2 PROJECT DESCRIPTION

2.1 The Proposed Project

Prevention of the impacts of flooding especially in the downstream areas is the main justification for this Project as indicated in Section 1.1. The concept of having a collection tunnel and three interception points (intake structures) is essentially based on the optimum solution to collect the stormwater, convey it to an outfall and discharge to the marine environment in a controlled manner. The proposed works are all based on avoiding the impacts to the environment and wherever possible minimizing the extent of any structures to mentioned in the foregoing section. The project justification (refer to Section 1.1) and the selection of the form of works (i.e. the tunnel, intake structures and outfall) was agreed in the PPFS and DMP. Cost benefit analyses of the various options were undertaken (with environmental considerations being given 10% of the weighting). This stage of the Project therefore focuses on optimising the agreed concept and avoiding or minimising the environmental impacts.

The proposed tunnel has been designed for a maximum flow of 210m^3/s. It will convey stormwater intercepted between the junction of Shing Mun Road and Wo Yi Hop Road and the Tso Kung Tam to the proposed outfall underneath the elevated section of Castle Peak Road at Yau Kom Tau. Runoff from the upland catchments will be collected via three proposed intake structures. Locations of these intakes and outfall structures are as follows:

- Intake I-1:In Kwai Chung, adjacent to the junction of Wo Yip Hop Road and Shing Mun Road;
- Intake I-2:At Lo Wai, adjacent to Lo Wai Road;
- Intake I-3:At Tso Kung Tam, about 350m off Route Twisk; and
- Outfall O-1:At Yau Kom Tau, underneath the existing Castle Peak Road.
- The location plan and context of the Project is illustrated on **Figure 1.1.** Illustrations of the three intake structures and the outfall and cascade are given in **Figures 2.15, 2.18, 2.20 and 2.24**. **Plate No. 2.1-2.4** indicate the conditions around the intake structures.

2.2 Option Selection

2.2.1 Background

The Option Selection Study was reported upon separately in July 2003 and was based on a thorough review of all available relevant information including information from the DMP Study and PPFS and site visits. It concluded that for many reasons including minimizing environmental impacts of disposal of tunnel spoil, the preferred option for the proposed drainage tunnel is the shortest one. Although the fundamental concept remains the same, this option varies slightly from the option investigated in the PPFS in alignment, length, intake locations and percentage of runoff to be captured.

In order to provide the background to and the basis for the EIA, the following sections summarise the findings of the Options Selection Study. For full details reference should be made to the Final Options Selection Report – June 2003. A summary of the Options Selection Report is given in the following paragraphs.

The Options Selection was essentially based on the principle of avoiding environmental impacts as far as practical where avoidance is not possible (for example the works must be within the vicinity of the streams and some impact is anticipated), then minimisation is the key principle. While the Options Selection Report did not explicitly use the term "environmental considerations" in the selection process, avoidance or minimisation of environmental aspects underpin the entire selection process.

Bearing in mind the primary objective of the proposed drainage tunnel is to improve the flood protection level in Tsuen Wan and Kwai Chung areas without any significant additional improvement works required in the downstream urban drainage system, only those options that fulfil this requirement were evaluated although a substantial number of options were explored before the four shortlisted options were assessed.

It is important to note that one of the criteria for selecting the tunnel options is the requirement for the enactment of the Drainage Tunnels (Statutory Easement) Ordinance. A minimum of three tunnel alignments were considered. As the enactment of the Ordinance has significant impacts on the programme and cost of the proposed works, this requirement was taken as a criterion for the evaluation of the tunnel options.

In addition, the Brief has specified a list of other criteria for the evaluation of the tunnel options and they are grouped, with similar nature, into the following list:

- i Reuse of the stormwater;
- ii Impacts on existing buildings and future development and restriction in land uses;
- iii Disturbance to build up area during construction;
- iv Impact on existing ground conditions (including water inflow/ ingress/ treatment/ potential instability and settlement);
- v Cost effectiveness (cost-benefit analysis);
- vi Tunnel, intake and outfall designs;
- vii Operation and maintenance; sedimentation and hygienic condition;
- viii Construction methodology;
- ix Effectiveness in intercepting stormwater in the box culvert along Kwan Mun Hau Street/ Luen Yan Street/ Ma Tau Pa Road; and
- x Effectiveness in resolving the flooding problem around Belvedere Garden.

As mentioned above, although environment/ecology was not specifically mentioned in the list, the principle of avoidance or minimisation was a basic tenet adopted for this Project.

2.2.2 Tunnel Options

Various proposals were considered for the tunnel were identified which were ultimately narrowed down to five feasible options (refer to **Figure 2.26**). These were as follows:

- Option 1 – The PPFS Option;
- Option 2 – The Modified PPFS Option;
- Option 3 – The Shortest Option;
- Option 4 – The Option without Encroachment on Private Lots i.e. no enactment of the Drainage Tunnel (Statutory Easement) Ordinance is required; and
- Option 5 – Key component of this option was to reuse the collected runoff.

For Option 5, a detailed assessment was conducted in consultation with WSD regarding the conveyance of collected runoff to the Lower Shing Mun Reservoir and Yau Kam Tau Water Treatment Works for reuse. Apart from the constraint in the capacity of the Reservoir, impacts on Sha Tin and Tai Po Drainage Basin due to overflow of the Reservoir, geotechnical impacts etc., reservations were expressed in relation to the use of collected runoff for potable water in terms of water quality. Cost benefit analyses also indicated that Option 5 would be more expensive than purchasing water from Mainland China and thus no further consideration was given to that Option.

Furthermore, Working Paper No.1 – "Water Reuse Scheme" was prepared which investigated the feasibility of diverting the collected stormwater to other existing WSD facilities. In that Working Paper, six options were assessed in terms of their topographical and geographical considerations, constructability, operational and maintenance requirements, water quality, continuity of water supply and economical considerations. However, having gone through a detailed assessment, it was concluded that none of the water reuse schemes were attractive and should not be further pursued.

The diameters and lengths of the different tunnel options are shown in **Table 2.1.**

Table 2.1 Data Summary of Tunnel Options

	Length of Main Tunnel (6.5m Dia.) (m)				Length of Adit Tunnel (m)		
	I-1 to I-2	I-2 to I-3	I3 to O-1	Total Length (m)	From I2 (4.5m Dia.)	From I3 (5.5m Dia.)	Total Length (m)
Option 1 (PPFS)	1443	1910	1963	***5316***	130	80	***210***
Option 2 (Mod. PPFS)	1343	1976	1989	***5308***	13	45	***58***
Option 3 (Shortest)	1343	1826	1922	***5091***	13	47	***60***
Option 4 (No Private Lots)	1330	2369	1939	***5638***	859	50	***909***

The proposed tunnel Options 1, 2 and 3 will encroach on a number of private lots. A Drainage Tunnel (Statutory Easement) Ordinance is required to be enacted for constructing the tunnel. As the decision on whether to enact the Ordinance for this project would have a major influence on the selection of the preferred tunnel option, its implication is taken as one key criterion for evaluating the options.

Other than the Drainage Tunnel (Statutory Easement) Ordinance, the evaluation of the tunnel options is generally based on the criteria required under the Brief. The evaluation criteria and their associated weightings, which take account of the degree of potential impacts of the proposed tunnel options, are listed in **Table 2.2**.

Table 2.2 Evaluation Criteria and their Weightings

Criteria	**Weighting**
Drainage Tunnel (Statutory Easement) Ordinance	15
Impacts on existing buildings and future development, restriction in land uses	10
Impact on existing ground conditions	10
Cost effectiveness (cost-benefit analysis)	30
Tunnel and intake designs	10
Operation and maintenance, sedimentation and hygienic condition	12
Construction methodology	10
Disturbance to build up area during construction	1
Effectiveness in intercepting stormwater in the box culvert along Kwan Mun Hau Street/ Luen Yan Street/ Ma Tau Pa Road; and	1
Effectiveness in resolving the flooding problem around Belvedere Garden	1
Total	100

2.2.3 *Evaluation Results of the Tunnel Options*

Environmental impacts associated with the tunnels construction would largely be similar for all shortlisted options. Notwithstanding this a brief account of potential environmental impacts was included in the Options Selection Report (for the sake of completeness) and this detailed EIA examines the impacts associated with the preferred scheme.

The evaluation results based on various criteria for determining the preferable tunnel option are summarised in **Table 2.3**.

Table 2.3 Summary of Evaluation

Criteria	***Weighting***	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Drainage Tunnel (Statutory Easement) Ordinance	15	3	7	7	15
Impacts on existing buildings and future development, restriction in land uses	*10*	5	5.14	4.12	4.41
Impact on existing ground conditions	*10*	5	5.2	4.55	4.65
Cost effectiveness (cost-benefit analysis)	*30*	15	22.87	23.37	22.19
Tunnel and intake designs	*10*	5	5	6.5	3.5
Operation and maintenance, sedimentation and hygienic condition	*12*	6	6.5	7	4.5
Construction methodology	*10*	5	5.2	6.29	3.79

Criteria	*Weighting*	Option 1	Option 2	Option 3	Option 4
Disturbance to built up area during construction	*1*	0.5	0.5	0.5	0.5
Kwan Mun Hau Street/ Luen Yan Street/ Ma Tau Pa Road Box Culvert Deficiency	*1*	0.5	0.5	0.5	0.5
Flooding problem around Belvedere Garden	*1*	0.5	0.5	0.5	0.5
TOTAL	***100***	**45.5**	**58.41**	**60.33**	**59.54**

From the evaluation it was evident that the shortest option (Option 3) was most favoured. This involves least waste/spoil arisings as it is the shortest. This will also be of benefit following construction as there is less operation and maintenance requirements for the whole life of the tunnel which can also be translated into an environmental advantage.

Option 4 had an advantage in that it did not encroach on any private lots and as such would mean that no enactment of the Drainage Tunnel Ordinance would be required for the construction of the tunnel. No land would physically need to be resumed for constructing the tunnel. The tunnel would pass at more than 30m depth underneath these private lots forming only a potential constraint for future developments.

For the alternatives for completing the two missing sections of culvert at Junctions Ma Tau Pa Road/ Yeung Uk Road and Ma Tau Pa Road/ Texaco Road, it was concluded that the most cost-effective solution is still to complete the two missing sections of the box culvert. Adding an additional intake or diverting the flow via a new 525m long 3-cell culvert in Castle Peak Road were not considered to be practical.

Regarding the current flood prone area around Belvedere Garden, adding an intake in the concerned catchment to transfer a portion of the runoff to the proposed drainage tunnel would bring drainage improvement. However, comparing the respective costs of the two options, adding an intake above Belvedere Garden is not considered cost effective and is not recommended.

Vertical Alignment and Tunnel Size

As far as the vertical tunnel alignment is concerned, its variation is limited because it is highly controlled and constrained by topography, bedrock level of intake locations, the WSD water tunnel No. 3 and KCRC's West Rail Tunnel. Having examined various constraints, tunnel gradients of 1 in 55 for the section between intake I-1 and I-2 and 1 in 150 for the rest were recommended. The tunnel diameter was then determined with respect to the required hydraulic requirement. The principle criterion was to limit the amount of stormwater interception such that the tunnel size could be kept minimum while the intended hydraulic improvement to the urban areas could still be achieved. The other design criteria are:

- Limiting the peak velocity inside the tunnel for not exceeding 6m/s. This is the recommendation in the Sewerage Manual of DSD. In the preliminary design, a detailed assessment on this aspect had been carried out. It was noted that, to comply strictly with the maximum velocity requirements of 6m/s under 200 year storm event, the tunnel diameter would need to be much larger than 7.2m. This was considered not cost effective as the chance of occurrence of the high velocity was low. A more practical design approach by allowing flow velocity greater than 6m/s for rainstorms under 10 year storm events with no surcharge was recommended. Higher velocities under rainstorms greater than 10 year return period was considered acceptable as the occurrence of these events was not frequent. This would also result in smaller amount of C&D material to be generated.

- Limiting the occurrence of surcharge under peak flow. Surcharging the tunnel especially near the intake shafts would affect the energy dissipation efficiency of intake structures.

Based on the above hydraulic requirements, internal diameter of 6.5m is required for tunnel section between I-2 and O-1 and the tunnel size can be slightly reduced for tunnel section diameter I-1 and I-2. However, on top of the hydraulic requirements as described above, the construction methodology for the main tunnel should also be considered when determining the size of the tunnel. Two possible construction methods for the main tunnel were considered, namely tunnel boring machine (TBM) and drill and blast (D&B). The long length of tunnel (5.13km) means that high initial cost and time for TBM procurement is more than offset by the faster tunnel construction rate of TBM than D&B. TBM is therefore economically viable. For D&B construction methods, there are a number of adverse effects, including noise, vibration, potential damage to structures and management of explosives. It will also likely result in more 'overbreak' than TBM methods. From the construction economic point of view, TBM is therefore the preferred construction method option. However, a further consideration has been made by adopting a slightly smaller tunnel diameter between I-1 and I-2 in order to minimize the C&D material generated. Since the boring size of a TBM is fixed, variation of tunnel diameter will require either 1) two different TBM machines or 2) one TBM machine and D&B for a section of tunnel. However, these options have the following shortcomings:

- Both alternative arrangements will require a TBM to be retrieved from the shaft at Intake I-2. To enable this, the adit tunnel and the shaft diameter will need to be enlarged to 7.2m and about 15m respectively for the passage of the shield of TBM. This will increase the C&D material generated and the footprint of works near the existing stream bed, which will lead to more adverse impacts on the ecology.

- Additional cost will be involved for these alternative arrangements to cover the cost for mobilization of an additional TBM (for option 1), D&B operation (for option 2), excavation cost of adit tunnel and shaft at Intake I-2. To illustrate the financial implication of the alternatives, a smaller tunnel, say of internal diameter 6.0m, is assumed for the cost estimation. (The actual tunnel size should be larger than 6.0m in order to fulfil the hydraulic requirements as above.) The estimated reduction in C&D material generated and the additional cost required are summarized as follows:

	C&D material (m3)				Increase in construction cost
	From tunnelling	From structures	Total	Amount saved	
Original Option	282,180	59,592	341,772	-	-
Option 1	274,458	63,182	337,640	4,132	HK$125.5M
Option 2	278,130	63,182	341,312	460	HK$47.4M

With the above considerations, though there presents an opportunity to slightly reduce the size of tunnel section between I-1 and I-2, a single size tunnel diameter of 6.5m throughout the whole tunnel length was recommended for the overall cost effectiveness of the project as described below.

Assuming the tunnelling of section between I-1 and I-2 (smaller tunnel) is to be carried out simultaneously with the rest of the tunnel sections, the time implication may not be significant. However, compared with the cost required, this option is not cost effective. Therefore, adopting a single diameter throughout the whole tunnel length will bring the overall benefit to the Project.

Intake Structures

The intake structures are of more concern in relative terms due to the fact these involve works, by necessity, in streamcourses. Two of the intakes are also located in long stream courses. The three intake structures were included in the evaluation, again with avoidance/minimisation as the guiding principle. The following paragraphs illustrate the selection process and describe the reasons for selecting intake locations.

Intake I-1

The recommended intake structure is located at the confluence of two open channel adjacent to the junction of Shing Mun Road and Wo Yi Hop Lane. The current situation is indicated on **Plate 2.1** which shows the hard man made weir structure which currently exists.

Since the intake is already at the downstream end of several large tributaries, moving it to the upstream side would require more than one intake in the rural area. This would increase the extent of works and was therefore not recommended. Consideration had also been given to any possible intake on the downstream side of the existing weir. However, the areas further downstream are all fully developed urban areas and no suitable locations could be identified for stormwater interception without significant disruption to the local environment, and land take. The location of I-1 is optimal as it will only affect an already disturbed environment. It is shielded from general view and is located in the context of other similar structures.

Intake I-2

The PPFS location is downstream of the confluence of several tributaries. Only one intake is required which reduces the extent of works in the immediate vicinity. Moreover, as this location is adjacent to Lo Wai Road, residential houses, shops, temples and other temporary structures, human activities are considered relatively intense compared to other parts of the river. This location would generate the least environmental impact. Moreover, as the proposed intake is situated in the context of other similar structures, the visual impact to the environment is also minimised.

Apart from the PPFS location other possible intake locations were also explored. An alternative to Intake I-2 is located at the upstream side of the PPFS location. However, to capture the required amount of stormwater, two intakes would be required to intercept flow from the upstream main tributaries. This would increase the footprint of works and disturb more of the stream course. Moreover, in order to ease construction and maintenance the intake would need to be located adjacent to the WSD catchwater access road, however as this would result in the intake structure being very close to the Country Park it is not favoured.

A search for other possible downstream alternative location had also been undertaken. However, considering the availability of site access, constraints on government lands, and the existing natural stream conditions, no alternative intake location was identified as suitable. The PPFS location was recommended to be adopted, but was modified and improved upon to minimise environmental impacts as shown in **Figure 1.2**.

<u>Intake I-3</u>

Following a review of the PPFS proposal for I-3, an alternative intake location was identified and assessed.

The proposed PPFS location is downstream of two major streams. The potential turbulence and whirlpool effects created were not considered to be appropriate in terms of avoiding impacts on the receiving environment (stirring up natural sediment etc.). Therefore, an alternative location which is located about 200m further downstream of the original proposal has been examined and selected. There are the following advantages of the selected location.

- With the revised location away from the confluence of the tributaries, the performance of water interception will be more reliable.

- This alternative option would be more environmentally acceptable, because, by shifting the intake away from the confluence, the total area of riverbed to be affected would be smaller and less riparian habitats and vegetation areas affected.

- Although the proposed intake location is about 200m from the upstream end of the waterfall (Sam Dip Tam), the operation of the intake will not affect the waterfall. It is because the Intake I-3 will only start to intercept stream flow when rainfall reaches 30mm/hr (or stream flow rate is approximately $44m^3/s$). Moreover, the intake will only intercept 38% of stream flow at 200-year storm event and the majority of flow will still be allowed to flow downstream through the waterfall.

- From the landscape and visual impact point of view, since the proposed intake is about 2.5m high and is located at the bottom of the natural valley with dense vegetation on slopes, it is shielded from most of the sensitive receivers. Besides, this location is not easily accessible by road access and nature trail, the visual impact to visitors is limited.

Since the alternative location still falls within the proposed ecological park, consideration was given to locating this intake outside the proposed ecological park. A possible intake location on the upstream side of the ecological park was considered but deemed to be unacceptable as it would be within the Country Park, more than one intake would be required to satisfy the hydraulic requirements, and hence more environmental impacts would be anticipated (and thus conflicts with the avoidance/minimisation principle). Moreover, since these locations are at a higher level and deviate from the main tunnel alignment, deeper vertical shafts and longer adit tunnels are required. These will result in higher construction cost, longer programme and more construction and demolition material.

Another alternative location which is on the downstream side of the waterfall has also been examined. However, the following disadvantages are noted and this location was not taken forward.

- Since the ground level of this alternative location (30mPD) is much lower than the selected location (60mPD), the vertical tunnel alignment has to be lowered by about 30m accordingly. With this revised arrangement, the tunnel will be bored between two existing tunnels, i.e. WSD Water Tunnel and KCRC West Rail tunnel. This is will be a risky operation and is not desirable. Moreover, the clearance between the drainage tunnel and the WSD Water Tunnel, which is already very tight, will be further reduced to 14m. Besides, the proposed tunnel will also encroach onto the KCRC Railway Protection Zone with only 13m separation from the KCRC West Rail tunnel. The tight clearances between the drainage tunnel and the existing tunnels are not preferred.

- By lowering the whole tunnel alignment, the depth of Intake I-1 and I-2 drop shaft will be dramatically increased by 30m. The construction time and cost will increase.

- At the outfall, the invert of the tunnel outlet structure will be lowered to about -1mPD. A large portion (about 500m) of the tunnel will be submerged most of the time and which is undesirable from maintenance point of view. Besides, the stormwater will directly be discharged to the sea without any dissipation of energy which will create undesirable marine impacts (e.g. scouring of seabed and potential disturbance to marine traffic in close proximity to the outfall).

- This intake is located further away from the drainage tunnel and thus the adit tunnel will be lengthened by more than 100m, resulting in increased construction time and cost.

- From the landscape and visual point of view, this alternative intake location is closer to the urban area and is more exposed to the nearby visual sensitive receivers (eg. Allway Gardens, Tsuen Wan Centre and Yan Chai Hospital Lim Por Yen Secondary School). The visual impact will be more serious and difficult to mitigate.

Considering all of the above factors, Intake I-3 has to be located within the project site of the ecological park. The currently proposed location would cause the minimum environmental impact to the surrounding area and every attempt (see the paragraphs below for the design of access ramp and intake structures (under the heading of Intake I-2 and I-3)) has been made to reduce the extent of works required in this area in order to minimize the potential impact to the proposed ecological park.

Modifications to the location are shown on **Figure 1.3**.

On top of the above, in view of the steep topography of the area, a proper access ramp is required to facilitate regular inspection and maintenance of the intake structure. The location and arrangement of the access has also been selected carefully. To minimize the impacts to the natural indigenous habitat, the access ramp has been designed to sit on a man made slopes. Moreover, to reduce the extent of works, the access ramp is designed to 3.5m wide with 1 in 10 gradient which is the minimum design requirements.

Intake O-1

The outfall structure is located at the location recommended in the PPFS. The seafront between the Tsuen Wan and Kwai Chung is already congested with existing developments and the PPFS location avoids conflicts with existing buildings and structures. It also avoids encroachment onto private lots. In addition, an arch structure had also been constructed under the Highways Department's Contract for the improvement of the Castle Peak Road to accommodate the outfall structure.

For the arrangement of the outfall structure, apart from the cascade outfall which has been adopted in the current design, an alternative outfall structure in the form of drop shaft has also been examined. This alternative option would involve formation of massive underground structure constructed by drill and blast method under the existing slopes. The drill and blast operation would seriously affect the stability of these slopes and disturb the nearby residents. Maintenance of this underground structure would be another major concern. Therefore, this alternative option has not been adopted and the cascade structure was selected for further investigation. The arrangement of the outfall culvert has subsequently been modified by raising the outlet platform to 4.5 mPD.

For the maintenance access to the tunnel portal, the PPFS proposal (see **Figure 2.31**) by providing an access ramp connecting the Castle Peak Road to the tunnel outfall was not preferable because the newly constructed bored pile wall under the Highways Department's Contract "Castle Peak Road Improvement Between Area 2 and Ting Kau, Tsuen Wan" would block fully the proposed entrance of this access. This access would also require extensive site formation works and slope stablization works. An alternative proposal (see **Figure 2.32**) by making use of the existing road to Fung Chik Sen Villa has also been investigated. The major issue associated with this option is that the road is located within the private lots. A substantial effort had been made on reviewing the lease conditions and land status plans in the Land Registry Office and Survey and Mapping Office. However, no relevant information on the right of way of the road could be identified and this option was also not recommended. Another alternative option of providing car lift had also been examined. However, considering the high maintenance cost and the low frequency of use, it was not considered a cost effective option and not recommended to be taken forward. Having examined and evaluated against all other alternative access provision, constructing a spiral access ramp is considered the most cost effective option. It could link up the existing Castle Peak Road to the proposed upper and lower stilling basin and require the lesser extent of land for construction.

Intake Design for Intake I-2 and I-3

The stormwater interception structures of Intakes I-2 and I-3 have been critically reviewed to minimize the impact on the existing streams. In the PPFS, the intake structure was in the form of a side weir structure with twin vortex drop shafts for intercepting and conveying the target streamflow. The major shortcoming of this arrangement is that the whole width of the existing stream would be engineered to a concrete structure adversely affecting the existing ecological condition especially on the aquatic fauna. Besides that, the operation of the side weir would cause an increase in water level (maximum up to 1.5m) at the upstream of the intake structure inundating a large piece of lands and causing washouts/ erosion of existing banks.

With an aim to reduce the footprint of the works, rise in water levels at the upstream of the intake and the associated environmental impacts, an alternative intake arrangement has been examined and adopted eventually. The alternative intake structure comprises an on-line weir structure and a single drop shaft for streamflow interception and conveyance. The major merit of this arrangement is that the structure will be located only be the side of the existing stream affecting only a small portion of the stream. The extent of works will also be largely reduced. (Please refer to **Table 7.9** for the detailed assessment of the habitat loss for the original and revised schemes). Moreover, unlike the original side weir, the on-line weir will not affect the water level on the upstream side of the channel and thus reducing the extent of possible washouts/ erosion of the existing banks.

Comparison of the general arrangements and the extents of works affected of the original and alternative intake design are shown on **Figure 7.7** and **7.8**.

2.2.4 Recommendations

Based on the evaluation conducted for the shortlisted tunnel options, it was recommended to take Option 3 – the shortest tunnel option into the next stage and carry out further investigation on its engineering feasibility, environmental impact, traffic impact, land requirements etc.

Since the preferred Option 3 encroaches on a number of private lots, it will require either the enactment of the Drainage Tunnel (Statutory Easement) Ordinance, resumption of the private lands affected or creating easement through negotiation. A further recommendation of the Options Selection Report was that a ‘Design and Construct’ type of contract in a single form of contract would be the most appropriate form of delivery.

2.3 Construction Methodology

2.3.1 Rationale

At this stage of the Project the methodology described is based on the best information available. The methods proposed are practical and feasible and most likely forms of construction it must be recognised that the Contractor may ultimately opt to use different methods for delivering the Project. The rationale for using the methodology described in the following paragraphs is that it is practical, feasible and would be a favoured method for construction

Selecting appropriate methods is vital as this will also determine the extent of any mitigation which may need to be applied to ensure the legislative requirements and the standards for environmental protection can be achieved.

In the event any of the aspects of the construction works cannot achieve the environmental protection requirements, then a condition may be included in the future Environmental Permit precluding the use of certain equipment or methods.

It is therefore very important to ensure that there is flexibility in the construction methods assessed in the EIA to reduce the constraints imposed on future Contractors in terms of the methods they can adopt (always assuming these meet the prevailing standards and guidelines).

2.3.2 Construction of tunnel and underground structures (Figures 2.1 to 2.13 refers)

The drainage tunnel will be lined to avoid seepage of groundwater and thus drawdown of water table is unlikely. The main tunnel will be constructed using a Tunnel Boring Machine (TBM). The direction of drive of the TBM excavation will be from outfall to Intake I-1. The general sequence of the works is as follows:

- Construction of access road to the outfall portal from the Castle Peak Road. This access is envisaged to be formed from the Castle Peak Road. As the outfall portal is located in the mid-hill, the access road will be largely formed by extensive cut and fill activities.
- Site formation work for the outfall portal. A platform of tunnel portal will be formed and retained by a series of bored pile retaining wall.
- Mobilization of support plant and equipment to the outfall portal.
- Commencement of tunnel excavation by using TBM method.
- C&D material will be delivered to the portal for subsequent transportation to the fill bank/ public fill.
- Completion of TBM drive and retrieval of TBM from Intake I-1

Other than the main tunnel, there are other ancillary underground structures which need to be constructed. They include:

- Man access vertical shaft and stormwater drop shaft at Intake I-2 and I-3. They are about 42m and 15m below ground level respectively. The soil portion of the excavation will be retained by pre-bored 'H' soldier pile while the rock section will be mostly unsupported. The excavation through rock section will be by drill and blast method. (The details and phasing of construction for intakes will be described in Section 2.3.3 to 2.3.7).
- At the bottom of the stormwater drop shaft, there will be a deaeration chambers (horizontal) and they will be constructed by drill and blast method.
- Adit tunnels will be constructed to connect the drop shafts to the main tunnel. They will be constructed by drill and blast method.

2.3.3 Construction of surface structures

Apart from the underground structure, there are also some surface structures in the project. These structures are all located at the intake and outfall locations.

2.3.4 Intake I-1 (Figures 2.14 to 2.15 refers)

Most of the works at Intake I-1 including the construction of maintenance works area and spiral access ramp will be undertaken on sloping area which mainly involve slope cutting works, installation of soil nails, construction of retaining walls, site formation and excavation, pilings.

The construction of the proposed weir at the entrance of the drainage tunnel, the overflow weir and the sluice gate at Intake I-1 will partially block the existing Kwai Chung Nullah for site works and require temporary diversion of stream flow. It is assumed that the construction works are to be carried out in 3 phases within a dry season as below:-

- Phase 1 – The transition between the junction of the two existing channels and the proposed tunnel entrance will be constructed in this Phase. An approximate 15m long section at the confluence of Kwai Chung Nullah and its tributaries is required to be partially (approximately over half of the width) occupied for construction. Concrete beams with cement sealing the gaps, temporary pumping or even sheetpiles and cofferdam, will be employed for temporary diversion of the flows.
- Phase 2 - After completing Phase 1, the water will be diverted to the section of nullah modified in Phase 1. At this Phase, an approximate 12m long of the other half of the nullah will be closed for constructing the overflow weir and sluice gate to the existing box culvert. Similar to Phase 1, temporary diversion of the flows will be implemented.
- Phase 3 – In this Phase, the remaining part of the Shing Mun Channel will be constructed following a similar sequence as Phase 2. Same as Phases 1 and 2, sand bags, earth bund, temporary pumping or even sheetpiles and cofferdam will be employed for temporary diversion of the flows.

2.3.5 Intake I-2 (Figures 2.16 to 2.18 refers)

The construction activities in Intake I-2 will mainly involve the channel modification works, construction of retaining wall on the western side of the channel, vortex chamber and its associated on-line approach channel, the dropshaft and underground deaeration chamber, the man access shaft and connecting tunnel.

The construction of intake structure will require temporary and partial blockage of the existing Tai Ho Nullah. It is assumed that channel flow diversion works will likely be divided into 4 phases within 3 years as follows:-

- Phase 1 – Constructing the low flow channel on the western side of the existing channel by forming the new channel wall along the western embankment and diverting the dry weather flow under the existing Lo Wai Bridge to the west. Because of the limited work space available, the channel will be formed by pre-bored H pile while, to preserve the environment, the channel base will be formed as a natural river bed by using granular material. The works are scheduled to be carried out in a dry season and will take approximately 5 months for completion. The construction works will occupy less than one fourth of the existing channel and concrete beams with cement sealing the gaps, sheetpiles or cofferdam will be used for temporary flow diversion.
- Phase 2 – Constructing the dropshaft, the underground deaeration chamber and the audit tunnel to the main tunnel by temporarily closing part of the channel (approximately one third of the channel width). The stream flow will be diverted to the completed widened channel on the western side. Since the location of drop shaft is close to some sensitive structures, such as temples and CLP cable, the peak particle vibration will be restricted to 25mm/s and 13mm/s respectively. A preliminary assessment recommends that the first 10m of the shafts in Intake I-2 will be constructed by hand digging, i.e. no blasting will be adopted. For the deeper section, including the remaining depth of shafts, deaeration chamber and the audit tunnel, drill and blast method will be adopted. The construction of each shaft will take approximately 14 months. Concrete beams with

cement sealing the gaps, sand bags, sheetpiles or cofferdam will be used for temporary flow diversion.

- Phase 3 – Constructing the on-line approach channel slab, the vortex chamber and the associated trash grill. The works will mainly involve excavation, formworks and concreting. These works are scheduled to be carried out in a dry season and will take approximately 5 months for completion. The construction works will occupy two third of the channel width. During construction, the stream flow will pass the site through the remaining part of the river on the west. Concrete beams with cement sealing the gaps, sand bags, sheetpiles or cofferdam will be used for temporary flow diversion.
- Phase 4 – constructing the remaining works for the intake structure which mainly include the construction of partition wall and top slab of the approach chamber and vortex chamber. The duration of work will be limited to one month and, to speed up the process, precast elements, such as precast wall, will be adopted as far as possible.

2.3.6 Intake I-3 (Figures 2.19 to 2.22 refers)

Intake I-3 mainly involves the construction of the vortex chamber and its associated on-line approach channel, dropshaft, aeration chamber and audit tunnel, access road and slope works.

Before the construction of the intake structure, an access road is required to be formed. The construction of access road will mainly involve slope cutting and filling works and will take 5 months to be completed. After completion of the slope works, hydroseeding or other temporary measures will be taken to minimize the generation of dust. Having constructed the access road, the construction of the intake structure will then be proceeded and it will be divided into 3 phases as follows:-

- Phase 1 - Constructing the vortex chamber, drop shaft, underground deaeration chamber and audit tunnel. The works will only be carried on the slope and no major impact to the existing stream is envisaged. The drop shaft, deaeration chamber and audit tunnel will be constructed by the drill and blast method. The works will take approximately 9 months for completion.
- Phase 2 – Constructing the western on-line approach channel and its associated guide walls, the trash grill and minor channel modification works at upstream of channel. Partial blockage of the existing channel will be required and concrete beams with cement and sheetpiles will be adopted where appropriate. The works mainly involve excavation works, formwork and concreting works and are scheduled to be executed in dry season and will be completed within 5 months.
- Phase 3 – Constructing the remaining part of the approach channel and its associated guide walls, the trash grill and minor channel modification works. The construction method will be similar to those in Phase 2.

The construction activities will be carried out on the formed platform and will not disturb the existing stream.

2.3.7 *Outfall O-1 (Figures 2.23 to 2.25 refers)*

The works at Outfall O-1 will include the construction of tunnel portal, cascade, box culvert underneath the improved Castle Peak Road, spiral access ramp and laying of rip-rap on the seabed of the outlet.

Since most of the works will be undertaken on the existing slopes, earthworks will be required for the formation of haul roads and the tunnel portal. To minimize the extent of slope works, the construction of wing walls of cascade, portal and spiral access ramp will adopt the bored pile walls, soil nails and retaining walls. Apart from the slopes works, the construction activities will be mainly general civil engineering works such as formworking and concreting works.

The spiral access ramp will be formed with bored pile wall. Upon completion of this ramp, the temporary access road will be reinstated.

The box culvert will be constructed underneath the Castle Peak Road. The southbound of the Castle Peak Road will be an arch-bridge structure and the box culvert will be constructed by precast and in-situ method leaving the arch structure intact. While the northbound of the Castle Peak Road will be an at-grade road and the box culvert is inevitably constructed by open excavation. This section of box culvert will be constructed section by section in order to minimize traffic disruption. Rip-rap will be laid on existing seabed without any dredging or site formation works being carried out. This means there will be no dredging undertaken for this project.

2.4 Construction Programme

The construction and implementation programme is attached as **Appendix A**. This has been used in the EIA for the specific assessments as described in subsequent sections.

2.5 Mechanism of Intake Design

2.5.1 *Intake I-1 (Figures 2.14 to 2.15 refers)*

A 4.5m (H) x 5m (W) concrete wall is provided in front of the entrance of the existing box culvert with a small opening of 0.75m (H) x 1m (W) at the bottom while a 1.6 high weir will be provided at the entrance of the tunnel. Under normal conditions, stream flow will pass into the downstream drainage system through the small opening at the existing box culvert. When rainfall events with intensity greater than 30mm/hr, the water level will rise higher than the crest level of the weir at the entrance of the tunnel and part of the stormwater will be diverted to the tunnel.

The flow interception rates at Intake I-1 are summarized in the **Table 2.4**.

Table 2.4 Interception of Flow at Intake I-1

Storm return period	Total upland flow (m^3/s)	Flow intercepted (m^3/s)	Interception percentage
200-yr	62.79	59.37	94%
50-yr	48.40	44.83	93%
10-yr	36.09	32.76	91%
2-yr	19.95	16.97	85%

2.5.2 *Intakes I-2 and I-3 (Figures 2.16 to 2.22 refers)*

The intake structure primarily consists of a dry weather flow channel (DWFC) and an on-line intercepting channel. Under low flow condition, the stormwater will flow through the DWFC by-passing the vortex chamber. For rainfall events with intensity greater than 30mm/hr, the water level will rise higher than the top level of the DWFC and the intake will start intercepting flow into the drainage tunnel through the on-line approach channel.

The flow interception rates at Intakes I-2 and I-3 are summarized in **Tables 2.5** and **2.6**.

Table 2.5 Interception of Flow at Intake I-2

Storm return period	Total upland flow (m^3/s)	Flow intercepted (m^3/s)	Interception percentage
200-yr	80.38	53.40	66%
50-yr	62.05	38.50	62%
10-yr	46.32	26.00	56%
2-yr	25.69	10.23	40%

Table 2.6 Interception of Flow at Intake I-3

Storm return period	Total upland flow (m^3/s)	Flow intercepted (m^3/s)	Interception percentage
200-yr	252.47	97.09	38%
50-yr	194.90	71.82	37%
10-yr	145.48	47.02	32%
2-yr	80.69	21.28	26%