6. WATER QUALITY ASSESSMENT

6.1 Introduction

The water quality assessment has followed the guidelines presented in *Annex 14* of the Technical Memorandum to the EIAO. The assessment has focussed on the construction and operational impacts associated with implementing Route 10 (NLYLH) and the Report provides details of mitigation measures and monitoring requirements to ensure residual impacts are acceptable and comply with current standards and guidelines.

Two components have the potential to affect water quality in the long term. These are the northern tower of the Tsing Lung Bridge and the Toll Plaza located between Fa Peng and Tso Wan on Lantau. A viaduct on piles traverses the small bay at Yi Chuen and will have minimal impact on water quality during both construction and operational phases.

Other components are on structure, at grade, in cuttings or in tunnel. The alignment crosses a number of watercourses, which are considered in Section 7 of this Report and as part of the Drainage Impact Assessment studies (in cases where diversions of water courses may be required).

In accordance with the requirements of the Technical Memorandum to the EIAO, the assessments given in the following sections are, as far as practical, quantitative.

6.2 Legislation and Standards

Protection of marine water quality during and following construction is governed by the following legislation and standards:

- the Water Pollution Control Ordinance (WPCO) (Cap. 358);
- the Technical Memorandum to the WPCO on the Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters; and
- Water Quality Objectives (WQO's) ascribed to the North Western Water Control Zone (NWWCZ) and the Western Buffer Water Control Zone (WBWCZ). Relevant Water Quality Objectives (refer *Table 6.1*).

Table 6.1 Marine Water Quality Objectives for the North Western Waters Water Control Zone

Water Quality Objective		Part or Parts of Zone	
		North Western Waters	Western Buffer
A.	**AESTHETIC APPEARANCE**		
	(a) Waste discharges shall cause no objectionable odours or discolouration of the water.	Whole zone	Whole zone
	(b) Tarry residues, floating wood, articles made of glass, plastic, rubber or of any other substances should be absent.	Whole zone	Whole zone
	(c) Mineral oil should not be visible on the surface. Surfactants should not give rise to a lasting foam.	Whole zone	Whole zone
	(d) There should be no recognisable sewage-derived debris.	Whole zone	Whole zone
	(e) Floating, submerged and semi-submerged objects of a size likely to interfere with the free movement of vessels, or cause damage to vessels, should be absent.	Whole zone	Whole zone
	(f) Waste discharges shall not cause the water to contain substances which settle to form objectionable deposits.	Whole zone	Whole zone
B.	**BACTERIA**		
	(a) The level of *Escherichia coli* should not exceed 610 per 100mL, calculated as the geometric mean of all samples collected in a calendar year.	Secondary Contact Recreation Subzones	Secondary Contact Recreation Subzones and
	(b) The level of *Escherichia coli* should be less than 1 per 100 mL, calculated as the running median of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	Tuen Mun (A) and Tuen Mun (B) Subzones and Water Gathering Ground Subzones	Fish Culture Subzones Bathing Beach Subzones
	(c) The level of *Escherichia coli* should not exceed 1,000 per 100 mL, calculated as the running median of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	Tuen Mun (C) Subzone and other inland waters	Water Gathering Ground Subzones
	(d) The level of *Escherichia coli* should not exceed 180 per 100 mL, calculated as the geometric mean of all samples collected from March to October inclusive. Samples should be taken at least 3 times in one calendar month at intervals of between 3 and 14 days.	Bathing Beach Subzones	Other inland waters

Water Quality Objective	Part or Parts of Zone	
	North Western Waters	Western Buffer
C. COLOUR		
(a) Waste discharges shall not cause the colour of water to exceed 30 Hazen units.	Tuen Mun (A) and Tuen Mun (B) Subzones and Water Gathering Ground Subzones	Water Gathering Ground Subzones
(b) Waste discharges shall not cause the colour of water to exceed 50 Hazen units.	Tuen Mun (C) Subzone and other inland waters	Other inland waters
D. DISSOLVED OXYGEN		
(a) Waste discharges shall not cause the level of dissolved oxygen to fall below 4 mg per litre for 90% of the sampling occasions during the whole year; values should be calculated as water column average (arithmetic mean of at least 3 measurements at 1m below surface, mid-depth and 1m above seabed). In addition, the concentration of dissolved oxygen should not be less than 2mg per litre within 2m of the seabed for 90% of the sampling occasions during the whole year.	Marine waters	Marine waters excepting Fish Culture subzones
(b) Waste discharges shall not cause the level of dissolved oxygen to be less than 4mg per litre.	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones, Water Gathering Ground Subzones and other inland waters	Fish Culture Subzones
E. pH		
(a) The pH of the water should be within the range of 6.5-8.5 units. In addition, human activity shall not cause the natural pH range to be extended by more than 0.2 unit.	Marine waters excepting Bathing Beach Subzones	Marine waters
(b) Human activity shall not cause the pH of the water to exceed the range of 6.5-8.5 units.	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones	Water Gathering Ground Subzones

Water Quality Objective	Part or Parts of Zone	
	North Western Waters	Western Buffer
(c) Human activity should not cause the pH of the water to exceed the range of 6.5-8.5 units.	Other inland waters	Other inland waters
(d) The pH of the water should be within the range of 6.0-9.0 units for 95% of samples collected during the whole year. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.5 unit.	Bathing Beach Subzones	-
F. TEMPERATURE Waste discharges shall not cause the natural daily temperature range to change by more than 2°C.	Whole zone	Whole zone
G. SALINITY Waste discharges shall not cause the natural ambient salinity level to change by more than 10%.	Whole zone	Whole zone
H. SUSPENDED SOLIDS		
(a) Waste discharges shall neither cause the natural ambient level to be raised by more than 30% nor give rise to accumulation of suspended solids which may adversely affect aquatic communities.	Marine waters	Marine waters
(b) Waste discharges shall not cause the annual median of suspended solids to exceed 20 mg per litre.	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones	Water Gathering Ground Subzones
(c) Waste discharges shall not cause the annual median of suspended solids to exceed 25 mg per litre.	Other inland waters	Other inland waters
I. AMMONIA The un-ionized ammoniacal nitrogen level should not be more than 0.021 mg per litre, calculated as the annual average (arithmetic mean).	Whole zone	Whole zone
J. NUTRIENTS		
(a) Nutrients shall not be present in quantities sufficient to cause excessive or nuisance growth of algae or other aquatic plants.	Marine waters	Marine waters
(b) Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.3 mg per litre, expressed as annual water column average (arithmetic mean of at least 3 measurements at 1m below surface, mid-depth and 1m above seabed).	Castle Peak Bay Subzone	Marine waters
(c) Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.5 mg per litre, expressed as annual water column average (arithmetic mean of at least 3 measurements at 1m below surface, mid-depth and 1m above seabed).	Marine waters excepting Castle Peak Bay Subzone -	Marine waters

Water Quality Objective	Part or Parts of Zone	
	North Western Waters	Western Buffer
K. 5-DAY BIOCHEMICAL OXYGEN DEMAND		
(a) Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 3 mg per litre.	Tuen Mun (A), Tuen Mun (B) an Tuen Mun (C) Subzones and Water Gathering Ground Subzones	Water Gathering Ground Subzones
(b) Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 5mg per litre.	Other inland waters	Other inland waters
L. CHEMICAL OXYGEN DEMAND		
(a) Waste discharges shall not cause the chemical oxygen demand to exceed 15 mg per litre.	Tuen Mun (A), Tuen Mun (B) an Tuen Mun (C) Subzones and Water Gathering Ground Subzones	Water Gathering Ground Subzones
(b) Waste discharges shall not cause the chemical oxygen demand to exceed 30 mg per litre.	Other inland waters	Other inland waters
M. TOXIC SUBSTANCES		
(a) Waste discharges shall not cause the toxins in water to attain such levels as to produce significant toxic, carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to toxicant interactions with each other.	Whole zone	Whole zone
(b) Waste discharges shall not cause a risk to any beneficial use of the aquatic environment.	Whole zone	Whole zone
N. TURBIDITY Waste discharges shall not reduce light transmission substantially from the normal level.	Bathing Beach Subzones	Bathing Beach

Marine Waters

Protection of existing or potential beneficial uses from the effects of implementing the Scheme is a key concern to be addressed in the EIA. Beneficial uses of marine and coastal waters include the following sub-divisions:

- areas of ecological or conservation value including marine conservation areas, existing or gazetted proposed marine parks and marine reserves, sites of special scientific interest (SSSI), existing or gazetted proposed country parks and special areas, wetlands, mangroves and important freshwater habitats;

- areas for abstraction of water for potable water supply;
- water abstraction for irrigation and aquaculture;
- fish spawning grounds, fish culture zones, shellfish harvesting/culture site and brackish/freshwater fish ponds;
- beaches and other recreational areas;
- water abstraction for cooling, flushing and other industrial purposes; and
- areas for navigation/shipping including typhoon shelters, marinas and boat parks.

Beneficial uses in the vicinity of the Tsing Lung Bridge (northern tower), but not necessarily within the area of influence, include beaches and waterways used for navigation and shipping (Ma Wan Channel and Urmston Road).

In the vicinity of the Toll Plaza between Fa Peng and Tso Wan the beneficial uses include navigation and shipping (Kap Shui Mun Channel).

Surface Waters

For surface water the beneficial uses are defined in the Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters as follows :

- Group A abstraction for potable water supply (includes water gathering grounds and Country Parks);
- Group B irrigation (mainly in the agricultural areas of North West New Territories);
- Group C pond fish culture (mainly in Yuen Long); and
- Group D general amenity and secondary contact recreation (including those draining to marine waters via nullahs).

The majority of inland waters within the Study Area are defined as Group D.

During construction the criteria for the protection of water quality are stipulated in the Technical Memorandum (TM) on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters. The TM was issued under the Water Pollution Control Ordinance (WPCO) and gives guidance on the permissible effluent discharges based on the type of receiving waters (foul sewers, storm water drains, inland and coastal waters). The limits control the physical, chemical and bacterial quality of effluents.

Any person(s) discharging into the receiving waters should apply for a licence and must ensure that the quality of the effluent meets the requirements stipulated in the licence issued. In the absence of any licensing conditions at this stage, the TM standards can be adopted as a reference. Relevant TM standards for Group D waters (generally encountered in the Study Area) for selected parameters are listed in *Table 6.2*.

Table 6.2 TM Standards for Discharges to Group D Water (all units in mg/l unless otherwise stated)

Flow Rate m^3/day Determinand	**≤200**	**>200 and ≤400**	**>400 and ≤600**	**>600 and ≤800**	**>800 and ≤1000**	**>1000 and ≤2000**	**>2000 and ≤3000**	**>2000 and ≤3000**
pH (pH units	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10
Temperature (°C)	30	30	30	30	30	30	30	30
Colour (lovibond units) (25mm cell length)	1	1	1	1	1	1	1	1
Suspended solids	30	30	30	30	30	30	30	30
BOD	20	20	20	20	20	20	20	20
COD	80	80	80	80	80	80	80	80
Oil & Grease	10	10	10	10	10	10	10	10
Iron	10	8	7	5	4	2.7	2	1.3
Boron	5	4	3.5	2.5	1	1.5	1	0.7
Barium	5	6	3.5	2.5	1	1.5	1	0.7
Mercury	0.1	0.05	0.001	0.001	0.001	0.001	0.001	0.001
Cadmium	0.1	0.05	0.001	0.001	0.001	0.001	0.001	0.001
Other toxic metals individually	1	1	0.8	0.8	0.5	0.5	0.2	0.2
Total toxic metals	2	2	1.6	1.6	1	1	0.5	0.4
Cyanide	0.4	0.4	0.3	0.3	0.2	0.1	0.1	0.05
Phenols	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1
Sulphide	1	1	1	1	1	1	1	1
Sulphate	800	600	600	600	600	400	400	400
Chloride	1000	800	800	800	600	600	400	400

Flow Rate m^3/day Determinand	≤200	>200 and ≤400	>400 and ≤600	>600 and ≤800	>800 and ≤1000	>1000 and ≤2000	>2000 and ≤3000	>2000 and ≤3000
Fluoride	10	8	8	8	5	5	3	3
Total phosphorus	10	10	10	8	8	8	5	5
Ammonia nitrogen	20	20	20	20	20	20	20	10
Nitrate + nitrite nitrogen	50	50	50	30	30	30	30	20
Surfactants (total)	15	15	15	15	15	15	15	15
E. coli (count/100ml)	1000	1000	1000	1000	1000	1000	1000	1000

Once the Scheme has been implemented, sources of pollution will relate to highway and tunnel drainage, and to effluent generated by the workers at the Toll Plaza and administration buildings.

6.3 Baseline Conditions

EPD carries out routine water quality monitoring of marine waters (and bathing beaches) and the reports are published annually. Routine monitoring stations which are relevant are NM1 which is located immediately to the west of the Tsing Lung Bridge and WM4 for the Toll Plaza, refer to *Figure 6.1*. Water quality statistics for these stations are included as *Table 6.3*.

Table 6.3 Marine Water Quality in the Southern Section

Determinand		NM1	WM4
Temperature (°C)	Surface	23.4 (17.0 - 28.4)	23.4 (16.8 - 28.3)
	Bottom	22.1 (16.8 - 26.1)	22.5 (16.8 - 28.1)
Salinity (ppt)	Surface	26.3 (18.1 - 34.1)	29.2 (18.9 - 34.2)
	Bottom	32.5 (30.5 - 34.1)	32.8 (30.9 - 34.2)
Dissolved Oxygen (% Saturation)	Surface	79.8 (61.1 - 98.4)	81.2 (60.4 - 100.2)
	Bottom	69.5 (45.5 - 94.1)	74.0 (52.1 - 93.9)
Dissolved Oxygen (mg/L)	Surface	5.8 (4.7 - 7.3)	5.8 (4.6 - 6.9)
	Bottom	5.1 (3.2 - 6.8)	5.3 (3.6 - 6.8)
PH		8.1 (7.8 - 8.3)	8.1 (7.8 - 8.3)
Secchi Disc Depth (m)		1.9 (1.5 - 2.9)	2.2 (1.3 - 4.0)

Determinand	NM1	WM4
Turbidity (NTU)	5.0 (2.5 - 6.8)	4.9 (1.8 - 8.6)
Suspended Solids (mg/L)	6.2 (4.2 - 11.3)	7.2 (3.4 - 14.0)
Silica (as SiO_2) (mg/L)	1.8 (0.5 - 4.6)	1.2 (0.4 - 2.6)
5-day Biochemical Oxygen Demand (mg/L)	0.4 (0.3 - 0.9)	0.4 (0.2 - 1.0)
Nitrite Nitrogen (mg.L)	0.04 (0.01 - 0.12)	0.03 (0.01 - 0.12)
Nitrate Nitrogen (mg/L)	0.24 (0.06 - 0.56)	0.16 (0.06 - 0.28)
Ammoniacal Nitrogen (mg/L)	0.07 (<0.01 - 0.15)	0.09 (0.01 - 0.17)
Total Inorganic Nitrogen (mg/L)	0.35 (0.20 - 0.60)	0.28 (0.20 - 0.37)
Total Nitrogen (mg/L)	0.57 (0.35 - 0.86)	0.51 (0.38 - 0.84)
Ortho-phosphate (mg/L)	0.03 (0.02 - 0.04)	0.03 (0.02 - 0.05)
Total-Phosphorus (mg/L)	0.10 (0.05 - 0.24)	0.12 (0.07 - 0.25)
Phaeo-pigment (µg/L)	1.67 (0.20 - 4.27)	1.40 (0.20 - 5.63)
Chlorophyll-α (µg/L)	1.5 (0.47 - 3.27)	1.86 (0.53 - 7.37)
E.coli (cfu/100mL)	441 (123 - 1977)	160 (30 - 1133)
Faecal Coliforms (cfu/100mL)	873 (160 - 2683)	240 (40 - 2000)

In the Study Area water quality varies throughout the year and wide ranges in salinity, dissolved oxygen, nutrients and suspended solids concentrations are recorded. This concurs with our detailed understanding of the water body which has been accrued from surveys, monitoring and auditing of projects in the area of influence for over a decade. Long term trends indicate that the level of E.coli has increased in the area over the last decade. This is an issue which needs to be taken into account when assessing the disposal of effluent generated by the construction workers and those at the Toll Plaza and associated facilities during the operational phase.

Although station WM4 is located offshore from the Toll Plaza it does give an insight into the water quality in the general area. Water quality in the vicinity of WM4 was found to be relatively turbid with wide ranges in dissolved oxygen concentrations and nutrients. This is not surprising considering the pollution loads received by the adjacent Victoria Harbour and North Western Water Control Zones.

6.4 Sensitive Receivers

Water quality sensitive receivers have been defined in accordance with the requirements of the Hong Kong Planning Standards and Guidelines and have been transposed into the Technical Memorandum of the EIA Ordinance. As required under the Study Brief all water bodies, water and stream courses, groundwater systems and other sensitive or beneficial uses (bathing beaches, sea water or cooling water intakes, marine life etc.) have been identified.

Sensitive receivers have been identified as follows:

- Tsing Lung Bridge
  - bathing beaches - Dragon Beach, Angler's Beach Gemini Beaches, Hoi Mei Beach, Casam, Lido, Ting Kau and Approach Beaches. The closest beach is however located approximately 3 km from the site of the northern pier of the Tsing Lung Tau bridge and is thus outside the area of influence;
  - seawater intake at Chok Yuen Tsuen (WSD Pumping Station); and
  - marine life including the Ma Wan Mariculture Zone
- Fa Peng and Tso Wan
  - marine life.

Both the construction and operation phases have been taken into account when assessing the impacts on sensitive receivers identified above and illustrated in *Figure 6.1*.

6.5 Construction Phase Assessment

6.5.1 Potential Sources of Impacts

As identified above there are two main components of the Project that could affect water quality during construction viz. Tsing Lung Bridge (Northern Section) and the Toll Plaza between Fa Peng and Tso Wan. For both of these components construction activities have been identified, a preliminary construction programme drawn up and the impacts assessed in accordance with the requirements of the TM. The other structure which will be constructed over water is the Yi Chuen viaduct. This will be constructed with minimum disturbance to the receiving waters, using bored coated piles and a concrete link beam above water level to provide ship protection. The piers will have negligible impact on receiving waters during or following construction.

6.5.2 Assessment Methodology

Construction Phase

The assessment methodology which has been adopted is as follows:

- define the type and extent of construction activity (reclamation, dredging, concrete batching, finishing etc.);
- identify the expected duration of activities and specific locations;
- define the potential impacts, for example, increases in suspended solids and potential release of pollutants to the water column in the case of dredging or sourcing fill material; and
- make recommendations for measures to minimise residual impacts to acceptable levels.

Implementation of the aforementioned works may result in increases in suspended solids, E.coli and could adversely affect aesthetic quality (in particular litter and oil). The impact assessments and the mitigation measures have thus focused on these parameters.

The major influence on the levels of suspended solids in the waters in the vicinity of the Study Area is the fresh water flows from the Pearl River which carry high suspended solids loads especially during the wet season.

Suspended solids (SS) concentrations in the aforementioned areas are summarised in *Table 6.4*.

Table 6.4 Annual Mean and Maximum Suspended Solids Concentrations (mg/L)

Year	NM1	WM4
1993	19(49)	11(23)
1994	22(31)	16(47)
1995	15(40)	9(27)
1996	6(11)	7(14)

Note ( ) maximum suspended solids concentrations

The WQO is expressed in terms of a 30% increase above background levels. Background levels will be defined as part of the EM&A procedures. However, for the purposes of this assessment, it has been assumed that for marine works undertaken in the vicinity of the Tsing Lung Bridge the SS concentration should not exceed 8 mg/l during construction (refer to NM1 Station). At the Toll Plaza, between Tso Wan and Fa Peng, the works should not cause the SS concentrate to exceed 9 mg/l (refer to Station WM4) in order to comply with the WQO's. The actual baseline data which will be used to determine control limits during the construction phase will be defined through surveys as part of the EM&A works (before marine works commence).

The water courses which will be traversed or diverted as part of the construction of the route are not included in the EPD River Water Quality Monitoring programme, and no data has been published upon which to base a preliminary description of the water quality. However, these streams have been surveyed as part of the ecology surveys and are described in Section 7 of this Report.

6.5.3 Tsing Lung Bridge

From engineering considerations the northern tower of the Tsing Lung Bridge needs to be founded in the area shown on *Figures 6.2 & 6.3*. To provide ship impact protection for the northern tower the base of the column will be surrounded by reclamation. The areal extent of this reclamation is 26,000m^2 with a volume of 224,100m^3.

Ground investigations have revealed minimal marine deposits in the area to be reclaimed. A small pocket of marine deposits was identified in the area of the proposed seawall. A design concept has been developed to minimise water quality and waste disposal (spoil) impacts as far as practical which is as follows:

- adopt a "no-dredge" solution;
- for pockets of marine deposits treat in-situ with ground improvement techniques such as deep cement mixing (injection of chemical deep into soft deposits which reacts, like concrete, to stiffen the materials), sand piles or stone columns (with geo-grid reinforcement) to avoid dredging;
- excavate the seabed to suitable rock at the location of the tower foundation;
- construct concrete caissons off-site and float to site;
- form the remainder of seawall; and
- fill caisson with tremie concrete prior to completion of reclamation.

Construction of Seawall and Armouring

Water quality issues relating to construction of the seawall depend largely upon the construction methods employed. It is intended that the seawall will be formed without dredging and thus the construction of the seawall will have minimal impact on receiving water quality. Although no specific mitigation measures are required for this activity, other than those generally applied for the protection of marine waters, it is recommended that care is taken when placing rock on the seabed to minimise disturbance of any loose material. Limited water quality monitoring is proposed to confirm that the impacts are minimal. The scope and extent would need to be agreed with EPD prior to commencing the construction and therefore monitoring works.

Excavate Rock by Underwater Blasting

The excavation of rock to provide a suitable foundation for the northern tower will be undertaken over a period of around two months and will involve underwater blasting.

Activities associated with this aspect of the works include the preparation of the site, drilling holes within which the charges are placed and firing the charges. Grab dredgers will then remove fragmented rock. The diameter of the resulting materials will be large (cobbles or above) and as such no off-site migration of fines is expected. No specific mitigation measures will be required for water quality other than those

generally applied to marine waters. For protection of marine life the mitigation measures suggested in Sections 7 and 8 should be adopted.

Concrete Caissons

Two caissons will be cast off-site and floated to site. A location for a casting yard has not yet been identified and will be subject to separate assessment during the Detailed Design. Only a small area (18m diameter dry docks) will be required for the casting and this could be outside Hong Kong. Measures for the protection of water quality will encompass this area and will include the avoidance of pollution from washout of batching plants and from debris when the caissons are floated out.

Complete Reclamation

Off-site migration will be minimised by first constructing a seawall. Fill will then be placed behind the seawall thereby limiting the effect on water quality. As this activity will be undertaken behind a seawall in what is in effect an isolated situation, there will be no adverse impacts on receiving waters by off-site migration of sediments.

Other Construction Activities

Other construction activities will be defined as part of the engineering assessment and include, for example, the need for concrete batching and the washing out of such facilities. Mitigation measures will be defined in accordance with the requirements of the existing guidelines provided by EPD (ProPECC Note PN1/94 "Construction Site Drainage") to ensure full compliance with the TM. Sewage and other waste arisings will be treated and disposed of in accordance with the TM. Temporary treatment facilities such as package treatment plants will be included as Environmental Protection Measures requirements in the Contracts.

6.5.4 Toll Plaza

Construction of the Toll Plaza will require the following activities to be undertaken:

- dredging for seawalls;
- construction of seawalls and reclamation;
- construction of viaducts/bridges;
- cutting/haulage soil;
- blasting of rock/haulage;
- handling stockpiling of construction materials (batching plant);
- construction of carriageways (bitumen macadam);
- plant storage and construction of site offices; and
- building construction.

Dredging for Seawalls

Less than 0.45Mm^3 of marine deposits will be removed prior to forming the seawalls for the reclamation for the Toll Plaza between Fa Peng and Tso Wan. As stated previously the design concept is to minimise dredging as far as practical. However along the alignment of the seawall the marine deposits are too thick and too extensive to leave in situ. Thus dredging must be carried out to provide a stable foundation for the seawall.

Dredging is scheduled to be undertaken over a 2-month period with a total daily production rate of around 9,500m^3/day (assuming two dredgers). As the dredging will take place in two relatively shallow embayments, the number of items of plant that can be operational at any given time will be restricted (for access and marine safety reasons). This is of benefit to the environment as the impact on water quality, marine mammals and marine traffic will be limited. It has been identified that it is feasible to extend the period of dredging to reduce production rates and thus further reduce impacts on receiving water quality.

The areas to be dredged are effectively shallow embayments with low current velocities. As such it is expected that sediments released to the water column during dredging will be deposited close to the source with little off-site migration. It has been identified that the closest water sensitive receiver is the Ma Wan Fish Culture Zone. This sensitive receiver is located around 3km from the dredging site and is separated from the source of sediment by the swift flowing Kap Shui Mun Channel.

While it is understood that any sediments released into the Kap Shui Mun Channel would be rapidly dispersed by the strong tidal flows, it is prudent to take cognisance of other marine construction works which could take place in the area. Other projects which have been identified within the Study Area and could be scheduled to be constructed within the same period as Route 10 (NLYLH) are Penny's Bay Reclamation, Container Terminal No. 9 (CT9) and the dredging for the Dangerous Goods Anchorage at Tang Lung Chau. A cumulative impact assessment has been carried out (under the approved EIA for the Dangerous Goods Anchorage at Tang Lung Chau on behalf of Civil Engineering Department) using sediment transport modeling results that have assumed sediment release from all of these sources. The results confirm that with the dredging rates assumed the water quality impacts will be acceptable providing the combined rate of dredging from Route 10 (NLYLH) and the Dangerous Goods Anchorage at Tang Lung Chau. does not exceed 9,500m^3/day

The programme given in the Feasibility Study under Agreement No CE 26/94 "Tsuen Wan Bay Further Reclamation: Tang Lung Chau Dangerous Goods Anchorage Area" (refer to *Annex E*) indicates dredging taking place at a different time than that for the construction of the Toll Plaza. Nevertheless, during the detailed design liaison between the two Projects will be required to ensure that the combined rate of dredging does not exceed that specified. In any event this should not present a problem as both the extent and duration of the dredging for the Toll Plaza is limited.

Notwithstanding the foregoing the following measures may be considered for the protection of water quality and marine life:

- limiting the cumulative dredging for the Toll Plaza and Tang Lung Chau DGA (which includes the cumulative effects of dredging for Penny's Bay and CT9) to a maximum daily dredging rate of 9,500m^3;
- provision of additional measures to minimise release of sediments to the water column such as the use of closed grabs or silt curtains; and
- inclusion of water quality monitoring in the monitoring and audit schedule for the duration of marine works at the Toll Plaza.

Reclamation and Filling

The design intention is first to construct the seawall and then to fill behind it. This procedure will reduce the potential for off-site migration of "fill", although it is noted that the particle size of fill is much greater than soft marine deposits and as such these materials are less likely to be transported off-site. Notwithstanding the foregoing it is recommended that no rainbowing or rehandling basins are used on site and that material is only placed behind an external seawall or temporary rock bund. With the inclusion of such measures it is expected that water quality impacts can be reduced to acceptable levels.

Other Activities

Potential impacts that may arise from the construction of the other facilities shown above include:

- run off due to erosion of exposed surfaces, uncontrolled run off from plant maintenance, materials handling and other works areas;
- litter from packaging materials and waste construction materials; and
- construction workforce sewage.

For the protection of water quality, it is recommended that the contractors provide dedicated works areas for, inter alia, the following activities:

- the application of protective coatings or finishings to construction materials;
- bentonite mixing;
- concrete batching;
- mixing of fertilisers or other materials used in the landscaping works; and
- fuel storage, refuelling or vehicle maintenance.

Provision of a dedicated drainage system around all these works areas for the collection and containment of any materials or spillages will be a stated requirement in the contract. It is recommended that spent materials or spillages be either reused or containerised and disposed of off-site in a manner which is acceptable to EPD.

All process waters, including washout water from any concrete batching plant employed on-site or water used for testing the structures and fittings should be disposed of or treated to ensure compliance in accordance with the provisions of the TM. Disposal of wastewater generated on site will be in accordance with the requirements of the ProPECC PN1/94. All domestic effluent will be disposed of via a package treatment plant and effluent disposed of in accordance with the requirements of the TM.

6.5.5 Tai Lam Chung Tunnel

The available information suggests that the rock mass is generally tight with low values of rock mass permeability. Local and perhaps heavy water inflows could be experienced during tunneling related to specific geotechnical features such as continuous weathered joints. Portal areas can be susceptible to high rates of vertical transmission during periods of heavy rainfall. Six streams cross the line of the tunnel on the surface.

The proposed tunnel alignment will encroach on the WSD water gathering ground for the Tai Lam Chung Reservoir both in terms of surface runoff and groundwater catchment. The tunnel will act as a drain during construction and throughout its service life and could therefore divert groundwater flow from WSD reservoirs, tunnels and catchwaters. In the Preliminary Design the loss of yield has been quantified and the zone of influence of the tunnels has been defined. An assessment has been carried out to quantify the possible effects using data from the Site Investigations and a detailed groundwater monitoring programme developed for both the current and subsequent Assignments.

A model of the groundwater regime has been developed using the computer programme SEEP/W (Geosolve) to determine whether potential significant 'Loss of Yield' exists. The assessment is especially relevant to the dry season when recharge to the Reservoir will be potentially low. Hydrogeology including springs and streams was also examined.

The conclusion drawn from the assessment was that there will not be a measurable loss of yield associated with the alignment. Notwithstanding the foregoing it is recommended that baseline monitoring be established as part of the Drainage Monitoring and Audit Programme using piezometers. The locations will be determined during the detailed design stage of the project.

Inspection of the WSD catchwater tunnel as part of this Assignment indicated dripping water from the rock mass only in certain zones. Experience from the water supply delivery tunnels, Tai Po to Butterfly Valley Project, approximately 400m from the Shing Mun Reservoir is that water inflows are very low and do not impact on the Reservoir.

Dewatering of the tunnels will generate waste-water which is heavily charged with suspended solids and adsorbed oils. Pretreatment of these wastes using settling basins, skimmers and flocculators may be required prior to discharge to receiving waters in order to achieve the standards required under the Technical Memorandum and Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters.

6.6 Post Construction Water Quality Impact Assessments

6.6.1 Potential Sources of Impacts

General Wastes

Post construction impacts relate to the possible changes in the tidal flow or sediment transport/deposition regimes and the possible consequences on water quality as a result of constructing the Tsing Lung Bridge and the Toll Plaza. This Project will not generate any pollution load other than the highway and tunnel drainage which is being assessed under the Drainage Impact Assessment and effluent generated by the staff manning the toll booths, administration and control buildings.

Tsing Lung Bridge

For the assessment of the northern pier of the Tsing Lung Bridge consideration has been given to the physical extent of the reclamation, the position of the reclamation with respect to the main tidal flows and the changes in cross sectional area caused by the reclamation.

Toll Plaza

Particular attention has been given to the design of the Toll Plaza to minimise the impacts on the Fa Pang and Tso Wan embayments. The extent of the reclamation has been minimised as far as practical (from an engineering perspective) and the Government's stated objective of minimising construction waste has been taken into account in the design of this component of the Scheme. Dredging has been restricted to the removal of material prior to forming the seawall. The embayments are not totally infilled, thereby obviating the need for resumption of the villages. The natural shorelines and habitats have been protected by providing two channels/openings to allow tidal exchange.

6.6.2 Post Construction Stage Assessment

Tsing Lung Bridge

The area to be formed for the northern tower and ship protection for the Tsing Lung Bridge is located within an embayment (within the -8mPD contour) some 70m from the main tidal channel (-20mPD contour line). The fact that the formation of the land is within an existing embayment and does not intrude on main tidal flows (refer to illustrations in *Annex E*) means that the scope for alteration to sedimentation and flow regimes is limited. There is no pollution generated at the bridge tower and the reclamation does not affect dispersion of effluent from outfalls in the North West Water Control Zone. Water quality impacts are therefore acceptable.

It has been calculated that in order to provide adequate ship protection, an area of $0.2Mm^3$ of reclamation is required. The shape of the seawall has been carefully designed to avoid intrusion into the main tidal flows (refer to *Figure 6.3*). The reduction in cross sectional area between Tsing Lung Tau and Kwai Shek, illustrated on *Figure 6.4*, is calculated to be less than 1.5%. The previous proposal for the bridge, designed under the Sham Tseng Link Study, caused a reduction in cross section area of >3.5% and the northern tower was located within the main channel. The modelling results confirmed that a reduction cross sectional area of 3.5% was acceptable from a water quality perspective, therefore the present design will also be acceptable and would further improve the performance.

The modeling data contained in *Annex E* effectively demonstrates the differences between the scenarios where the bridge tower is located in the embayment and where the tower is located in the main channel. For the current situation where the tower is located in the embayment the residual impacts will be acceptable in terms of local tidal flow regimes. Local currents are expected to maintain both speed and direction once the reclamation is in place and no beneficial uses will be affected.

Toll Plaza

The proposed alignment is illustrated in *Figure 6.5* which shows that the effective embayments have been reduced by about 50%. The design concept for the Toll Plaza is to minimise reclamation as far as practical, to avoid encroachment on village land at Fa Peng and Tso Wan, to maintain the natural coastline and beaches and to retain the option of marine access for the villagers.

This has been achieved by providing openings (or channels through) the reclamation for the Toll Plaza as illustrated on *Figure 6.5*. To ensure adequate exchange of the waters between the embayments (at Fa Peng and Tso Wan) and the marine tidal waters, these openings have been sized at a width of 20m in the preliminary design. This concept is similar to the one incorporated into the North Lantau Highway where an opening was included as openings to ensure effective exchange of water between the Pak Mong Lake and the main tidal flows of North Western Waters. The bridge at Pak Mong has proved to be very successful in maintaining water exchange, water quality and ecological resources in the lake.

Calculations are contained in *Annex E* which indicate that, with openings of 20m at both northern and southern ends of the Toll Plaza, there should be adequate exchange of waters between the embayments and the main tidal flows to maintain water quality.

In future there will be no direct pollution load discharged into the embayments (as the domestic sewage from the villagers, presently 7 in number, will be collected in concert with effluent generated at the Administration Building). Effluent generated by the staff involved in operations at the Toll Plaza will be collected and treated prior to disposal. The number of staff engaged at the Toll Plaza and associated facilities is not expected to exceed 50 at any given time.

As there is no existing sewage treatment system serving this area, effluent will need to be treated prior to discharge. It is proposed that a package treatment plant is provided to achieve standards for discharge to Western Buffer Zone. Once further developments are constructed, as proposed under the Northshore Lantau Study, sewage will be treated centrally. Disposal/treatment requirements for all control facilities are outlined in *Table 6.5*.

Water Gathering Grounds, Drainage and Water Management within the Tunnel

Following construction, the potential impacts on water gathering grounds and inland water will relate to:

- paved area run off containing suspended solids with adsorbed hydrocarbons and heavy metals, principally lead, copper, zinc and iron;
- load spillage resulting from accidents; and
- drainage of tunnel wall washing water (undertaken probably every two weeks)

Two drainage systems have been developed during Preliminary Design. The systems are isolated to prevent contamination of the groundwater and watercourses.

- Pavement drainage:- collecting road surface water, washdown water from tunnel cleaning and seepage water that has entered the tunnel.

- Tunnel sub-drainage:- controlling groundwater seepage behind the lining.

Tunnel Pavement Drainage

Discharge onto the tunnel carriageway from routine maintenance or accidental spillage is drained into gullies on the low side of the pavement. Trapped gullies ensure containment of vapour in case of inflammable liquid spillage.

Pavement drainage will discharge at the portals into the adjacent highway drainage. Final discharge is into the either Ma Wan Channel or the Tai Lam Chung nullah outside the WSD catchment area.

Tunnel Sub-drainage

The road slab is supported on a sub-drainage layer in direct contact with the excavated rock surface in the tunnel invert. The sub-drainage layer has three main functions:

- to provide a permanent drain system to reduce groundwater pressure on the back of the tunnel lining;
- to relieve groundwater pressure below the road slab and secondary supports; and
- to regulate the excavated rock profile and support the road slab.

The layer is designed to have suitable filter characteristics to preserve its function as a drain. A geotextile mat between the road pavement and subdrain will assist in maintaining the seepage characteristics of the sub-drainage layer.

Perforated pipes installed throughout the main tunnels will drain the sub-base layer and carry backdrainage and seepage flows. The sub-base drains will discharge into silt traps at the portals.

6.7 Definition of Mitigation Measures

6.7.1 Construction Phase

Works Areas

Any discharges from works areas to water courses will be controlled under the Water Pollution Control Ordinance and licences will be required. The effluents must meet the Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters.

Standard mitigation measures which should be applied are:

- boundaries of works areas should be marked and surrounded by ditches or sand bags control run-off; run off should be diverted via silt retention ponds;
- exposed areas should be minimised by covering or reinstatement, through hydroseeding or landscaping paving etc. as soon as practicable;
- water from tunnel dewatering activities should pass through a silt and oil trap before being discharged to surface waters;

- water used for drilling works, boring and concrete casting should, as far as possible, be recycled, otherwise it should be passed through a silt trap prior to discharge;
- fuel tanks should be provided in bunded areas with bunds of capacity not less than 110% of the largest tank capacity, the bunds should be regularly drained of rain water and any spillages cleaned up immediately;
- maintenance areas should be paved with adequate drainage facilities with silt and oil interceptors and if possible be under cover;
- defined storage areas should be set aside for waste material and litter nets provided to retain wind blown litter; and
- sewage from toilets should be discharged into the local sewerage system where possible, otherwise package sewage treatment plants should be provided.

Dredging

Mitigation measures which need to be considered to minimise the release of materials to the water column during dredging include:

- minimise disturbance to seabed when dredging by controlling rate of lift;
- minimise leakage of dredged material when lifting (by using closed and sealed grabs and specifying maximum release rates);
- minimise loss of material during transport of material to disposal site; and
- disposal of material only at approved locations.

Mitigation measures will be defined for each situation or construction activity where potential effects on water quality could arise. The proposed mitigation measures will draw on best environmental practices and on MCL's extensive database of environmental protection measures developed from a decade of developing the monitoring and auditing procedures for projects during construction.

Reclamation

In addition to the general good site practice measures to be adopted, the following will also apply:

- fill will only be placed behind a seawall or temporary rock bunds;
- no rainbowing of materials will be allowed; and
- no rehandling basins will be used.

6.7.2 Post Construction Phase

Mitigation measures will be developed on the basis of suggesting modifications to engineering proposals as the designs are being developed. This approach was pioneered by MCL in Hong Kong and has been successfully demonstrated on many infrastructure projects over the last decade.

Mitigation to be applied during operation of the project should include:

- provision of package treatment plants at the Toll Plaza and associated office facilities and control at each control area, except So Kwun Wat, where the effluent can be directed to foul sewer;
- sediment traps incorporating oil separators should be installed at the Toll Plaza;
- emergency spill plans should be prepared as part of the operation and maintenance manual; and
- drainage from the tunnel (including the washing operations) should pass through sediment and oil traps sited at the portals prior to discharge. The traps should be cleared of oil prior to carrying out wall washes and all wastewater discharged to the drainage system must comply with the requirements of the Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters.

6.8 EM&A Requirements

Detailed mitigation measures based on the EIA and monitoring and audit requirements will be defined for inclusion in the EM&A Manual.

6.9 Conclusions

The water quality assessments confirm that the works can be carried out in accordance with the requirements of the Technical Memorandum. During the preliminary design measures have been included to minimise water quality impacts as far as practical. These include:

- adopting a drained not dredged reclamation;
- retaining natural embayments and shoreline at Fa Peng and Tso Wan by means of including openings in the Toll Plaza; and
- reducing the cross sectional area of Ma Wan Channel affected by the Northern tower of Tsing Lung Bridge.

During construction the assessments demonstrated that the water quality impacts due to dredging for the seawall at the Toll Plaza could be contained within acceptable levels and would comply with the TM requirements.

Following construction there will be only minor, and acceptable, changes to the local tidal flow regime as a result of providing reclamation at Tsing Lung Tau, and the Toll Plaza between Fa Peng and Tso Wan would be acceptable in terms of water quality and would allow the requirements of the TM to be achieved. No residual impacts are anticipated.

Table 6.5 Disposal of Effluent from Toll Plaza and Control Facilities

Location	No. of Persons	Flow m^3/day	Loads (kg/day) [mg/l]						Disposal
			SS (0.034)*1	BOD (0.034)*1	COD (0.070)*1	TKN (0.0067)*1	NH_3 (0.0040)*1	E.Coli ($3.5x10^{10}$)*1	
Lantau Toll Plaza	50 (max at any given time)	3	1.7 [567]	1.7 [567]	3.5 [1167]	0.335 [112]	0.2 [67]	$1.75E^{12}$	Package sewage treatment plant
Tai Lam Chung Tunnel Northern Portal Building	5 - 10	0.6	0.34 [567]	0.34 [5.67]	0.7 [1167]	0.067 [112]	0.04 [67]	$3.5E^{11}$	Foul Sewer
Control Facilities									
• So Kwun Wat	80	4.8	2.72	2.72	5.6	0.32	0.32	$2.8E^{12}$	Foul sewer
• Tsing Lung Tau	10 - 20	1.2	0.65	0.68	1.4	0.43	0.05	$3.5E^{11}$	Package sewage treatment plant
• Kwai Shek	5 – 10	0.6	0.34	0.34	0.70	0.067	0.04	$3.5E^{11}$	Connect to Northshore Lantau Developments when complete development
• Tai Lam Chung	5 - 10	0.6	0.34	0.34	0.70	0.067	0.04	$3.5E^{11}$	Foul sewer
Discharge Standard		<10m^3/*2 day	1200	1200	3000	-	-	-	

* 0.060m^3/cap/day assumes employed population from the sewerage manual.
*1 per capita pollution
*2 Foul sewer