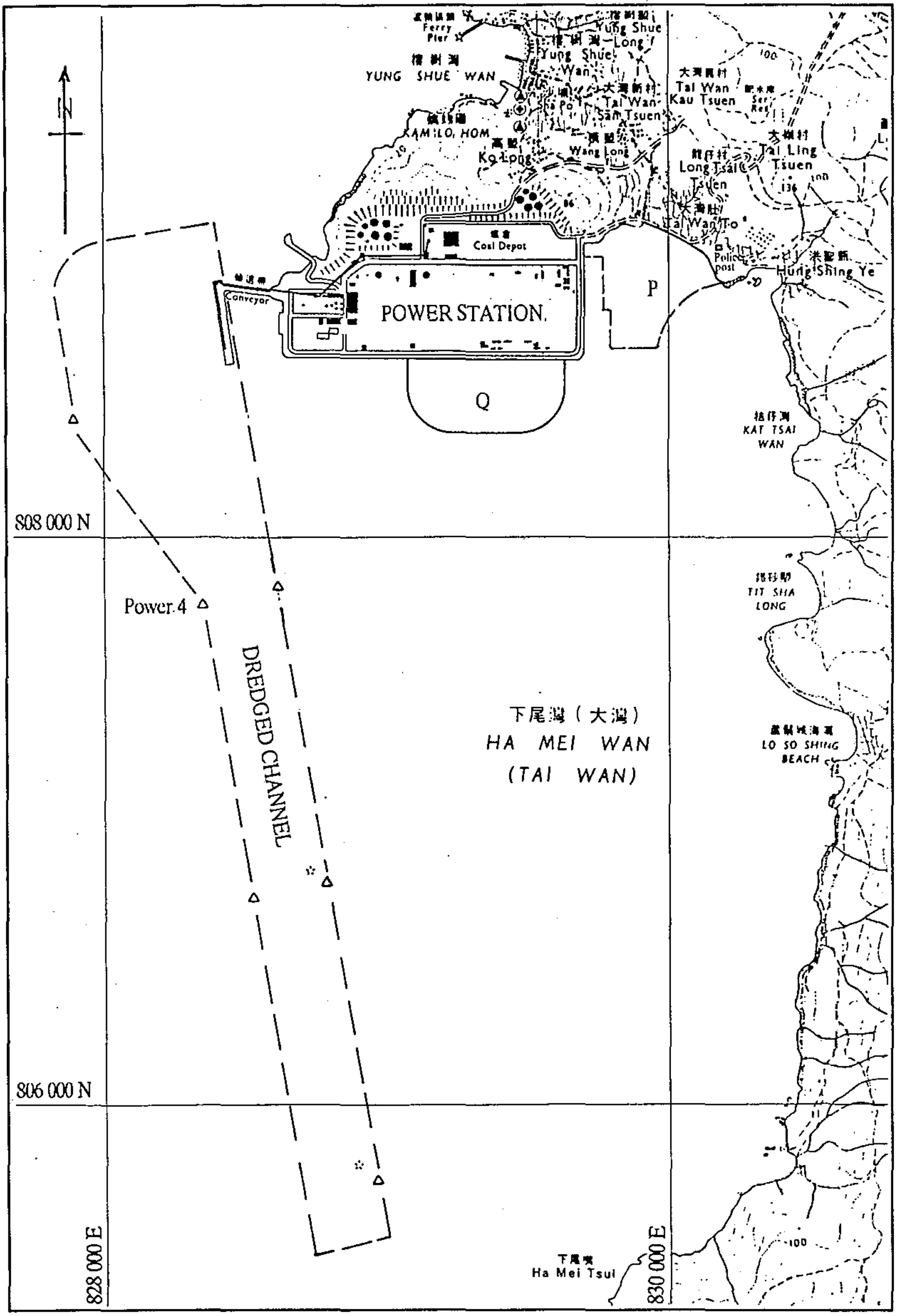


Figure 2.1 The Site

3 THE LAGOON

3.1 The expected production of PFA over the next few years is some 700 m^3 per day and the expected life of the lagoon is about 6 to 8 years. Thus the lagoon is to have an ultimate capacity of 1.5 Mm^3 of PFA. In addition it will accommodate the occasional discharge of PFA slurry of 46,000 m^3 in a day.

3.2 To accommodate the capacity within the confines of the site the marine mud is to be excavated and the PFA is to be built up as a mound on the eastern side, this will also be landscaped to serve as a screen to works beyond (Figure 3.1). The marine mud excavated during construction will be transported under licence to a designated area for marine disposal.

3.3 In devising engineering proposals for the lagoon a number of environmental constraints have been considered:

(i) the lagoon must not significantly affect the local hydrodynamics

(ii) seepage from the lagoon, must not significantly affect the local water quality

(iii) the lagoon must not be visually intrusive

(iv) construction duration should be the minimum possible to reduce local disturbance

3.4 There are also a number of engineering constraints that influence various aspects of the preliminary designs:

(i) the soft marine muds are not sufficiently strong to support a perimeter structure, thus the perimeter structure has to be founded in the firmer underlying alluvial deposits

(ii) the storms in the area generate strong waves. These have to be guarded against in the shape and height of the perimeter. The chance of overtopping the perimeter is intended to be minimal

(iii) the lagoon envelops the power station's second cooling water intake. The proposals have to provide for uninterrupted flow of seawater to the power station throughout construction and in the permanent works. This is to be achieved by providing a culvert passing along the western side of the lagoon and through the perimeter on the south western corner.

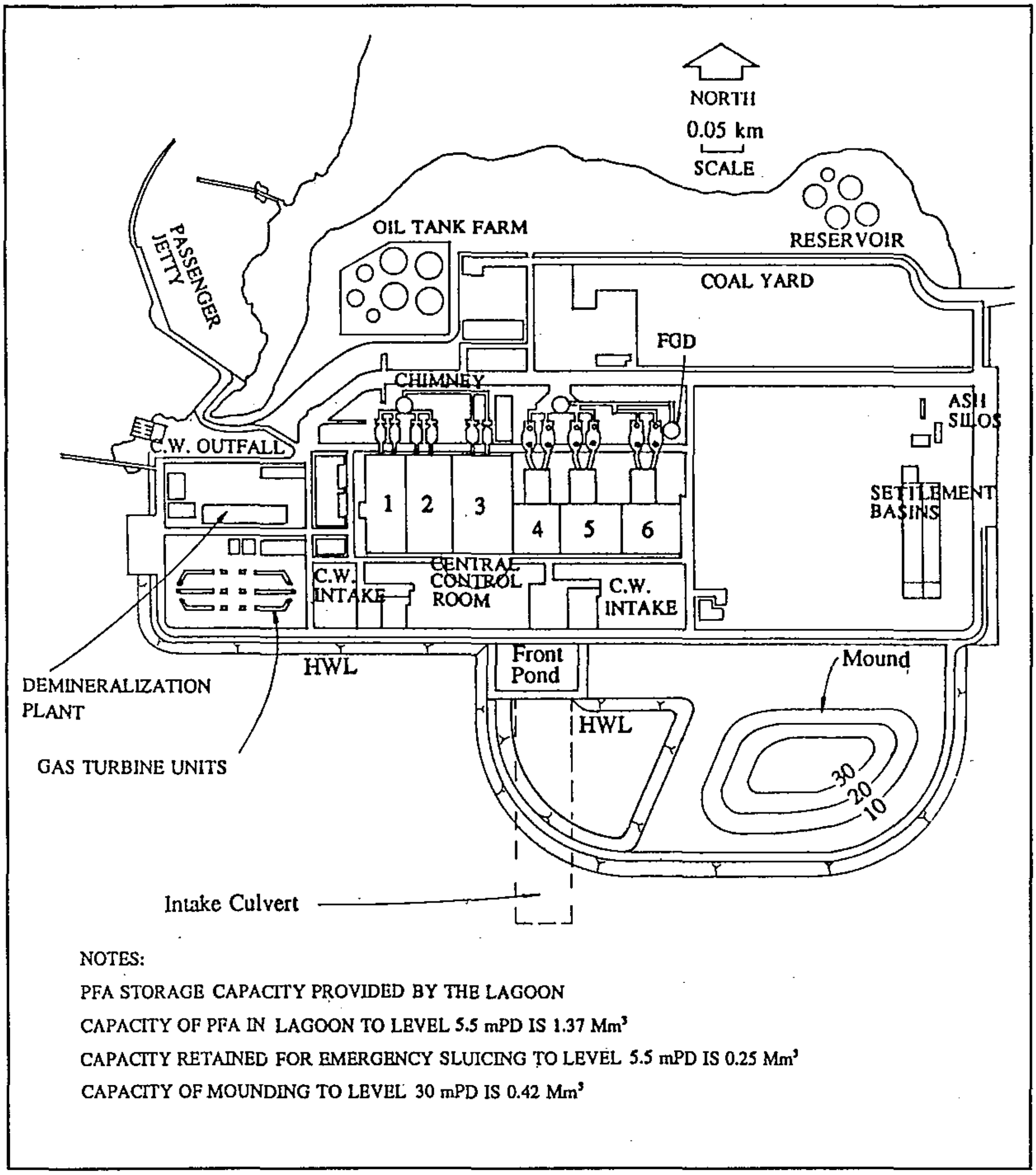


Figure 3.1 Lagoon Location

Perimeter Options

3.5 Various options for the perimeter have been investigated, these would use a variety of construction materials and methods. Each one has been developed to a stage such that they can be assessed for their ability to meet the environmental and technical constraints.

3.6 There are a number of features that all the perimeter options would have in common:

(i) the same plan dimensions

(ii) rounded corners at the south eastern and south western corners of the lagoon to soften the visual impact of the lagoon

(iii) an intake culvert at the western end of the lagoon to convey water to the second cooling water intake.

3.7 A conventional embankment option (Figure 3.2) would be formed of sand fill and protected from wave attack by stone armouring on the outside. The inside would be lined with a series of graded materials, or filters, to prevent the egress of PFA particles. To form a firm foundation the marine mud would be removed permitting the embankment to be formed on the underlying alluvial deposits.

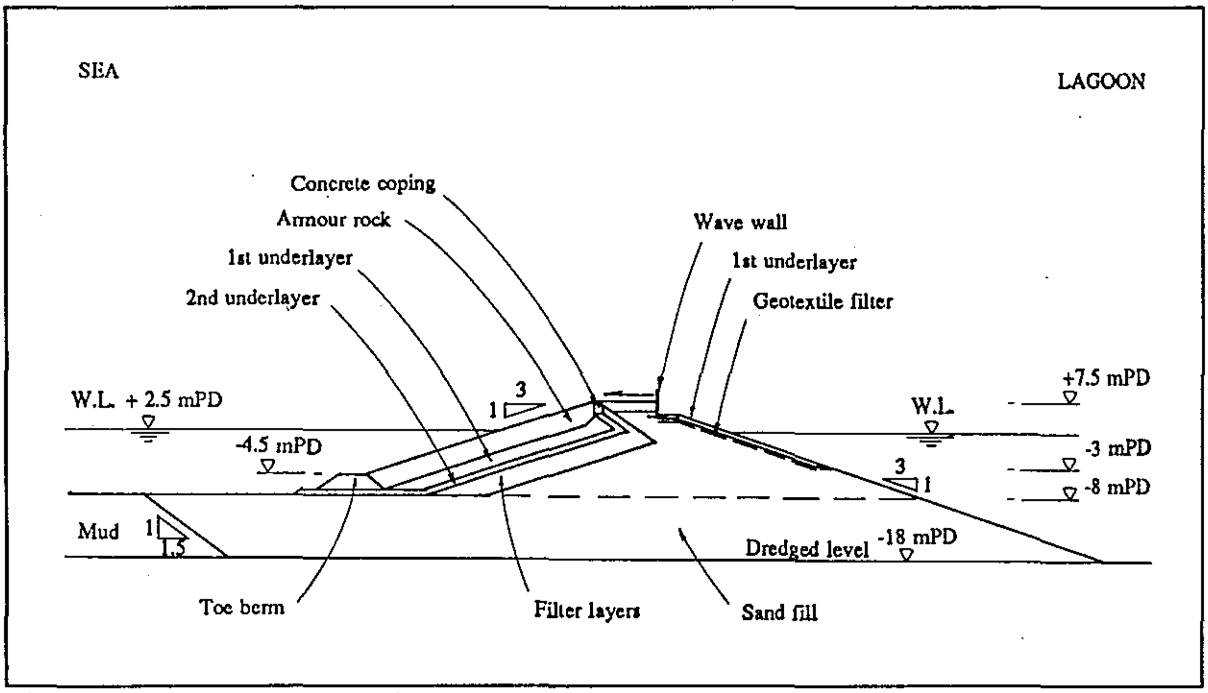


Figure 3.2 Embankment Perimeter

3.8 A perimeter formed from a series of abutting concrete caissons would be founded on a sandfill and rubble foundation (Figure 3.3). The caissons would be about 20 m in diameter and constructed in a remote casting yard before being floated into position and sunk. Once in position the caissons would be filled with marine sand to make them sufficiently stable to withstand the predicted wave attack during storms. Properly designed filters on the inside of the perimeter would be provided to prevent the loss of PFA particles through the foundations or between the caisson units.

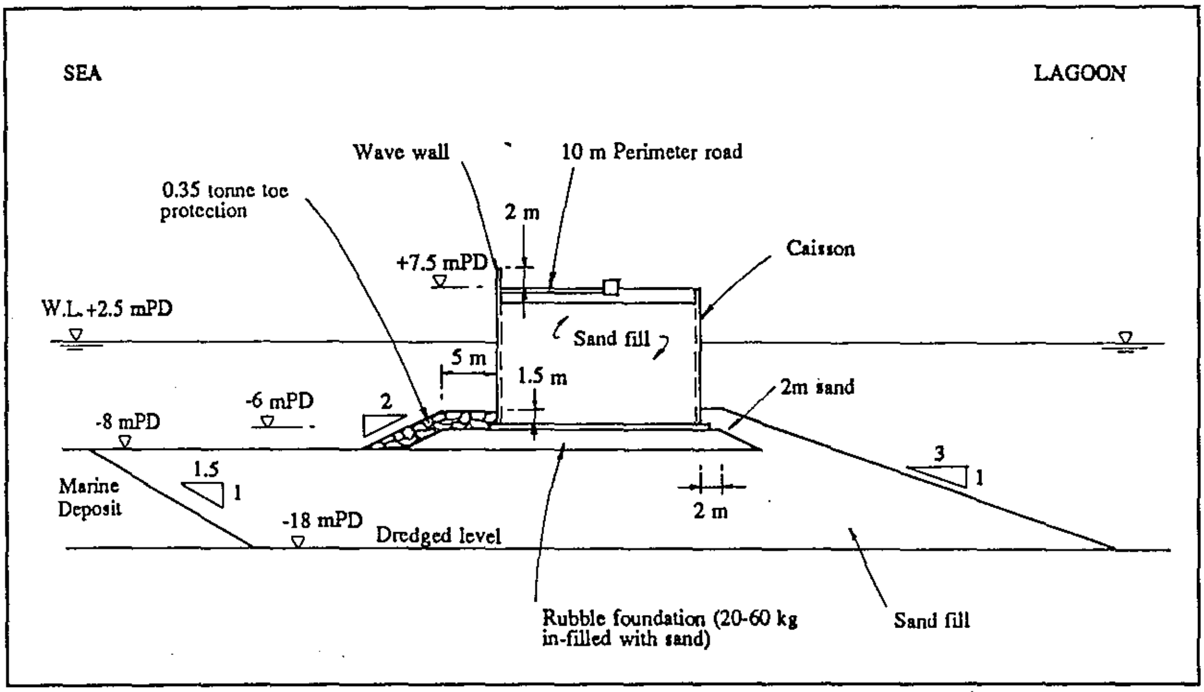


Figure 3.3 Caisson Perimeter

3.9 A combination of caissons and revetment provides some of the advantages of both the options for an embankment or caisson perimeter alone (Figure 3.4). The caissons would be smaller and could be fabricated near the site. The outer revetment would be formed of marine sand and protected from wave attack by stone armouring in the same arrangement as that for the embankment option.

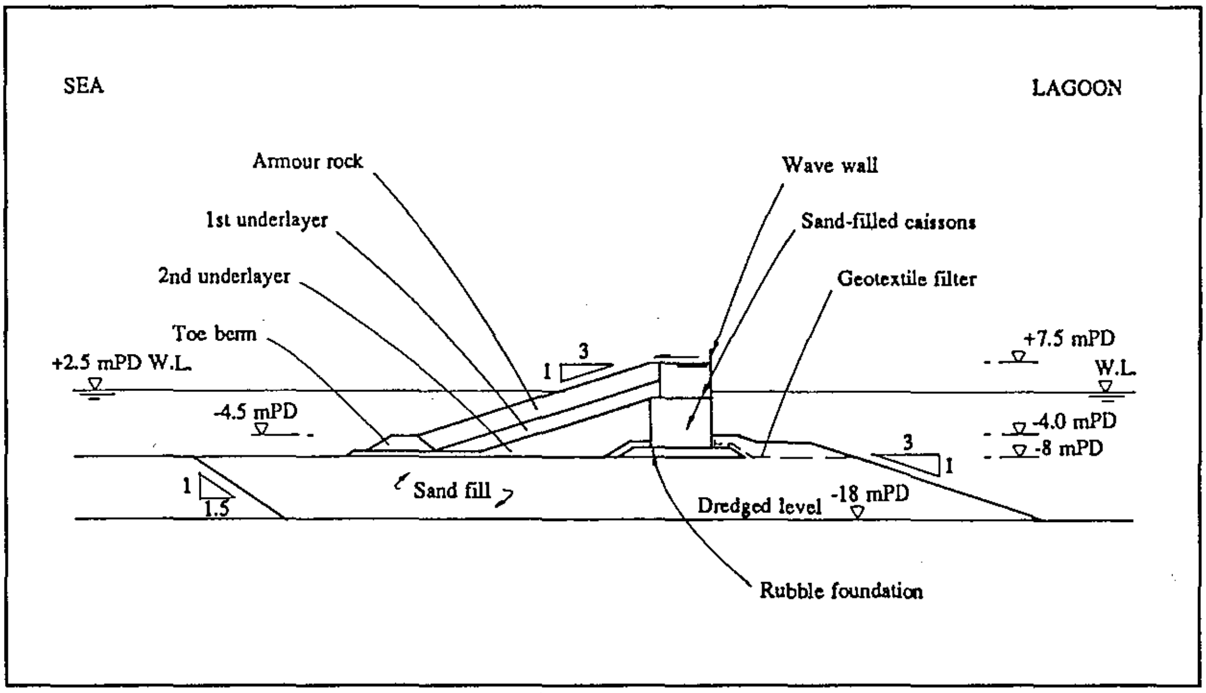


Figure 3.4 Caisson with Revetment Perimeter

3.10 The use of concrete block sea walls are common in Hong Kong. A similar technique could be used to form two outer skins infilled with sand (Figure 3.5). The concrete blocks would be cast off-site and transported to site by barge. The wall would have similar dimensions to that of the caisson option.

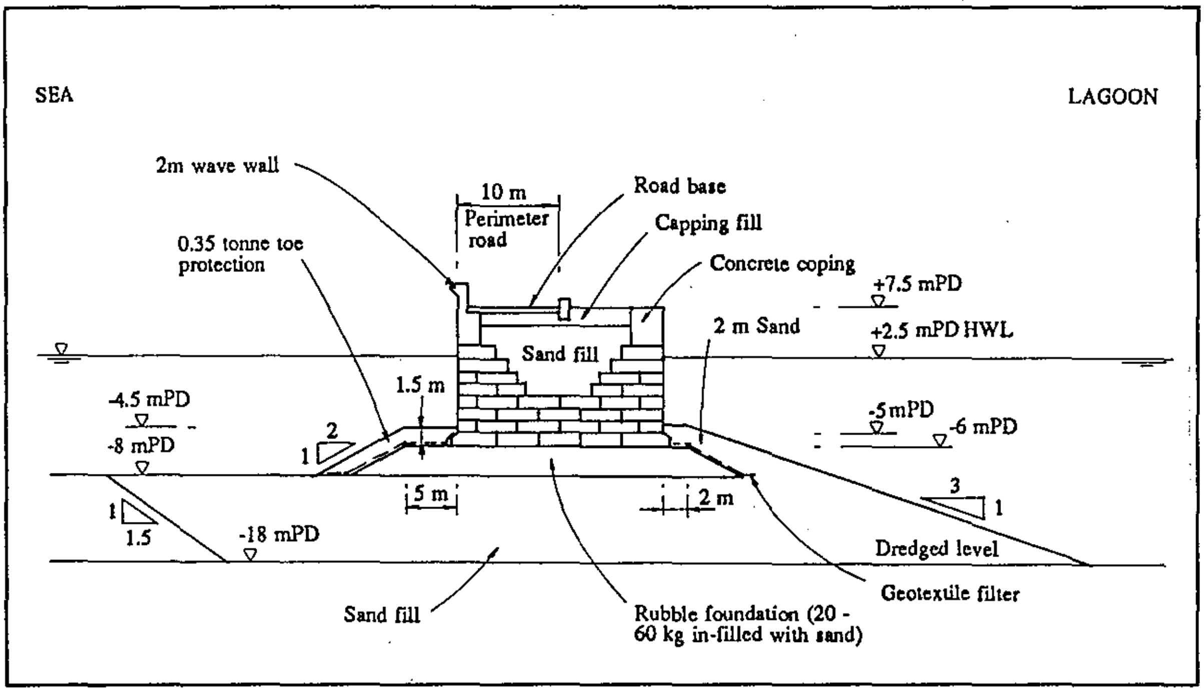


Figure 3.5 Quay Wall Perimeter

3.11 Ash lagoons in Japan have been constructed by driving a series of steel H piles and then connecting them with sheet piles to form two outer skins to the perimeter (Figure 3.6). The perimeter would then be infilled with sand, and capped with a concrete wave wall.

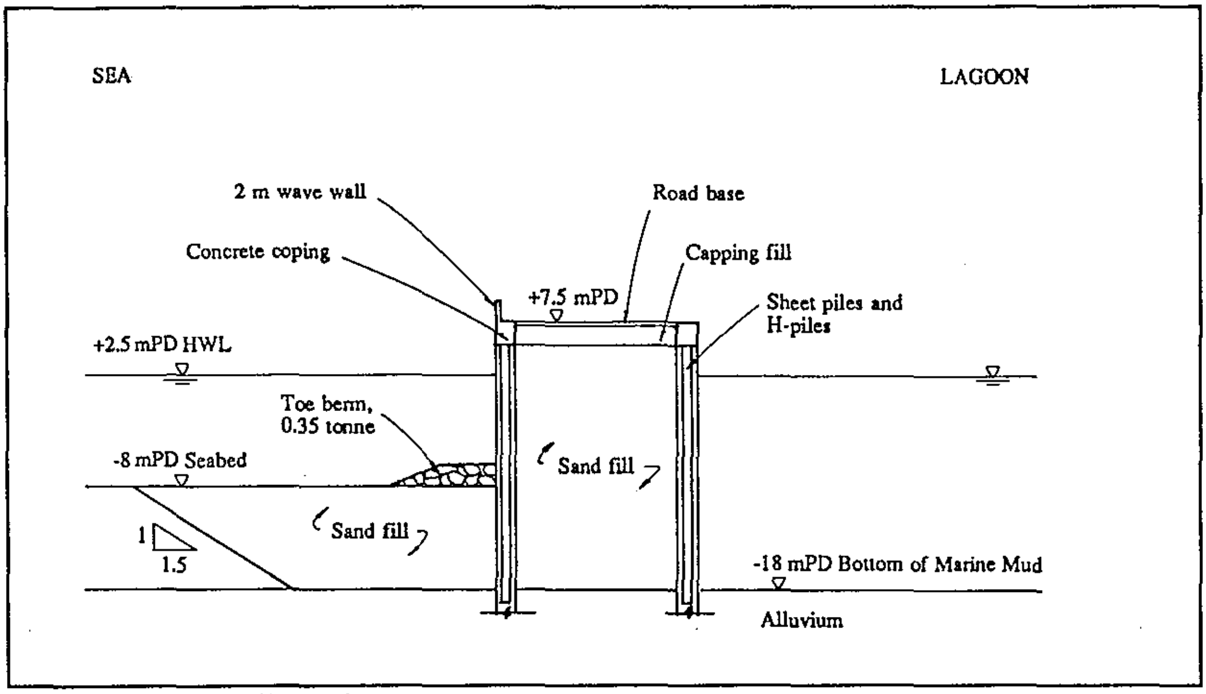


Figure 3.6 Steel Pile Perimeter

3.12 A steel pile arrangement similar to that used for the stations existing typhoon shelter could be adapted to form the perimeter (Figure 3.7). The perimeter barrier would be formed by a series of interlocking tabular piles capped with a reinforced concrete platform and wave wall. This would be given lateral support by raking tabular piles on either side.

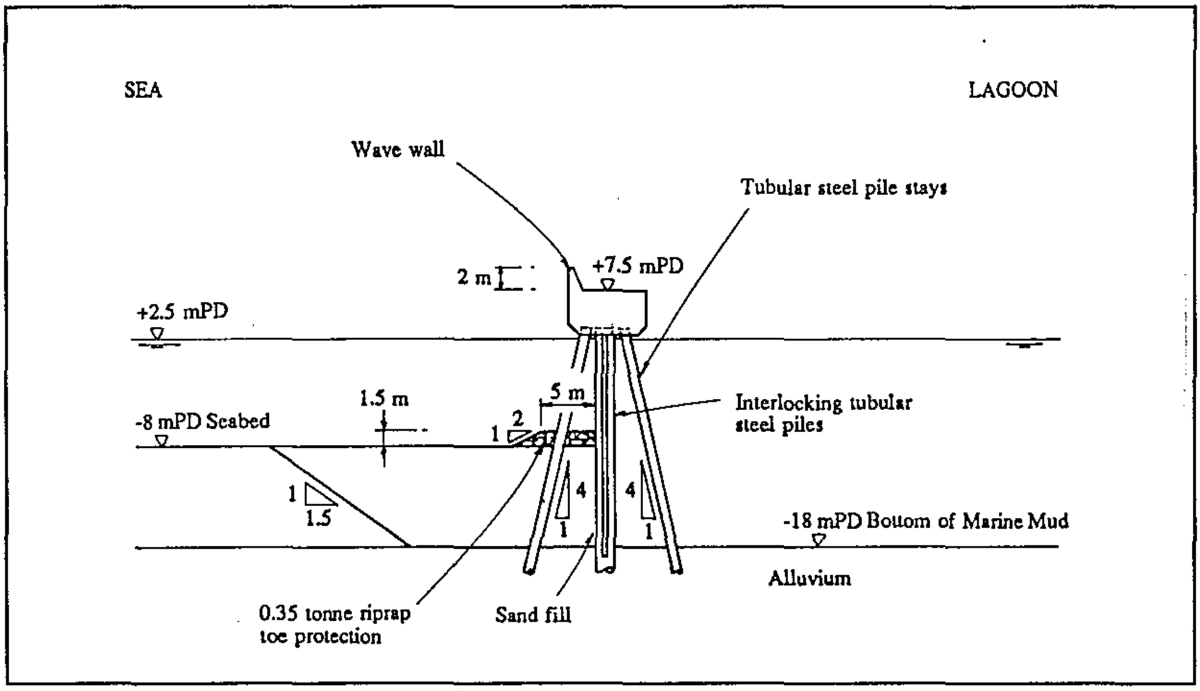


Figure 3.7 Tubular Steel Pile Perimeter

Preferred Option

3.13 The various options have been compared and two options have been chosen as potentially having the best combination of environmental and engineering attributes, these are the conventional embankment option and the caisson with revetment option. Of these two the embankment option may be marginally better. They both have the following environmental and engineering characteristics:

Environmental

(i) the seaward aspect of the perimeter is of a similar form to that of the existing station and will blend visually with it. The other options present a vertical face in stark contrast

(ii) the marine fauna will re-colonise the sloping revetment. Colonisation of a vertical wall would be quite different

(iii) the substantial form of the embankment and revetment will provide considerable inherent security against storm damage or accidental impact from large vessels. Also the perimeter would not be subject to the possibility of corrosion damage

(iv) the construction period would be relatively short, because construction techniques are relatively straight forward (limiting the possibility of construction delays) and bulk filling operations can be carried out using modern high capacity equipment

Engineering

(i) the construction is relatively straightforward and is capable of being built using readily available machinery and construction equipment

(ii) only a small portion of the work need be land based

(iii) the form of construction is relatively insensitive to unforeseen ground conditions during construction and sufficiently flexible to accommodate minor settlements after construction

(iv) the finished works will be effectively maintenance free, by contrast steel piles would require regular anti-corrosion measures

Details of Embankment Option

3.14 The proposed layout of the lagoon is given in Figure 3.8 with relevant cross sections in Figure 3.9. The cooling water intake culvert is to be founded on an extension to the embankment foundation, on the western edge of lagoon. The quay wall construction for the intake pond will pass over the intake culverts and extend to join the existing embankment on either side of the existing cooling water intake.

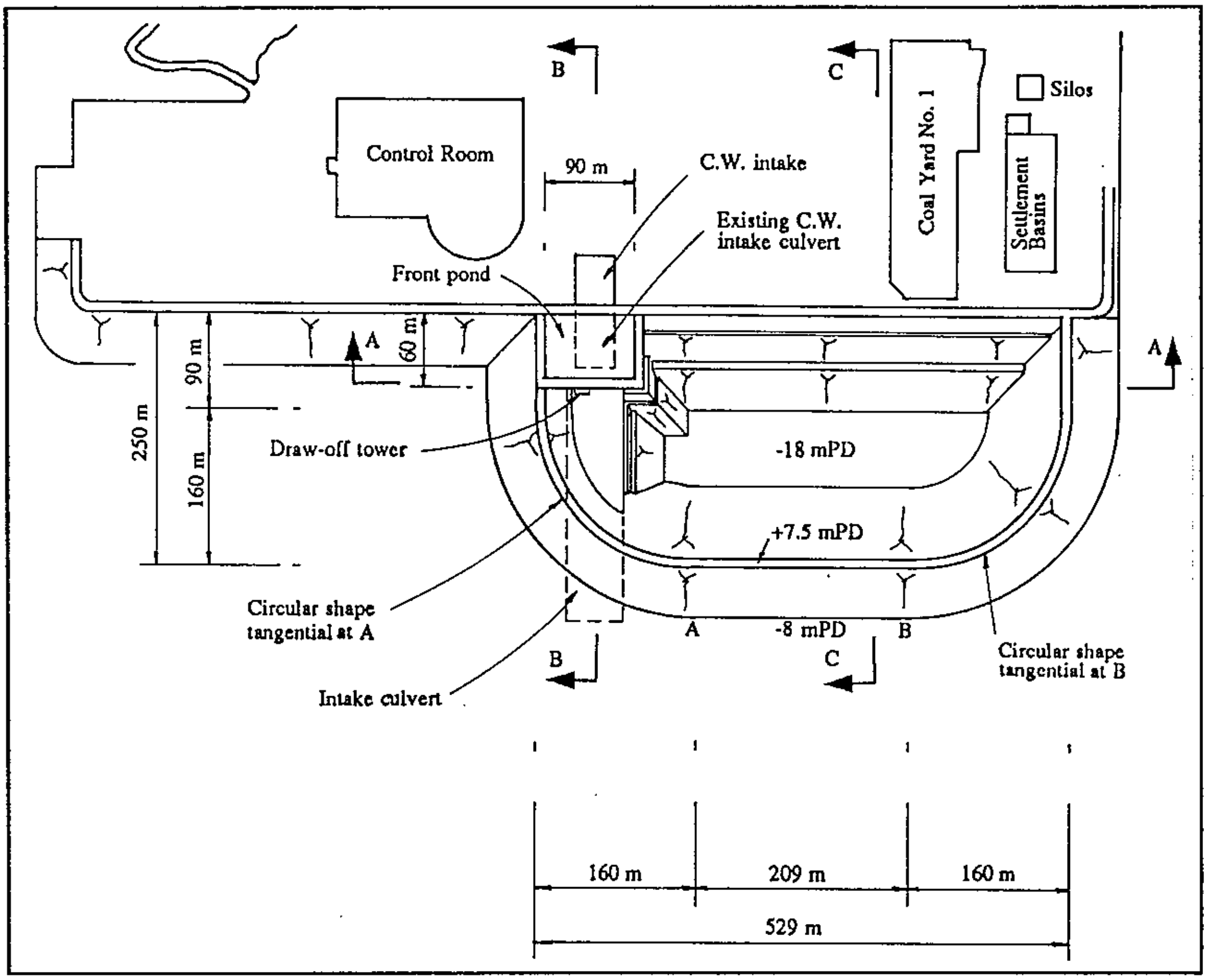


Figure 3.8 Lagoon Layout with Embankment Perimeter

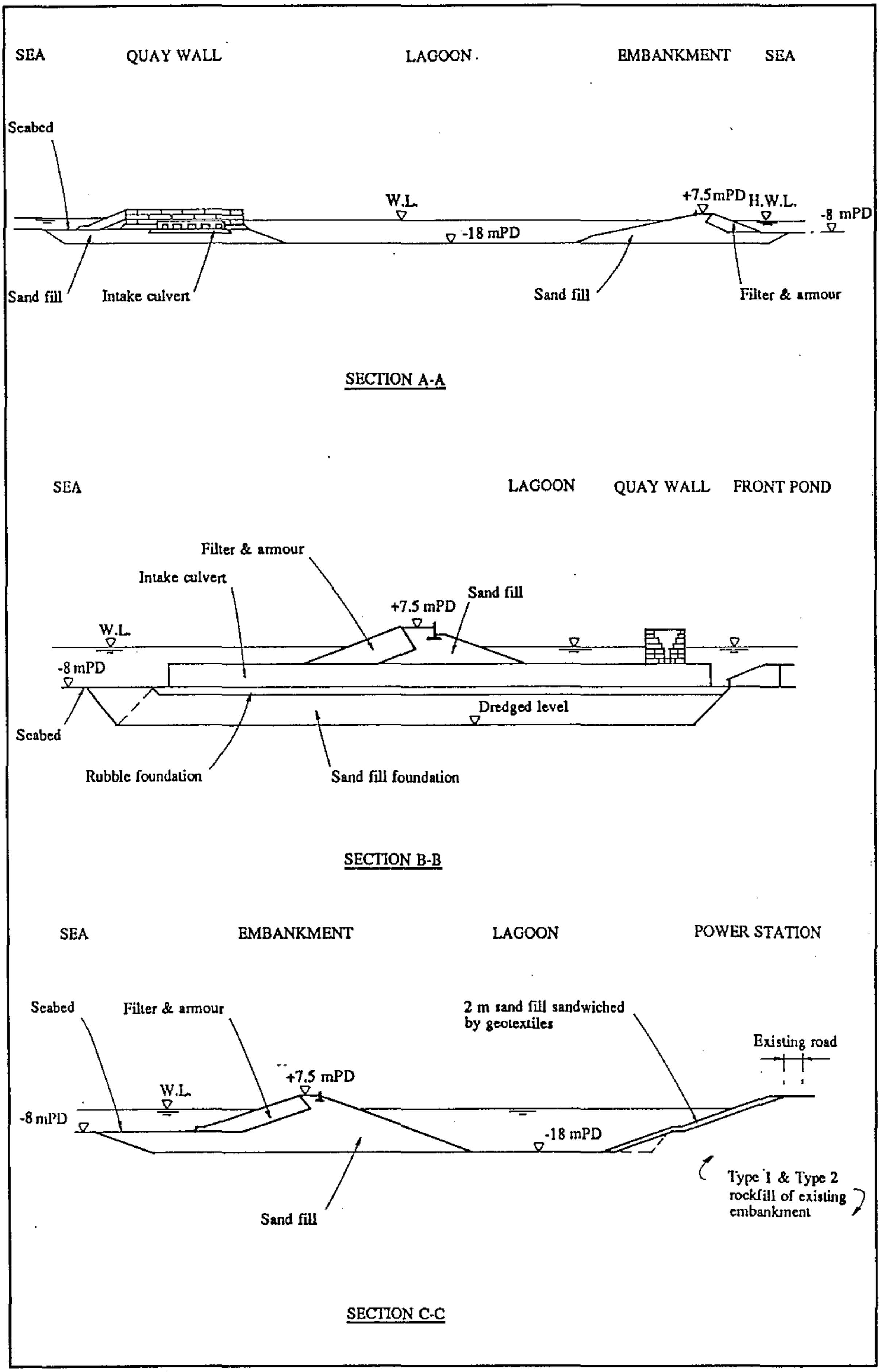
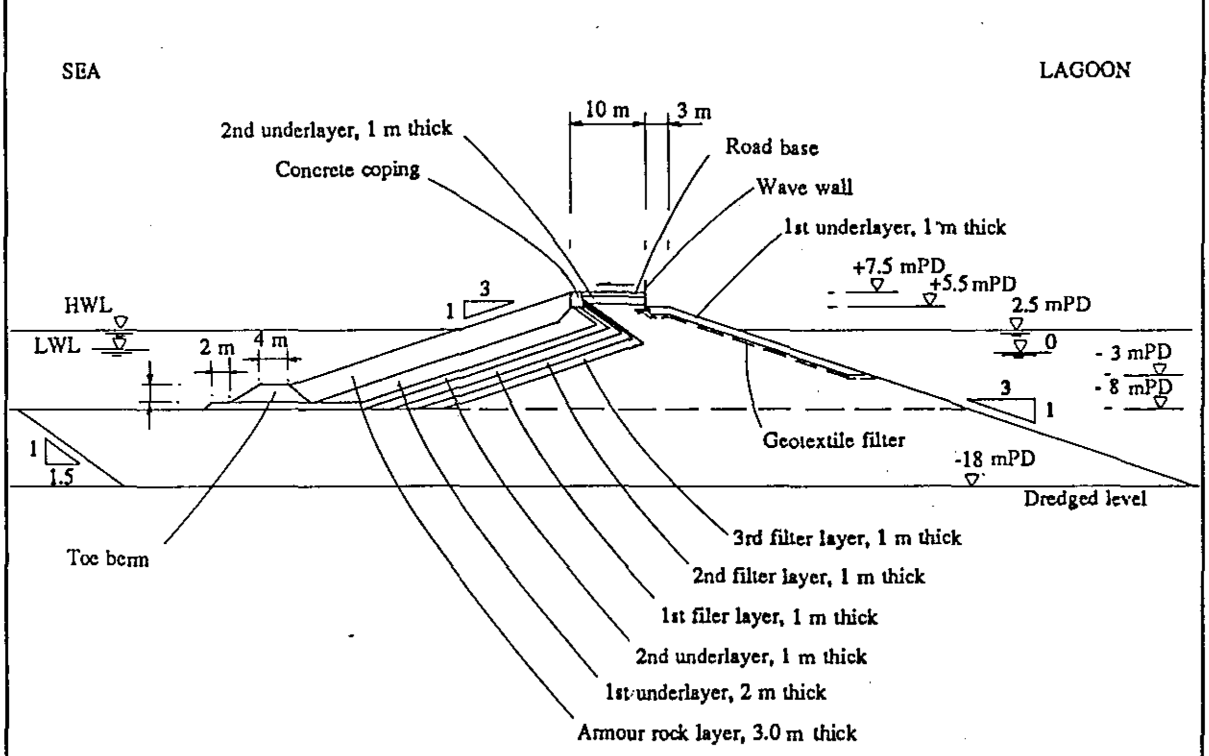


Figure 3.9 Sections of Lagoon

3.15 The typical section of the embankment has a 10 m crest width with a wave wall at the back (Figure 3.10). This arrangement is compatible with the existing station platform and the crest allows for dissipation of waves running up the embankment. The outer revetment is to be protected with stone armour and the necessary underlayers. The heart of the embankment will be formed of marine sand which has a distribution of grain sizes suitable for limiting seepage to and from the lagoon. The inner face will be protected from the minor wave action that may occur within the lagoon. The protection will consist of a stone surface underlain by a geotextile.



Layers	Rock size gradation	
Armour rock layer	6000 kg	- 12000 kg
Toe berm	3000 kg	- 5000 kg
1st underlayer	560 kg	- 1040 kg
2nd underlayer	20kg	- 60 kg
1st filter layer	0.41 kg	- 23 kg
2nd filter layer	7.5×10^{-3} kg	- 42.5×10^{-3}kg
3rd filter layer	0.375×10^{-3} kg	- 2.125×10^{-3} kg
Core material	Marine Sand (fine to medium)	

Figure 3.10 Embankment Cross Section

3.16 The existing power station revetment consists of rock armour overlying highly permeable general fill. Before this is to form the northern perimeter of the lagoon the rock armour will be removed to expose the type 2 material and treated to prevent the particles of PFA escaping the lagoon in a suspension of seepage water (Figure 3.11). The type 2 material will be screeded with a fine sand to prevent damage to the overlying geotextile. Above this a series filters will be placed. These will have gradings suitable for arresting the egress of PFA particles to be placed on top.

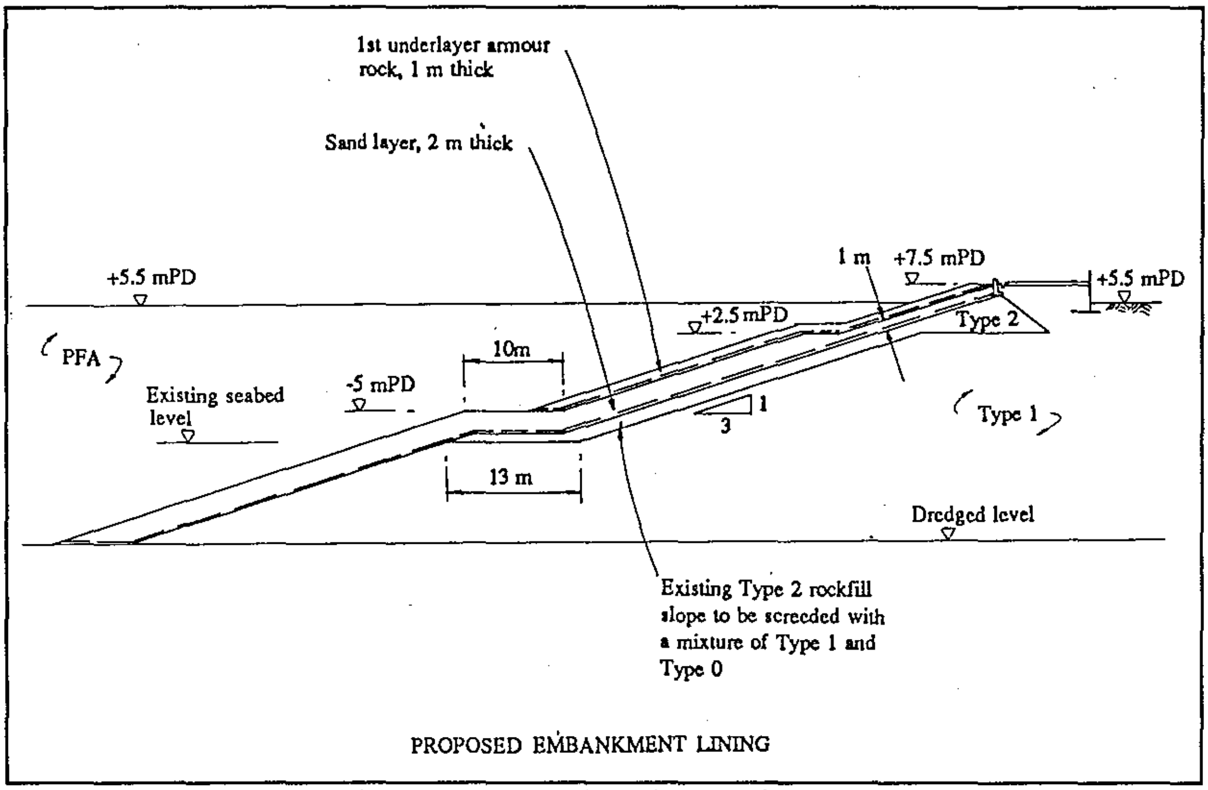
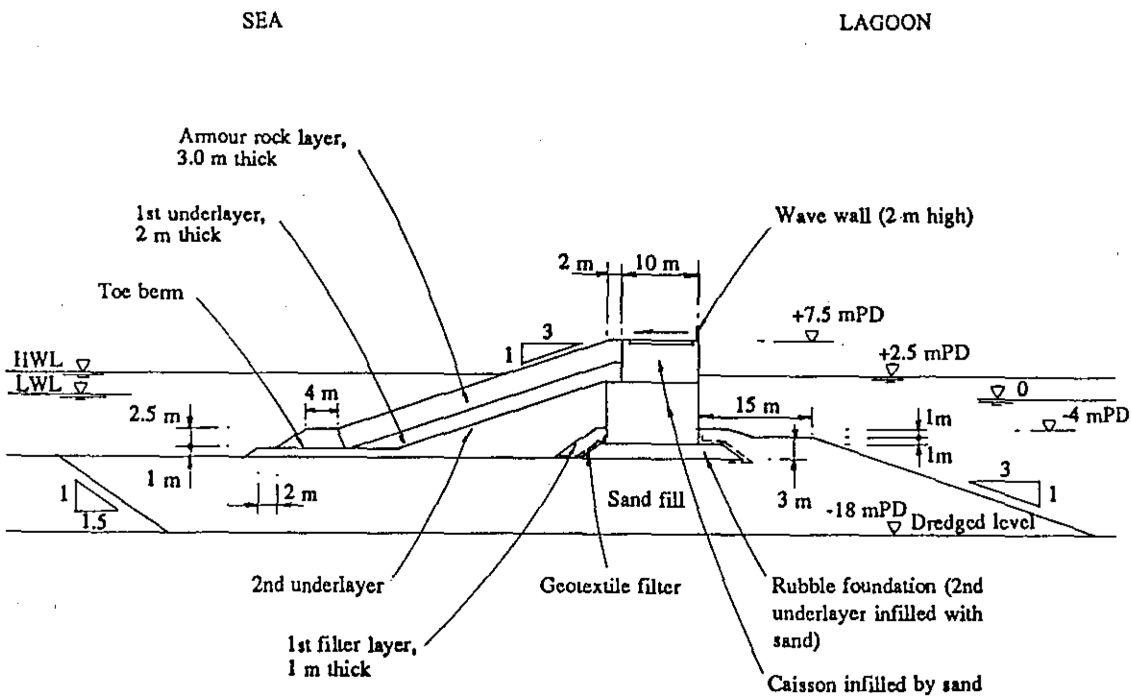


Figure 3.11 Northern Perimeter - Proposed Typical Section

Details of Caisson with Revetment Option

3.17 The seaward form of the revetment would be similar to that of the embankment option (Figure 3.12) formed of sand fill and protected from wave attack with a rock armour facing. The sand fill foundations would be formed in much the same way as those for the embankment option. The caissons, on the lagoon face, would support the revetment . The caissons are small enough to be precast close to site and then manoeuvred into position over the foundations. The caissons would then be slowly flooded to come to rest on a bed of rubble. Filters and seals will be required on the inside face of the perimeter to prevent PFA particle migration through the perimeter.



Layers	Rock size gradation
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1st underlayer	560 kg - 1040 kg
2nd underlayer	20 kg - 60 kg
1st filter layer	0.41 kg - 23 kg
Core material	Marine sand (fine to medium)

Figure 3.12 Caisson with Revetment Section

3.18 Inlet culvert details and interfaces with the existing power station platform would be similar to that of the embankment option.

Material Sources

3.19 The principal materials required for the perimeter will be rock and sand for the embankment option, and concrete if the caisson with revetment option is adopted. These materials are common construction materials in Hong Kong and difficulties with supply are not envisaged.

3.20 The size of rocks required for armouring the sea revetment and the smaller gradings for underlayers are all available from quarries either within Hong Kong or nearby (Figure 3.13).

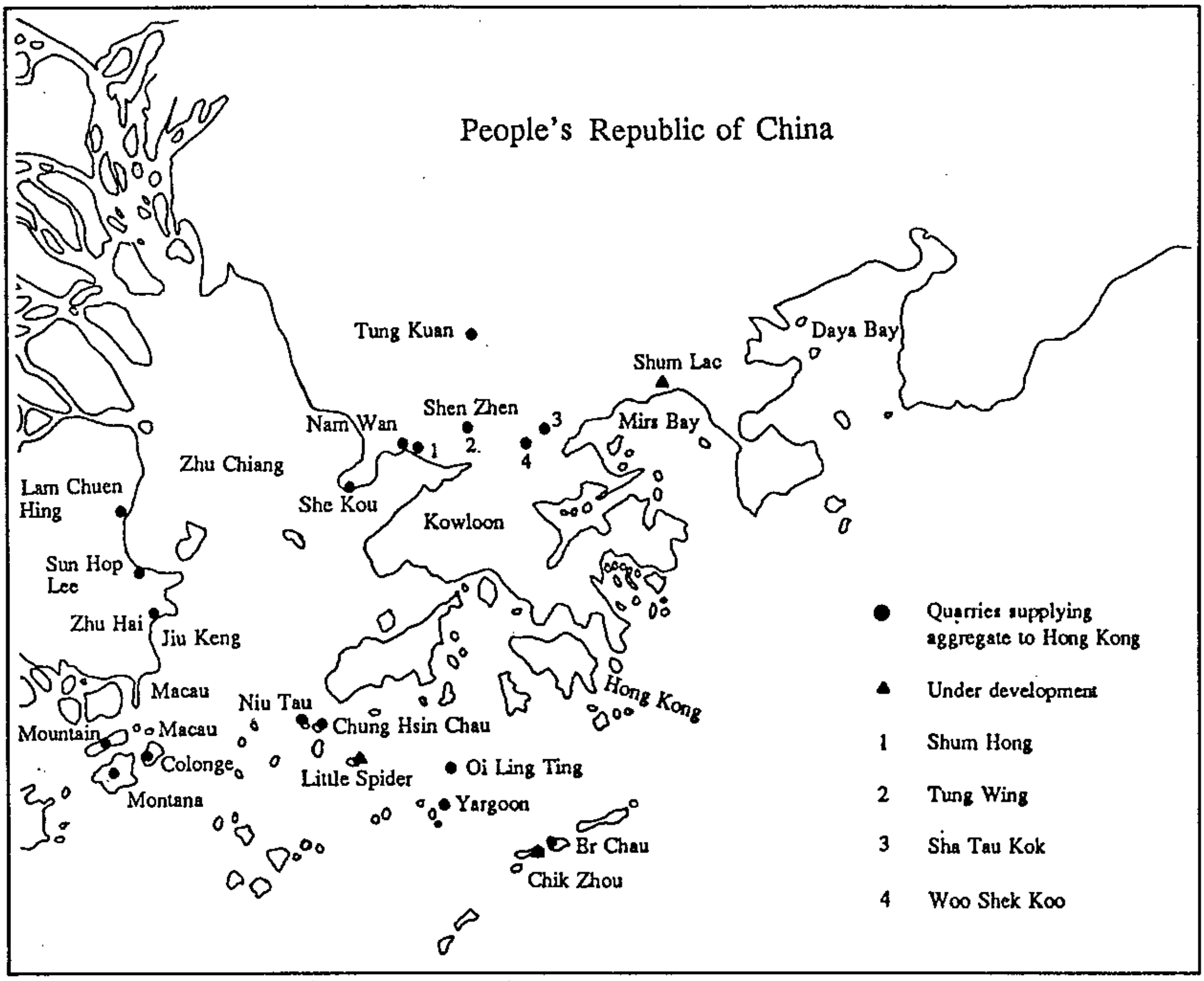


Figure 3.13 Quarries in PRC Supplying Hong Kong

3.21 In recent years extensive surveys of available marine sand deposits have proved the existence of substantial reserves within Hong Kong waters. Exploitation of these reserves has already proved to be viable on a number of large projects. The sources vary in grading, thus careful selection of the sources will permit different marine sands to be used for both the hearting and various filter layers required to prevent PFA particles migrating through the perimeter (Figure 3.14).

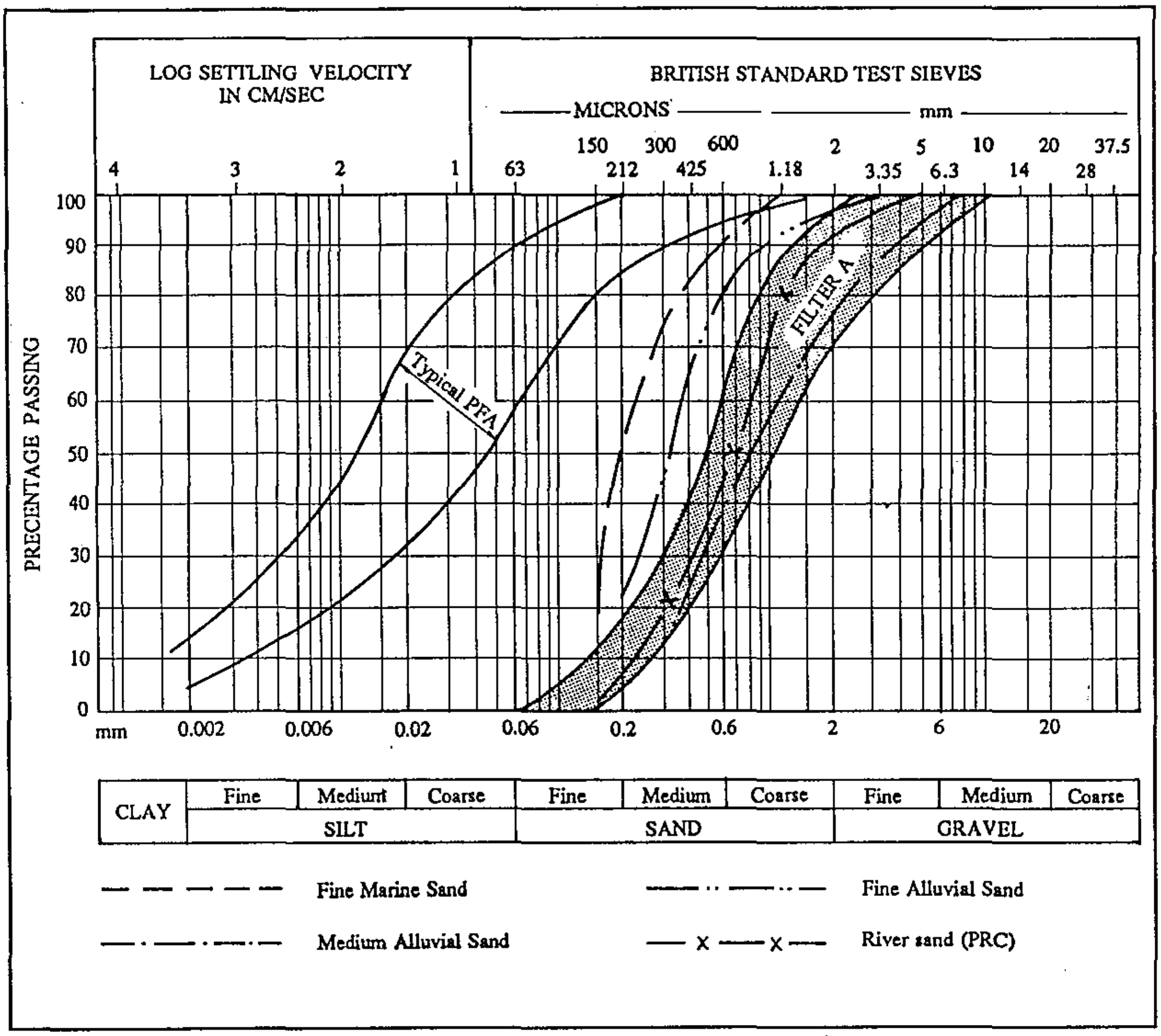


Figure 3.14 Grading of PFA and Appropriate Filters

4 LAGOON CONSTRUCTION

4.1 The reduction of any environmental impacts resulting from construction involves not only careful assessment and management of construction operations but also the limiting of the construction period to a minimum. Although the final choice of construction methods is for the contractor, he will have to remain within all governmental criteria and contractual specifications in force at the time. However an assessment of the likely impacts can be made, based on similar construction projects and techniques used in Hong Kong. The impacts have been assessed for the construction of the embankment option, because it is the preferred option, but the assessment of the caisson with revetment option would be similar.

Principal Construction Operations

4.2 There will probably be six main construction operations, much of which will be conducted as marine based activities. In addition to these six there will be the construction of a draw-off tower adjacent to the front pond. However this is small and unlikely to present any significant impact, thus it is not discussed further in relation to construction operations. The six main operations are:

(i) foundation preparation

(ii) bulk filling of foundations and embankments

(iii) construction of the intake culvert

(iv) front pond quay wall construction

(v) lagoon closure

(vi) construction of perimeter road and wave wall

4.3 The removal of some 1.6 Mm^3 of marine mud from the sea bed is required for the preparation of a firm foundation. The mud will be dredged and disposed of in a suitable marine area. Although there is a registered area of Cheung Chau for the disposal of dredged mud, the eventual location for disposal will be dependent on agreements between EPD and the contractor at the time of construction.

4.4 The foundations and main embankment will be formed by a marine bulk filling operation. The majority of the 1.62 Mm^3 marine sand will be placed from bottom or side discharging barges. The fill will then be compacted to increase the inherent strength of the embankment and reduce the permeability. The construction will proceed from the west towards the eastern end to afford some protection to subsequent works from the prevailing waves. Thus the placing of rock armour will proceed closely behind the formation of the main embankment. Also, the early preparation of the western end will permit the early completion of the intake culverts.

4.5 The intake culverts will be formed as precast units, transported to site by submersible barge and then sunk into position. The foundation for the units will have been formed as part of the previous two operations, involving the dredging of the marine mud and replacement with marine sand.

4.6 The construction of the quay wall for the front pond will require the placing of about 3100 pre-cast concrete blocks to form the double, back to back quay wall. The construction sequence will be arranged such that water inflows to the cooling water intake will always be maintained. The northern side of the front pond will be left open to the sea until the intake culverts are in operation. The construction of the quay wall will be part marine and part a land based operation. These sections close to the existing power station revetment will probably require the placing of units from the land.

4.7 Prior to the final closure of the lagoon at the western end the removal of the existing 0.07 Mm^3 of rock armour from the power station revetment will be carried out. By this time the station revetment will be fully protected by the lagoon perimeter. This rock armour will then be used for the lagoon perimeter. The exposed slope will be prepared with a geotextile, sand and rock to form a filter to the northern perimeter to the lagoon. Once this has been achieved the lagoon's eastern perimeter can be closed and completed.

4.8 The finishing of the perimeter embankment will be construction of the perimeter road and wave wall. The wave wall may be formed of pre-cast units or cast in-situ concrete. The nature of the construction activities will depend to a great extent on the contractor's working methods and also in part on the design details.

Construction Programme

4.9 The optimum sequence for the various operations is crucial if the minimum construction programme is to be achieved. The main element is the early preparation of the foundations of the western end to permit the early completion of intake culverts and front pond. The expected total construction period is just under two years, about 21 months (Figure 4.1). The expected duration of each of the principal operations is:

(i)	foundation preparation	4 months
(ii)	bulk filling of foundations and embankment	13 months
(iii)	construction of the intake culverts	7 months
(iv)	front pond quay wall construction	6 months
(v)	lagoon closure	9 months
(vi)	construction of perimeter road and wave wall	7 months

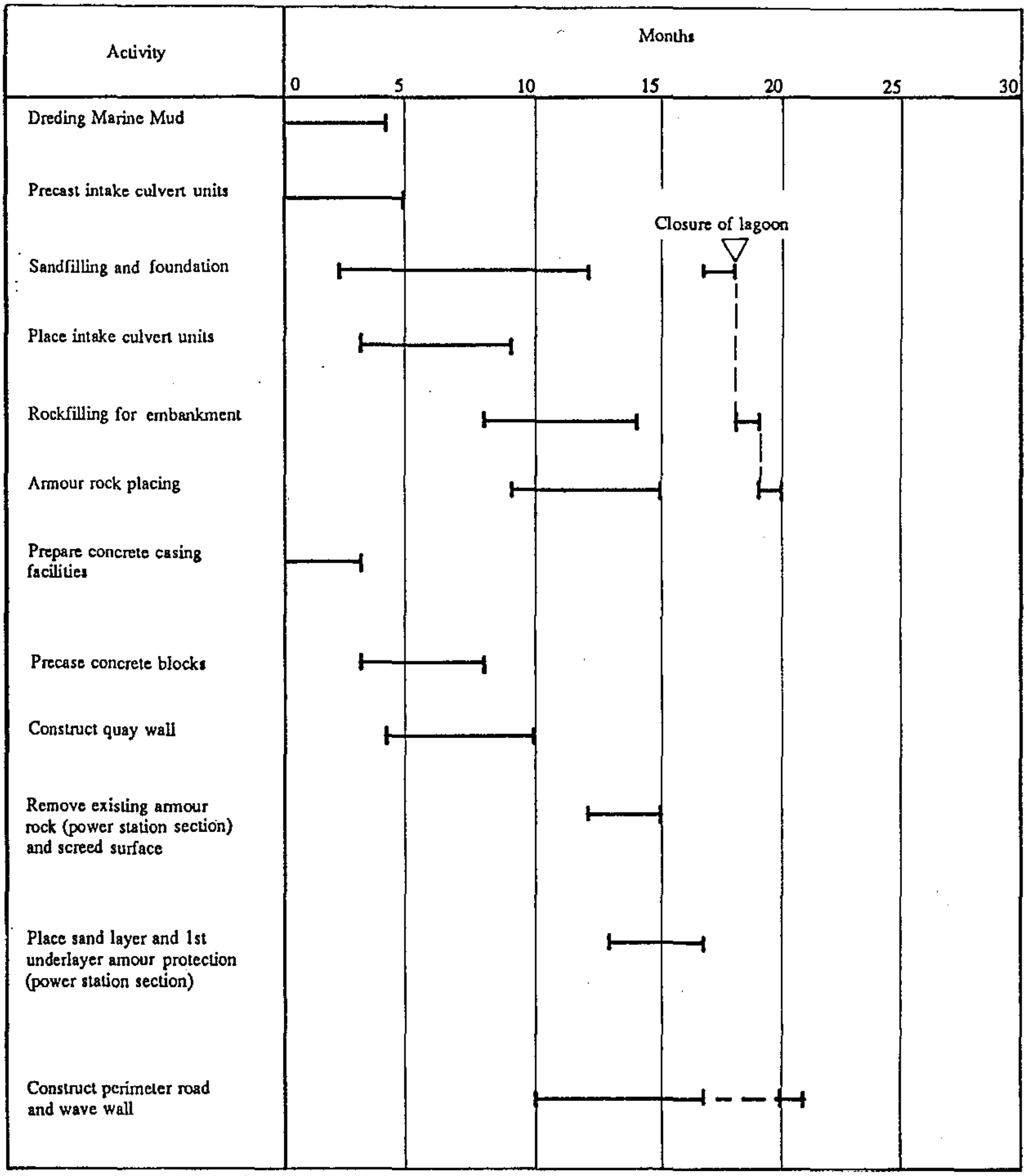


Figure 4.1 Estimated Construction Programme

Construction Effects

4.10 During the construction period there will be a number of environmental effects, some of them permanent and some temporary. However all of them will be limited in extent and significance. The effects are related to impacts on:

(i) marine biota

(ii) sea water quality

(iii) noise

(iv) visual impact

(v) community reaction

(vi) tourism

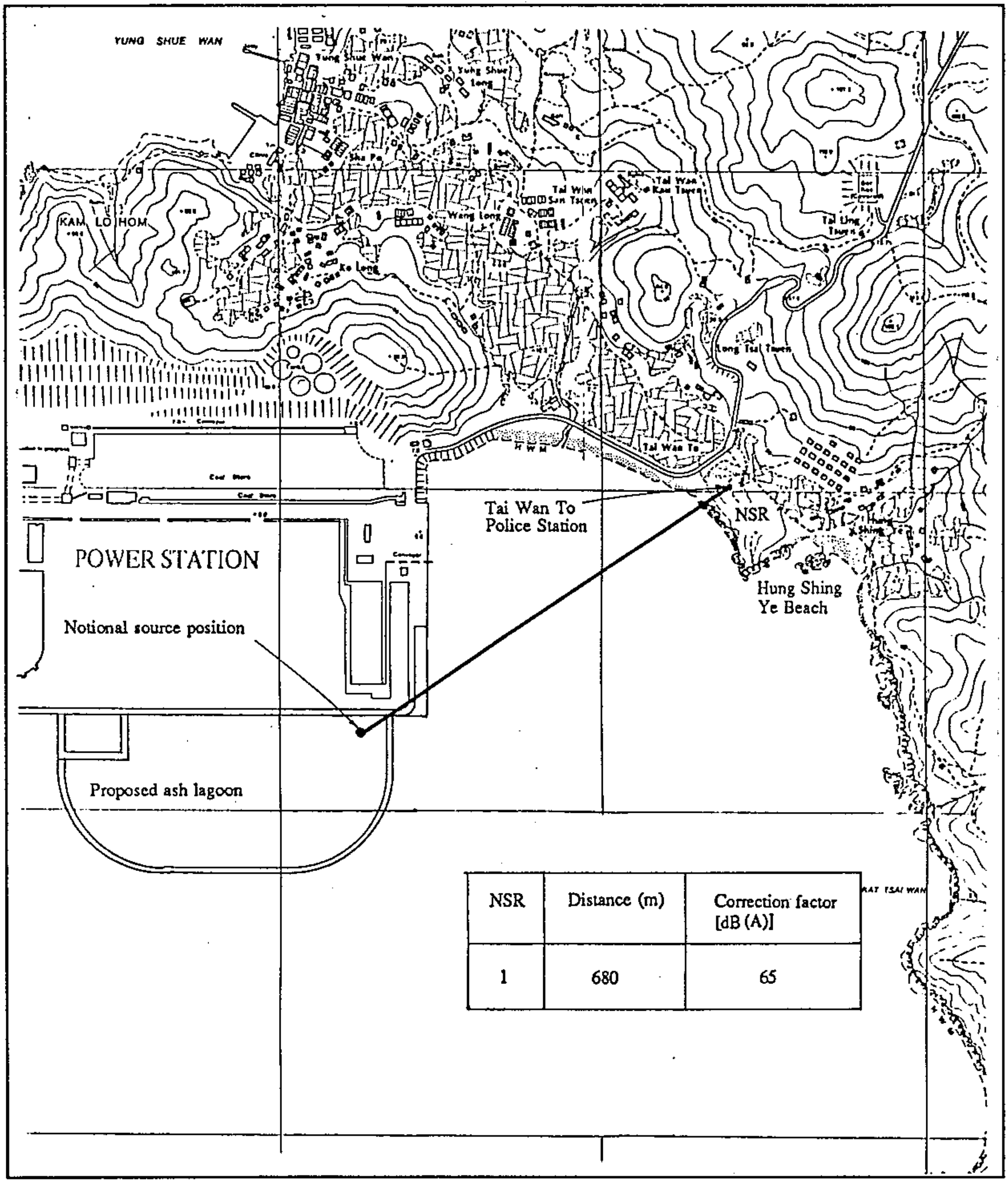
(vii) employment opportunity derived from construction

4.11 Although the marine biota is reasonably diverse it is not unique, nor is the site a nursery or unique habitat (Section 2.3). Thus a limited area of the seabed will be lost during construction but this is not a significant size in the context of Ha Mei Wan bay or other similar areas in Hong Kong waters. The population of free swimming organisms will not be significantly affected by the loss of this area in Ha Mei Wan.

4.12 The construction activities will have no permanent effect on the local sea water quality. During construction there may be temporary but localised effects. Turbidity due to the marine dredging operation may increase. However this can be limited by the specification of good working practices and is distant from the bathing areas of Hung Shing Ye and Tai Wan To beaches. The marine mud around the power station are in a healthy state (IAR) thus the release of excessive nutrients or toxins during the dredging operations is unlikely.

4.13 The visual impact of the construction activities, particularly the impact of the marine vessels is to be kept to a minimum by reducing the construction period to the minimum possible. The impact of the marine traffic is likely to be small because of the distance to the beaches from which they could be seen, and because there is currently marine traffic associated with material movements to and from the power stations eastern quay. The permanent effect of the construction is the finished works, which have been designed to blend with the existing forms of the power station. The major part of the visible works will be the external revetment, the form of which has been chosen to be similar to that of the existing station. The PFA transport mechanism, mainly conveyors may also be visible, although almost indiscernible from a distance, will also be similar in form to existing facilities to provide visual continuity.

4.14 The area around the power station is a quiet rural setting, and government technical memoranda rate such areas as having the highest noise sensitivity rating. As such the noise from any construction work should not exceed 60 dBA at the nearest habitation, this is taken to be the Tai Wan To police station (Figure 4.2). The noise generated from any of the principal operations have been assessed, presuming likely operating methods and equipment, and have been found to be within the limits (Table 4.1). Combinations of various principal operations have also been assessed and found to be acceptable, except during restricted hours (1900 to 0700 hours and any time on a general holiday, including Sundays).



NSR	Distance (m)	Correction factor [dB (A)]
1	680	65

Figure 4.2 Noise Sensitive Receiver

	Noise [dB(A)]						TSPL [dB(A)][1]	CNL [dB(A)][2] at NSR
<u>Operation 1 (4 months)</u>:	- Dredging Marine Mud							
1 Grab dredger	112	> 115	> 115.5	>			)	
1 Trailer dredger	112	>		> 116			)	
2 Support barges	104	> 107	>	>			) 116	116-67[3] = 49
	104	>		>			)	
<u>Operation 2 (13 months)</u>:	- Sandfilling for foundation - Rockfilling for embankment - Armour rock placing							
3 Bottom dump barges	104	> 107	>				)	
	104	>	> 110	>			)	
	104	> 107	>	> 115	>		)	
4 Derrick lighters	104	>		>	>		)	
	104	> 107	>	>	>		)	
	104	>	> 113.5		>		)	
	104	> 112.5	>		>	>	)	
3 Grab dredgers	112	>			> 122	>	)	
	112	> 115	> 118	>	>	>	)	
	112	>	>	>	>	>	)	
5 Backhoes	112	> 115	>	> 120.5	>	>	)	
	112	>		>		>	) 122	
	112	> 115	>	>		> 122	)	122-67[3] = 55
	112	>	> 117			>	)	
	112	> 112	>			>	)	
6 Vibro compaction probes	80	>		>		>	)	
	80	> 83	>	>		>	)	
	80	>	> 86	> 87	> 87	>	)	
	80	> 83	>	>			)	
	80	>					)	
	80	> 80	> 80	>			)	
<u>Operation 3 (7 months)</u>:	- Placing of intake culvert units.							
1 Submersible barge	104	> 104	>				)	
2 Floating cranes	112	>	> 115.5	>			)	
	112	> 115	>	>			)	
2 Tug boats	110	>		> 117.5			) 118	118-67[3] = 51
	110	> 113	> 113	>			)	
							)	
<u>Operation 4 (6 months)</u>:	- Quay wall construction for front pond							
1 Derrick lighter	104	> 104	>				)	
		>	> 115.5	>			)	
2 Land-based cranes	112	> 115	>	> 116			) 116	116-67[3] = 49
	112	>	>	>			)	
<u>Operation 5 (9 months)</u>:	- Remove existing armour rock and screed surface - Place sand layer and 1st underlayer armour protection - Sandfilling and foundation - Rockfilling for embankment - Armour rock to placing							
3 Derrick lighters	104	> 107	>				)	
	104	>	> 113.5	>	>		)	
	104	> 112.5	>	> 118.5	>		)	
4 Backhoes	112	>		>	>		)	
	112	> 115	>	>	> 118.5		) 119	119-67[3] = 52
	112	>	> 117	>	>		)	
	112	> 112	>		>		)	
1 Vibro compaction probe	80	>					)	
1 Bottom dump barge	104	> 104	> 104	> 104	>		)	
<u>Operation 6 (7 months)</u>:	- Construct perimeter road and wave wall							
1 Graders	113	> 113.5	>				)	
			> 115	>			)	
2 Compactors	105	>	>	>			)	
	105	> 110	>	> 118			) 118	
1 Concrete batching system	108	>		>			)	118-67[3] = 51
2 Backhoes	112	> 115	> 115	>			)	
	112	>					)	

Remarks:
(1) Total Sound Power Level
(2) Corrected Noise Level
(3) Correction Factor for Distance Attenuation between the NSR and the construction site [-65 dB(A)], partial screening of NSR [-5 dB(A)] and NSR being a building [+ 3 dB(A)]

Table 4.1 Estimated Noise Levels from Principal Construction Operations

4.15 The Lamma community gives the impression that the rational and plans for the lagoon have been accepted, albeit reluctantly in some cases. This impression has been reinforced by the discussions held during the ash management exhibition held on Lamma from 13th October 1989 to 15th October 1989, when all the proposed works for the ash management strategy were presented and explained to Lamma residents. Subsequently the Lamma Conservation Society have publicly announced their acceptance of the plans. Consequently significant adverse community reaction to the lagoon's construction is not expected.

4.16 The principal tourist activities in the area are bathing, picnics, pleasure boating and restaurants, these are associated with:

(i) Tai Wan To beach

(ii) Hung Shing Ye beach and restaurants

(iii) Lo So Shing beach

(iv) Ha Mei Wan bay for pleasure craft

4.17 The attendance of the beaches appears to have been rising since 1985 (Government attendance figures for gazetted beaches), and residents report that pleasure craft attendance has also been rising over the years. The majority of the attendance is probably during the three months of June, July and August. The construction activities will not affect water quality or restrict current swimming or sailing facilities thus it is highly unlikely that many beach users will be discouraged. Lo So Shing is 1.5 km to the south and east of the site, so there is unlikely to be any effect on the beach area. Hung Shing Ye and Tai Wan To beaches are both closer and consequently the minor visual intrusion of construction work may give a less attractive aspect, likewise for a number of the pleasure craft anchorages off the beaches. However the facilities themselves will not be affected and the attendance will probably not be affected.

4.18 Much of the construction work will be associated with the specialist marine activities, thus the contractor will probably use his own skilled staff for the particular duties. However the small amount of land based work for the perimeter road, wave wall and quay wall construction may require skilled and semi-skilled labour for which there may be a limited scope for local employment. Depending on the contractor's method of working, a minimum of 20 persons may be required.

Environmental Audit

4.19 Environmental auditing procedures will be instituted throughout the construction period to provide a methodical framework for monitoring and control procedures. The environmental audit will also report regularly to provide information both to HEC management and to government authorities on the effects of the construction activities. Two audits will be carried out in the first year and one in the second year of construction. A further audit will be carried out sometime after construction completion to assess any long-term effects of construction and assess the accuracy of the EIA.

Environmental Monitoring

4.20 Monitoring is required to provide the necessary data for an informed assessment of the environmental impacts of the various activities and to what extent any impacts persist beyond the completion of the activities. This can only be achieved by measuring the relevant parameters before, during and after the activities.

4.21 The sea water quality will be monitored at three locations close to the construction site, and one remote from the site ST4 to determine ambient conditions (Figure 4.3). Samples will be collected on three occasions prior to construction to determine baseline conditions. During construction samples will be taken at 14 day intervals for the first 3 months and then at 28 day intervals from the rest of the construction period. Samples will also be taken on three occasions following construction completion at 28 day intervals for post construction analysis. On each occasion both physical and chemical parameters will be measured to government specifications or better.

4.22 Noise will be monitored throughout the construction period at HEC's two existing monitoring stations at Ching Lam and Hung Shing Ye, using existing equipment and methods. This equipment will not be able to separate the noise due to construction from noise due to the power station and other sources, thus some analysis of the results will be required to arrive at the effect of construction.

4.23 Although subjective judgements of the effect of construction on tourism may be made the quantifiable method proposed here is to assess the government statistics for the attendance at the gazetted beaches of Lo So Shing and Hung Shing Ye. These figures will also be affected by other factors such as the season and weather conditions, which would have to be allowed for in the assessment.

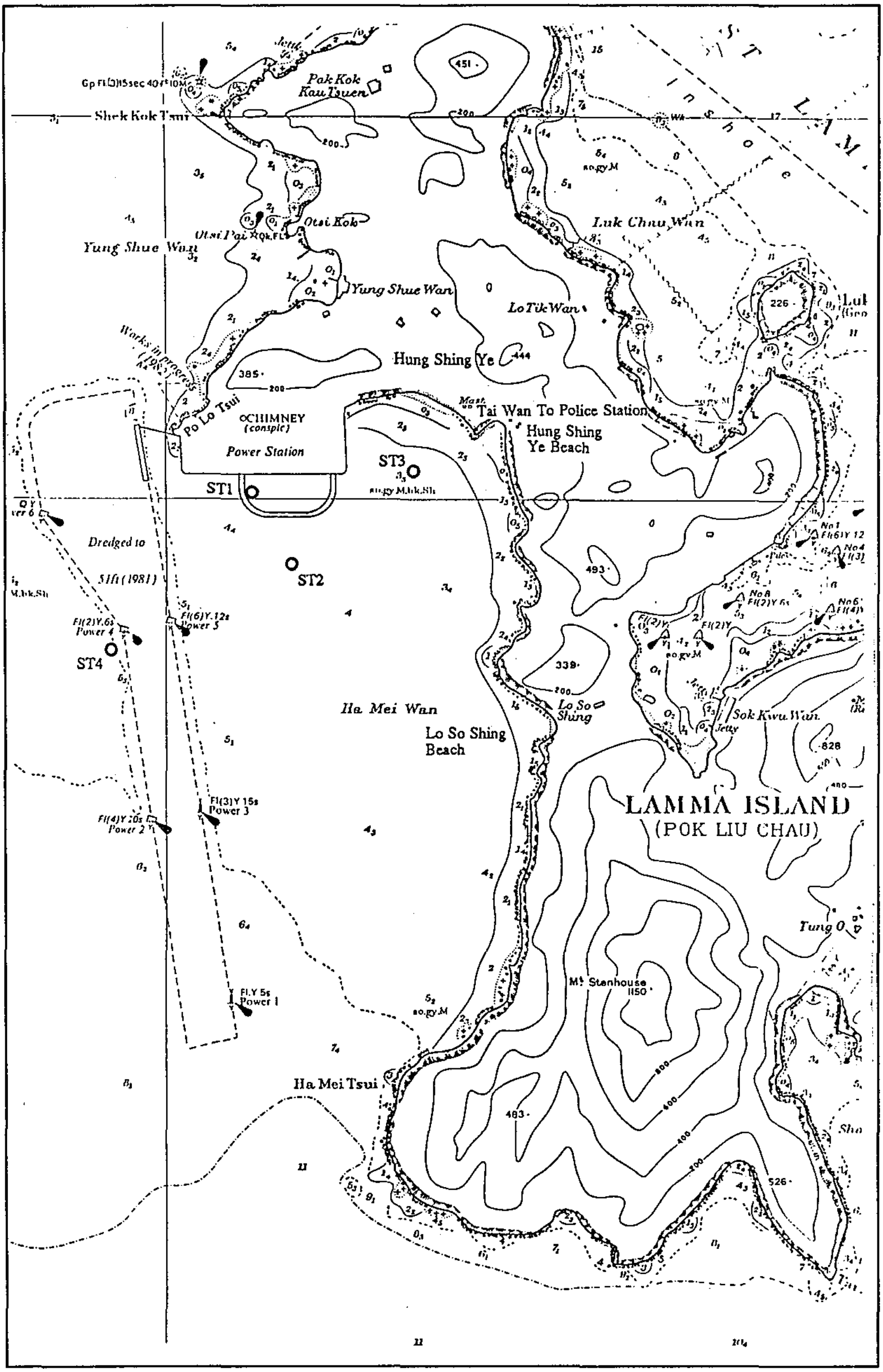


Figure 4.3 Sea Water Sampling Stations - Construction

Control Procedures

4.24 The control procedures for the various effects relate primarily to the adherence to a minimum construction period and the control of dredging operations. Although the effects of dredging are likely to be small, various working methods can be used in the operations to mitigate impacts, these are:

(i) mechanical grabs shall be designed and maintained to avoid spillage and seal tightly while being lifted. Closed grabs shall be used

(ii) ladders of bucket dredgers shall be designed to minimise disturbance of the sea bed

(iii) cutters of cutter suction dredgers shall be suitable for the materials being excavated and shall be designed to minimise overbreak and sedimentation around the cutter

(iv) washing out or overflowing of hoppers on hopper dredgers or barges while dredging and loading material will not be permitted in Ha Mei Wan

(v) the decks of all vessels shall be kept tidy and free of oil or any other substances or articles which may be washed overboard. Rubbish shall not be dumped in the sea

5 LAGOON OPERATION

5.1 The operating systems for the lagoon are associated with the placing of the PFA, its removal (harvesting) if necessary and measures to control the environmental impact. These systems are:

(i) PFA transport and placing systems

(ii) PFA harvesting system

(iii) PFA sluicing system

(iv) landscaping

(v) water quality control system

(vi) floater collection system

(vii) dust suppression system

PFA Transport and Placing System

5.2 To achieve a greater density of placed PFA and thus maximise the capacity of the lagoon the PFA will be placed in a conditioned (moist) form. PFA will only be placed in the lagoon when it cannot be transported off-site for alternative use. Therefore the transportation system has to be compatible with the existing conveyor system.

5.3 Various options and routes for extending and adapting the existing conveyor system have been explored. The recommended option is to use a series of belt conveyors of similar type to those existing (Figure 5.1). The route for the conveyors takes the PFA from a point to the north and west of the ash silo, along the western side of the Ash Settlement Basins and to the Lagoon (Figures 5.2 and 5.3). The advantage of this option is that it is the least congested route and provides the greatest operational and maintenance space.

5.4 The lagoon is to be filled progressively in a number of stages (Figures 5.4, 5.5, 5.6), so that the more significant environmental impacts can be mitigated at the earliest opportunity. The initial stage will be the formation of a working platform at the eastern end of the lagoon, from which machinery can be used to place PFA for future stages. Once the working platform has been established the filling will proceed in a westerly direction along the lagoon's northern perimeter to limit the seepage through the existing power station revetment. Stage 3 will be the extension of this PFA lining to the eastern end and southern side of the lagoon. Once this has been achieved the platform at the eastern end can be raised into a mound to form a landscaped screen. This will screen the operations from views from the beaches around the bay. In the final stages the filling of the lagoon will progress westwards with the extension of the landscaped mound.

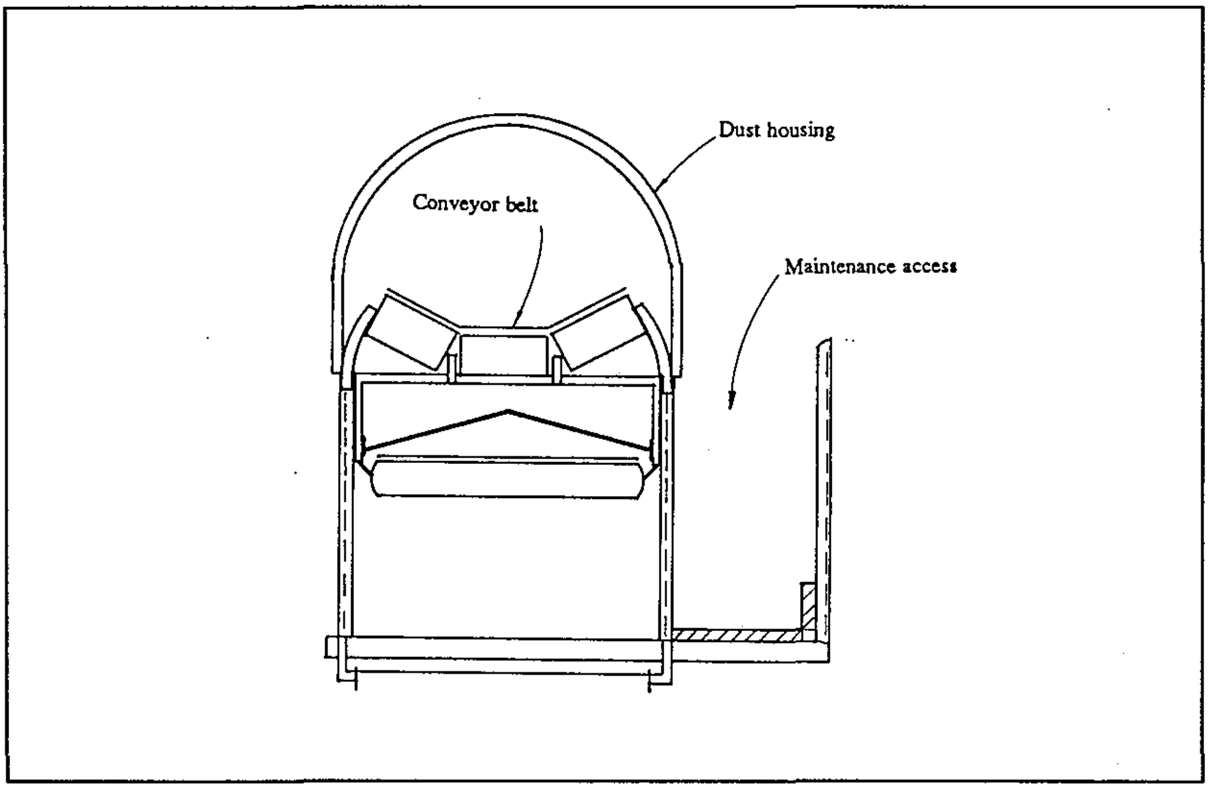


Figure 5.1 Typical Enclosed Deep Troughed Conveyor

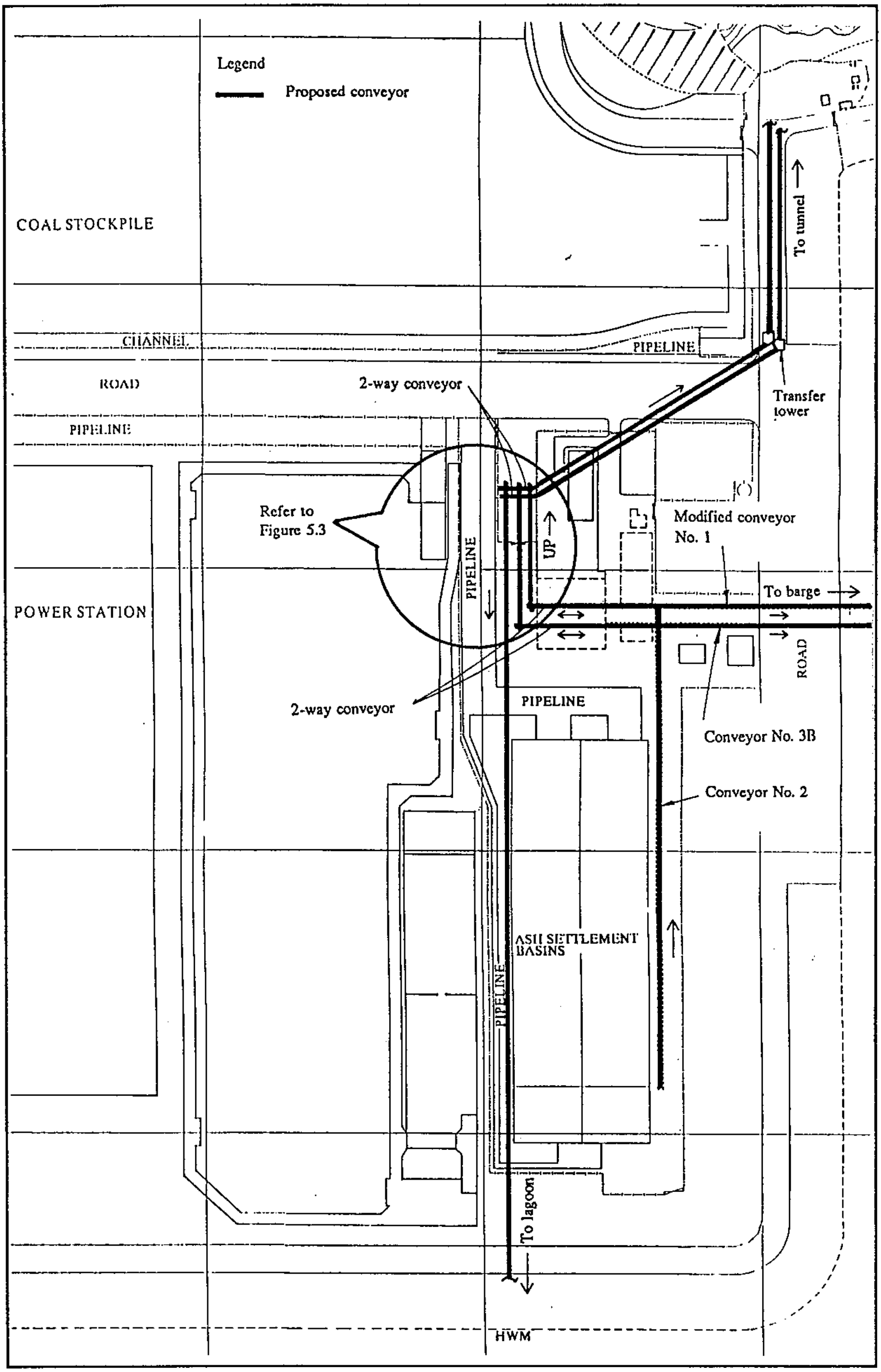


Figure 5.2 Proposed Conveyor Routes

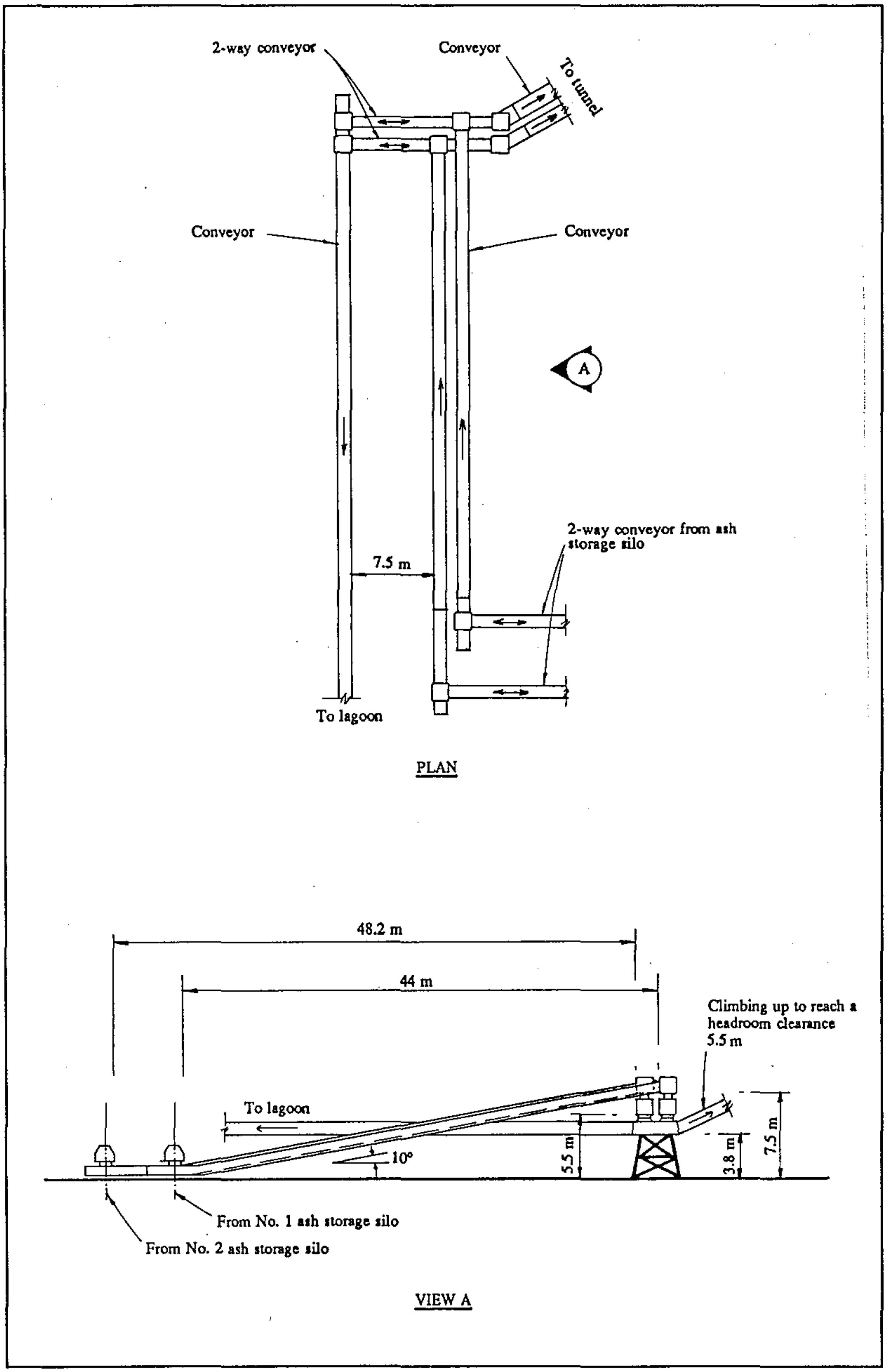


Figure 5.3 Details of Proposed Conveyor Routes

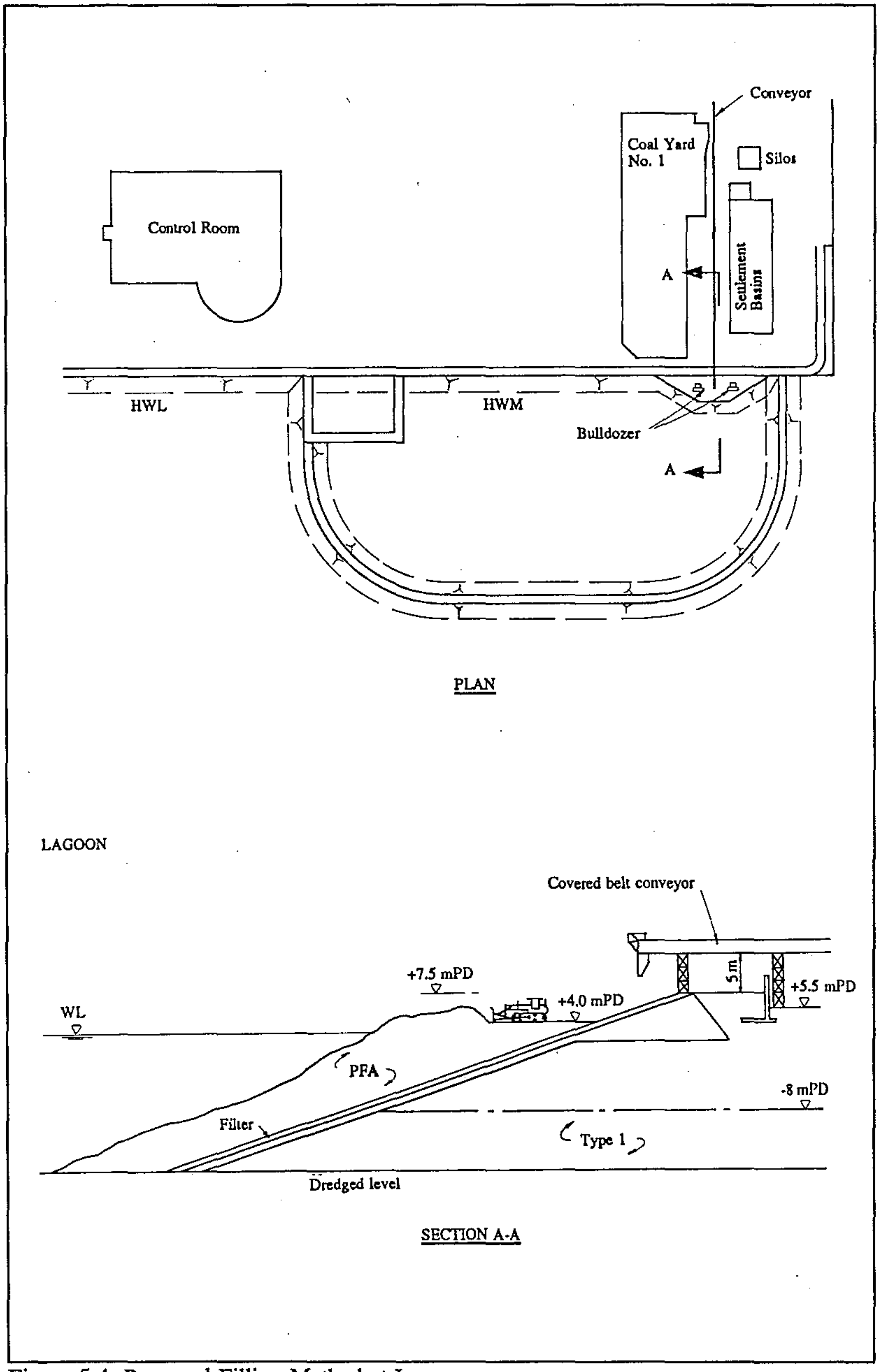


Figure 5.4 Proposed Filling Method at Lagoon

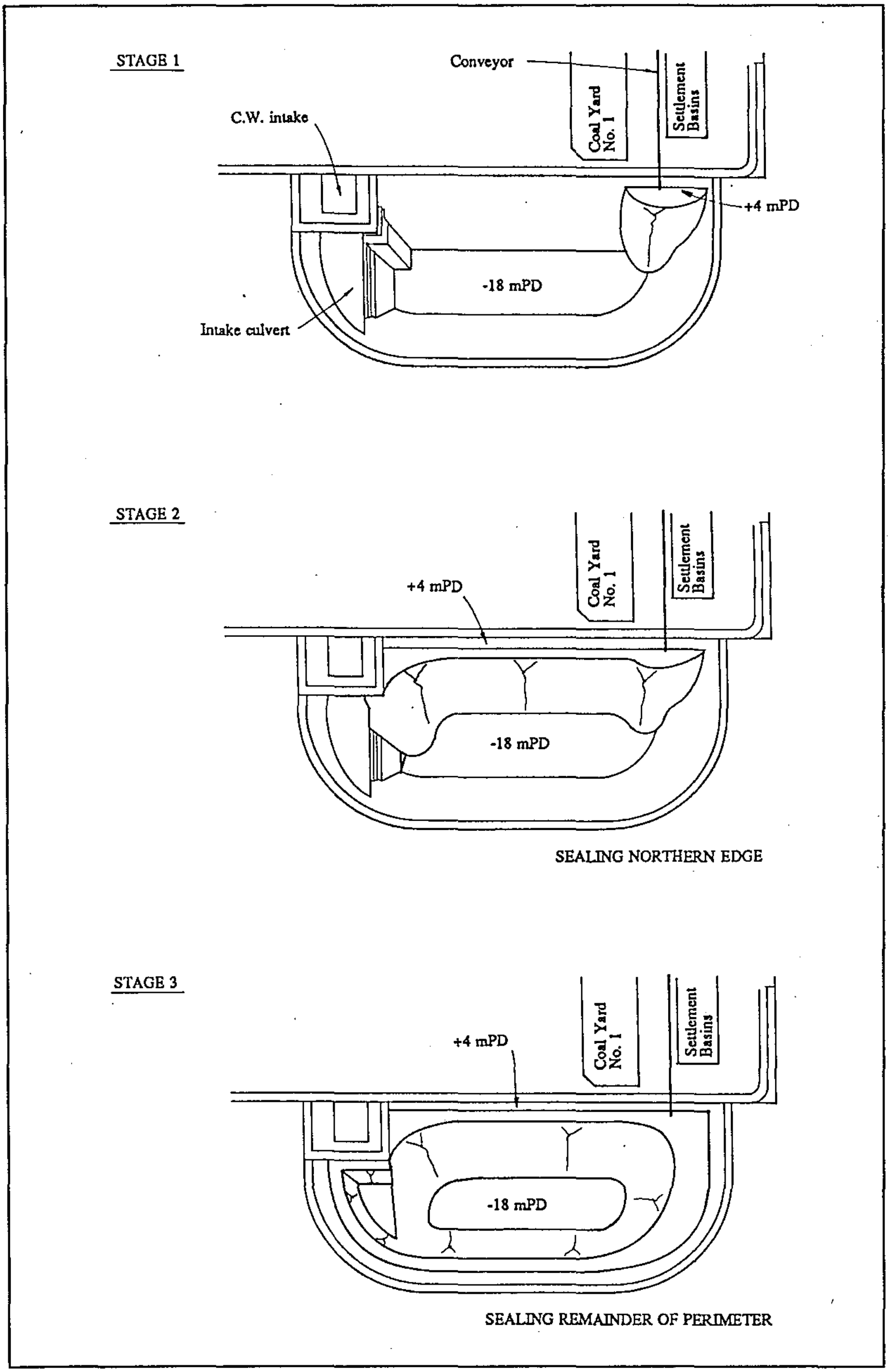


Figure 5.5 Proposed Filling Sequence - Stages 1 to 3

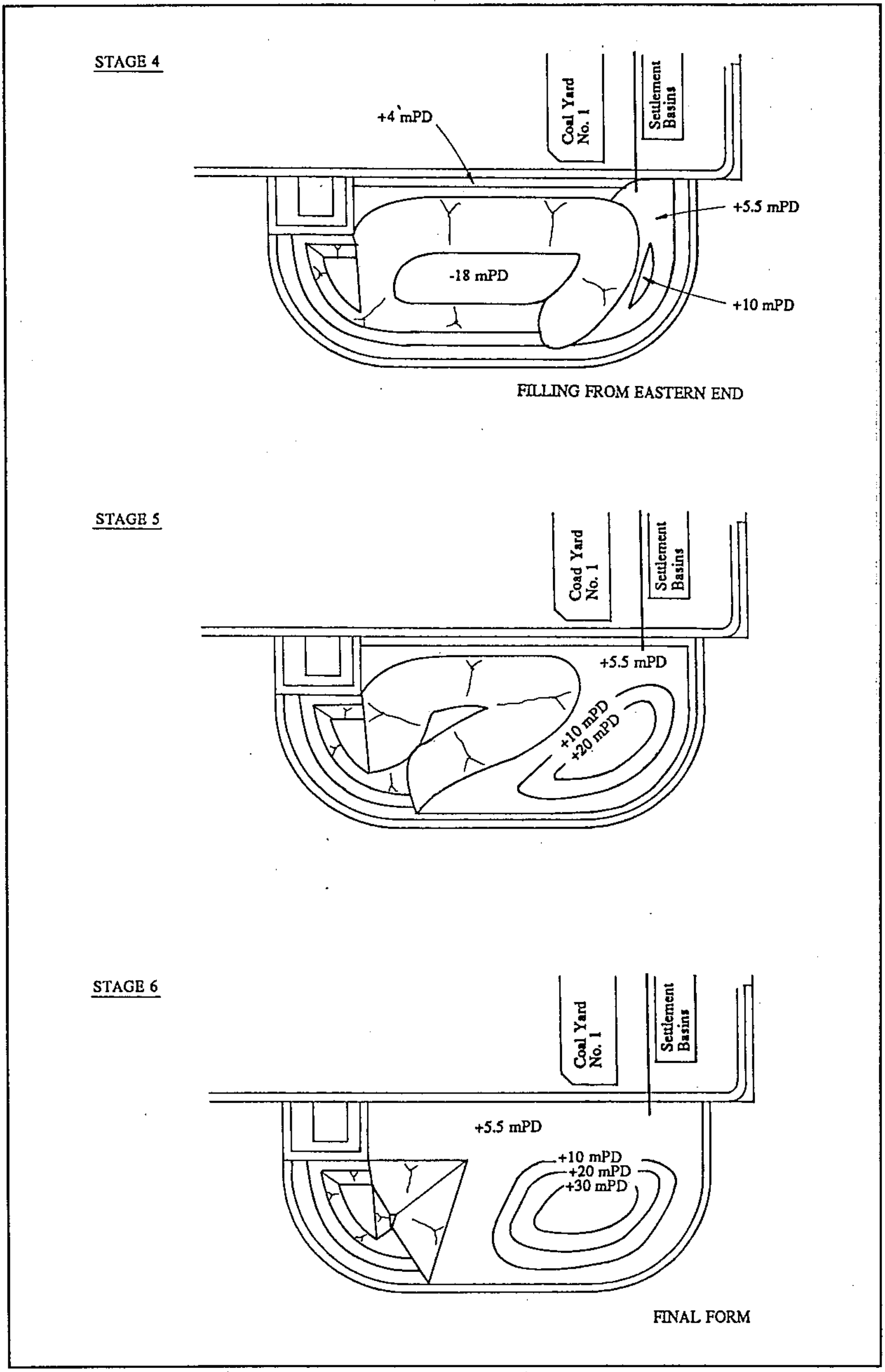


Figure 5.6 Proposed Filling Sequence - Stages 4 to 6

PFA Harvesting System

5.5 At times there may be sufficient demand for PFA from industrial or landfilling operations to justify the removal (harvesting) of PFA from the lagoon. The harvesting could be from both above and below sea level, whilst always maintaining the landscaped screen to the east of the lagoon. PFA below water would be removed by a crawler crane with a clam-shell grab (Figure 5.7). It would be stockpiled to reduce the moisture content to that of a moist, conditioned PFA before transportation by lorries to the station's barge loading area. In this state it will not present a dust problem. PFA above water would be excavated by backhoes and loaded directly into lorries for delivery to the barge loading quay. A wheel washing system to be installed at the entrance to the lagoon will prevent PFA being dropped on the power station roads by vehicles leaving the lagoon.

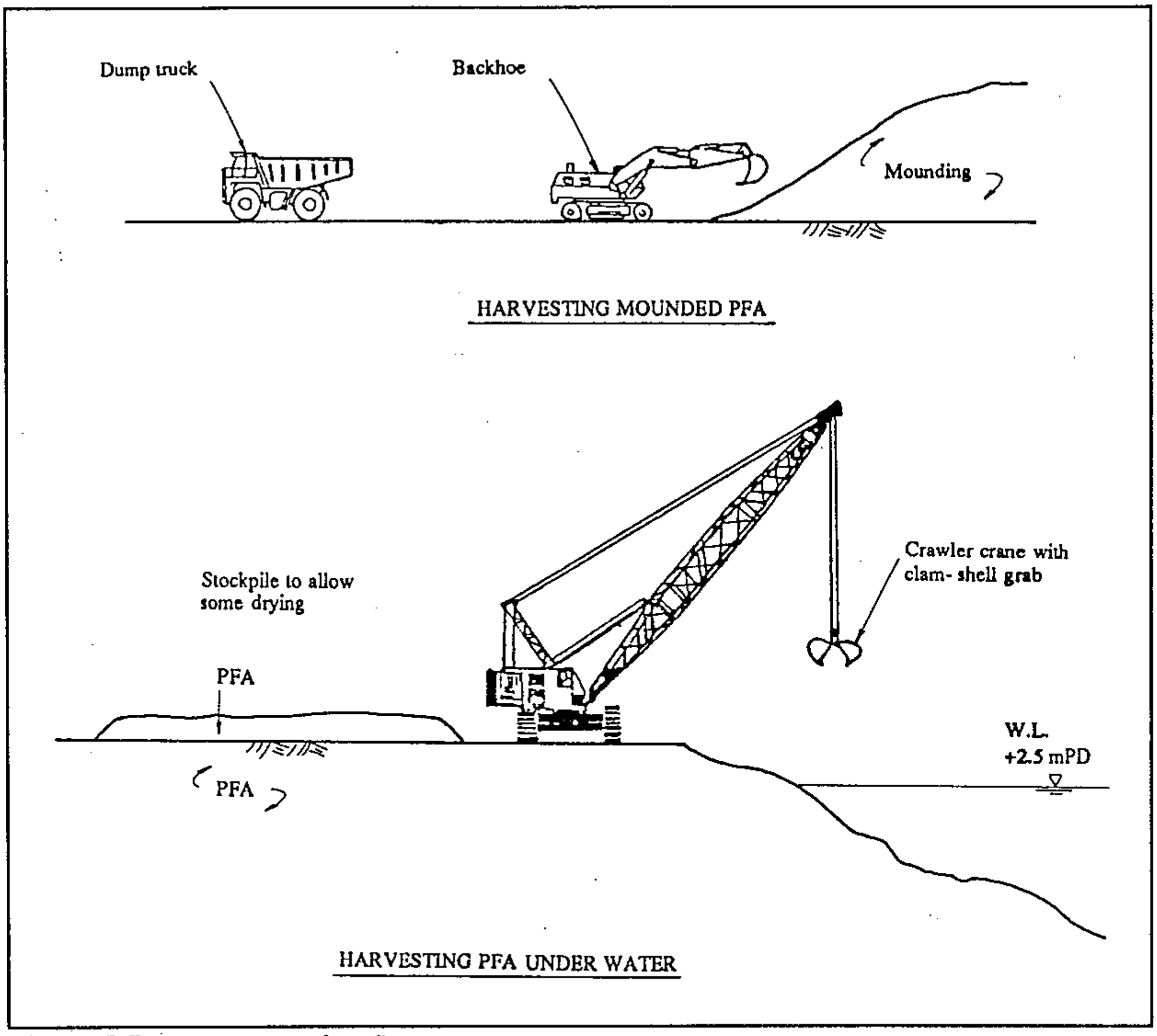
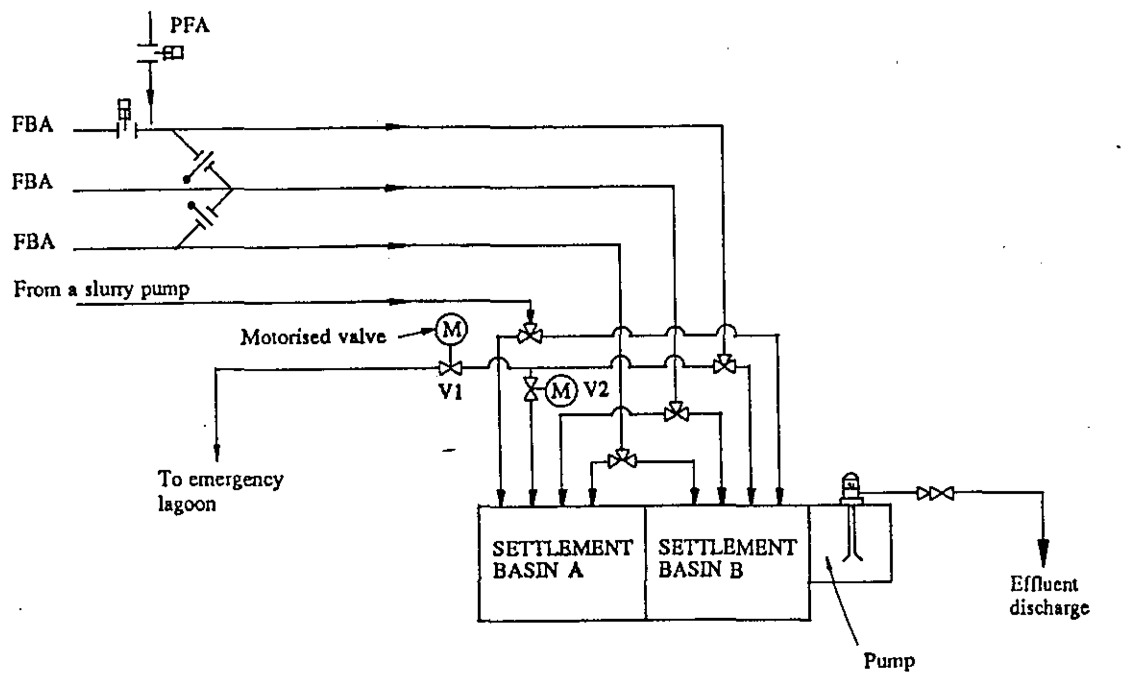


Figure 5.7 PFA Harvesting System

PFA Sluicing System

5.6 On occasions PFA will have to be discharged to the lagoon as a slurry and not in the normal conditioned form. This facility already exists for discharge to the ash settlement basins. Various options have been studied for the extension of the system to the lagoon. The most desirable is the extension of the pipeline from the ash settlement basins directly to the lagoon (Figure 5.8). However the power of the existing pumps may be insufficient for the extended distance and the proposed alternative is a number in-line booster pumps, installed near the ash settlement basins (Figure 5.9). On any one occasion the discharge to the lagoon would not exceed 46,000 m³/day.



Notes : Valves V1 & V2 can be replaced by a 3-way valve if space allows

Figure 5.8 Emergency Sluicing System - Pipeline Extension

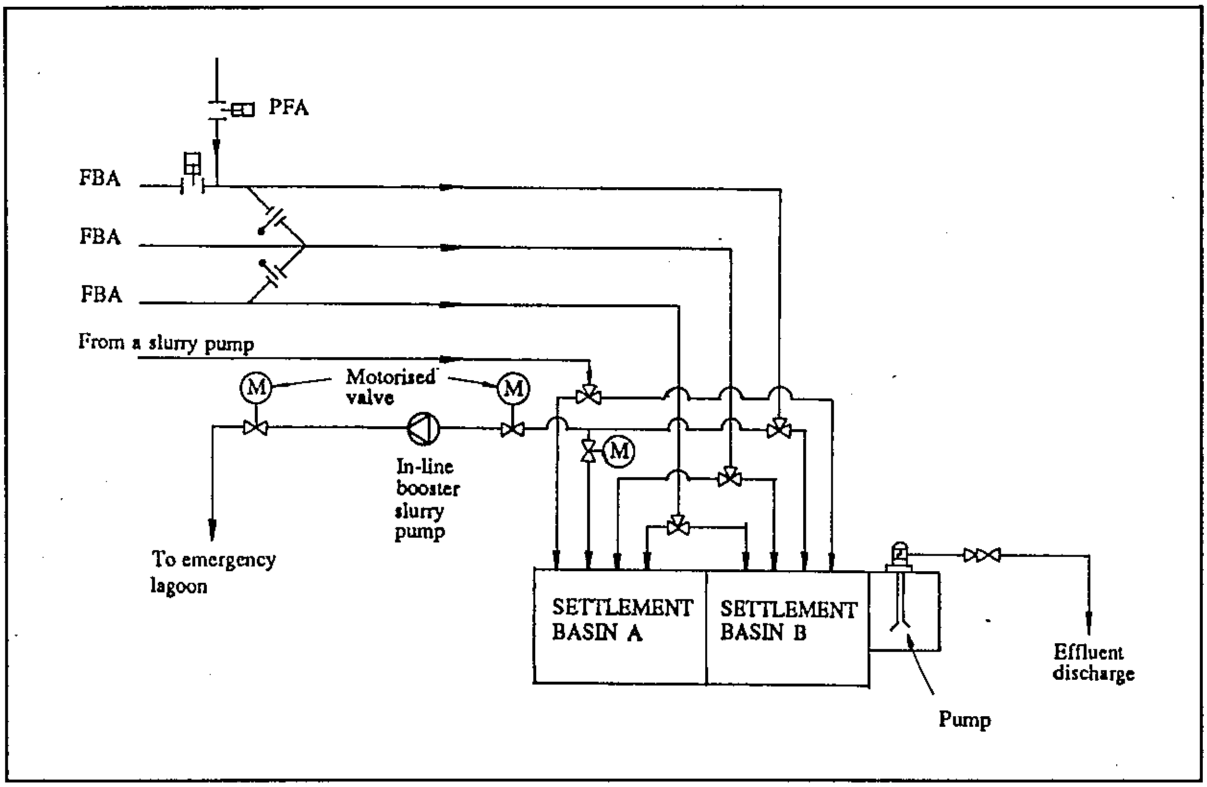


Figure 5.9 Emergency Sluicing System - In-Line Booster

Landscaping

5.7 The outer slope of the mound at the eastern end will be formed at a gradient of about 1 on 2. A nominal 250 mm of soil medium will be placed over the PFA to provide soil structure, nutrients and the moisture retention potential necessary to sustain healthy vegetation (Figure 5.10). The slope will be planted with shrubs and small trees to provide variety and yet be consistent with the surrounding hillsides. The slope will also have a series of drainage channel to collect stormwater and direct it to the lagoon (Figure 5.11). The expected maximum daily rainfall is 54,000 m^3. In times of dry weather the landscaped area will be irrigated with fresh water.

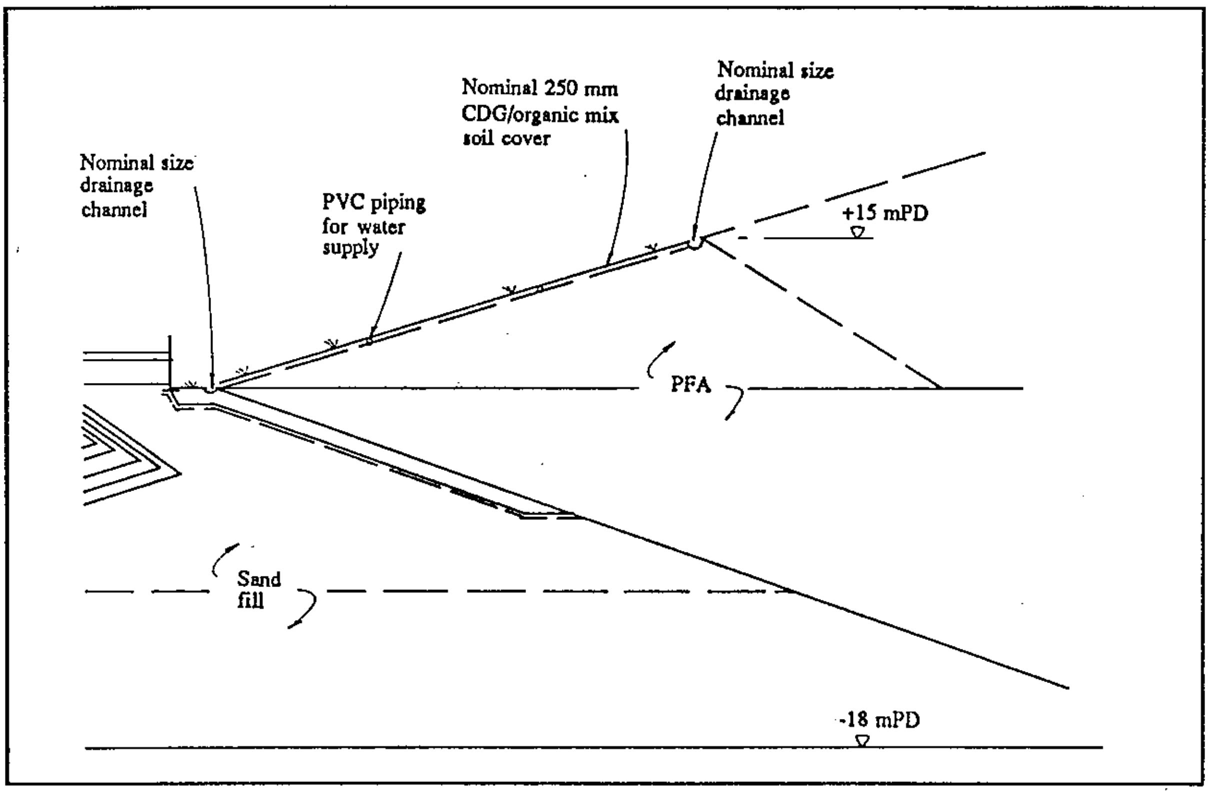


Figure 5.10 Landscaping

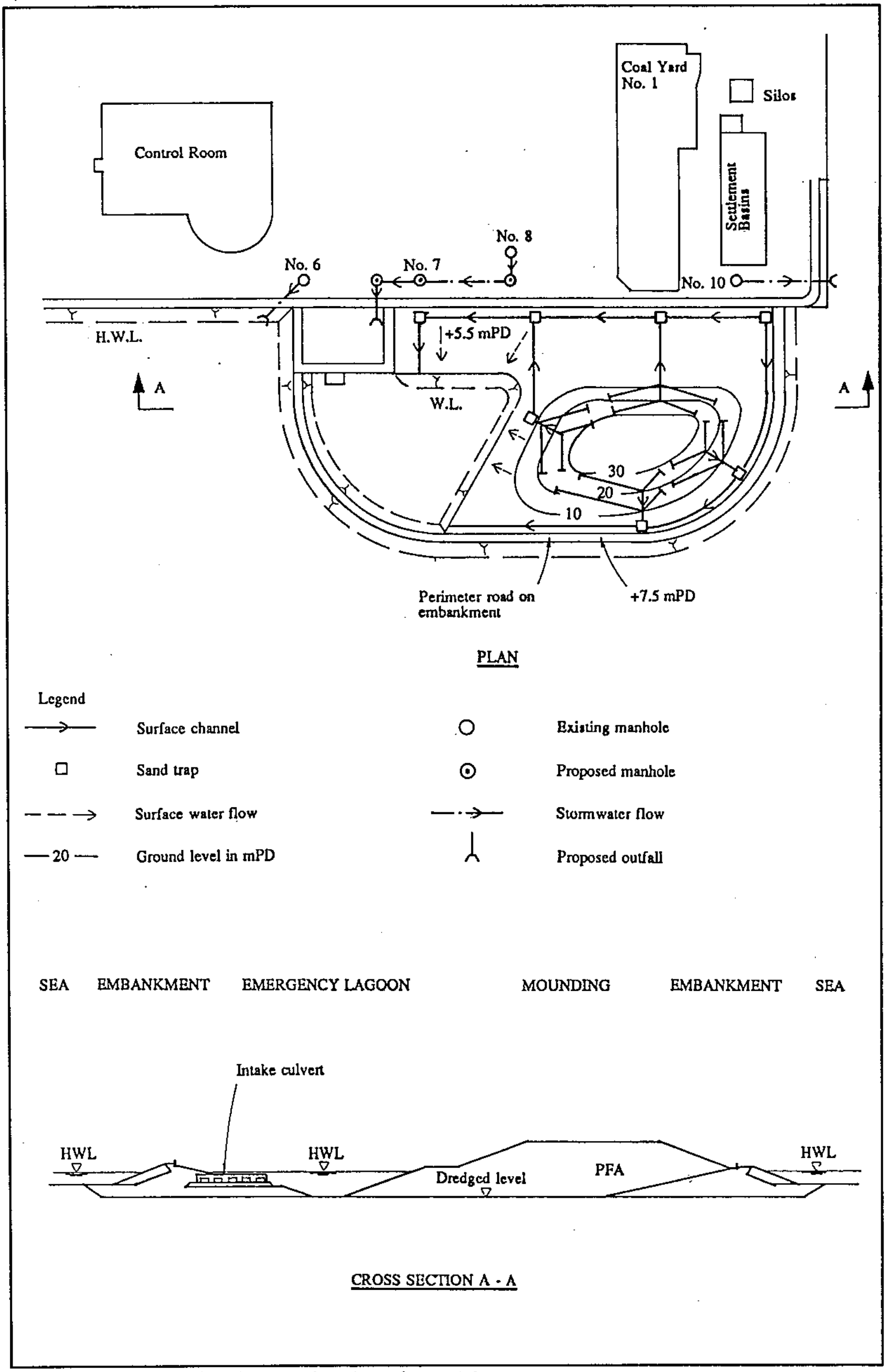


Figure 5.11 Completed Mound and Drainage Plan

Water Quality Control System

5.8 The perimeter of the lagoon has been designed to prevent PFA particles from migrating across the perimeter and into the surrounding seawater. However various chemical can be dissolved from the surface of the particles. These may be carried by seepage through the perimeter which will be, to a certain extent, permeable. Since the deposited PFA will itself reduce the permeability, the daily quantity of seepage will reduce over the life of the lagoon by a factor of about 100 to about 600 m^3/day.

5.9 The factors affecting the chemical composition of the lagoon water are numerous and subject to many inter-related processes. However estimations of the water quality have been made on the basis of extremely conservative assumptions and the process of dispersal in Ha Mei Wan has been carried out using sophisticated mathematical modelling techniques with resolutions down to about 80 m. EPD agree with the results of the investigations and are satisfied with the expected sea water quality.

5.10 Not withstanding these expectations a positive means of controlling the water quality within the lagoon is advocated. To remain within the water quality criteria set within the Government's Technical Memorandum of Effluent Discharges, a quantity of lagoon water is to be discharged daily through the station's cooling water outfall to the West Lamma Channel. Again, based on various conservative assumptions, the quantity to be discharged is 20,000 m^3/day. This discharge is to be achieved by pumping from a draw-off tower at the western end of the lagoon (Figure 5.12). This draw-off tower will accommodate six pumps capable of pumping this 20,000 m^3/day or the maximum stormwater runoff (Figure 5.13).

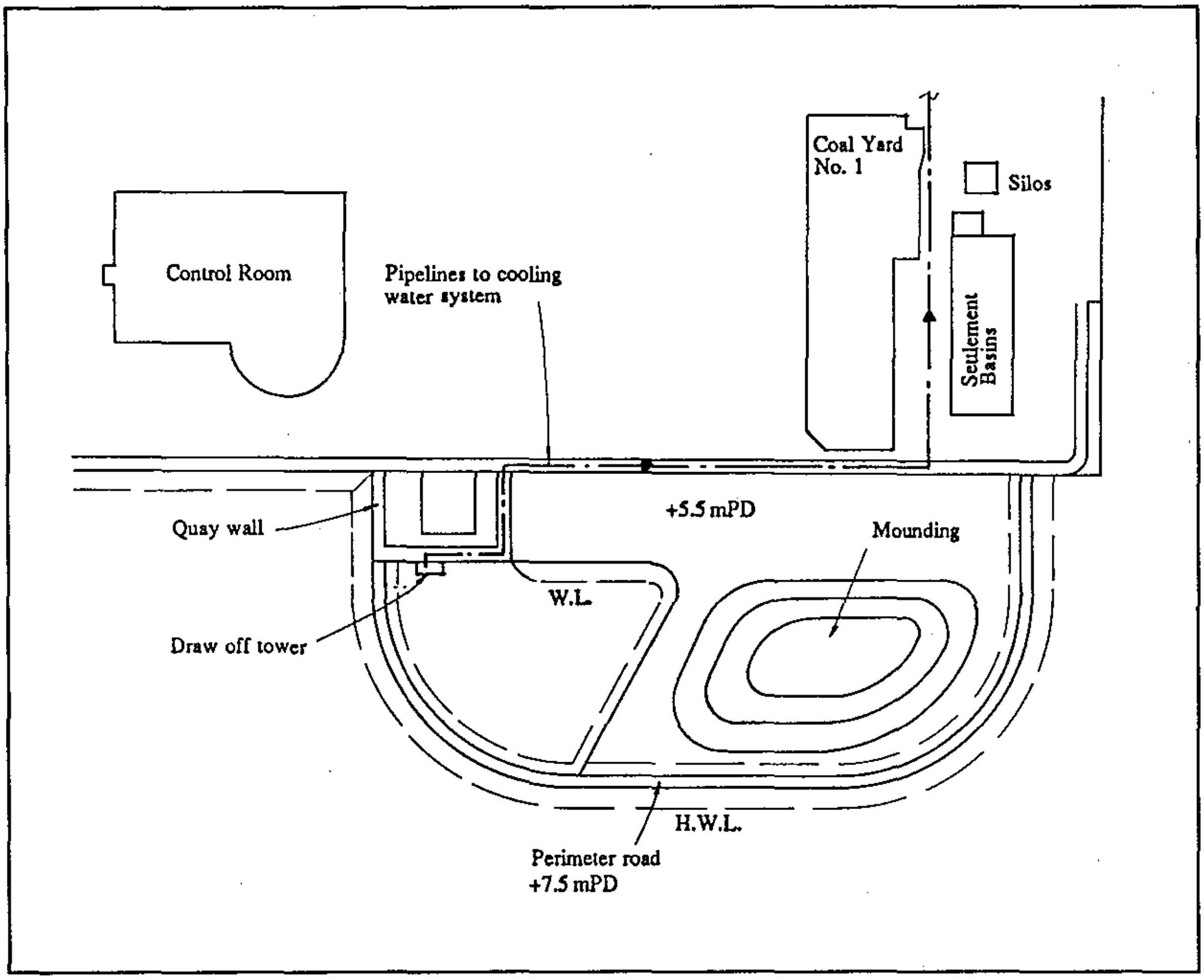


Figure 5.12 Draw Off Tower Location

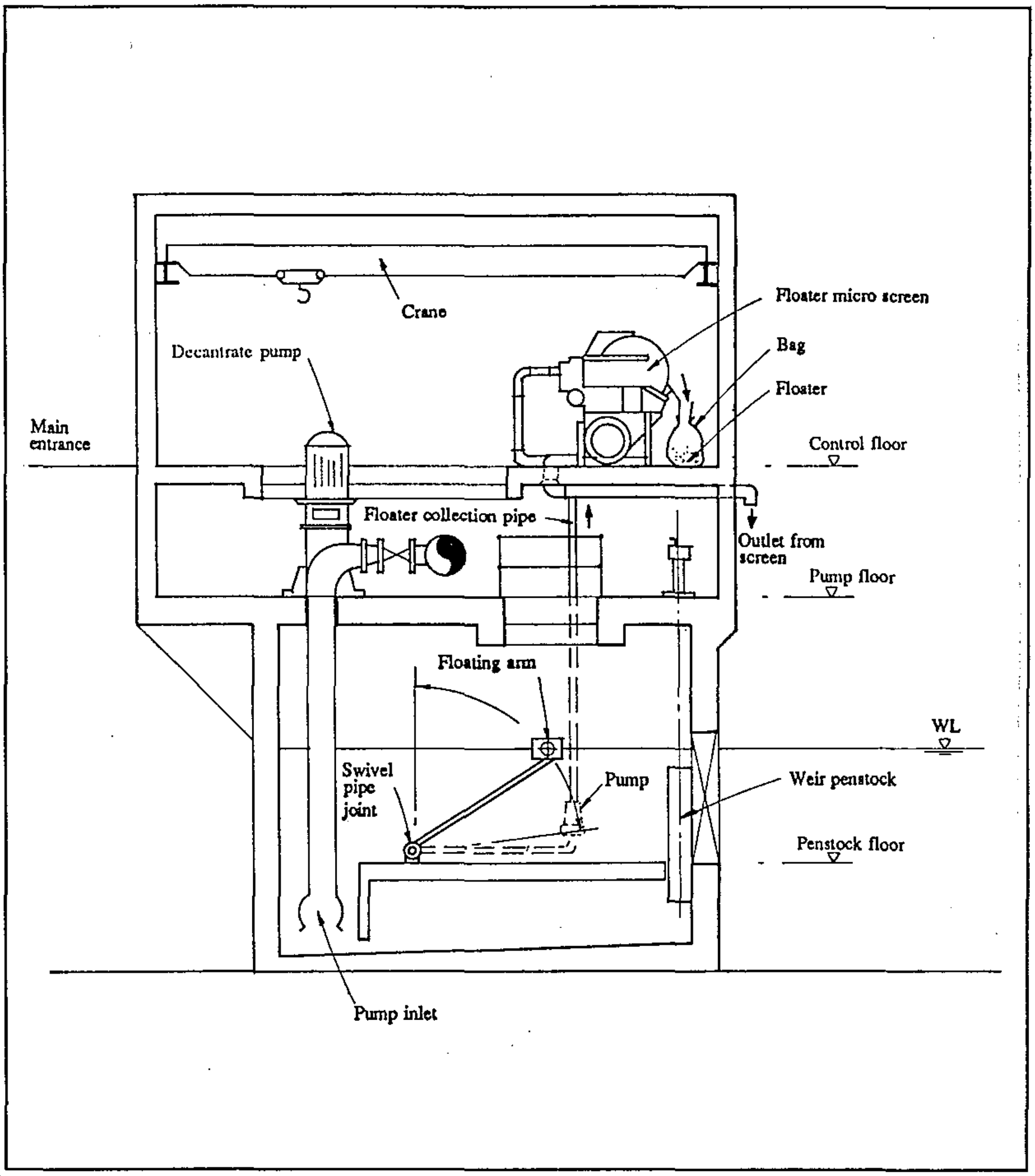


Figure 5.13 Cross Section of Draw Off Tower

Floater Collection System

5.11 PFA has a collection of various size small particles, the majority of which are heavier than water. However a small portion are hollow spheres (floaters) which tend to float on water. If allowed to build up on the surface of the water they form a solid raft and the surface can dry out and blow with the wind. To prevent this build up a floater collection system is proposed. The prevailing wind direction in the area of the lagoon is from east to west and consequently the floaters will collect around the draw-off tower. Within the tower a skimming device will pump off the floaters as a slurry. They will be separated on a rotating drum screen and bagged for disposal (Figure 5.14). Should the floaters fail to collect around the draw-off tower a floating boom will be provided to draw the floaters to the tower for collection.

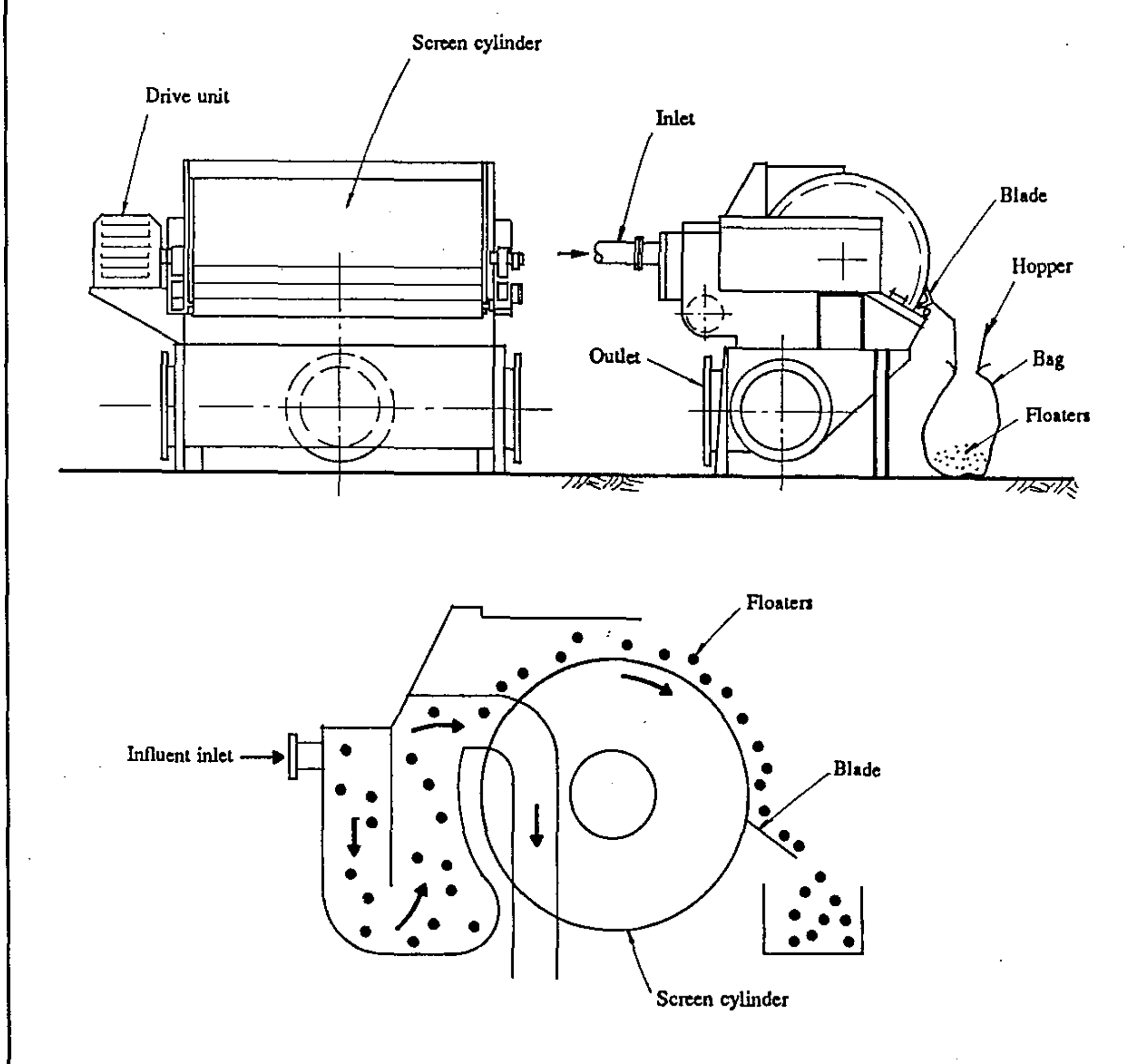


Figure 5.14 Floater Screening

Dust Suppression System

5.12 Providing PFA remains moist and is not disturbed by constant machinery traffic PFA develops a hard crust and a dust problem does not arise. To ensure that newly placed PFA remains sufficiently moist and that any dust problem that may arise can be quickly suppressed, a dust suppression sprinkler system is to be installed. The system will be mobile to accommodate the advancing filling operation. It is to consist of a submersible pump on a floating platform in the lagoon, which will pump lagoon water through a series of mobile sprinklers (Figure 5.15). Once areas have been filled to their final form they will be landscaped to prevent erosion and reduce visual impact. Those areas on the western side of the mound that must remain temporary open will be compacted so that they will form the characteristic crust and so prevent erosion by either wind or rainfall.

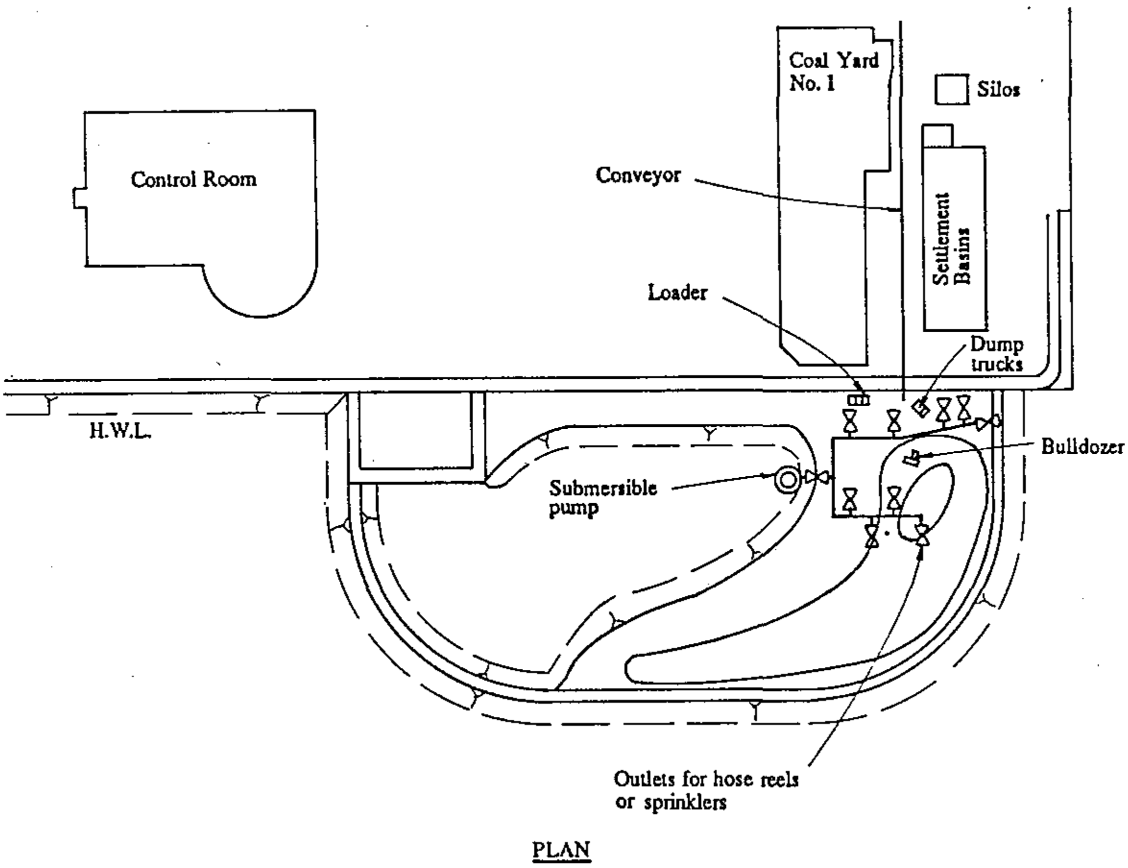


Figure 5.15 Typical Sprinkler System for Dust Suppression

Operating Effects

5.13 In the preparation of the proposals various measures have been incorporated to mitigate identified adverse impacts of the lagoon's operation, and to ensure that the predicted impacts fall within acceptable criteria. These effects are associated with:

(i) sea water quality

(ii) marine biota

(iii) dust

(iv) noise

(v) visual impact

(vi) community reaction

(vii) tourism

5.14 A rational approach has been used to derive the maximum likely effects of the lagoon filling operations on the seawater quality, and how this quality might vary around the Ha Mei Wan bay under the influence of the circulating currents. Under the worst circumstances the elevation of the metals content in the water immediately around the lagoon (less than 100 m) is probably 5 μg/l although the upper bounds of all variables is 15 μg/l, even though some of these variables are mutually exclusive. These metals will dissipate to much lower concentrations with increasing distance from the lagoon. PFA does not contain organic chemicals thus there will be none of the effects associated with these forms of chemical. EPD agree with the results of the investigations and are satisfied with the expected quality of the bathing water.

5.15 Although some marine biota are in food chains that lead eventually to humans and are to a certain extent bio-accumulators of metals, there is expected to be no significant increase in the metal content of these species. Thus there will be no significant effect on the marine species or the food chains due to lagoon operations.

5.16 The operational proposals and control procedures for filling and harvesting PFA have been drawn up with particular attention to the concerns associated with the generation of dust. The measures to be incorporated into the lagoon's operation should prevent a dust nuisance from arising.

5.17 There is to be a certain number of mechanical equipment associated with the operations of the lagoon, such as conveyor belts, a bulldozer, vibratory compactor, loader and lorries. The noise associated with this equipment has been assessed, whilst taking a number of conservative assumptions, in line with methods laid down in Government Technical Memoranda. The resulting noise (Table 5.1) from the operations is expected to be within the Government criteria (Technical Memorandum on Noise) in an area that is designated as having the highest sensitivity to noise.

Equipment	Noise [dB(A)]							TSPL[1]	CNL[2] for NSR
3 conveyors	90	>					)		
	90	> 93	>				)		
	90	>	>115	>			)		
1 bulldozer	115	>115	>	>			)		
1 Vibratory compactor	105	>		>119	>		)		
1 Loader	112	>113	>	>	>		)	120 dB(A)	120-65[3]-5[4]+3[5] = 53
3 Lorries	112	>	>117	>	>		)		
	112	>115	>		>	120	)		
	112	>			>		)		
1 Pump (electrical)	88	>112	>112	>112	>		)		

Notes:
(1) Total Sound Power Level
(2) Corrected Noise Level
(3) Correction factor for noise attenuation
(4) Negative correction factor for partial screening
(5) Positive correction factor for being a building

Table 5.1 Estimated Noise Levels from Operating Systems

5.18 The form of the lagoon has been devised to be compatible with the existing power station platform, and the operations in the latter stages of filling will be substantially behind the landscaped mound. In the initial stages the level of PFA filling will be at about 4 mPD, some 3.5 m below the crest of the lagoon embankment. Thus the operations will be substantially hidden from those views with aspects from the beaches on Ha Mei Wan.

5.19 The ash management exhibition held on Lamma Island in October 1989 appears to have allayed local concerns with respect to lagoon operations. Therefore further significant community reaction to the lagoon is not expected.

5.20 Lagoon operations will have no physical effect on the local tourist facilities (the beaches and restaurants) thus no significant effect on tourism is expected.

Environmental Audit

5.21 The environmental audit system will methodically check the lagoon's activities, its effect on the local environment and provide a framework for the monitoring and control procedures. The procedures will note those activities that are within the pre-defined environmental criteria, highlight those that transgress criteria, and institute control procedures or remedial measures when required. The audits report will reassure HEC management and regulatory agencies that the lagoon is being operated in an environmentally acceptable manner. The process will also permit a post project analysis to be carried out to examine the accuracy of the original environmental impact assessment. Following the cessation of the filling operations the regular audits will continue until the impacts are stable or are steadily reducing, at which point an appraisal of the environmental impact assessment can be carried out.

5.22 Environmental audit reports will be produced regularly throughout the operating life of the lagoon. In the first year of operation there will be two audit reports and they will be produced annually thereafter. This frequency will be reviewed and revised as necessary as part of the audit process. The scope of the audit will cover the following:

(i) the quality of sampling and analytical procedures associated with the monitoring

(ii) consider factors that may influence monitoring results, such as tidal seasonal or local weather effects

(iii) ascertain whether other factors, such as construction activities nearby, have influenced monitoring results

(iv) identify the operations within the lagoon which were concurrent with sampling e.g. harvesting or sluicing of PFA

(v) whilst considering the foregoing, identify those environmental impacts that are within or outside the defined criteria

(vi) recommend measures or control procedures to mitigate those impacts that fall outside the criteria, and identify trends which may eventually transgress criteria if measures are not taken

(vii) review impacts that cannot be quantified, such as visual impact

(viii) review and consider complaints or reactions from the public relating to the lagoon operations. If appropriate, recommend suitable actions which could be implemented

(ix) review and revise if necessary the monitoring procedures

(x) revise the scope and frequency of the environmental audit to reflect changes in impacts and lagoon operating procedures

(xi) carry out an analysis to compare the predicted impacts with the actual impacts, and to comment on any discrepancies

Environmental Monitoring

5.23 The environmental effects associated with lagoon operations will be measured whenever possible by quantifiable scientific methods, to Government standards where appropriate. The results can then be compared with the predefined environmental criteria.

5.24 The seawater quality will be measured both inside and outside the lagoon, in accordance with the procedures set out in the Technical Memorandum on Effluent Standards. Initially samples will be taken at monthly interval from four sites, two inside the lagoon, one adjacent to the eastern end of the lagoon and the fourth in the West Lamma Channel for reference (Figure 5.16). Following the first year of operation the monitoring may be modified in light of experience and the sampling period extended to two months.

5.25 Shrimps will also be caught in Ha Mei Wan to measure the effects on marine biota. Shrimps will be caught at 3 month intervals both before operations commence and during the first year of operations. The samples will be analysed for their heavy metal content and the results compared with the Government guidelines for acceptable metal levels in sea food [Food Adulteration (Metallic Contamination) Regulations Cap 132 Section 55(1)].

5.26 Dust will be monitored using HEC's two existing high volume air samplers, one at the east gate and the other on top of Reservoir road. These instruments draw approximately 1.5 m^3/min through a filter to collect airborne particulates. The particulates can be weighed and if necessary microscopically examined to determine whether any PFA is present in the air. The measurements will be taken in accordance with USEPA Standard Method 40, CFR Part 50 Appendix B. The samplers will be indicative of the air borne dust in the area as a whole and will not be able to measure that of the lagoon operations in isolation. However previous monitoring will indicate background variation and the careful recording of operational activities will be indicative of the lagoon's operational effect. Acceptable levels for total suspended particulates are specified in the Air Pollution Control Ordinance. The criteria for total suspended particulates are:

(i) the concentration of total suspended particulates in air averaged over any 24 hour period shall not exceed 260 microgrammes per cubic meter more than one a year.

(ii) the concentration of total suspended particulates in air averaged over a year shall not exceed 80 microgrammes per cubic metre.

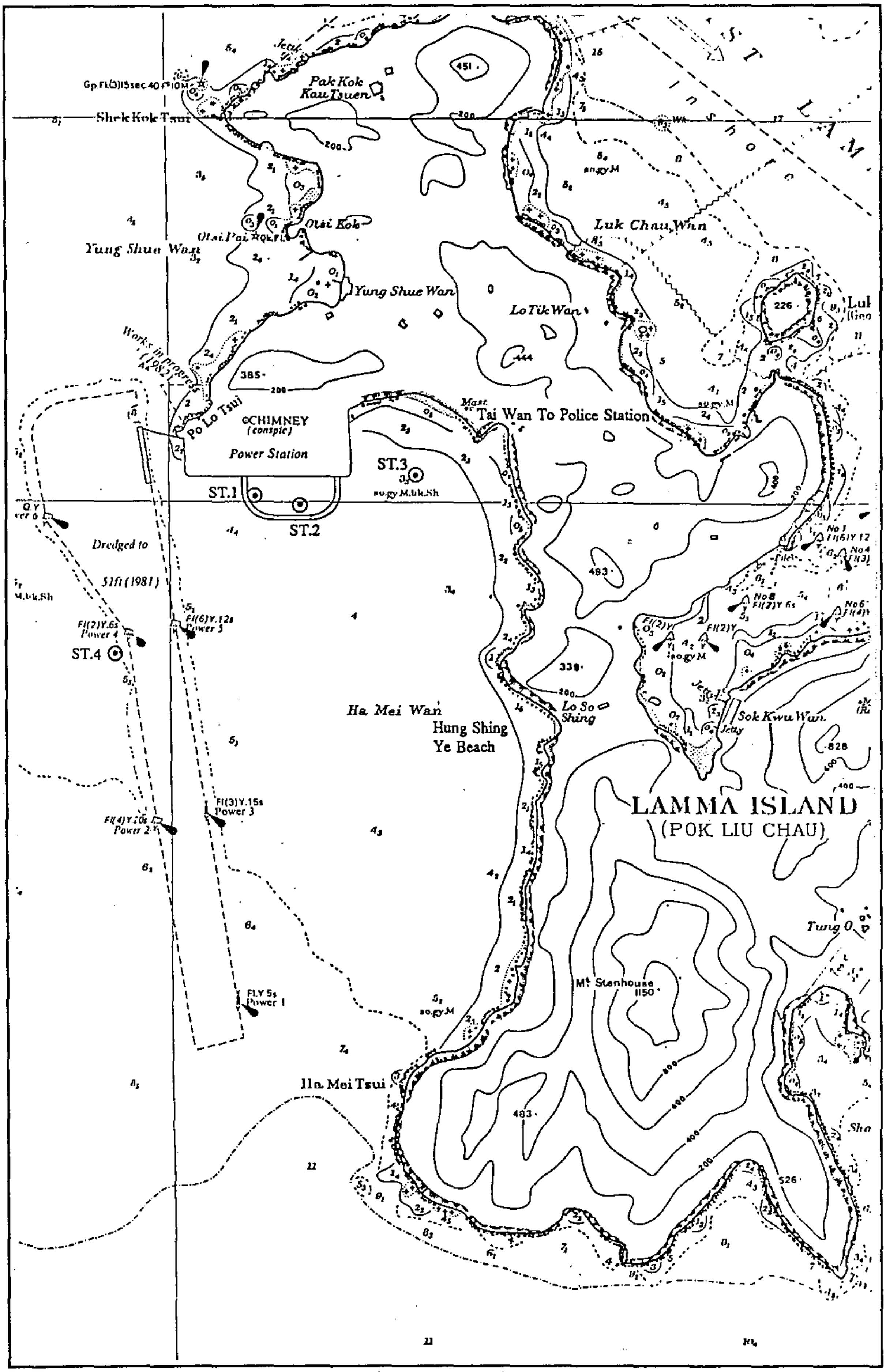


Figure 5.16 Sea Water Sampling Stations - Operations

5.27 Noise will be measured during the operation of the lagoon at HEC's two existing monitoring stations at Ching Lam and Hung Shing Ye, using existing equipment and methods. This equipment will not be able to separate the noise due to lagoon operations from noise due to the power station and other sources, thus some analysis of the results will be required.

Control Procedures

5.28 A clearly defined reporting procedure will ensure that results of monitoring are available as soon as possible to personnel controlling the lagoons operating systems.

5.29 The water quality within the lagoon will be positively controlled by the use of the decantrate system, discharging 20,000 m^3 of water a day to the West Lamma Channel. The operating procedures are intended to be sufficiently flexible that it can be altered should the water quality either within the lagoon or in the bay prove to transgress the criteria and be due to the lagoon operations. On the occasions when emergency sluicing occurs the pumping of decantrate will be suspended for a number of hours to allow the suspended solids to precipitate and thus fall with the criteria permitting the resumption of pumping.

5.30 The various dust suppression techniques are intended to prevent a dust nuisance from arising. However the measures are also sufficiently comprehensive to mitigate an impact should it arise from the handling and storing of PFA.

6 CONCLUSIONS

6.1 Prior to this third stage of the environmental impact assessment of the Ash Management Study for The Hongkong Electric Company Limited, various options for the disposal of PFA were explored in the Initial Assessment Report (1989) (IAR). The IAR concluded that a lagoon adjacent to the power station should be an integral, and key element of the strategy. Subsequent to this, a preferred site for a lagoon of 1.5 Mm^3 capacity on the south eastern corner of the power station was adopted.

6.2 The third stage of the EIA has developed a preliminary design of the lagoon structure and its operating systems. These proposals have taken due regard of the environmental effects of both the likely construction techniques and the operational activities throughout the facility's life. Various measures have been incorporated into the design to reduce the expected impacts to within criteria acceptable to EPD.

6.3 Of all the options considered for the form of the lagoon perimeter, the embankment has the greater number of advantages, although the caisson wall with revetment is comparable. Thus the majority of the discussion centres around this option, but much of it is equally applicable to the alternative.

6.4 All the issues identified for this third stage of the EIA have been addressed and the effects are likely to fall within generally accepted criteria for the environment. The local community on Lamma gives the impression that the need for a lagoon is accepted although some concerns remain. This report has readdressed these concerns, relating to subjects such as dust control and effects on tourism.

6.5 The construction of the lagoon will take about two years and environmental audits will be carried out initially at 6 month intervals. The capacity of the lagoon is suitable for about six to eight years of PFA production. However, the eventual period of active PFA filling will be determined by the demand for PFA from industry and landfilling sites. Two environmental audits will be carried out in the first year and then annually for the period of the filling operation. Following the cessation of the filling operation the regular audits will continue until the impacts are stable or are steadily reducing, at which point an appraisal of the environmental impact assessment can be carried out.

6.6 Given that a lagoon has been found to be necessary for the provision of an element in the PFA disposal strategy, the proposals for an embankment present the least impact and various measures are to be instituted to reduce to a minimum those that do exist. A methodical assessment of the EIA and the lagoon performance is to be provided by instituting an environmental monitoring and audit system. This is to be carried out during both the construction and operational phases of the lagoon. The auditing system will not only provide affirmation of the expected performance of the lagoon, but also identify transgressions of criteria and institute remedial measures to rectify the situations should they arise.

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