

# **HONG KONG-SHENZHEN WESTERN CORRIDOR: ENVIRONMENTAL CHALLENGES FROM EIA STUDY TO CONSTRUCTION**

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## **BACKGROUND AND ENVIRONMENTAL CHALLENGES**

For every infrastructure project, there are tough hurdles and challenges. Hong Kong-Shenzhen Western Corridor (HK-SWC) is no exception and got a few.

HK-SWC is the fourth vehicular boundary crossing between Hong Kong and Mainland China. It is a dual three-lane highway across Deep Bay, linking the north-western territory of Hong Kong with Shekou of Shenzhen. This is a joint project between the governments of Hong Kong Special Administrative Region (HKSAR) and Shenzhen, each side responsible for the design and construction of the portion of HK-SWC within its own territory. To ease passage of goods and travellers through the boundary crossing, the boundary crossing facilities (BCF) of both governments are to be co-located at the Shenzhen landing point of the crossing.

There are many challenges for the HK-SWC project, including three major ones. The first challenge comes from its location at the environmentally important but sensitive ecosystem of Deep Bay. The second challenge is due to the joint implementation of the HK-SWC by two governments which have different laws and standards; in particular, Shenzhen has different criteria for environmental impact assessment (EIA) and is not bound by Hong Kong's Environmental Impact Assessment Ordinance (EIAO), Cap. 499, S.16. The third one is due to the extremely fast track implementation of the project, with only four years and four months for investigation, planning, EIA study, conceptual design, detailed design, tender documentation, tendering, construction commencement, and all the way to substantial construction completion. Other environmental challenges include disturbance zone, bird collision with man-made structures and compensation of loss in mudflats.

### **Deep Bay**

As soon as the investigation and planning consultancy of the project started in August 2001, there were critical issues relating to Deep Bay that seemed to be bordering insurmountability and the project was like a mission impossible.

Deep Bay is well known for its high ecological value. The coastal area of Deep Bay comprises extensive low-lying inter-tidal mudflats and large stands of mangrove forests. The mangroves and the mudflats provide refuge for a wide variety of crustaceans including the rare horseshoe crab species and other fauna, such as mudskippers. Locating on the main East Asia migration route, Deep Bay has been serving as a 're-fuelling stop', wintering ground and breeding ground for tens of thousands of birds, including the endangered species of Black-faced Spoonbill.

Mai Po in the Inner Deep Bay is about 6 km northeast of the project site. It is well known for its extensive mangrove forests (about 380 ha), reedbeds (45 ha) and the traditionally operated shrimp ponds known as 'gei wais' (240 ha). Under the Convention on Wetlands of International Importance especially as Waterfowl Habitat (commonly known as the 'Ramsar Convention', which is an international treaty signed in Ramsar, Iran in 1971 with an objective to conserve and promote the wise use of wetlands), Mai Po was designated as a 'Wetland of International Importance' in 1995. Mai Po is best known as a heaven for birds. World Wide Fund (WWF) Hong Kong reported that about 72% of all the bird species recorded in Hong Kong have been found in Mai Po [Figures 1 and 2]. Mai Po is a core feeding ground for resident birds as well as tens of thousands of migratory birds which have flown thousands of kilometres from as far north as Siberia and as far south as New Zealand, including globally significant numbers of several threatened bird species.

Figure 1 – Egrets and Grey Herons in Mai Po



Figure 2 – Cormorants in Mai Po



However, since Mai Po is located on mudflats near the mouth of Shenzhen River, sedimentation at the river mouth has in recent decades raised the surface of mudflats to an extent that the originally inter-tidal 'gei wais' in Mai Po can only get their fresh supply of shrimps and fishes from Deep Bay via purposely dredged inlet channels across the raised mudflats. Sedimentation at the channel beds has put Mai Po 'gei wais' under threat since the tidal exchange of water between Deep Bay and the 'gei wais' via the channels, whereby fresh supply of shrimps and fishes enter the 'gei wais' with the high tides, can only take place on certain days of the month when the tide levels are high enough. With inadequate supply of fresh food, the function of the 'gei wais' as feeding ground for birds is adversely affected. In the early stage of the project, WWF Hong Kong had stated that they would object to any bridge scheme of HK-SWC, as they were worried that the numerous bridge supports in the waters of Deep Bay would slow down the water current at the inter-tidal mudflats and hence accelerate the *sedimentation rate*.

Deep Bay is designated as a water control zone under Water Pollution Control Ordinance (Chapter 358). In addition, there is also a requirement in the consultancy brief of the investigation and planning consultancy agreement that 'In assessing the drainage impacts, the Consultants should note the potential requirement of prohibiting discharge of runoff directly into Deep Bay water body due to environmental protection considerations. In such case the Consultants shall work out appropriate designs to meet the environmental requirements'. The main concerns being the *first foul flush* of road runoffs after dry seasons and also the *accidental chemical spillage* from vehicles.

Vehicles generate road sludge. Road runoff from HK-SWC would carry dust, grit, oil and grease. The first flush flow after dry season carries most of the pollutants and is the main concern; subsequent flow generated from rainstorms is expected to be relatively uncontaminated. If the road runoff from the whole alignment of HK-SWC (which is 5.5 km long, with 3.5 km within Hong Kong and 2 km within Shenzhen) were to be collected by drainage system to some treatment tank on the shore instead of direct discharge into Deep Bay, the drainage pipe inside the bridge deck void will need to be more than one metre in diameter for each carriageway and a huge space would be needed on the shore for the tank. Apart from the space requirements, this would also impose significant burden to the government, as the operating and maintenance costs of such drainage and treatment systems would be very high.

In the informal consultation meetings with various green groups in the early stage of the project, three green groups raised their concerns that in the event of car accident involving dangerous goods vehicle (DGV) on HK-SWC, there would be a possibility that hazardous chemicals on the DGV would be spilled to Deep Bay either (i) directly (whole truck crushed through the vehicle parapet and fell to Deep Bay, or some chemical containers fell off the DGV into Deep Bay) or (ii) indirectly through the bridge drainage system into the waters of Deep Bay when containers got damaged during the accident and the contents leak to the road surface and enter the drainage gullies. The green groups were worried that this would cause an ecological disaster in Deep Bay. Some members of the green groups voiced their preference on the tunnel options of HK-SWC, as this would eliminate the problem of accidental chemical spillage into Deep Bay. However, DGVs of categories 1, 2 and 5 are prohibited

from entering tunnels in Hong Kong but there was clear directive to the project team that this fourth boundary crossing should be designed to serve also the DGVs.

Pak Nai, about 5 km south-west of the project site at outer Deep Bay, has one of the major seagrass communities in Hong Kong. In view of the rarity and ecological importance of seagrass, Pak Nai was designated as a Site of Special Scientific Interest (SSSI) in 1980. The HK-SWC alignment has to avoid this location whenever practical.

In addition to the presence of a variety of ecologically sensitive habitats, Deep Bay is also an important site supporting local fisheries industry. Inter-tidal channels of Shenzhen and Shan Pui Rivers located along the eastern margin of Deep Bay discharge fresh water into the bay, forming a brackish environment for coastal fisheries and commercial oyster cultivation, which has long been a mainstay of the Deep Bay economy with Lau Fau Shan as the centre of the industry. It would be impractical to avoid the oyster beds in choosing the HK-SWC alignment as oyster beds were found on the mudflats all the way between Lau Fau Shan and Pak Nai. Any potential impact to the *oyster farming* during construction and operation stages of the project would need to be carefully addressed or otherwise the oyster industry could raise objection during road gazettal or EIA public exhibition period and cause undue delay to the project.

### **One project - Two governments**

HK-SWC is the first mega scale highway project ever implemented jointly between the governments of Hong Kong and Shenzhen. Green group members were sceptical about the adequacy of Shenzhen's environmental protection measures, especially during the construction of the Shenzhen section of HK-SWC on Deep Bay. They were concerned that EIAO could only control projects within HKSAR boundary and therefore the Shenzhen section of HK-SWC, being in Shenzhen waters of Deep Bay, would be out of bounds to Hong Kong green groups, despite the fact that there is only one Deep Bay ecosystem. They were worried about the enforcement of environmental mitigation measures for the project on the Mainland as it was impossible to enforce them across the boundary.

### **Extremely fast track implementation programme**

The project has an extremely tight implementation programme, with only four years and four months for the investigation, planning, EIA study, conceptual design, detailed design, tender documentation, tendering and award of construction contract, and substantial construction completion. The whole project has to be covered under two separate consultancies, namely the Investigation and Planning Assignment (HyD Agreement No. CE39/2001) and the Design and Construction Assignment (HyD Agreement No. CE51/2001). In order to fully utilize the tight time frame, Highways Department has obtained special approval from EACSB on commencement of CE51/2001 prior to the completion of CE39/2001 on the condition of independent assessment board for CE51/2001. Road gazettal has to be carried out prior to completion of EIA study. This has imposed a big challenge to the project team as there would not be any slack time for merry-go-round or U-turn in the decision making process; scheming has to be done within the shortest time and any proposed scheme must be the best scheme acceptable to all stakeholders. In particular, the whole EIA process must be accomplished in one-go, or otherwise the detailed design, road gazettal, land clearance, and commencement of construction contract would all be delayed.

### **Disturbance zone**

In the second round of consultation in February/March 2002 with the green groups, the project team received comments that the HK-SWC bridge might cause physical disturbance to birds resulting in birds not using the mudflats near the bridge, both during construction and operation of the bridge. The green group representatives stated that the KCRC's 'Sheung Shui to Lok Ma Chau Spur Line' EIA has set precedent on this issue by depicting an 'Exclusion Zone' of 50m on both sides of the bridge alignment. This would mean that any mitigation measure within 50m from the alignment would not

be considered effective. It would have serious impact to the project as habitat restoration within this limit would not count and hence the project site limit would have to be extended to beyond 50m each side of the alignment in order to have any 'effective' on-site compensation/mitigation measure.

Owing to the extremely fast track nature of the project, the project site limit has already been set at 50m clearance from each side of the HK-SWC based on engineering consideration and this has been included in the gazette plans which were scheduled for gazettal on 15th March 2002 under the Roads (Works, Use and Compensation) Ordinance, Chapter 370, in order that the necessary land clearance exercise could be completed in time without causing delay to the commencement of the construction contract. Any amendment to the plans would cause undesirable delay to the implementation of the fast track project.

### **Bird collision with man-made structures**

In meetings between Hong Kong and Shenzhen sides on the HK-SWC project, Shenzhen side has expressed a very strong desire of having landmark cable-stayed bridges at the navigation channels of Deep Bay. However, there were concerns from the Hong Kong green groups that the towers and the stay cables of the bridges would cause bird mortality, especially as the bridge would cross the flight paths of the migratory birds which fly from the Southern hemisphere to Mai Po. If this were not resolved quickly, the project team would be squeezed between the Shenzhen authorities and the Hong Kong green groups and the project could not proceed any further.

### **Compensation of loss in mudflats**

The project would result in loss of mudflats during the construction and operation stages. In particular, during construction of the foundation for the HK-SWC bridges, a temporary access bridge about two kilometres long would be required along the HK-SWC alignment to allow construction access to the foundation sites of the HK-SWC bridges from shoreline to the inter-tidal mudflats, as the mudflats would be too soft for the construction vehicles and the water depth would be too shallow most of the time for the marine vessels. The area of mudflats occupied by the temporary access bridge would be substantial. There were comments from the green group members during the informal consultation meetings that the loss of mudflats should be compensated on a like-for-like basis, i.e. inter-tidal mudflats lost must be compensated by an equal area of inter-tidal mudflats, no matter how small the quantity would be.

Some green group member suggested flattening the slope of the mudflats so that some of the mudflats which are above the high tide level would fall within the inter-tidal zone again. But this would require extreme precision in the dredging work which would be difficult to achieve practically. Also, the dredging work itself within Deep Bay might trigger another EIA exercise.

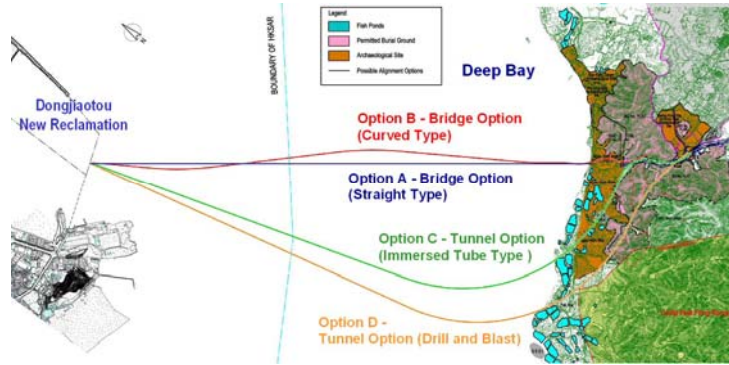
The other option was to form new islands which would basically be inter-tidal humps in the seabed so as to create more inter-tidal mudflats. However, this would slow down the tidal current in Deep Bay and consequently have an adverse impact to the water quality and also sedimentation rate in Deep Bay and thus environmentally unacceptable.

## **SELECTION OF BRIDGE ALIGNMENT**

With the above concerns in mind, alternative bridge alignments and landing points were carefully considered during the EIA study stage. At the time of study, Mainland had already completed their investigation of landing point options and fixed their landing point of HK-SWC at Dongjiaotou in Shekou of Shenzhen. The project team had to consider alignment options with this as a constraint. After a thorough brainstorming of all possible alignment options, four alignment options comprising two bridge options and two tunnel options [Figure 3] were selected for detailed evaluation and comparison in order to determine the preferred option.

Option A was a bridge alignment which was basically a straight line linking the BCF at Dongjiaotou to Deep Bay Link. Option B was another bridge alignment which was a slight variation of Option A by replacing the straight alignment with a very gentle S-curve. The increase in length due to the gentle curve was only about 0.3% which was insignificant. Option C was an immersed tube tunnel option and Option D was a drill-and-blast tunnel option.

Figure 3 - Alignment Options



In order for the tunnel to connect to Deep Bay Link which would be located on elevated ground, long ramp would be needed for either Option C or Option D. For a straight tunnel alignment, the ramp structure would be partly located on the mudflats and obstruct the tidal flow, with the result that the water quality and sedimentation rate in Deep Bay would be adversely affected. Accordingly, the tunnel options have to be swung sideways from the straight bridge alignment so that the whole ramp structure would be located on land.

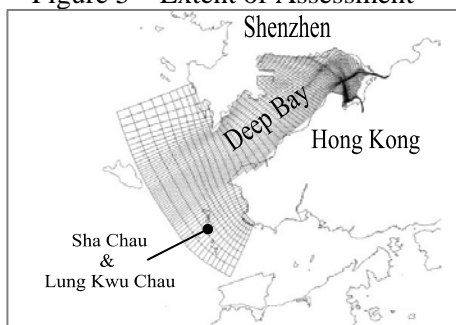
A detailed ranking exercise has been conducted for the four alignment options. In all, twenty-one factors were considered and the environmental factors constituted 46.9% of the total score [Figure 4]. In order to test the sensitivity of the finding, the relative weights of the individual factors were varied to form twenty test scenarios in addition to the base scenario. From the ranking exercise, the bridge options A and B have much higher scores than the tunnel options C and D. The tunnel options were not favoured because of their expensive cost, long construction period, limitations in use to dangerous goods vehicles (DGVs of categories 1, 2 and 5 are banned from using tunnels in Hong Kong), and most important of all, their impact to the environment in both the construction and operation stages, as the tunnels required long ramp structures within the Mainland waters of Deep Bay in order to connect to the BCF located at the reclamation at Dongjiaotou. Such ramp structures would cause a reduction in flushing capacity two times higher than that for the bridge options. The evaluation exercise revealed that Options A and B were environmentally superior to Options C and D, having less impacts on air quality, water quality, ecology, waste and cultural heritage. Options A and B had close scores and their ranking alternated in the sensitivity tests. Eventually, Option B was selected as it would afford a better view to the cable-stayed section of the bridge and offer a more interesting scenic experience to travelers on the bridge.

Figure 4 - Alignment Options Ranking Exercise



## SEDIMENTATION RATE AND WATER QUALITY

Figure 5 – Extent of Assessment



To address the concern on the change in sedimentation rate and water quality in Deep Bay due to the HK-SWC bridge, different hydrodynamic and water quality modelling scenarios have been formulated in the EIA. The reclamation at Dongjiaotou for the BCF, the Shenzhen section of HK-SWC and the future unconfirmed reclamation in Shenzhen coastline of Deep Bay were included in the modelling scenarios. To ensure that the impacts would be extensively assessed, the model extended from Inner Deep Bay to Sha Chau and Lung Kwu Chau as shown in Figure 5.



In order to minimize impacts to the sedimentation rate and water quality in Deep Bay, the project team has taken substantial effort to obtain agreement by Shenzhen side to increase the typical span length of the HK-SWC bridge from the originally planned 50m to 75m, thereby reduced the pier number from 106 pairs to 70 pairs. Also, the piers were designed with streamline shape and the pile caps of the bridge piers were designed to be embedded below seabed in order to reduce obstruction to the tidal flow. Moreover, the oyster poles within the project site limit would be cleared prior to commencement of construction activity to improve tidal flow.

### **Increase of Sedimentation Rate**

The increase of sedimentation rate due to the bridge and the reclamation at Dongjiaotou was predicted as 0.3 to 0.5 mm/year at Mai Po and Ramsar Site, and approximately 1.3 to 1.5 mm/year at Shekou, Ngau Hom Shek, and Lau Fau Shan. The increase would be insignificant when compared with the existing sedimentation rates, and the evaluation demonstrated that natural processes would be the dominant factors in controlling sedimentation rate in Deep Bay.

To further alleviate the concern of WWF Hong Kong on sedimentation rate, and to contribute to the long term goodness of Deep Bay ecosystem, the project team proposed additional enhancement measures by carrying out dredging of an existing 1.9 km inlet water channel linking Inner Deep Bay to the largest 'gei wai' (Gei Wai nos. 16/17, of 24.3 ha) inside Mai Po Nature Reserve to restore its tidal flushing and exchange capacity so that more fish and shrimps would be brought into the gei wai through the inlet channel. This would restore the function of the gei wai as the core feeding ground for birds including the Black-faced Spoonbill.

The dredging work [Figure 6] commenced in June 2003. In order to minimize the disturbance to migratory birds, the work had to be completed before the start of the wintering period for migratory birds in November 2003. Compounded by extremely difficult site condition, effect of tidal water and tight programme, the dredging work itself was a great challenge. To overcome the site constraints, the contractor had manufactured an amphibious dredger to carry out dredging in areas where the water depth was extremely shallow and the dredged sediment was carried away for disposal by self-propelled spoil barges. Silt curtain was installed to confine the dredging areas to avoid spreading of sediment plumes. To accelerate the progress, a 24-hour shift working hour was also adopted. The dredging work was completed on 31 October 2003. It was predicted that the benefits of the improvement to water exchange capacity of the gei wai would be able to last for decades.

Figure 6 – Dredging of Inlet Water Channel Linking Gei Wai 16/17 to Deep Bay



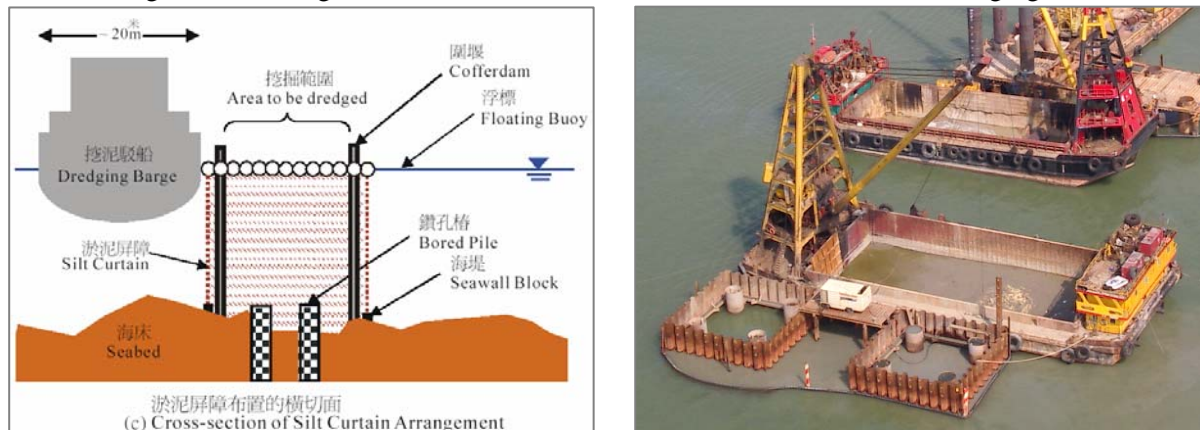
### **Impacts on Water Quality**

Impacts on water quality due to construction site runoff, wastewater from general construction activities and operation of the HK-SWC bridge have been assessed in the EIA. The increase of sediment loading during construction and operation stages was expressed in terms of the percentage increase of suspended solids (SS). The water quality model assessed that the most significant increase of suspended solids would be during construction stage (17.32% increase of SS at Mai Po during dry season and 15.08% increase of SS at the area between Ngau Hom Shek and Pak Nai SSSI during wet

season). However, there was no exceedance of Water Quality Objectives (WQO) at all assessment points and in both the construction and operation stages, the increase of pollution loading to Deep Bay was insignificant.

To mitigate any potential impact on Deep Bay during construction of HK-SWC, cofferdams and silt curtains have been provided for all marine sediment dredging work as shown in Figure 7.

Figure 7 – Arrangement of Silt Curtains and Cofferdam for sediment dredging work



## FIRST FOUL FLUSH OF ROAD RUNOFFS AFTER DRY SEASONS

A road drainage system would be provided to collect road runoff from the road surface of HK-SWC bridge. The collected road runoff would either be discharged into Deep Bay or be released to the mudflats depending on the location of the drainage pipe. From previous study by Drapper et al (2000), pollutants in road runoff on general roadways included suspended solids, phosphorus, total Kjeldahl nitrogen, copper, lead and zinc. Deep Bay is an ecologically sensitive area and the discharge of pollutants from the road drainage system might overload the natural dilution capacity of Deep Bay and adversely affect the environment.

The protection to the environment in Deep Bay relies on the implementation of best management practices to reduce the contaminants from the road surface to the waters and the mudflats of Deep Bay. The most effective way to minimize the impact is to reduce the contaminants at source. The provision of 'end of pipe' treatment was considered as a secondary control and would be less effective.

All vehicles travelling between Hong Kong and Shekou currently use roads that lie within the Deep Bay catchment. Road runoffs from these roads are discharged directly into Deep Bay through the normal road drainage systems without special treatment. This will form the base case for the assessment.

After the HK-SWC is constructed, vehicles travelling between Shekou and Hong Kong will likely take the more direct route through the bridge rather than using the existing coastal roads. The main difference between the base case and the case with HK-SWC is that the location of the discharge of road runoff would be changed. In the base case, all discharge is made through stormwater drainage outfalls around the shoreline of Deep Bay, where water is relatively stagnant. In the case with HK-SWC bridge, a portion of the discharge (due to the vehicles that change their routes from coastal roads to HK-SWC bridge) would be made through drainage outlets from the bridge which would lie near the middle of Deep Bay where there is flowing water.

Contaminants from vehicles are related to travelling distance. There would be a reduction of vehicle-generated contaminants for those vehicles which change their routes from the lengthy coastal roads to the more direct HK-SWC bridge.

The HK-SWC bridge may attract vehicles from the existing vehicular crossings including Sha Tau Kok, Lok Ma Chau and Man Kam To. Sha Tau Kok is a relatively small border crossing and is mainly used by vehicles that go to the eastern part of Shenzhen and beyond. It is expected that few vehicles there would be attracted to HK-SWC crossing. The main portion of vehicles attracted to the HK-SWC crossing would be those using Lok Ma Chau crossing. However, Lok Ma Chau crossing remains within Deep Bay catchment and the discharge from those vehicles using Lok Ma Chau crossing would still eventually enter Deep Bay.

The University of New South Wales Research Report No. 204 entitled 'Stormwater Quality from Road Surfaces - Monitoring of Hume Highway at South Strathfield' provides some information on the pollutant concentration from roads. Key findings of the report are presented below:

- (1) It has been found that dry weather build-up of contaminants reaches equilibrium after 10 days. It was found that after 10 days contaminant deposition rates were similar to removal rates caused by air turbulence. A probable reason for this is the contaminant can stick to the road but once there is a layer of contaminant they cannot stick to each other.
- (2) It was found that the contaminant equilibrium would be maintained until a cleansing event. Cleansing events were defined as wind events exceeding 21 km/hour or storm events with rainfall exceeding 7 mm/hr.
- (3) From graphs of storm events it appear that contaminant concentrations in runoff are negligible after 20 to 30 minutes.
- (4) Lead concentrations are low and in the order of micrograms ( $10^{-6}$ ) per litre. The instant peak in the first foul flush recorded was 400 micrograms/litre or 0.4 mg/l. The concentration in terms of a rainfall event is practically nil.

Considering the above, it can be inferred that contaminant load in runoff is actually a minority problem, with the majority of contaminants being blown from the road surface. Hence the most effective means to control road pollutants of HK-SWC from entering Deep Bay is the regular removal of contaminants from the road surface to avoid contaminant accumulation.

It was proposed to clean the road sludge by vacuum air sweeper/truck, which is readily available from commercial markets, on a routine basis of about twice every week, so as to eliminate the build-up of contaminants and hence significantly reduce the pollution level in the first foul flush after dry seasons. In addition, standard road gullies with silt trap would be provided along the HK-SWC bridge to collect road sludge in storm runoff. Monitoring of the road runoff quality would also be carried out during operation of HK-SWC to review the road cleaning frequency and effectiveness. In this way, the headache problem of "first foul flush after dry seasons" was resolved in a cost-effective and environmentally friendly manner.

## **ACCIDENTAL CHEMICAL SPILLAGE FROM VEHICLES**

One of the key concerns on water quality impacts during the operation of the HK-SWC is the possible spillage of chemicals in case of vehicle accidents on the bridge, particularly for accidents involving Dangerous Goods Vehicles (DGV). The types of chemicals may consist of petrol or possibly corrosive or toxic chemicals. Accidental release of these chemicals from vehicles may enter Deep Bay through the road drainage system causing a hazard to the ecological system in Deep Bay.

In the early stage of the project, the project team considered various options including an isolated bridge drainage system so that any spilt chemical would be collected by the drainage system to treatment tanks installed inside the bridge deck void for subsequent treatment. However, some chemicals float on water, some sink and some even dissolve in water and it would be impossible to separate the spilt chemicals from the stormwater for storage in a special treatment tank. In fact, some



chemicals would become dangerous by interaction with water and it would be risky to carry the chemicals inside drainage pipe and store inside the deck void. An internal explosion inside the deck void may cause a bridge collapse. Also, treatment of hazardous chemicals within a confined space would pose a serious threat to the maintenance personnel.

The project team conducted a search of the action plans for chemical spillage in the coastal roads of Deep Bay and found that there are existing emergency response plans being implemented by government departments to deal with chemical spillage due to vehicle accidents on roads. To tackle the problem for the case of HK-SWC, an Emergency Response Framework has been prepared and presented in the EIA to consolidate all relevant existing emergency response plans and to recommend operational guidelines to minimize the potential water quality and ecological impacts associated with a spillage incident on HK-SWC. With prompt response and good co-ordination amongst relevant government departments, it is expected that possible chemical spillage incidents on the bridge would be suitably controlled to minimize impacts on Deep Bay. Before HK-SWC commences operation, a detailed Emergency Response Plan would be developed to enhance the established response actions in order to take due consideration of the need to protect the ecologically sensitive Deep Bay environment.

## **OYSTER FARMING**

Oyster farming on the mudflats of Deep Bay is extensive, from Lau Fau Shan all the way to Sheung Pak Nai. Oyster farmers plant bamboo sticks covered with cement paste at the inter-tidal mudflats to enable the settlement and growth of oysters. When the oysters have grown to considerable size, the bamboo sticks would be removed from the mudflats and suspended in oyster rafts which float in deeper water of Deep Bay, so that the oysters could grow further at the better environment before they are harvested.

At the location of HK-SWC site, the bridge alignment would straddle an existing oyster bed tenancy area, according to information from Lands Department. With the decline of oyster industry in recent decades, the tenant has ceased oyster farming in the tenancy area. However, outsiders who have no sub-tenancy agreement with the tenant have occupied the tenancy area for their own oyster cultivation. There is no physical boundary delineating oyster beds of the individual oyster farmers. In view of the complexity of the ownership of oyster beds in the project site area, contact and dialogue have been established in the very early stage of the project with the tenant, local rural committee as well as the oyster farmer associations. In addition, an independent oyster study has been carried out and an allied task force comprising representatives from various government departments has been established to monitor the water quality in the vicinity of the site, to ensure that the oyster farming would not be adversely affected by the construction activities of the project.

### **Independent Oyster Study**

As a public relation exercise and to give a peace of mind to the neighbouring oyster cultivators, the project team has conducted additional water quality monitoring along both sides of the site boundary and commissioned Professor Lam Kwan-sing of City University of Hong Kong to carry out an independent investigation to assess the impact of the bridge construction work to oyster cultivation in Deep Bay.

Besides interviewing the oyster cultivators, Professor Lam had extensively reviewed international literature and the environmental information collected under the project's environmental monitoring and audit (EM&A) programme and the additional water quality monitoring. Based on the available information, a risk assessment of the impact on oyster cultivation was made. It was concluded that the works had not caused any environmental impact upon the oyster cultivation in Deep Bay. The findings were also reported to and accepted by the Yuen Long District Council on 14 October 2004.

## **Task Force Inspection on Water Quality**

In order to ensure that the Contractor has properly carried out the works under the Environmental Permit conditions, Highways Department, Environmental Protection Department and Agricultural, Fisheries and Conservation Department allied to form a task force in March 2004 to carry out inspection on the site. Particular attentions were paid to the impact on water quality due to the works and minimization of environmental nuisance caused by the movement of construction vessels.

Observations of any non-conformance/violation of the environmental requirements were immediately brought to the attention of the Contractor for prompt rectification/improvement. So far no violation of the Environmental Permit conditions was observed. Furthermore, in order to prevent spillage of excavated materials into the sea, the task force had constantly reminded the Contractor to improve the site cleanliness and tidiness on the temporary access bridge.

Complaints on water quality during the progress of the marine works were minimal. The task force inspections had initially proceeded on a weekly basis. After all marine foundation and substructure works had been completed, inspections were reduced to bi-weekly and eventually at monthly intervals.

## **ONE PROJECT - TWO GOVERNMENTS**

### **Coordination with Shenzhen Side**

The project team understood from various consultations that the interface with Shenzhen side for both the EIA study and the EM&A programme was one of the major public concerns as Deep Bay is a single ecological system in geographical term.

The EIA study was therefore not only concentrated on the impacts within the HKSAR but also included all the pollution impact sources from Shenzhen side in the study regime. A series of liaison meetings with Shenzhen side officers were carried out at an early stage to collect the information necessary for the EIA study, such as the air and water pollutions sources and loadings and the programme of reclamations along the coastline of Shekou.

Although the EM&A programme had to be carried out separately to satisfy the respective laws and legislations of both Regions under the one country two systems policy, an Environmental Liaison Group (ELG) amongst the governments, consultants and contractors from both sides was set up. Regular ELG meetings have been held to monitor the environmental performance, to deal with any cross-boundary pollution arising from the construction works and to coordinate with interface arrangement of any construction environmental issues. Thanks to the concerted effects of the project team members and the Contractors, no exceedance in water quality parameters was detected so far due to the construction works from both sides.

## **EXTREMELY FAST TRACK IMPLEMENTATION PROGRAMME**

Owing to the extremely fast track implementation programme of the project, there was no room for merry-go-round or U-turn in the decision making process. All schemes formulated within the shortest time must be acceptable to all stakeholders; the programme could hardly afford any objection of any proposed scheme by the relevant stakeholders. Accordingly, early involvement of all stakeholders in the development of the project schemes was essential.

Vigorous public consultations were carried out immediately after the commencement of the CE39/2001 consultancy and continued throughout the whole EIA process. The project was first introduced to the EIA Sub-committee of the Advisory Council on the Environment in September 2001, followed by another informal dialogue in June 2002. Three rounds of consultations with five green groups were held during the period between September 2001 and June 2002. The aims of these

consultations were to keep the concerned parties abreast of project status, alignment selection, EIA findings, and to solicit their views and exchange ideas, which were instrumental in shaping the focus of the EIA study.

Consultations were also carried out in various local communities including the District Councils of Tuen Mun and Yuen Long as well as the Rural Committees of Tuen Mun and Ha Tsuen. A Liaison Group with the oyster farming representatives was established to maintain dialogues between government departments and the oyster farmers.

With the early implementation of public consultations with various parties in particularly the green groups, their concerns could be taken into account during both the EIA study and detailed design stage of the project. As a result, the EIA Report could be approved under the EIAO within a very short period of time and all objections lodged under the Roads (Works, Use and Compensation) Ordinance were withdrawn unconditionally. The withdrawal of all objections permitted the project to be authorized without escalating to the Executive Council. These were vitally critical to enable smooth implementation of the project in an extremely fast-track programme.

## **DISTURBANCE ZONE**

In view of the concerns of green groups that the construction and operation of HK-SWC might cause a disturbance to the birds so that the birds would not feed near the bridges resulting in loss of habitat and would not fly above or underneath the bridges resulting in habitat fragmentation, the project team had carried out review of various international literature and also conducting additional field surveys of Black-faced Spoonbill and other birds at some existing bridge structures with similar inter-tidal habitats.

Route 3 Flyover above the mudflat of Kam Tin River, Shatin Road above the artificial Shing Mun River Channel, Tsing Tsuen Bridge over Rambler Channel in Hong Kong and Lotus Bridge spanning the inter-tidal mudflat between Taipa-Coloane Reclamation Areas [Co-Tai (路氹)] in Macau SAR and Hengqing Island (橫琴島) of Zhuhai (珠海) having similar width and height with the HK-SWC bridge and with frequent bird flying activities in the vicinity were selected for conducting the additional field survey.

Field survey conducted at Route 3 Flyover and Lotus Bridge revealed that shorebirds would feed beneath the bridge. Shading of the mudflat by the bridge did not adversely affect the birds and therefore the bridge above would not change and thus cause fragmentation of the habitat beneath. In addition, birds were observed flying over or beneath all studied bridges, where routine flew of birds including Black-faced Spoonbill to and fro the roosting and feeding habitats had been observed at Lotus Bridge. The field observation successfully demonstrated to the concerned parties that bridges present no barrier effect on birds.

During construction stage of the HK-SWC, it is frequently observed that the mudflats and mangrove area in close vicinity to the construction site are utilized by birds. Site photos showing local egrets and traveling of groups of Cormorants to and fro Pak Nai and Mai Po over the temporary access bridge are included in Figure 8 and Figure 9 respectively. As part of the EM&A programme, birds monitoring has been conducted on a monthly basis during construction stage to study the distribution of birds feeding along the tideline and on the inter-tidal mudflat within 500 m on either sides of the construction site. The distribution of bird species is compared with the baseline data and that on the control site at Sheung Pak Nai. The observations indicate that there is no construction impact on the distribution of birds feeding on the inter-tidal mudflat. This corroborates that bridges would not be barrier to birds even during construction stage.

Figure 8 – Birds Wading and Feeding Next to the Construction Site



Figure 9 – Groups of Cormorants Travelling above the TAB



In addition, there was a record high of 311 nos. of Black-faced Spoonbills, which amounted to one quarter of the world population of this endangered species, recorded in Deep Bay in January 2005, based on the International Black-faced Spoonbill Census 2005. This further demonstrates that the construction of HK-SWC has no adverse impact to this species.

## **BIRD COLLISION WITH MAN-MADE STRUCTURES**

In order to address the concern of green group members, the project team carried out extensive literature review of over 1,500 publications on bird collisions with man-made structures. Most of the data were obtained from studies in North America, Europe, Asia, Africa and South America. The reviewed literature covered a 117-year period from 1884 to 2001. In addition, input was sought from biologists actively involved in bird research, conservation and management.

Based on the available data from North America, only less than 0.02% of total bird mortality is attributable to collisions with tall (i.e. over 250 m in height) man-made structures, including unlighted cable-stayed telecommunication towers and power lines, light-houses and exhaust stacks locating on prominent topographic feature such as ridges or mountain peaks which serve as birds' navigation guide, transparent noise barrier, windows and building glazing. The characteristics of the tall structures which caused bird fatalities are:

- height of tower structure (some over 600m, most threatening over 250m);
- siting of tower on prominent topographic feature that may be used by birds as a navigation guide;
- isolated tower;
- lighting of tower using floodlights thereby causing confusion to birds in foggy weather; and
- staying of tower by guy-wires that are thin and hardly visible at night.

After thorough review, potential hazard of bird collision to the HK-SWC bridge structures was assessed to be unlikely for the following reasons:

- the maximum height of the bridge structures (which is at the location of the cable-stayed bridge tower) is less than 150 m;
- HK-SWC is located in Deep Bay without any prominent topographic feature in the vicinity;
- cable-stayed portion of bridges are not isolated, but attached to the rest of the bridge;
- precautionary measures were incorporated in the architectural lighting design, so that flood lights would be switched off during foggy weather; and
- unlike the power lines, the cables of the cable-stayed bridge are about 30 cm in diameter and readily visible to the birds.

In addition, bridge management and maintenance personnel would be required to collect (if possible) and report all cases of bird mortality on the bridges during the operation stage of HK-SWC, and the architectural lighting design would be reviewed if considered necessary. During construction stage of HK-SWC, the site staff have not observed any case of bird mortality on the construction site, even when there have been numerous crane barges operating along the HK-SWC alignment.

## COMPENSATION FOR LOSS OF MUDFLATS

It was assessed in the EIA that the mudflat of up to 0.752 ha which functions as a feeding ground of birds and a potential nursery ground of a rare benthic organism, horseshoe crab would be temporarily loss due to the construction of HK-SWC. In order to minimize unnecessary disturbance to the mudflats caused by the operation of machinery, a temporary access bridge was built to accommodate the construction plant and to provide gateway for delivery of logistics to the deeper waters, thus lessen the impacts of construction activities to the mudflat and ease the traffic of marine-based vessels in the deeper waters. Its construction was based on the modular concept, making up of standard size steel decks supported on free standing steel pipe piles as shown in Figure 10.



Figure 10 – Temporary Access Bridge (TAB)

At the early stage of the project, before the study on disturbance zone was completed, the project team had been actively brainstorming for ideas of compensation of mudflats outside the project site area as it was not certain at that time whether the mitigation measures within the project site limit could be counted or not. The project team had come up with an idea of removing the existing oyster shells found at the mudflats near the shoreline of Deep Bay believed to be dumped by oyster farmers after the oysters were removed. The area of the covered mudflats was about 10 ha, which would be able to compensate for the mudflat loss during construction stage if disturbance zone were eventually found to



be applicable to the project. However, after seeking the views of the locals, they replied that the oyster shells were their private property and Government had to purchase the shells from the locals. Fortunately, at the same time, the project team had got the results from the study on disturbance zone. Hence Government could save the money of purchasing the dumped oyster shells.

With the study on disturbance zone which proved that this would not be applicable to the project, the compensation for loss of mudflats is accomplished by restoring the oyster beds within the project site limit to mudflats. It was also proposed that all construction materials and wastes would be cleared from the mudflats after the construction period and the mudflats would be restored to its original low and smooth profile. Without the occupation by oyster clutches within this area it was estimated that there would be a net increase of at least 7 ha mudflats after the completion of construction.

As a gesture of environmental friendliness, the project team also proposed an enhancement measure of the removal of exotic mangroves species and weeds (such as *Sonneratia* spp.) on the mudflats within Inner Deep Bay, thus restoring the mudflats and improving water exchange in gei wais. Those exotic species have shown a tendency to grow and reproduce so fast that threaten the local mangrove species within Inner Deep Bay. By the end of October 2004, a total of 1,553 nos. of *Sonneratia* spp. within Inner Deep Bay were removed under the construction contract of HK-SWC, with majority along the water channel connecting gei wais to Inner Deep Bay and on the mudflats of Mai Po.

## **MITIGATION MEASURES DURING CONSTRUCTION STAGE**

The construction contract was awarded to Gammon-Skanska-MBEC Joint Venture on 1 August 2003. Under the construction contract, the Contractor is required to formulate strategic solutions on ecological mitigation measures recommended in the EIA Report for the construction stage. Both temporary works and ecological mitigation measures were designed, planned and strictly implemented in such a way that would facilitate the construction of HK-SWC while minimizing the disturbance to the environment including the mudflats and mangroves in the proximity.

### **Consideration of Surface Runoff from the Temporary Access Bridge**

In addition to fulfilling the contractual requirement of building the temporary access bridge, the Contractor also implemented control measures to ensure that the operation of the temporary access bridge would not adversely affect the habitats underneath. The temporary access bridge was constructed to be anti-leak against the spillage of lubricants, fuel and chemical on the bridge. Gaps between the sheet-piles that form the bridge deck were all sealed with caulking compound. Periphery PVC drainage channels and silt interceptor tanks equipped with oil-absorbent foam as shown in Figure 11 were installed along the edge of the deck to intercept all surface runoff from the temporary access bridge.

### **Innovative Environmental Measures**

Innovative methods were developed and formulated in collaboration with the Contractor to minimize disturbance to the habitats during the construction of the permanent foundation works. Many of these methods were unique to the project and were not normally practised in other traditional construction projects.

Y-shaped funnel as shown in Figure 12 was mounted over piling casing to intercept spillage of wastewater and spoil material during the grabbing activity of bored pile construction, and an oversized casing was fitted over individual temporary piling casing as double protection against the leakage of contaminated water during piling excavation. The excavated spoil material was kept in temporary storage tank for interim storage prior to delivery to the disposal sites.

Figure 11 – Drainage Channels and Interceptor



Figure 12 – Y-Shaped Funnel over Piling Case



To minimize the impact to water quality, the excavation of marine sediment for the construction of buried pile caps was carried out within cofferdam, made up of inter-locking sheet-piles. The cofferdam was further enclosed by silt curtain outside.

Whenever possible, wastewater generated from construction activities was recycled or re-circulated by circulation tanks for use in other operations. Prior to discharging to sea, wastewater was treated by sedimentation tanks and a wastewater treatment system comprising chemical coagulation, desilting and pH control processes.

Steps were also taken to install additional drip trays on all major piling plant and equipment including crawler crane, reverse circulation drill, power pack and generator, to control spillage of lubricants and fuels from the machinery. These preventive measures had successfully kept the site clean, and provided a better working environment for the workers.

### **Increased Environmental Awareness**

The Consultants have arranged regular environmental meeting and visits with the Contractor, the Environmental Team (ET), the Independent Environmental Checker (IEC) and the Environmental Protection Department (EPD) to brief and monitor the environmental / ecological performance and to share experience during implementation of measures. Drills on accidental oil spillage onto the temporary access bridge and onto the marine water have been organized to provide workers with an opportunity of putting theory into practice. The Contractor has also conducted additional water quality monitoring prior to the commencement of major construction work to monitor the water quality during marine-based site preparation works.

## **CONCLUSION**

Team efforts of the Client, the Consultant and relevant government departments contributed to the success of the timely completion of the investigation, planning, design and tendering stages of the project. As a result, the construction contract was able to commence one month earlier than the target commencement date in the extremely fast track programme. In addition to team efforts, early involvement and consultation with green groups and other stakeholders was also a key to the success.

During the ongoing construction stage, with the partnering of the Contractor and the project team, and the establishment of the allied task force, the project would surely be able to maintain the momentum carried from the earlier stages and achieve substantial completion of construction in time.

The project successfully demonstrated that an infrastructure development could harmonize with an ecologically important environment and the local communities despite a tight implementation programme.