2. DESCRIPTION OF PROJECT

2.1 Justifications and Benefits of the Project

2.1.1 In Hong Kong, life and property are from time to time under threat of flooding due to heavy rainfall. A key objective for stormwater management and flood control is to provide a reasonable level of protection against flooding and hazardous water flow, thereby reducing to an acceptable level the potential risk of loss of life and property damage.

2.1.2 In an urbanised area such as Northern Hong Kong, stormwater management is focused on the physical stormwater drainage systems. Stormwater drainage systems are designed to collect and convey rainfall-runoff for safe discharge into a receiving watercourse or the sea. Traditionally stormwater drainage systems are constructed underneath existing public roads. However, in the project area space within the public roads is very limited and is congested with utilities.

2.1.3 The Drainage Services Department (DSD) commissioned the Northern Hong Kong Island Drainage Master Plan (DMP) Study in 1996 to assess the existing drainage systems. The Study area covers about 30 km^2, comprising 16 districts from Kennedy Town in the west to Siu Sai Wan in the east, with a residential population in excess of half a million people. Many of the existing drainage systems in the lower catchment are situated in major residential and commercial districts, warranting a high standard of flood protection to mitigate against possible major flood damage costs and consequential disruption.

2.2 Consideration of Flood Alleviation Options

2.2.1 A number of alternative options were considered in the DMP for providing the recommended flood protection standard to the study area. The investigated options which have been identified based on the need to control runoff and flooding within the urbanised environment of the study area are:-

- Reduce flows entering the drainage system (runoff control)
- Attenuate stormwater flow (retention)
- Increase conveyance capacity of existing drainage systems
- Flow diversion
- Overland flow control
- Mechanical pumping
- Flood proofing

2.2.2 Runoff control is used to reduce the peak runoff generated from a rainfall event through increased vegetation cover, storage in surface depressions, infiltration into the soil, etc. These methods are most effective at controlling the peak runoff generated during smaller rainstorm events. Within Hong Kong Island, the availability of land for implementing runoff control measures is extremely limited.

2.2.3 Attenuation refers to the temporary storage of water such that the peak outflow is less than the peak inflow. Methods of retention storage include constructed basins (impounding reservoirs, cavern storage), roof top storage, dry and wet ponds, etc. The volumes of water associated with extreme rainfall events are very large and accordingly, the volume of storage required for effective flood control would be large. Within the Study Area, there are no areas suitable for large storage basins to be

constructed.

2.2.4 Conveyance capacity improvement refers to increasing the size of the existing system so as to enable the design flows to safely pass. This is the most common method for increasing the capacity of urban drainage systems. However, increasing the size of the existing drainage pipes would necessitate considerable disruption to traffic flows and lives as existing drainage systems are dug up and replaced. In addition, there are a number of other utilities and underground obstructions which could make construction in these urban areas very expensive and disruptive. This option can therefore be considered for limited areas but not as a solution for the entire Study Area.

2.2.5 Flow diversion involves interception of the flows and channelling them through a new route to the sea. For urban areas like Northern Hong Kong Island, flow diversion would require the new route to be constructed within an underground tunnel to minimise the impact of construction. This is the preferred option and is the focus of the present EIA.

2.2.6 Overland flow control is essentially controlled flooding. For this option, flooding would be allowed to occur but the flood waters would be channelled at surface level along specially designed and designated flood routes. Currently there is a lack of space within Hong Kong to construct such flood routes and the suddenness of flooding means that public safety could not be guaranteed.

2.2.7 Mechanical pumping could be used for increasing the rate of discharge to the sea. This is effective for areas where flooding is due to limited discharge rates rather than the capacity of the existing system. However, there is lack of space within Hong Kong from Causeway Bay via Central to Western to build the pumping station and the associated pipework.

2.3 Project

2.3.1 Assessment of the possible flood alleviation options for Northern Hong Kong Island during the DMP Study identified that diversion of the flood flows through a tunnel is the preferred option as it effectively deals with the large volumes of water whilst minimising the impact on property, people and the environment.

2.3.2 The feasibility of constructing the Project has been confirmed through extensive investigations and study. The preferred option of a stormwater drainage tunnel to divert flows was evaluated and confirmed to be the preferred option based on technical, economical and environmental impacts. An environmental review of the preferred scheme has confirmed that there are no insurmountable environmental impacts associated with the construction and operation of the scheme.

2.3.3 Following confirmation of the drainage tunnel option as the preferred scheme, a number of alternative alignments were identified and evaluated. The selection of the preferred alignment has considered issues such as technical requirements, land issues, project cost, construction programme, environmental impact and landscape impact. The key points relating to environmental issues are reported in this chapter.

2.3.4 The Project will intercept and divert storm flows from significant watercourses that drain into the commercial and residential areas of Northern Hong Kong Island, and convey the intercepted flow via a tunnel system to the sea. The general alignment of the main tunnel starts from Tai Hang in the east of the project area and discharges to

the western portal outlet that will be located on the western coast of Hong Kong Island adjacent to the Lamma Channel. Two locations for the western portal are considered in the present Chapter with the preferred site being located near Cyberport. The locations of the Project including the tunnel alignment and the intake shafts are shown on Figures 2.1, 2.1(a) to 2.1(c).

2.3.5 The horizontal alignment will pass beneath the fringe of the urban areas in the mid-levels of North-Western Hong Kong Island. The tunnel alignment passes below the Tai Tam, Aberdeen, Pok Fu Lam and Lung Fu Shan Country Parks, but the portals and intake shafts are outside of these Parks. From the eastern portal on Tai Hang Road, adjacent to the Haw Par Mansion, the tunnel is generally aligned in a south-western direction and passes beneath the western edge of the Tai Tam Country Park. The tunnel passes underneath the Braemer Hill Gas Tunnel, WSD's Tai Tam Conduit and HEC's Nam Fung to Parker Cable Tunnel while passing above the Aberdeen Tunnel. The average depth of the tunnel is approximately 225m below ground with a maximum depth of approximately 340m.

2.3.6 Since a portion of the proposed tunnel route passes below the boundaries of Pok Fu Lam, Aberdeen, Lung Fu Shan and Tai Tam Country Parks, the project is classified under item Q1 in Schedule 2 of the EIAO as a Designated Project. The location of Country Park areas along the tunnel alignment are shown on Figures 2.4, 2.4A & 2.4B.

2.3.7 Seven horizontal alignment options have been considered as part of the preliminary design of the project and these are discussed in more detail in Chapter 2.6.

2.3.8 The vertical alignment of the main tunnel is restricted by the elevations of the proposed eastern and western portals of the tunnel, and the elevation of the Aberdeen Tunnel over which the tunnel must past. The elevation of the eastern portal is relatively high within the project area (about 43mPD) while the elevation of the western portal is near sea level. In order for the tunnel to pass over the Aberdeen Tunnel the main tunnel will have an initial gradient of 1 in 349 which steepens after the Aberdeen Tunnel to 1 in 204. Figure 2.2 shows the horizontal and vertical alignments of the preferred tunnel system.

2.3.9 The diameter of the tunnel is designed to convey the intercepted flood flows for a 200-year storm event occurring across the complete catchment. The internal diameter of the initial section of the main tunnel, before the Aberdeen Tunnel, is 6.25m, while the remaining tunnel has an internal diameter of 7.25m.

2.3.10 Thirty five intake locations have been identified within the project area that are suitable for intercepting flood flows and thereby benefiting the lower urban areas by reducing the flood risk. To maximise the objectives of flood alleviation in the lower catchment all intakes are located as low as possible within their respective catchments in order to intercept as much flow as possible. The choice of sites to locate individual intakes is limited by the following constraints: for ideal flood alleviation in the lower catchment the intake must be as low as possible within the catchment; the site must be owned by the government; the site must have sufficient area for the intake structure; the site must have vehicle access for construction and maintenance access; and, in order to connect the intake to the main tunnel there must be a clear alignment for the adit that does not pass beneath privately owned land. Figures 2.3-1 to 2.3-35 show the locations and boundaries of each intake site.

2.3.11 The most upstream intake structure, which intercepts flow within the stream adjacent to the Tiger Balm Gardens and is the largest intercepted flow, is combined with the eastern portal. This intake structure is unique compared to the other intake structures as it consists of a weir that impounds the existing watercourse and a diversion channel for the flood water to flow into the start of the main tunnel (Figure 2.14). The general design of the intake is to initially dissipate the energy within the highly turbulent and fast flowing stream flow within an energy stilling basin before discharging the flow into a short tunnel that links the natural watercourse with the main tunnel. The stilling basin will also trap large stones and boulders mobilised by flood flows and enhance the sedimentation of fine particles. A trash and security screen will prevent unwanted public access to the tunnel and trap most debris.

2.3.12 Investigation to identify other possible location for the Eastern Portal has been carried out but the site that is near to Haw Par Mansion is considered the most ideal location with due consideration of the following factors:

- The stream by the side of Haw Par Mansion collects a significant amount of flow from the catchment area above Haw Par Mansion. The catchment area is about 19% in area of the total catchments to be intercepted by the proposed drainage tunnel. Without intercepting the flow from this stream, it will significantly reduce the flood protection provided by the tunnel scheme to the lower catchment area;
- In order to maximize the volume of water interception, the Eastern Portal has to be located as near to the downstream end of the catchment as possible. The selected site is the nearest site on the outskirt of the urban area;
- Relocation of the portal site further upstream means reduction in the catchment area to be intercepted. In addition, it will inevitably involve a substantial site formation works resulting in a greater loss of natural habitats;
- Relocation of the portal site further downstream means to build the portal in the urban area. No ideal sites that is large enough for the portal is identified; and
- The Eastern Portal is a gateway to the tunnel for daily operation and maintenance purpose. The current site for eastern portal is in close proximity to Tai Hang Road, providing an easy access to the portal.

2.3.13 The remaining intakes are all located on steep watercourses across the project area. Because the watercourses are extremely steep there is no opportunity to construct sediment and debris traps upstream of the intake locations. Therefore through necessity these intakes have an innovated design that was specifically developed to ensure large stones, boulders and debris are prevented from entering the intake while maximising the intakes hydraulic efficiency and conveyance of sediments. Their design is shown in Figure 2.17. These intakes are a combination of two hydraulic structures.

i. Firstly, the flow will enter the intake structure through a bottom rack intake which comprises of a screen with bars aligned with the watercourse placed on its invert. The flow ‘falls’ through the screen into the structure beneath. The proposed spacing between bars is sufficiently wide enough to ensure effective flow diversion while maximising the prevention of large stones, boulders, larger wood, and debris from entering the tunnel system. The bar sizes are also large enough to support material resting on the bars and also will allow for some leaves and litter to be trapped. Lateral beams below the bars will facilitate structural support and aid trapping of leaves and litter. It is intended that all reject material (large stones, boulders, debris, leaves and litter) will accumulate at the downstream end of the screen ready for removal by maintenance staff. The screen will effectively be self

cleansing and should not block during flood events.

ii. Below the screen the flow passes into a vortex inlet before flowing down the vertical drop shaft. The vortex inlet forces the flow entering the drop shaft into a helical flow pattern which reduces the vertical acceleration of the flow while increasing the energy dissipation within the drop shaft, and provides a stable central air core that allows entrained air within the flow to escape back up the drop shaft.

iii. All the untrapped sediment, small stones and leaves will be conveyed through the screen down to the tunnel system. In light of this, a sand trap will be provided at the bottom of each drop shaft to trap the coarser particles and small stones (Figure 7.9). The trap will be most effective for low flow condition. It should be noted that there is unlikely to have litter present within the flow approaching the intake because the catchments are mostly natural catchments or country parks.

iv. Any vegetation and leaves that pass through the intake will be flushed through the tunnel system by the storm flow and will discharge into the sea similar to what occurs for all currently operating stormwater intakes and drainage systems. Some of this material will float on the surface of the sea but because of flow conditions within the tunnel system and site constraints at the tunnel outlet (the Western Portal) there are no formal facilities proposed to further trap leaves or other floating material. Maintenance, including the removal of leaves and other potential floating debris, will be carried out on the water courses at the intakes and within the tunnel system itself before the onset of every wet season to minimise the amount of leaves and floating debris that may discharge to the sea. Leaves and other debris floating within the discharge plume would be collected should it be necessary following large storm events. Based on the balance of maximising the effectiveness of the tunnel system preventing flooding in the lower catchments of Northern Hong Kong Island and the occasional discharge of leaves during extreme storm events into the sea, the latter is considered a reasonable residual impact.

2.3.14 All intakes will include a low flow bypass to allow pre-determined baseflows to bypass the intake structure and discharge into the existing drainage system (Figure 2.18).

2.3.15 The intakes are connected to the main tunnel via vertical drop shafts and adits. The depths of the drop shafts range from 15 metres up to about 180 metres. Chambers are placed at the bottom of the drop shafts to dissipate energy and remove entrained air within the flow. The flow then passes through a system of adits which are smaller tunnels with an internal diameter of 2.3 metres, before joining the main tunnel. The gradient of all adits is 1 in 200.

2.3.16 The outlet structure at the western portal will dissipate the energy of the diverted flow within the tunnel before discharging into the Lamma Channel using an energy stilling basin (Figures 2.19 & 2.20). The energy stilling basin will reduce the velocity of the discharging flow thereby helping to protect the existing sea floor of the Lamma Channel. To increased protection an armour layer of riprap will also be placed on the sea floor in the vicinity of the western portal.

2.3.17 Two sites that are investigated as being suitable for the location of the western portal are constrained by existing land use, slopes and the coastline to build a sediment trap at the western portal. However the reduction in the flow velocity within the stilling basin could enhance the sedimentation of the fine particles, reducing the amount of fine

particles being flushing through the tunnel system into the sea. Nevertheless, for EIA assessment, the possible adverse impacts on water quality without any sedimentation at the discharge outlet are considered and assessed, and mitigation measures are proposed wherever necessary.

2.3.18 Both the eastern and western portals provide vehicle access to the tunnel system and all drop shafts are designed with sufficient internal diameters to allow entry for maintenance staff using suitable equipment.

2.3.19 Limited improvements to urban drainage system have been recommended in flood prone catchments not serviced by the Project. These urban drainage improvements are not subject to the EIA process.

2.4 Consideration of Construction Techniques

Construction of Tunnels and Adits

Tunnel Boring

2.4.1 Tunnel boring machines (TBM) are commonly used for the excavation of longer tunnels. The advantages of excavation by TBM are relatively high production rates compared with alternative methods for rock excavation, a controlled excavation profile, and low vibration and noise generation.

2.4.2 Given the length of the main tunnel, the unit cost for excavation using a TBM compares favourably with other methods of excavation. TBM construction is therefore proposed for the main tunnel excavation. A double-shielded machine is proposed that will minimise water ingress, although progress rates for an un-shielded TBM are generally slightly higher. This could avoid seepage of groundwater and thus drawdown of watertable.

2.4.3 TBM excavation consists of an approximately 180m long machine including back-up units. Excavated material is carried by conveyor over the back-up units from where it can be carried out of the tunnel by either conveyors or rail cars. Operation of the TBM requires electricity to be delivered to the unit via an 11kv cable within the tunnel. Ventilation and lubrication of the cutting face is necessary to prevent the build up of dust arising from excavation.

Drill & Blasting

2.4.4 Drill and blasting is commonly used for the excavation of hard rock tunnels. Blasting is a relatively cheap method of construction. In addition, relative to TBM excavation, blasting does not require the lengthy period up-front for procurement nor the large area for assembly. Excavation by blasting is not a continuous operation and consequently has lower production rates than TBM excavation. The progress rates for blasting are affected by the time to drill the holes, charge the explosive, remove the material and install temporary supports. In addition, the progress is affected by the delivery of the explosives and the need to retain blast induced vibrations within the threshold limits. Generally, blasting results in greater vibration than TBM excavation, but for less duration.

2.4.5 Blasting is seen as the most suitable method of excavation for the adits due to the relative cost of alternative methods of construction. Blasting is not seen as a suitable

method of excavation for the shafts due to the noise generated. Given the proximity of the intake shaft locations to sensitive receivers, blasting would need to be severely restricted to remain within the noise restrictions. Construction of shafts by drill and blast would also necessitate the shafts to be constructed larger than the 2.3m diameter required to enable spoil to be removed. This would consequently lead to slower progress and would also cause difficulties at many intake shaft locations, where the working area is very restricted.

Chemical Blasting

2.4.6 An alternative to the use of conventional explosives is to carry out drill and blast operation using chemical explosives. These include penetrating cone fracture and propellant systems. These methods are subject to the same restrictions and regulations as conventional blasting. In theory, chemical blasting should result in lower vibrations although this depends on finding experienced operators.

2.4.7 Similar to conventional blasting, the use of chemical blasting requires a number of discrete operations (drill holes, place explosive, blast, muck out and place supports). However, the cost of the chemical explosives is considerably greater than that for conventional explosives. In addition, the blast cycle takes considerably longer than conventional blasting, which limits the number of blasts achievable in a day. For the above reasons, these methods are normally only used in specialised applications such as blasting very close to existing structures.

2.4.8 The use of chemical blasting for the construction of the tunnels and adits is seen as unlikely given that conventional blasting is a more economical method of construction. In addition, chemical blasting offers no advantages in terms of programme as its use is subject to obtaining blasting permits and addressing the same issues of storage, delivery and handling as conventional blasting.

Mechanical and Non-Explosive Systems

2.4.9 Mechanical and non-explosive systems have the advantage that they are not subject to the approvals process of blasting nor the need for special precautions. There are a number of systems available, although these are generally more expensive than blasting and many of these systems have not been fully proven.

2.4.10 Examples of non-explosive systems for rock excavation include radial-axial splitters, controlled foam injection, water injection, and plasma blasting (electrical). Many of these systems produce lower vibrations than conventional blasting. These systems are however more expensive and production rates are lower than for blasting.

2.4.11 It is likely that some of these systems are employed for construction of adit junctions, surface work and some of the smaller adits. Unlike blasting, using these systems work can be carried out at the same time in other parts of the tunnel.

Construction of Drop Shaft and Intakes

Raise Boring

2.4.12 Raise boring method (RBM) is a technique which can be used for vertical construction of a shaft in very competent rock. Excavation is carried out by a reamer which is pulled back towards the rig. As such, this technique can only be used for construction

of straight shafts or adits where access is available to both ends. The system does not have any provision for temporary support of the excavation and as such is only suitable for areas where the rock is self supporting.

2.4.13 Raise boring method does offer the advantage of continuous production with good advance rates and can be operated without requiring a large working area at ground level. This is a particular advantage for the construction of the shafts, where the working area is often tight. Shafts built using this technique could only be constructed once the main tunnel and adits have been completed.

Reverse Circulation Drilling

2.4.14 This drilling technique is used for pile construction from the surface but it is equally appropriate for shaft construction. It consists of a drilled hole with compressed water or drilling mud used for flushing out the cuttings. Excavation can either be carried out using a rotary coring bit or a percussive hammer. Reverse circulation drilling (RCD) is the fastest of the surface excavation techniques, although it is more expensive.

2.4.15 Relative to other surface construction techniques, RCD rigs require less working space. However, the process generates slurry which needs to be dewatered prior to removal from site. The dewatering plant requires additional land take and as such, this method may not be suitable for some of the more restricted sites.

2.4.16 RCD construction has the advantage that this method is well suited to a wide range of geological conditions. As such, this method of construction is well suited for those shafts which cannot be constructed using the raised boring machine.

Hand Excavation

2.4.17 Hand excavation of shafts is particularly suited to excavations within softer material and shallow excavations. Hand excavation generally requires much smaller working areas at the surface than alternative excavation methods although progress rates are considerably lower. Temporary support and ventilation must be carefully designed to ensure the safety of workers during construction.

Conclusion

2.4.18 By comparing the pros and cons of the various construction methods as mentioned above, Tunnel Boring Machine, Raise Boring method and Drill & blasting method are the most practical construction method for the drainage tunnel, intake shafts and adits respectively. The assessment results, recommendations and conclusions have been addressed in this EIA report based on the proposed construction techniques/methods.

2.5 Consideration of Tunnel Alignment Options and Intake Locations

2.5.1 Seven possible tunnel alignments were investigated before selecting the Project. These seven alignment options are summarised in Table 2.1 and shown in Figures 2.5-2.12. In all cases the intakes are positioned on existing main drainage paths that intersect with the tunnel alignment. At these locations the flows are intercepted and directed to the tunnel. Photos taken at the proposed intake locations are shown in Figure 2.13.

2.5.2 While the engineering team has identified a set of seven different alignment options, in environmental terms the potential for impact is simplified into three impact zones:

- Eastern Portal located adjacent to the Haw Par Mansion (this is common to all tunnel alignment options);
- The tunnel alignment between the Eastern Portal and the Western Portal of which there are 7 options considered; and
- The Western Portal location. There are two alignment options considered, the first immediately north of Cyberport and the second is located on the very western edge of Hong Kong Island adjacent to the Sulphur Channel.

2.5.3 Where there are specific differences between alignment options, they are discussed in terms of environmental indicator areas e.g. air quality (dust), noise, ecology, cultural heritage, visual and landscape and water quality.

2.5.4 There are three main selection criterions that have been used to identify the locations of the proposed intakes. The first is that the sites must be located adjacent to the watercourses to allow for flow to be intercepted and diverted into the Project; the second is that vehicle access to the intakes must be possible for construction and maintenance reasons; and thirdly their location should be low within the catchment to maximise the amount of flow that is diverted thereby maximising the effectiveness of the project. At each intake site the layout of the site is dependent on the surrounding environment including access arrangements, existing nearby structures, ground topography, position of existing trees, and existing habitat.

Table 2.1: Alignment Selection

<table>
<tr><th>Option</th><th>Alignment</th><th colspan="2">Tunnel Alignment Description</th><th>Western Portal Location</th><th>Abbreviated Option Name / Figure Number</th></tr>
<tr><th></th><th></th><th>Eastern Portal to Lung Fu Shan</th><th>Lung Fu Shan to Western Portal</th><th></th><th></th></tr>
<tr><td rowspan="2">A</td><td>1</td><td rowspan="2">passes under urban areas in Jardine's Lookout and Mid Levels</td><td>passes below urban areas, below Mt Butler to the Sulphur Channel</td><td>Sulphur Channel</td><td>A1 / Figure 2.6</td></tr>
<tr><td>3</td><td>a sinuous alignment below Pok Fu Lam to Cyberport</td><td>Cyberport</td><td>A2 / Figure 2.7</td></tr>
<tr><td rowspan="2">B</td><td>9</td><td rowspan="2">a sinuous alignment south of Option A and outside the footprint of the urban area</td><td rowspan="3">passes below urban areas, below Mt Butler to the Sulphur Channel</td><td rowspan="3">Sulphur Channel</td><td>B1 / Figure 2.8</td></tr>
<tr><td>11</td><td>B2 / Figure 2.9</td></tr>
<tr><td rowspan="3">C</td><td>21</td><td rowspan="3">a straighter alignment than Option B and south of Option A outside the footprint of the urban area</td><td>C1 / Figure 2.10</td></tr>
<tr><td>23</td><td>a sinuous alignment below Pok Fu Lam to Cyberport</td><td rowspan="2">Cyberport</td><td>C2 / Figure 2.11</td></tr>
<tr><td>29</td><td>a straighter alignment below Pok Fu Lam to Cyberport</td><td>C3 / Figure 2.12</td></tr>
</table>

2.6 Consideration of Environmental Issues

2.6.1 The key environmental issues for assessment were divided into two sub-sections: construction and operation. These are described in the following paragraphs and were used for environmental evaluation of the seven alignment options.

2.6.2 Potential impacts during the construction phase:

- Dust impacts on Sensitive Receivers (SR) at the tunnel portals;
- Noise impacts on Noise Sensitive Receivers (NSRs);
- Water quality impacts from polluted construction water migrating offsite;
- Excavated spoil handling, including identification of material reuse;
- Permanent or temporary ecological impacts affecting directly or indirectly the stream habitats at the portals and intake sites; and
- Impacts on sites of cultural heritage.

Potential impacts during the operation phase:

- Marine water quality impact at the tunnel outfall during storm water discharge; and
- Visual and landscaping impacts at the Western and Eastern portals.

2.7 Eastern Portal

2.7.1 The Eastern Portal, which is common to all tunnel alignment options, will be established adjacent to an existing watercourse at the southern end of a car park immediately east of the Haw Par Mansion and south side of the Tai Hang Road. During construction, activities in the works area will include:

- initial excavation/breaking to establish the portal;
- excavation and construction of the stream diversion structure;
- assembly and operation of the tunnel boring machine;
- handling of the spoil;
- supply of materials for construction of the stream diversion structure and tunnel; and
- establishment and dis-establishment of site offices.

2.7.2 Standard working procedures will be required to ensure adverse impacts are minimised. It is expected that construction activities will generate dust, although these can be mitigated through simple site based measures.

2.7.3 Construction and operation of the Eastern Portal will have limited ecological impact. For the construction phase, the impact will mostly be associated with minor construction activity within the existing streambed.

2.7.4 Although the Eastern Portal is located adjacent to Haw Par Mansion, construction and operation should have no significant impact on the cultural heritage of the building. During the operation phase the only foreseeable impact is visual which can be mitigated with suitable landscaping and architectural measures.

2.8 Tunnel Alignment

2.8.1 The tunnel boring machines will create a tunnel running from the Eastern Portal to the Western Portal located on the west side of HK Island. There are three routes identified.

Alignment Options A1 and A3 lie beneath the urban area and are considered to have a higher potential for creating impact from structural borne noise.

2.8.2 Spoil from the excavation of the tunnel will be removed via the Eastern and Western Portals. These will be the principal working areas for access and egress to the tunnel construction areas. Although there are limited differences in respect of spoil quantities removed, the selected alignment Option C29 will generate the least quantities of Construction and Demolition material (C&D) material.

2.9 Western Portal

2.9.1 The Portal will be an engineered structure specifically designed to discharge tunnel flow into the sea while maximizing dissipation of the flow's energy. The emerging tunnel will have a diameter of 7.25 metres (internal diameter), it will pass into a rectangular profile channel that will widen to about 18 metres over a distance of about 80 metres. Thereafter the flow will pass into an energy dissipating structure that discharges directly into the sea. The layout of the proposed structure is shown in Figure 2.3-35. Most of the structure will be below sea level and it is proposed that all of the structure will be below final ground level to make the site more visually attractive. The Portal will also be the site where a TBM will start construction of the tunnel alignment working from the western portal. In both cases, no reclamation is required to position the stilling basin.

2.9.2 There was two tunnel discharge locations considered depending on the tunnel alignment. The first is located immediately north of Cyberport and for the second is located immediately west of Mount Davis, within the Sulphur Channel.

Cyberport Portal Site

2.9.3 The portal will be constructed on an existing reclaimed area of land beneath the northern access road to Cyberport. The portal will be close to SR's at Cyberport and its tunnel alignment passes beneath the Queen Mary Hospital. Potential impacts of this alignment include the potential impact on residential property and the Queen Mary Hospital from Structure Borne Noise. During the operation phase concerns may include the portal's visual impact, the visual impact from silty discharge, possible smothering of marine fauna and possible impact on Fish Culture Zones (FCZ).

2.9.4 The closest sensitive receivers to the Cyberport site are those that are located high on the headland of Point Breeze about 150 metres to north of the site. The portal may have visual impact on those SR's located high enough, however the structure will be shielded by the Cyberport access road and will be covered by reinstated ground leaving only the air vent, access road and outlet at the shoreline visible. SRs in Cyberport will be shielded from direct line of sight by the existing Sewerage Treatment Works whereas SRs located on the water, to the west of the site, will have uninterrupted views of the portal structure.

2.9.5 During construction dust could be generated from construction activities. Simple site precautions will be required to ensure that adverse impacts are minimized.

2.9.6 The impact of structure borne noise during construction of the tunnel on the Queen Mary Hospital will need to be assessed to determine acceptable levels of impact. At the portal sensitive receivers are remote from the site and severe impact is not anticipated

if normal precautions are adopted.

2.9.7 The sea floor immediately adjacent to the portal site is already altered due to the construction of the reclamation. A temporary pier will be constructed on the sea floor and then replaced with an area of permanent armour rock (refer to Figures 2.15 and 2.16). Because the sea floor is already in an altered state the impact of the proposed pier and armour is unlikely to adversely affect the existing environment. However, possible smothering of benthic organisms due to additional silt discharge will need to be addressed. Likewise, the effect on benthic organisms on the seabed and the Fish Culture Zones (although they are remote being 4.5km from the site) on the east side of Lamma Island will need to be addressed.

2.9.8 There are seawater intakes north of the site for Queen Mary Hospital (300 metres) Sandy Bay (1200 metres) and proposed intake at Telegraph Bay (500 metres). The discharge plume into the sea will need to be modelled to determine if the suspended solids within the plume and the freshwater both interfere with the intakes. Similarly, any silt plume migration would have an impact over a large area and would be visible to elevated SRs on the west side of HK Island including Cyberport.

2.9.9 No sites of cultural heritage have been identified in relation to either the proposed tunnel alignment or the western portal site.

Mount Davis Portal Site

2.9.10 Alignments A1, B1, B2 and C1 pass beneath Mount Davis to a portal structure on rocky shore immediately south of the Sulphur Channel. The alignment and portal are remote from residential developments on Mount Davis Road. The entrance into Victoria Harbour through the Sulphur Channel is considered to be one of the "gateways" to Hong Kong. The presence of a large outer structure on the promontory would be highly visible to observers on boats entering and leaving Victoria Harbour. There is potential for silt to enter Victoria Harbour creating visual impact and impact on sea water intakes in addition to loss of rocky shore habitat and possible smothering of benthic organisms.

2.9.11 There are no land based SRs in the immediate area. The closest are isolated developments on Victoria Road however these are screened by intermediate topography. Receivers on the water to the west will have uninterrupted views of the portal and any spillway structure. Benthic organisms on the seabed could be affected by silty discharges, though currents are swift and advection and dispersion is likely to be high in this area. There are seawater intakes within Victoria Harbour serving Kennedy Town.

2.9.12 During construction, dust could be generated from general portal construction. However, the site is remote and simple site precautions should ensure acceptable levels of impact.

2.9.13 The discharge plume into the sea will need to be modelled to determine if the suspended solids within the plume and the freshwater both interfere with domestic intakes. Likewise the model will show the risk of smothering of benthic organisms due to additional silt discharge. Any silt plume migration would have an adverse impact over a large area and could be visible within Victoria Harbour.

2.9.14 No sites of cultural heritage have been identified in relation to either the proposed

tunnel alignment or the western portal site.

2.10 Intake Structures

2.10.1 On the alignment between the Eastern Portal and the Western Portal 35 intake structures will be constructed on existing stormwater flow paths to collect surface water. An intake diversion structure and drop shaft will be constructed to take water down to the level of the tunnel and a horizontal adit will take the flow from the base of the shaft into the tunnel.

2.10.2 The intake structures will require the construction of a concrete flow interception structure with safety and operational covers, and secure access points. The structures will be more visually prominent than the existing flow channel. The intake sites can be close to existing residential properties that are sensitive to noise, air quality and visual impact. While the structures themselves may occupy an existing built site, some may encroach upon vegetated slopes and temporary work areas typically extend into vegetated slopes.

2.10.3 The vertical shafts will require the excavation, removal of spoil material and the fixing of pre-cast concrete liners. Most of the shafts will be constructed from the bottom up, using a Raised Boring Machine. If the shaft is remote from the main tunnel a connecting adit will be constructed underground.

2.10.4 It is anticipated that the adits will be constructed using drill and blast methods. As the adits will not be directly connected to the surface and will be constructed at depth (in general, 60m – 200m below the surface), the noise associated with this construction method will be very limited.

2.10.5 The intakes for Alignment Option A are either sited directly over, or close to, the tunnel alignment. For these intakes some noise impact is expected.

2.10.6 For Alignment Options B and C the intake locations are further away from the urban area. The expected noise impacts during construction activities are therefore lower than that expected for alignment options.

2.10.7 Spoil from the construction of the adits will be removed via the tunnel to the two portals. Similarly, shafts constructed using the Raise Bore method will have spoil removed via the tunnel to the portals. It is anticipated that this construction method will be used for the majority of shaft excavation although alternative methods will be required for those few shafts where the ground conditions are unsuitable for Raised Bore construction techniques. In these cases, spoil from the shafts would be removed at the surface at each intake site.

2.10.8 During the construction of the intakes all flow within the watercourses will bypass the construction sites and continue flowing in to the existing downstream drainage system. Therefore the existing drainage capacity in the downstream lower catchments will not be affected or get worsen by the construction of the Project. When the tunnel system is operating the potential flooding in the lower catchments will be substantially reduced.

2.11 Conclusion on Option Selection

2.11.1 For the Eastern Portal near Haw Par Mansion which is common to all alignment options and there are no clear environmental differences. On the alignment itself, the TBM will have minimal environmental impact but as Alignment Option A passes beneath the urban area there is a higher possibility of structure borne noise and for this reason it is considered to be less environmentally attractive than Alignment Options B and C.

2.11.2 The locations of the proposed intake structures is restricted by watercourse alignments, land availability and construction and maintenance access so provision of the intake structures will need to address visual impacts and potential to adversely affect cultural and heritage sites, noise, air (dust), water quality and solid waste management during construction phase.

2.11.3 The Western Portal may impact on seabed ecology due to the local introduction of silt and fresh water, potential impacts on seawater intakes and the visual impact at the portal structure itself. However the impacts are broadly similar for both tunnel alignments and at both western portal sites. The portal at Cyberport will be closer to SRs and there is a higher potential for impact, though mitigation is available. The Mount Davis site is undeveloped and it could be argued that this increases severity of the visual impact and silt could enter Victoria Harbour. For this reason the Mount Davis portal is considered to be marginally less environmentally attractive.

2.11.4 From an environmental perspective there are only minor differences between alignment options but in engineering terms there were more definitive differences and Alignment Option C3 was selected as the Project. The main advantage of this alignment option is to avoid encroachment upon private land lots and with greater separation between the tunnel centre line and the private lots (wherever possible). This has the added environmental benefit of minimizing the potential construction noise and fugitive dust impacts to the residential / GIC units on private lots. The adopted portal site will prevent damage to rocky shore habitats under the current Project design since it is proposed to be constructed on existing reclaimed land.

2.12 Hong Kong West Drainage Tunnel

2.12.1 Following an extensive engineering, environmental and economic review of possible intake shaft locations, outfall locations and tunnel alignments, the following option was chosen:

- A continuous main drainage tunnel – the first section of 4.5 kilometres with an internal diameter of 6.25 metres from Tai Hang Road to Aberdeen Tunnel, and from the Aberdeen Tunnel to Cyberport the second section of tunnel of about 6.0 kilometres in length with an internal diameter of 7.25 meters;

- A system of Adits with total length of about 7.5 kilometres and internal diameter of 2.3 meters that connect the intakes with the main drainage tunnel;

- Thirty five intakes that will intercept existing flows and divert them via 30 dropshafts to the drainage tunnel. The intakes will include the in-stream flow diversion structure (including screen for preventing debris and large stones from entering the tunnel system), vortex inlet to facilitate stable flow within the drop

shaft, the drop shafts, a low flow bypass channels and maintenance platforms. The drop shafts vary in height with the shortest being 8 metres and the longest being approximately 180 metres;

- An outlet to the sea at Cyberport that includes an energy stilling basin to ensure low velocity outflows into the Lamma Channel;

- Two tunnel portals at the east and west end of the tunnel alignment. The eastern portal in combined with the largest intake structure and the western portal is combined with the outlet structure. Both portals provide for vehicle accesses for maintenance purposes.

2.13 Design and Construction Programme

2.13.1 The design and construction phase is expected to commence in end 2005. Tentative Construction Programme for the proposed drainage tunnel is May 2007 to Nov 2011. The maximum tentative construction programme for the deepest intake shaft is about than 12 months.

2.14 Concurrent Projects and Potential Cumulative Impacts

2.14.1 There are no scheduled concurrent public works in the vicinity of the proposed tunnel portals, intakes or tunnel alignment. No cumulative construction impacts are likely to arise from this Project.

2.14.2 Potential cumulative impacts in terms of water quality during the operation phase with the concurrent operation of the Cyberport Sewage Treatment Works in the short term are provided in Section 7.