13 SUMMARY AND CONCLUSIONS

13.1 INTRODUCTION

This Section provides a summary of the results and conclusions of the technical assessments of the power station component of the Lamma Extension project, as described in detail in the previous Sections of this Part of the EIA Report.

13.2 AIR QUALITY ASSESSMENT

The air quality assessment for the power station, which is presented in *Section 4* of this Part of the Report, contains six components:

- a review of the baseline conditions;
- physical (ie wind tunnel) modelling of the combined impacts of emissions from the existing and proposed power stations;
- numerical modelling of the impacts of the proposed power station on air pollution levels throughout the SAR, especially photochemical pollution;
- a quantitative review of potential impacts on air quality in the wider Pearl River Delta Region;
- an assessment of greenhouse gas emissions and mitigation options for HEC's overall operations; and
- an assessment of construction dust impacts.

13.2.1 Baseline Air Quality

Review of the monitoring results obtained from EPD and HEC monitoring network from 1992 to 1996 revealed that the measured SO_2 and NO_2 concentrations are well within the Air Quality Objectives (AQOs). The maximum hourly concentrations of an average day were chosen for the background levels for the assessment of the cumulative impacts. The background levels for hourly SO_2 and NO_2 are $33\mu g\ m^{-3}$ and $80\mu g\ m^{-3}$ respectively for the urban areas and $23\mu g\ m^{-3}$ and $49\mu g\ m^{-3}$ respectively for the rural/new development areas. For daily and annual averages, it is considered that average annual means for the 5 years period from 1992 to 1996 should be used. The background concentrations for daily and annual SO_2 and NO_2 are $20\mu g\ m^{-3}$ and $51\mu g\ m^{-3}$ respectively for the urban areas and $10\mu g\ m^{-3}$ and $28\mu g\ m^{-3}$ respectively for the rural/new development areas.

13.2.2 Wind Tunnel Modelling

Flow Visualisation Tests

Flow visualisation smoke tests generally indicated that larger impacts would be likely to occur with high wind speeds (around 12 to 15 m s^{-1}) than lower speeds

(less than 9 m s^{-1}). The tests also suggested that impacts would be greater on or near Lamma Island than on Hong Kong Island or Cheung Chau.

Plumes from the taller stacks may overshoot the local terrain on Lamma Island. However, plumes from the shorter stacks were observed to directly impinge on the hilly terrain of Lamma Island. It was also observed that wake effects caused by the hilly terrain on Lamma Island had the potential to influence plumes emitted from the shorter stacks, and hence cause the most significant impacts in the vicinity of the facility. The potential impacts at these locations were further evaluated in the quantitative tracer gas measurements to determine a proposed stack height for the new plant.

Stack Height Determination

Based on the results of the flow visualisation experiments, quantitative tracer gas measurements were made for five wind speeds at 26 receptors on Lamma Island only. *Table 13.2a* presents the worst-case measured SO_2 and NO_2 levels for the three stack heights which were tested. The worst case concentrations occurred consistently for all three stack heights at 15 m/s when the wind direction was from 200°.

Table 13.2a ***Worst-Case Air Quality Impacts due to New Stacks Serving CCGT Units***

Source	Stack Height (mPD)	Worst-Case Concentration Ratio (%)	SO_2 (μg/m³)	NO_2 (μg/m³)
6x300 MW CCGT	90	0.368	28	51
6x300 MW CCGT	110	0.250	19	35
6x300 MW CCGT	130	0.208	16	29

For stack height determination the most pessimistic scenario of emergency oil firing was used. The results suggested that a significant reduction in impacts can be expected with the 110 mPD stack when compared to a 90 m stack. Impacts would be further reduced by extending the stack height to 130 m, but a much smaller benefit was indicated. An exceedance of the one-hour objective of 800 μg m^{-3} for SO_2 was predicted with the 90 m stack height for the oil-firing scenario. This exceedance was predicted without considering background concentrations or additional sources operating at the Lamma Island facility. A 110 mPD stack height was therefore recommended for the new power station.

Prediction of Combined Impacts in 2002 and 2012

Air quality impacts due to the combined operation of existing and proposed sources were then tested with further quantitative tracer gas measurements. Predicted maximum hourly, daily and annual average concentrations were derived at each receptor for SO_2 and NO_2 respectively. The results indicated that there would be no breaches of the Air Quality Objectives (AQOs) with peak load operations of the new power station in year 2012.

Significant improvements in ambient air quality were indicated for the commencement of operations of the new gas-fired power station, when compared with the base case in 2002. Long term impacts as measured by the annual averages at each receptor were considered to be very low. Generally speaking, the predicted SO_2 and NO_2 concentrations are well within the AQOs for all modelled receptors.

Evaluation of Predicted Impacts

The wind tunnel modelling results suggest that there should be no exceedances of the AQOs for the three modelled scenarios (ie with the existing plant only in 2002; the new plant fully operational in 2012; and the additional operation of a proposed waste-to-energy incineration facility (WEIF) at Lamma Island in 2012), even when background air quality is considered .

This conclusion is applicable to conditions in the wind tunnel which resemble the neutral atmospheric stability conditions, commonly known as Stability Classes C and D according to the Pasquill-Gifford Classification Scheme. It is widely accepted that such atmospheric conditions are most representative for modelling worst case impacts during the full load operating conditions of the power station. At the request of the EPD, this premise was reviewed with data from the Hong Kong Observatory for 1993 to 1997. Based on surface observations at Cheung Chau and the upper air measurements at King's Park, it was found that the occurrence of stable conditions is so insignificant as not to warrant a detailed air quality assessment. Only 24 morning or evening stable cases with southwest winds were identified over the five-year period, and only a fraction of those occasions would be expected to coincide with high load power plant conditions. It is estimated that the total number of hours with high load coinciding with southwest winds and stable conditions may be as low as three times over five years.

Notwithstanding the fact that occurrences of stable conditions are rare during conditions of high power station loads, a supplementary 5 year episodes analysis was undertaken to address air quality impact during periods of stable or unstable atmospheric conditions and to examine episodes when levels of pollutant are high. The analysis concluded that the results of the wind tunnel modelling were adequate for the assessment of worst case air quality impacts for this EIA study.

Concerning the emergency oil-firing scenario, a high level availability analysis indicated that, based on preliminary engineering details, the availability of gas supply is 99.65%. It should be noted that the remaining 0.35% does not necessarily mean that there is an average outage of approximately 1.3 days per year. Even on the rare occasion of emergency oil firing, the above results suggest that the AQOs will not be exceeded.

Conclusions

The wind tunnel modelling study concluded that:

- a stack height of 110 mPD is adequate for the combined cycle gas turbine (CCGT) units at the new power station, as confirmed by detailed tracer gas measurements at key locations identified in flow visualisation tests;

- the net and cumulative impact of the operation of the new 1800 MW power station with the existing power station in year 2012 will not cause any exceedances of the relevant AQOs for SO_2 and NO_2 at identified receptors in the near-field of the power station;

- the operation of the WEIF will not cause any constraints to the proposed development of the 1800 MW new power station and vice versa;

- an general improvement in ambient air quality and reduction in the annual emissions of SO_2 and NO_2 are predicted in year 2012 compared to year 2002 due to the shifting of power station loads from the coal-fired units to the gas-fired units, despite an overall increase in electricity output from 2794 MW to 3916 MW; and

- in the unlikely situation of emergency oil firing, the expected air quality impacts are still within the relevant AQOs.

13.2.3 *PATH Modelling*

Modelling Approach

The PATH photochemical air quality modelling system was used to identify the *incremental* impact on air quality of the new power station at Lamma Extension, by predicting air quality at hourly intervals throughout the SAR (under selected meteorological conditions), *with* and *without* the emissions from the proposed new facility. The outputs of the model are a true cumulative assessment of emissions from existing and proposed units at Lamma, the proposed WEIF, motor vehicles, area sources, industrial facilities, marine vessels and other sources in Hong Kong.

Two scenarios were developed for the year 2012:

- *Scenario A*: all emissions *excluding* the emissions from the new CCGT units at Lamma Extension; and

- *Scenario B*: all emissions *including* the emissions from the new CCGT units.

For each scenario a total of six model runs were undertaken using PATH. A key concern was the possible impacts of the CCGT units when prevailing winds are southwesterly and any plume emitted from the proposed facility would be directed towards Hong Kong Island and Kowloon. A meteorology simulation for such conditions has already been developed for PATH. Five additional days were simulated which together encompass the range of meteorological conditions that prevail in Hong Kong over the course of a year. By combining the results of these simulations annual average concentrations of pollutants may be estimated.

Analysis of Predicted Impacts: Southwesterly Day

The following table presents the maximum one-hour concentrations of nitrogen dioxide, sulphur dioxide and ozone for the day with southwesterly winds.

Table 13.2b ***Predicted Maximum One-hour Concentrations***

Pollutant	*Concentration ($\mu g\ m^{-3}$) (b)*		
	Scenario A	*Scenario B*	*CCGT Increment(a,c)*
SO_2	192 (Deep Bay)	192 (Deep Bay)	3.8 (Kowloon) *114 (NW of Sha Tin)*
NO_2	104 (NW Kowloon)	105 (NW Kowloon)	19.5 (Western) *86 (NW Kowloon)*
O_3	117 (Mirs Bay)	117 (Mirs Bay)	4.4(Aberdeen) *84 (Deep Bay)*

Notes:
(a) *The maximum incremental impact attributable to the proposed CCGT units is not coincident either temporally and/or spatially with the maximum reported concentrations under Scenarios A and B.*
(b) *Location of peaks shown in corresponding cells in the table.*
(c) *Italicised data are the Scenario B concentrations for the maximum impact hour.*

Under Scenario B all concentrations are at least 50% below the AQOs. As a percentage of the relevant AQOs, the maximum contributions of the proposed CCGT units to levels of NO_2, SO_2 and O_3 are 6.5%, 0.5% and 1.9% respectively.

Although some minor increases in ozone levels are predicted to occur to the north of Lamma, the main effect of the emissions is to reduce ambient levels of ozone in the Lamma Island, Hong Kong Island and Eastern New Territories areas, as nitric oxide (NO) emissions tend to remove ozone from the atmosphere by titration.

Predicted maximum 24-hour concentrations of SO_2 and NO_2 are also well within the AQOs, and the largest incremental contributions of the CCGT units are 0.4% and 3.7% of the AQOs for SO_2 and NO_2 respectively.

The area of peak daily average concentrations of NO_2 extends from Kowloon to Sha Tin, with the maximum concentration predicted in Kowloon. The peak concentrations of SO_2 are less evenly distributed, with three areas predicted to have daily average concentrations exceeding 50 $\mu g\ m^{-3}$.

It can be concluded from this evaluation that the cumulative impacts of the proposed CCGT units under the "worst case" wind direction are well within the AQOs. The impacts attributable to the proposed new plant are considered to be negligible in the locations where those maxima are predicted to occur.

Analysis of Predicted Impacts: Other Days

The following observations can be made on the results of model runs for the other five days.

The predictions indicate that the cumulative impacts of emissions from both the new and existing power stations will not exceed the one-hour AQOs. The maximum predicted one-hour ground level concentration of sulphur dioxide (502 $\mu g\ m^{-3}$), falls well within the corresponding AQO (800 $\mu g\ m^{-3}$). The maximum one-hour concentration of nitrogen dioxide (152 $\mu g\ m^{-3}$) is about 51% of the AQO (300 $\mu g\ m^{-3}$). The maximum one-hour ozone level (153 $\mu g\ m^{-3}$) is well within the AQO (240 $\mu g\ m^{-3}$).

Predicted maximum 24-hour concentrations are all in compliance with the AQOs.

The maximum 24-hour sulphur dioxide concentration (126 $\mu g\ m^{-3}$) is approximately 35% of the AQO (350 $\mu g\ m^{-3}$). The figure for nitrogen dioxide (85 $\mu g\ m^{-3}$) is about 57% of the AQO (150 $\mu g\ m^{-3}$).

The maximum incremental impacts of emissions from the CCGT units on one-hour average and 24-hour concentrations are typically very low and tend to occur over the ocean rather than populated areas.

Estimates of Annual Average Concentrations

Data from the six days simulated were combined to produce a weighted average concentration that approximates to the annual average (see *Table 13.2c).*

Table 13.2c ***Maximum Annual Average Concentrations***

Pollutant	Concentration ($\mu g\ m^{-3}$) [b]		
	Scenario A	Scenario B	CCGT Increment[a]
SO_2	44.0 (Tsing Yi)	44.0 (Tsing Yi)	0.6 (West Lamma Channel)
NO_2	63.4 (Western Harbour)	63.4 (Western Harbour)	2.6 (West Lamma Channel)

Notes:
(a) The maximum incremental impact attributable to the proposed CCGT units is not necessarily spatially coincident with the maximum reported concentrations under Scenarios A and B.
(b) Location of peaks shown in corresponding cells in the table.

The assessment indicates that the annual average concentrations of nitrogen dioxide in the Western Harbour area are predicted to be approximately 80% of AQO. The predicted concentration of sulphur dioxide is well within the AQO (by about 55%).

The increment due to emissions from the CCGT units is 0.8% and 3.3% of the AQOs for SO_2 and NO_2 respectively, and is not predicted to arise at the same location as the peak predicted concentration arising from all sources addressed cumulatively.

Conclusions

In summary, it was concluded from the PATH modelling studies that the additional impacts of the new power station on air quality in the Hong Kong region would be acceptable and, in terms of their contribution to maximum predicted levels of key pollutants, largely insignificant.

13.2.4 *Regional Air Quality Review*

Pearl River Delta Air Quality Assessment

A quantitative assessment of the regional air quality impacts of a new power station was undertaken as part of the Stage 1 EIA, the results of which have been documented in the Technical Paper *Stage 1 EIA: Pearl River Delta Air Quality Assessment*. The findings of this earlier assessment were reviewed and updated for the purpose of this detailed EIA Study.

The *Pearl River Delta Air Quality Assessment* provided a broad evaluation of the potential regional impacts of atmospheric emissions from the proposed new power station. It evaluated two alternative fuel options (coal and gas) and different emission control technologies for nitrogen oxides. Emissions and their effects at the regional level were addressed, including consideration of sulphur dioxide, nitrogen dioxide, particulates, acid deposition, visibility and photochemical reactions. A three-dimensional prognostic mesoscale meterological model, the *Lagrangian Atmospheric Dispersion Model* (LADM), was used to model the air quality impacts from the proposed new power station. LADM consists of a mesoscale windfield model and a Lagrangian particle dispersion model to predict the pathways of pollutants released from the identified sources. Major existing and future pollution sources that are conducive to photochemical reactions were identified for inclusion in the simulations.

A comparison of scenarios with and without the new power station showed that the predicted maximum O_3 and NO_2 concentrations in 2012 differ very little, regardless of the technology or fuel used. Predictions for O_3 indicated that the new power station would actually reduce O_3 concentrations, although the magnitude of the reductions is small. The minimal effect of the new power station suggests that most of the O_3 originates from other existing sources. From the regional perspective, the contribution of the new power station to maximum NO_2 concentrations in the Pearl River Delta was approximately 1%. The new gas-fired power station emissions were also found to have little effect on fine particles and hence visibility.

The Study also investigated the contribution of HEC power plant emissions to acid deposition in the region, and estimated contributions of 3% and 1% for the years 2002 and 2012 respectively.

Summary of Review Findings

During the detailed EIA Study, estimates of NO_x and SO_2 emissions from all major sources in Hong Kong were updated and projected for the years 1995, 2002 and 2012, including the new gas-fired power station. The 1995 data were revised mainly in accordance with data developed for the PATH air quality modelling system, and projected with scaling factors developed from CTS-3, Territorial Population and Employment Data Matrices and other sources.

Pollutant concentrations were then re-estimated and it was found that with the introduction of the gas-fired station, HEC's contributions to the PRD regional NO_2 and SO_2 concentrations would amount to only 1.5% and 0.7% respectively in 2012. The proposed new power station will also help to reduce the overall acid deposition to the region by about 1%. Hence, it could be concluded that the contributions of the new gas-fired station to regional NO_x and SO_2 are negligible in the context of the marked increases in emissions from the whole PRD region.

In conclusion, the new gas-fired station would contribute negligibly to maximum regional concentrations of O_3, NO_2 and SO_2, since the emissions from an additional power station, compared to the existing emissions in the PRD region, are extremely small.

13.2.5 Greenhouse Gas Emissions

This component of the air quality assessment included the compilation of a greenhouse gas emissions inventory for all HEC operations, and an investigation of greenhouse gas mitigation measures.

The inventory was compiled for two base years (1995 for HFCs and SF_6, and 1990 for the other gases including CO_2 - as required by the Kyoto Protocol) and projected to 2002 and 2012. Total emissions (in CO_2 equivalent) are projected to increase from 1990 levels by 80% (5.11 Mt) and 62% (3.97 Mt) in 2002 and 2012 respectively, illustrating the beneficial impact of gas-fired operation after 2002 despite total electricity generation in year 2012 being 2.57 times that of 1990. Estimated greenhouse gas emissions *per unit of energy produced* are expected to fall from 1990 levels by 37% in 2012.

Mitigation options were investigated in the areas of increased production and distribution efficiency, use of fuels with intrinsically low greenhouse gas emissions, improved consumption efficiency, reduced fugitive emissions, and carbon sequestration. The potential effectiveness of these options was evaluated, and a range of mitigation measures for HEC operations were investigated.

Estimates of expected emission reductions in the year 2012 were derived from the use of these measures, both for the new development and its operations as a whole. A total of 6.5 million tonnes of emissions of CO_2 equivalent will be avoided in 2012 as a result of these measures (a 39% reduction in overall emissions), leaving an estimated total of 10.3 million tonnes for HEC operations in that year. The total mitigation achieved in 2012 will be more than HEC's total emissions in 1990.

HEC is committed to adopting all practical measures for reducing its GHG emissions, especially from the proposed 6 x 300 MW gas-fired power station. Measures such as base-load shifting to gas units, gas flaring and participation in afforestation programmes will be employed. However, since both Hong Kong's population and economy continue to grow substantially in the next decade, electricity consumption and GHG emissions will inevitably increase.

13.2.6 *Construction Dust*

The potential impacts on sensitive receivers of dust emissions from construction work associated with the Lamma Extension reclamation and power station development were estimated and evaluated.

Predicted dust concentration levels (without mitigation) at sensitive receivers were in the range of 104 to 178 $\mu g\ m^{-3}$ (hourly average) and 56 to 61 $\mu g\ m^{-3}$ (daily average), both well within the recommended criteria of 500 and 260 $\mu g\ m^{-3}$ respectively. No special mitigation measures (over and above good site and housekeeping practices as well as compliance with the Air Pollution Control (Construction Dust) Regulation) were proposed.

13.2.7 *Conclusions*

The potential air quality impacts of the proposed power station at Lamma Extension, and the cumulative impacts of emissions from both the proposed power station and other sources, have been quantitatively assessed with a combination of physical and mathematical modelling studies and desk top evaluations. The near-field, mid-field and far-field impacts of the new development are considered to be environmentally acceptable. Extensive gains in greenhouse gas emissions have been identified for the mitigation measures which have been proposed for the new project and HEC operations in general.

13.3 *WATER QUALITY ASSESSMENT*

The water quality assessment presented in *Section 5* addresses the potential construction and operational impacts of the power station.

13.3.1 *Construction Impacts*

The assessment of the water quality impacts of construction of the reclamation for the Lamma extension project was focussed on impacts on the hydrodynamic regime, and the dispersion of fine sediment in suspension during dredging and filling operations. Both aspects were assessed using computational modelling.

Hydrodynamic Assessment

The hydrodynamic assessment included a baseline scenario (current conditions), and scenarios for both the Lamma Extension reclamation on its own, and the combination of Lamma Extension and WEIF reclamations.

Discharges were calculated for each of the three scenarios. Modelled changes at the cross-section were found to be around 2 to 3%, which is a relatively small change. Large changes (15.8%) in the maximum discharge rate across the southeast cross-section are predicted for the Lamma Extension scenario in the dry season, although this reduces to 4.9% for the Lamma Extension/WEIF scenario. This apparent large reduction is shown for only for the maximum rate, as the average discharge rates change by only 2.0%. This shows that it is only occurring at the instantaneous maximum where large changes occur, and for the rest of the tide the changes are small. The results of the discharge analysis, even for the southeast cross section, show that the flushing characteristics of the area are not affected by the inclusion of the two reclamations.

The age of water analysis for the area to the east of the reclamation showed that the reduction in concentrations of the introduced substance reduced at approximately the same rate for all three scenarios. Neither the Lamma Extension reclamation nor the combination of the two reclamations affected the flushing characteristics of the area to the east, which includes the beaches at Lo So Shing and Hung Shing Ye.

The conclusion for the hydrodynamic modelling is that the neither the Lamma Extension reclamation alone, nor the combination of reclamations, significantly affected hydrodynamic conditions, in terms of water level, current speed, cumulative or instantaneous discharge, or flushing characteristics. Therefore, no mitigation measures are required.

Sediment Dispersion Modelling

Four scenarios were constructed to simulate different approaches to dredging operations and differing intensities of dredging activity. The most intensive of these (Scenario 1) was simulated for four representative tide types (wet and dry season, spring and neap tides), and the results were used to determine the "worst case tide and season", which was then used for simulations with Scenarios 2 and 3. The fourth scenario (involving simultaneous dredging and filling) is programmed for implementation in the wet season only, so wet season spring and neap tides were simulated.

The simulations showed significant exceedances of water quality objectives (WQOs) for suspended solids (SS) at a number of sensitive receivers (SRs) for the most intensive Scenario 1, for both wet and dry season runs, and it was concluded that a lower rate of dredging would be required to meet the WQOs. The dry season neap tide was determined as the "worst case".

Predicted SS levels for Scenarios 2 and 3 using these "worst case " conditions were considered to be environmentally acceptable with no exceedances of the WQO for suspended sediment, provided that mitigation measures were employed in the form of deployment of silt curtains on the eastern, southern and north eastern sides of the reclamation and additionally for Scenario 2 reducing the number of large dredgers working on the flood tide by one. Also, predicted deposition rates and impacts on levels of dissolved oxygen and ammonia were well below levels of concern for both of these scenarios.

The simulation of combined dredging and backfilling operations (Scenario 4) produced results which were considered to be environmentally unacceptable, with many large exceedances of the WQOs. These results indicate that fill material will have to be retained during sand filling to prevent loss of excessive fines to the water column, so sea walls should be in place before backfilling commences.

Cumulative impacts involving other projects, such as dredging for Container Terminal 9 and sand winning and backfilling at the South Tsing Yi Marine Borrow Area (STY MBA), were also considered in the assessment. Predicted impacts on levels of SS, dissolved oxygen and ammonia were found to be environmentally acceptable, although this conclusion relies on backfilling rates at South Tsing Yi not increasing significantly over current levels. It was therefore recommended that backfilling rates at the STY MBA and associated SS levels at selected SRs be monitored as part of the environmental monitoring and audit programme for the construction phase, and that dredging activity be regulated as required to prevent unacceptable impacts.

A range of mitigation measures have been developed and recommended as a result of the assessment, including constraints on dredging which corresponded to environmentally acceptable scenarios, implementation of silt curtains, reduction by one in the number of large dredgers working on the flood tide for Scenario 2 and recommended dredging methods, procedures and practices.

13.3.2 *Operational Impacts*

This part of the assessment examined the potential impacts of discharges of heated power station cooling water and residual chlorine, and potential changes in the local sedimentation regime.

Evaluation of Thermal Impacts

The assessment of the thermal discharge considered the same three types of scenarios as the hydrodynamic impact assessment (Section 13.3.1), and simulations were undertaken for a 15-day spring-neap tidal cycle in both wet and dry seasons. Results were used to determine the plan area of different contours of incremental temperature rise for the various scenarios and tidal conditions, and the temperature change at each of the SR stations.

The assessment found that the WQO (no more than 2°C rise) was met at all of the SRs, even with the combined discharges of the existing and proposed power stations and the WEIF.

Assessment of Chlorine Impacts

Both the existing and proposed power stations will discharge chlorine (which is used as an anti-fouling agent), and it was assumed that the proposed WEIF would use sea water for plant cooling. The dispersion and decay of residual chlorine in the marine environment was therefore modelled to assess potential water quality impacts.

HEC will commit to exploring the possibility of lowering the residual chlorine discharge concentration and of the potential for using alternative biocides.

It was found that the cumulative scenario of discharge from the Lamma Extension and the WEIF would only lead to localised impacts above acceptable concentrations of chlorine and so was found to be environmentally acceptable.

Assessment of Sedimentation Changes

This assessment was based on the hydrodynamic modelling for the construction phase which predicted tidal flow patterns in the vicinity of the reclamation. It was concluded that there would be no significant changes to either the tidal or sedimentation regimes as a result of reclamations constructed for the Lamma extension and WEIF projects. No significant changes in current speeds or flushing capacities were predicted, so the potential for additional erosion or deposition at the seabed was considered to be minimal.

Conclusions

This assessment concluded that the water quality impacts of the project would be acceptable, provided that the recommended mitigation measures are implemented. In particular, some regulation of dredging work at the site may be required to prevent cumulative impacts at some sensitive receivers from exceeding acceptable levels for suspended solids.

13.4 NOISE ASSESSMENT

13.4.1 Construction Impacts

The potential noise impacts of dredging, reclamation, piling, civil, structural, building and other construction work for the Lamma Extension project were assessed in this part of the noise assessment (*Section 6*).

Based on recognised data on sound power levels for the machinery and equipment to be used, and equipment inventories and work schedules for different phases of the project, noise levels at identified Noise Sensitive Receivers (NSRs) were estimated. The assessment found that predicted levels for both piling and general construction work were environmentally acceptable, even if work during hours restricted by the NCO is undertaken.

13.4.2 Operational Impacts

The operational noise assessment considered the potential impacts of all significant noise sources in the proposed power station complex, including gas and steam turbines, generator plant, heat recovery systems, and a wide range of electrical and mechanical equipment items (eg pumps, motors, fans and transformers).

Sound power levels in octave bands were assigned to each of the major external sources, and general equipment noise and internal turbine hall noise levels were estimated. A computer model of the plant was developed to predict the noise levels resulting from the large number of sources involved, taking into account atmospheric attenuation and the barrier effects of existing and proposed buildings and the local terrain.

The predicted noise levels at the nearest NSR at Hung Shing Ye were estimated for the combined impacts of both the existing and proposed power stations (see *Table 13.4a*).

The new plant will generally give rise to levels below those of the existing plant at this location. However, under the quietest operational states of the existing plant, cumulative plant noise levels may be increased slightly due to new plant operation, but at the higher operational loads, the new plant will not create any significant increases in overall plant noise exposures at the NSRs. Indeed, because the older plant will be operating at reduced total load following commissioning of the proposed extension, overall noise levels may actually decrease, particularly at night.

Table 13.4a ***Predicted Noise Levels - Hung Shing Ye/Tai Wan To ($L_{eq,\ 30min}$ dB(A)) - Facade Corrected.***

	New Plant	Existing Plant*	New + Existing
Daytime	45.1	summer 54.2	54.7
		winter 51.2	52.2
Nighttime	45.1	summer 47.6	49.5
		winter 47.6	49.5

Note:

* Based on the conservative estimates in Part B, Section 6.3.5, with a 2.5 dB façade correction added. Note, these levels are conservative estimates of the existing plant operation as they will inevitably contain some contributions from natural noise sources such as insects, wind, waves, etc.

At locations to the north of the existing plant (eg Wang Long, Ko Long), the existing buildings and the terrain act as barriers, significantly reducing noise levels due to the new plant to 30 dB(A) and below. At these locations, noise levels will be dominated by noise from the existing plant so any change is likely to be downwards for the reasons noted above.

On the basis of this assessment, plant noise during normal operation is not expected to give rise unacceptable environmental impacts, assuming the general utilisation of commercially-available low noise plant and equipment.

Noise levels may exceed the 85 dB(A) equipment specification during start up and high pressure steam venting or when certain emergency equipment (eg fire pumps) is operating. These sources may be audible in the local community under these conditions. However, assuming that the mitigation measures recommended in the assessment are implemented, and given the intermittent nature of such events, this is unlikely to give rise to significant noise impacts.

The assessment in *Section 6* also provides detailed guidance on approaches to mitigation for a variety of machinery and equipment to be used in the proposed power station. A further noise study during the detailed design of the plant is recommended to further refine the operational noise estimates. Noise compliance tests are recommended for major items of equipment, and a major noise survey after plant commissioning is proposed.

Conclusions

Both the construction and operational noise impacts for the proposed power station are environmentally acceptable.

13.5 *LANDSCAPE AND VISUAL IMPACT ASSESSMENT*

Section 7 of this Report provides an assessment of the landscape and visual impacts of the power station component of the project. The main potential impacts considered were the reclamation and power station construction works, the two chimneys serving the power station gas turbine units, two main power station buildings, two administration buildings and two raw water tanks to be located on the Lamma Extension. Sensitive receivers were identified on Lamma Island, Hong Kong Island, Cheung Chau, the West Lamma Channel, Discovery Bay, Mui Wo and Stanley, and views (photomontages) with the new development were produced for evaluation.

Views from many of the more populated areas on Lamma Island will be obstructed by the Po Lo Tsui headland, while those from many of the smaller villages and the recreation areas are largely impeded by the existing power station. Even the partial views that are available from some locations are not considered to have significant adverse impacts, as the existing station is larger and closer to viewers. However, the new station will be visible from Lo So Shing Beach as a separate entity.

For some of the more distant viewers, only the tops of the new chimneys will be visible, while for others the intervening distance and/or the existing visual character of the area (which is dominated by the existing power station) will reduce the expected impacts to negligible or acceptable levels.

Conclusions

The assessment has concluded that landscape and visual impacts will be acceptable **with the implementation of the proposed mitigation measures.** A number of mitigation measures are recommended to minimise potential visual impacts, including site layout, the form and arrangement of buildings and structures, the use of appropriate colours on particular features such as buildings and chimneys, and landscaping along the edges of the reclamation.

13.6 *WASTE ASSESSMENT*

Section 8 presents an assessment of potential impacts from the generation, handling, storage, collection and disposal of wastes arising from the construction and operation of the proposed power station at the Lamma Extension. Estimates were made of the types and quantities of waste that are expected to arise during each phase of the project. Options for waste minimisation, recycling, storage, collection and disposal of waste were examined, and measures for minimising the environmental impacts due to waste handling and disposal of wastes were recommended.

Construction Waste

Types of construction waste that were evaluated included dredged and excavated material, construction and demolition waste, chemical waste and general refuse.

To reduce the quantity of dredged material a reclamation method has been recommended which limits dredging to areas under the seawall and the northern half of the reclamation, thus reducing material arisings by 15%. This material is uncontaminated, and about 5.2 Mm^3 will require disposal at designated dumping grounds at an average rate of about 44,000 m^3 per day.

Arisings of excavated material are not expected to be significant, but at least 7000 m^3 of construction and demolition waste are anticipated. Chemical wastes are not expected to present a problem if recognised practices for minimising, handling and disposal of these wastes are followed. About 600 kg per day of general refuse is expected to arise during construction.

Operational Waste

This part of the assessment examined potential arisings of industrial and chemical wastes, sewage and general refuse. No significant impacts or concerns were identified for any of these waste types.

Mitigation Measures

Detailed mitigation measures based on the accepted hierarchy of waste management were developed for managing waste arisings during both construction and operation of the proposed project. These include:

- practices and procedures for minimising arisings of waste building products and materials, and industrial and chemical wastes;
- on-site reuse of excavated materials and other clean spoil;
- safe storage of chemicals and chemical wastes; and
- acceptable disposal options for different types of waste, such as dredged material, clean construction waste, chemical waste and general refuse.

Conclusions

No unacceptable waste impacts are expected from the construction and operation of this project.

13.7 LAND CONTAMINATION ASSESSMENT

The assessment of the potential for land contamination associated with the operation of the proposed power station (*Section 9*) focussed primarily on the light gas oil system for the power station, and the storage and handling of chemicals and other dangerous goods.

In particular, the assessment evaluated the design and engineering measures, operating and emergency procedures (including inspection and monitoring arrangements, and reporting and recording of incidents), material and waste management practices, and drills and training activities, that are proposed by HEC to prevent, and in the last resort, manage the consequences of spills, leaks and other losses during the storage, transfer and handling of the light gas oil.

In addition, the assessment proposed a series of preventative measures to minimise the potential for spills and subsequent contamination from the storage and handling of chemicals and chemical wastes.

Conclusions

The assessment concluded that the potential for land contamination would be minimal if the proposed measures are implemented.

13.8 MARINE ECOLOGY ASSESSMENT

The assessment of potential impacts on marine ecological resources (habitats and species) which is presented in *Section 10* has considered both the direct and indirect potential impacts during the construction and operational phases of the project.

13.8.1 Baseline Conditions

The baseline conditions for the assessment were established through a review of the available literature and field surveys. Based on this work, the following marine ecological sensitive receivers were identified:

- high ecological value subtidal habitat at Ha Mei Tsui (SW Lamma);
- Finless Porpoise habitat in the coastal waters off southwest Lamma (as defined by the main area where finless porpoise populations have been observed); and
- the potential South Lamma Marine Park or Marine Reserve.

The ecological values of hard and soft bottom habitats in the potentially affected areas along the west coast of Lamma were then evaluated using the criteria in Annex 8 of the Environment Impact Assessment Ordinance Technical Memorandum (*EIAO TM)*, which yielded the following overall assessments:

- *Low* ecological value habitats with low diversity and abundance including: sandy shores, hard bottom subtidal habitats at West Lamma Coast from Yung Shue Wan to Lo So Shing (sites T1 - T4), soft bottom subtidal habitats of the reclamation site and marine waters close to the power station;
- *Medium* ecological value habitats with key features being lack of disturbance, size and moderate conservation interest including: rocky intertidal habitats along the west coast of Lamma and, hard bottom subtidal habitats at Ha Mei Tsui North (site T5); and,
- *High* ecological value habitats with high conservation interest including: hard bottom subtidal habitats at Ha Mei Tsui South (site T6), and marine waters off the southwest coast of Lamma supporting finless porpoise population,

13.8.2 Impact Assessment

Direct impacts during *construction* will include direct loss of habitat due to the reclamation and indirect impacts due to water pollution. During the *operational* phase adverse impacts may be caused by the thermal discharge and residual chlorine in cooling water, and by entrainment or impingement of organisms in cooling water intakes.

Based on the results of the modelling work undertaken in the water quality assessment for the power station and an evaluation of the impacts in accordance with the *EIAO TM*, potential impacts to marine ecological resources during the construction phase of the project may arise from direct disturbances to habitats, or through changes to key water quality parameters, as a result of the reclamation for the Lamma Power Station Extension. No impacts are predicted to the medium value intertidal habitats identified from the field surveys. Subtidal assemblages of high ecological value (Ha Mei Tsui) are also not predicted to be impacted by either the construction or operation of the power station extension. Although the soft bottom habitat within the area to be reclaimed will be permanently lost, this habitat is of low ecological value.

Critical habitats utilised by the finless porpoise (eg coastal waters of southwest Lamma) are not predicted to be affected by either construction (dispersion of sediment plumes, vessel traffic, construction underwater noise) or operation (dispersion of cooling water and biocides, and vessel traffic) of the power station extension. The potential south Lamma marine park / marine reserve is not predicted to be impacted by either the construction or operation of the power station extension.

Mitigation measures specific to marine ecology include the provision of greater than 31,000 m^2 of rubble mound seawalls on the western and southwestern edges of the reclamation to facilitate recolonisation by soft corals and gorgonians. These low density assemblages cover an area of 30,000 m^2 located within the reclamation site and will be lost during construction of the power station extension. Other mitigation measures designed to mitigate impacts to water quality to acceptable levels (compliance with water quality objectives), including constraints on dredging, the use of silt curtains and site platform filling operations, are also expected to mitigate impacts to marine ecological resources.

Mitigation measures designed to avoid impacts of vessel traffic to marine mammals, were complied in consultation with Dr Tom Jefferson of the Ocean Park Conservation Foundation, include the rerouting of all vessels involved in construction or operation of the power station extension so they approach the power station from the north or via the East Lamma Channel. During construction stage, all usage of percussive piling works will only be performed on reclaimed land to avoid noise impact to marine mammals. This is expected to mitigate impacts to the finless porpoise centred off the southwest coast of Lamma Island.

The residual impacts occurring as a result of construction and operation of the power station extension are the direct loss of the low ecological value subtidal assemblages present within the reclamation site and the indirect loss of the low ecological value assemblages outside of the reclamation site. The loss of the habitat within the reclamation site can be partially mitigated through the provision of rubble mound seawalls on which soft corals and gorgonians assemblages (lost during the reclamation) can colonise and grow. This mitigation measure coupled with the finding that the habitat is of low ecological value combine to reduce the magnitude of the residual impact to acceptable levels. The assemblages lost outside of the reclamation site are of low ecological value and are expected to recolonise once construction works have ceased. In the light of this the residual impact is considered to be acceptable.

An ecological monitoring programme involving the use of a remotely operated vehicle will be conducted to monitor predicted impacts to the soft corals and gorgonians adjacent to the reclamation site and to report on the progress of recolonisation of the rubble mound seawalls once construction works have ceased. As an additional habitat enhancement measure HEC have undertaken to deploy a minimum of 400 m^3 of Artificial Reefs in Hong Kong waters at a site (or sites) to be decided upon in consultation with the Director of Agriculture and Fisheries.

Further monitoring and audit activities specific to marine ecology are not deemed necessary as those conducted to detect and mitigate any unacceptable impacts to water quality will serve to protect against unacceptable impacts to marine ecological resources.

13.9 FISHERIES IMPACT ASSESSMENT

As with marine ecology, the fisheries impact assessment (*Section 11*) considered both direct and indirect impacts on fisheries resources, fishing operations and fish culture activities during construction and operation of the power station component of the project. Potential impacts associated with loss of fishery areas and habitat which supports fisheries, increased pollution during construction, and the impacts of cooling water and chlorine discharges during the operational phase, were evaluated. A red tide assessment was also undertaken.

13.9.1 ***Baseline Conditions***

A desk top study was undertaken to establish the baseline conditions for the assessment, and the importance of fishery resources in areas that may be adversely affected by the project. The size and value of the catches for the Fishing Zones within the Study Area characterise them as of medium to high importance to Hong Kong fisheries. Specific areas to the south of Hong Kong are also recognised as spawning and nursery areas for important and high value commercial species, and these were established as sensitive receivers for the purposes of the assessment.

13.9.2 ***Impact Assessment***

Direct impacts during *construction* will include loss of habitat due to the reclamation (including approximately 22 ha of seabed, about 5% of the Po Law Tsui Fishing Zone which equates to a 0.05% decrease in the value of Hong Kong fishery and is regarded as low), and indirect impacts due to water pollution. During the *operational phase* adverse impacts may be caused by the thermal discharge and residual chlorine in cooling water, and by entrainment or impingement of organisms in cooling water intakes. Based on the results of the water quality modelling exercises, it is expected that the largest impacts during construction will be localised to within and around the construction works, and that fisheries resources will not be significantly affected.

The results of the thermal plume modelling for the power station show that the cooling water effluent is not predicted to raise the temperature of the water column to levels higher than those with the existing power station. It should be noted that the cooling water requirement for a combined cycle plant is only about half of that of a coal fired plant with the same MW output. Although the MW demand in 2012 is higher than that in 2002 (3916MW vs 2794MW) by 40% during peak demand time, the total cooling water quantity for both existing and

Lamma Extension is increased by less than 10% since the more efficient gas-fired units will be on base load and that fewer coal fired units need to be run compared with that in 2002. In fact, for most of the time throughout the year, the quantity of the cooling water required for existing and Lamma Extension combined in 2012 is less than that for the existing units alone in 2002, hence the thermal plume and entrainment impacts are not expected to be worse than existing conditions.

Significant residual chlorine levels are only likely to occur in close proximity to the outfall in the surface layers of the water column. Lethal or sublethal effects are not expected to occur to fisheries resources as research has indicated that adult fish will avoid areas where concentrations are elevated.

An extensive literature review and analysis was also undertaken to examine the relationship between elevation in water temperature and the occurrence of red tides. This analysis indicated that discharges with elevated temperatures are not thought to be the primary cause of red tides or harmful algal blooms, and that conditions arising from cooling water discharges from the new power station are not conducive to the initiation of a red tide or harmful algal bloom.

The assessment identified habitat loss in the Po Law Tsui fishing zone as a residual impact. The combination of the small area affected and the low dependency on the area by local fishermen (about 0.05% of catch value) combine to reduce the magnitude of this residual impacts to acceptable levels. It should be noted, however, that permanent loss of fishing ground may be subject to claims for *ex gratia* allowances which are administered by the Planning Environment and Lands Bureau.

The additional discharge of residual free chlorine in close proximity to the power station was also identified as a residual impact. However, as the concentration of chlorine is low in this area (0.01 mg L^{-1} - below field detectable levels) and below the level at which toxic effects have been demonstrated to occur for fish eggs, fry and adult, the severity of this residual impact is considered to be low.

The loss of fishing area can be partially mitigated through the provision of rubble mound seawalls on which more diverse and abundant ecological assemblages than present in the existing flat muddy seabed can colonise and grow. This may enhance the value of the area to the fishery by providing habitat for juvenile and spawning resources that is not present on the existing flat muddy seabed of the reclamation site.

In summary, based on an evaluation of impacts in accordance with the *EIAO TM*, it was concluded that the expected impacts during both construction and operation would be acceptable.

13.10 Hazards Assessment

Risk assessments for both the fuel gas-related and non-fuel gas hazards associated with operation of the proposed power station were carried out (see *Section 12*). The assessment of fuel gas-related hazards, which examined loss of containment, internal explosion and mechanical failure events, was qualitative, and a more detailed assessment is required at the detailed design stage. The non-fuel gas hazards examined include the light gas oil system, the use of hydrogen within the plant, and the handling of packaged dangerous goods.

Assessment of Fuel Gas-Related Hazards

For the gas receiving station and other fuel gas system facilities at the power station, loss of integrity is the primary hazard, but there are additional hazards associated with internal explosions within items of equipment and catastrophic failure of rotating machinery.

The consequences of a major release of fuel gas could be severe with little scope for protection or escape. For releases which are ignited a large fireball or flash fire may result, with fatal effects extending several hundred metres from the release location. The siting of the gas receiving station is generally favourable from an off-site risk perspective as it lies over a kilometre from the nearest residential population. Therefore, in the event of an accident, the effects would be largely confined to the transient marine population.

Various standards and codes of practice exist for high pressure systems such as gas receiving stations and other fuel-gas facilities at the power station. These standards recognise all of the hazards which have been identified and offer a variety of design solutions. One issue worthy of particular mention, however, is the design of the acoustic enclosure for the gas turbines. In their *Interim Advice Note on Health and Safety at CCGT and CHP Plant*, the UK Health and Safety Executive cite evidence that, despite provision of dilution ventilation, air distribution in enclosures is often inadequate, giving rise to the hazard of a gas explosion. This issue will require careful tracking through the design, construction, testing and commissioning of the power station.

One further issue which emerges from the risk assessment for the gas receiving station is the importance of safety management. Whilst the standards of "hardware" on gas-fired power plant may be similar, the standards of "software" (eg people, training, organisation) may vary considerably and this is a key determinant of the risk posed by such facilities to the public. The need for effective safety management arises from the recognition that most industrial accidents have their root cause in human error. An effective safety management system will assist HEC in meeting the requirements which GSO may impose when HEC come to apply for registration as a gas supplier.

It was concluded from the high level qualitative review of fuel-gas hazards that the risks associated with the proposed new power station are acceptable.

Assessment of Non-Fuel Gas Hazards

A systematic assessment was undertaken of the hazards posed by the transport, storage and handling of non-fuel gas dangerous goods (DGs) for the Lamma Extension project. This covered the alternative fuel (light gas oil) system, the additional hydrogen piping to be provided for generator cooling at the Lamma Extension, and the various packaged DGs which will be stored and handled at the power station. The assessment also reviewed possible incidents involving the non-fuel gas facilities (including the existing power station) which could escalate to involvement of the fuel-gas facilities.

The hazards associated with the light gas oil system relate mainly to fire, although explosion is also possible in certain circumstances. An assessment of the thermal radiation levels which could arise in a major fire at the Lamma Extension shows that they will not exceed injury levels at the nearest residential population on Lamma, but may be exceeded beyond the site boundary in the immediately vicinity of the LGO storage area and the LGO unloading jetty. This is unlikely to lead to fatal injury, however, as these areas are not routinely accessed by the public. The effects of an explosion involving the light gas oil system would be largely confined to the Lamma Extension site itself and are also unlikely to lead to fatal injury off-site.

The hazards of hydrogen relate to fire and explosion. The effects of an incident involving hydrogen, however, would not lead to fatal off-site injury, as the additional hydrogen pipework to be provided for this project is small bore, and operating at relatively low pressure.
The various packaged DGs to be stored at the site present a hazard in terms of fire, explosion, toxic injury (due to the generation of toxic fuel-gases by fire, decomposition or chemical reaction) and projectiles (rocketing of drums and cylinders in a fire). The toxic products released in a fire may cause injurious effects at the site boundary (eg respiratory difficulties) but are unlikely to lead to fatal effects. Furthermore, the relatively small quantities of DGs stored mean that the effects of fire, explosion or accidental mixing of chemicals (leading to toxic fuel-gas release) are also unlikely to have any significant off-site effects.

Various types of potential incidents at the Lamma Extension site could escalate to involve the fuel-gas facilities, including a major fire or explosion at the new DGs store, a fire involving the alternate fuel system (in the vicinity of the gas turbines), and catastrophic failure of pressure vessels or rotating machinery. However, the fuel-gas facilities at the Lamma Extension are well located with respect to incidents which could arise from other sources. They also include design safety features typical of such installations, including an emergency shutdown valve on the main gas supply pipeline and an emergency depressurising and flare system.

It was concluded from the risk assessment undertaken for the transport, storage and handling of non-fuel gas DGs that it is highly unlikely that there could be fatal injuries to persons off-site due to accidents involving these DGs. Based on the information available for this assessment, the combination of conditions that could conceivably lead to a fatality was considered to be incredible, and therefore no formal quantitative assessment of risks has been made in this report. However, for illustration purposes, a simple, "order of magnitude" quantitative risk assessment was undertaken for two scenarios in which fatal effects at the site boundary could conceivably arise. The assessed risks were at least two orders of magnitude below the accepted Risk Guidelines.

Conclusions

No unacceptable risks associated with either the fuel gas-related or non-fuel gas hazards were identified during the assessment. A more detailed risk assessment of the fuel-gas related hazards will be required when more detailed project information is available.

13.11 CONCLUSIONS

A detailed and comprehensive assessment of the potential impacts of the proposed new power station and associated facilities at the Lamma Extension site has been completed. No unacceptable or insurmountable impacts (including cumulative impacts associated with other projects and activities) are expected from the proposed development, provided the recommended mitigation measures are adopted and implemented.